Revision Schedule

Final Economic Analysis
June 2009

Rev	Date	Details	Prepared by	Reviewed by	Approved by
01	20th October 2008	First Draft	**John Miller** Transport Economist	**Simon Roberts** Technical Director	**Martin Edge** Director
02	27th November 2008	Final	**John Miller** Transport Economist	**Simon Roberts** Technical Director	**Martin Edge** Director
03	31st January 2009	Revised final with WTP	**John Miller** Transport Economist	**Simon Roberts** Technical Director	**Martin Edge** Director
04	11 June 2009	Revised final inc. IFC comments	**John Miller** Transport Economist	**Simon Roberts** **Technical Director**	**Martin Edge** **Director**

Scott Wilson
Scott House
Alencon Link
Basingstoke
Hampshire
RG21 7PP
UK
Tel +44 (0) 1256 310200
Fax +44 (0) 1256 310201

www.scottwilson.com

Table of Contents

Abbreviations

AADT	Annual average daily traffic
B/C	Benefit / cost ratio
CBA	Cost benefit analysis
CBCG	Central Bank of Montenegro
DM	Do minimum
DS	Do something
EIRR	Economic internal rate of return
EC	European Commission
EU	European Union
EU15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, UK
EU15+2	EU15 + Norway, Switzerland
EUR	Euro
EURm	Million euros
GDP	Gross domestic product
GOM	Government of Montenegro
HCV	Heavy commercial vehicle
HDM	Highway development model
HEATCO	Harmonised European approaches for transport costing and project assessment
IFC	International Finance Corporation
IRI	International roughness index
km	Kilometre
LB	Louis Berger SAS
LCV	Light commercial vehicle
MTMAT	Ministry of Transport, Maritime Affairs and Telecommunications
NPV	Net present value
O&M	Operation and maintenance
PPP	Public-private partnership
PPS	Purchasing power standard
SP	Stated preference
SW	Scott Wilson
TINA	Transport infrastructure needs assessment
USD	US dollar
VOC	Vehicle operating cost
VOT	Value of time
WB	World Bank
WTP	Willingness to pay

1. Introduction and strategic context

1.1 Introduction

The Government of Montenegro (GOM) is planning to proceed with the construction of the Bar - Boljare motorway. The International Finance Corporation (IFC) has been appointed to act as a lead advisor in the structuring and implementing of a public-private partnership (PPP) for the design, financing, construction, operation and maintenance of the motorway (the “Project”). IFC has in turn contracted Scott Wilson (SW) to carry out various technical analyses, including a review of the economic evaluations carried out by Louis Berger SAS (LB).

This document reports on the work carried out in the field of economics. It considers the economic issues relating to inputs to the traffic model, traffic forecasts and economic evaluation.

This report should be read in conjunction with the Traffic study and the Tolling report. In some sections duplication of text will be found between the three reports: this has been retained to ensure completeness of subject matter in each report.

1.2 Strategic context

In 2007-2008 LB carried out a “Feasibility Study for Two Highways in Montenegro”. One of the two highways is the proposed motorway from Bar to Boljare. The motorway would run from the Montenegrin coast near the port of Bar to the capital Podgorica and on to the Serbian border. At the border it would link up with the proposed Serbian motorway to Belgrade. It would also connect with routes to the regional capital cities of Sarajevo in Bosnia and Herzegovina, Tirana in Albania, Pristina in Kosovo and Skopje in the Former Yugoslav Republic of Macedonia. While the motorway does not form part of the European network of corridors, it is part of the core network of links (Figure 1.1). Furthermore, in April 2009 the Director of the EC Directorate of Transport stated that the Bar - Boljare Motorway will eventually be incorporated in the Trans-European Transport Network. The motorway therefore has a clear strategic role to play in the region.

The viability of the Project would be improved by the construction of the continuation of the Motorway on the Serbian side of the border. Construction of this Motorway was originally due to begin in 2008 but has been delayed due to a failed tender process. Nevertheless, the Government of Serbia has not changed its position of continuing to support the building of a Motorway linking Bar in Montenegro to Belgrade. The Serbian Minister of Transport has recently visited Montenegro and publicly reiterated his Government’s intentions regarding the construction of this motorway. With this in mind, the traffic model developed for the current study assumes that the Motorway from Belgrade to Boljare will be open by the time the northernmost section of the Bar - Boljare Motorway between Berane and Boljare is completed in the year 2016. A sensitivity analysis has been carried out however to consider the possible impact arising from the failure to complete the Motorway on the Serbian side of the border.

Figure 1.1 Strategic road links in south east Europe

Source: SEETO

In Montenegro the motorway is divided into five sections:

- Bar (Djurmani) - Virpazar
- Virpazar - Smokovac
- Smokovac - Matesevo
- Matesevo - Berane
- Berane - Boljare.

It is the intention of the GOM that the section north of Podgorica from Smokovac to Matesevo should be constructed first, followed shortly after by the remaining sections. It is anticipated that the construction of the first section should take four years, whereas the entire motorway is expected to be completed in seven to eight years.

The Government's decision to start construction with the Smokovac – Matesevo section is based on the idea that by linking the north and south of the country this section of the motorway is expected to provide very significant benefits, which reach far beyond the economic and financial benefits that can be quantified in a traditional analysis. For example, the existing road that connects the north of the country with the capital Podgorica is subject to frequent flooding and land slides, which often bring to a full and prolonged standstill the traffic on the only road between the north and south of the country. Such traffic interruptions are extremely disruptive to the economic life of Montenegro and carry a significant, although not easily quantifiable, cost. Although quantification of this and other similar benefits is beyond the scope of the present report, it is nevertheless important to point them out in the context of sequencing of the sections of the Bar-Boljare motorway (see also Section 2.1.3 for further details on the disparities in development of the northern and southern parts of the country).

2. Economic inputs to the traffic model

Section 2 of this report relates principally to inputs for the traffic model.

Traffic forecasts were made using a traffic model which is the subject of a separate report (Traffic Study Report dated June 2009). The traffic model requires several inputs that result from the economic analysis. These include forecasts of socio-economic variables.

2.1 Forecasts

The LB forecasts of traffic were based largely on forecasts of growth in population, GDP and applied elasticities. While this approach is sound in principal, a number of short-comings have been identified which are addressed in the current review.

The revised forecasts are based on conservative and credible assumptions relating to the underlying generators of transport demand. They do not take into account unpredictable events that have an extreme impact - so called “black swans”.

2.1.1 Population

Any increases or decreases in population or in the distribution of population will have a direct influence on the amount of traffic and on traffic patterns.

The regional population forecast of LB was based on the draft of the so-called Physical Plan of Montenegro. This plan has subsequently been updated and renamed the Spatial Plan of Montenegro. The population forecast of the new plan assumes that the Spatial Plan is fully implemented. Table 2.1 shows the forecast used in the LB study. The revised forecast of the Spatial Plan adjusted to the years appropriate for use in the current review is shown in Table 2.2.

A comparison of forecasts of the Physical Plan and the Spatial Plan reveals the following changes:

- the total forecast population of Montenegro has been reduced slightly in the Spatial Plan
- the declining populations of seven municipalities in the Physical Plan have been changed to slightly increasing (or less severely declining) population in the Spatial Plan.

Traffic to external zones is essentially traffic to Serbia. Forecasts of population in Serbia indicate that it is expected to remain more or less constant for the next 20 to 30 years (EPTISA 2007).

Table 2.1 Population forecast by municipality based on draft Physical Plan used by LB

	2007	**2012**	**2017**	**2022**	**2027**	**2032**	**2037**
Andrijevica	5,530	5,230	4940	4670	4750	4830	4920
Bar	42,640	46,140	49920	54010	54960	55930	56920
Berane	35,340	35,680	36030	36380	37020	37670	38330
BijeloPolje	50,820	51,500	52190	52890	53820	54770	55740
Budva	16,780	17,930	19160	20480	20840	21210	21580
Danilovgrad	16,790	17,130	17470	17820	18130	18450	18780
Zabljak	4,360	4,560	4770	5000	5090	5180	5270
Kolasin	9,920	9,870	9830	9790	9960	10140	10320
Kotor	22,050	20,980	19960	18990	19320	19660	20010
Mojkovac	9,310	8,450	7670	6960	7080	7200	7330
Niksic	75,340	75,410	75470	75540	76870	78220	79600
Plav	14,940	16,480	18190	20070	20420	20780	21150
Pluzine	3,900	3,490	3120	2790	2840	2890	2940
Pljevlja	35,130	34,310	33510	32720	33300	33890	34490
Podgorica	175,300	183,330	191720	200500	204030	207630	211290
Rozaje	23,890	25,470	27160	28960	29470	29990	30520
Tivat	14,210	14,970	15770	16610	16900	17200	17500
Ulcinj	21,770	23,770	25960	28340	28840	29350	29870
HercegNovi	34,010	35,280	36590	37950	38620	39300	39990
Cetinje	18,010	17,440	16880	16340	16630	16920	17220
Savnik	2,820	2,660	2510	2370	2410	2450	2490
Montenegro	632,860	650,080	668,820	689,180	701,300	713,660	726,260

Source: Louis Berger SAS (2008) Technical Memorandum no. 2, Table 4.

Table 2.2 Revised population forecast by municipality based on Spatial Plan

	2003	**2007**	**2016**	**2021**	**2026**	**2036**
Andrijevica	5785	5,789	5,797	5,802	5904	6008
Bar	40,037	40,822	42,644	43,692	44462	45246
Berane	35068	36,119	38,601	40,053	40759	41477
BijeloPolje	50,284	51,535	54,466	56,166	57156	58163
Budva	15,909	16,366	17,441	18,069	18387	18711
Danilovgrad	16,523	16,588	16,736	16,819	17115	17417
Zabljak	4,204	4,187	4,150	4,129	4202	4276
Kolasin	9,949	9,911	9,825	9,778	9950	10126
Kotor	22,947	23,116	23,502	23,719	24137	24562
Mojkovac	10,066	10,236	10,628	10,853	11044	11239
Niksic	75,282	76,892	80,641	82,802	84261	85746
Plav	13,805	14,187	15,085	15,609	15884	16164
Pluzine	4,272	4,257	4,222	4,203	4277	4352
Pljevlja	35,806	36,072	36,678	37,019	37671	38335
Podgorica	169,132	175,155	189,501	197,973	201462	205012
Rozaje	22,693	24,003	27,233	29,212	29727	30251
Tivat	13,630	13,789	14,152	14,358	14611	14869
Ulcinj	20,290	20,658	21,511	22,000	22388	22782
HercegNovi	33,034	33,264	33,788	34,083	34684	35295
Cetinje	18,482	18,428	18,307	18,240	18561	18889
Savnik	2,947	2,911	2,831	2,787	2836	2886
Montenegro	620,145	634,284	667,741	687,366	699,479	711,806

Source: Spatial Plan of Montenegro until 2020, Table 11, and Consultant's analysis

2.1.2 GDP

The LB study based GDP forecasts on those of the Central Bank of Montenegro (CBCG) for the period 2006 - 2020[1]. The CBCG "most likely" scenario forecasts average growth in total GDP of 6.0 percent per year and 5.4 percent per year in terms of GDP per capita. This was assumed by LB to continue to 2021, with slightly lower growth rates thereafter in keeping with the greater level of uncertainty that is inherent in longer term forecasts. Thus the assumed rates of growth of GDP per capita were 3.6 percent per annum during the period 2022 to 2027 and 2.4 percent per annum between 2028 and 2037.

However, in the current economic climate, the short-term forecast may be regarded as somewhat optimistic. The most recent IMF country report for Montenegro[2] presents a lower forecast as shown in Table 2.3.

Table 2.3 GDP / capita forecast annual growth rates for Montenegro

Year	Percent per year
2008	5.40*
2009	2.00
2010	2.00
2011	4.00
2012	4.50
2013	4.50

** Actual data*
Source: IMF

From 2014 onwards, the CBCG forecasts were used. The combined IMF / CBCG forecasts were adjusted to average annual rates of growth for the time periods being used in the current review. . The resulting rates are shown in Table 2.4.

Table 2.4 GDP / capita annual growth rates for Montenegro

Period	Percent per year
2007 - 2016	3.98
2017 - 2026	4.5
2027 - 2036	2.5
2037 - 2046	2.4

Source: IMF and Consultant's analysis

The CBCG[3] reports that the share of the grey economy in GDP is estimated at 15 to 30 percent. This activity is not fully reflected in published statistics. Thus, it may be assumed that in the future activity will gradually transfer from the grey economy to the official economy. This will have the apparent effect in the figures of more rapid growth than is experienced in reality. The objective of forecasting economic activity in this study is ultimately to produce forecasts of traffic which is related to real growth. The growth rates used in this study may therefore produce levels of GDP that appear low, but these levels do not include the legitimisation of activities currently being carried out in the grey sectors. An alternative way of regarding this issue is to assume that currently published economic data may underestimate the true situation. However, as an input to the mechanism for forecasting traffic, this is of no significance. This study adopts a "broadly credible" approach rather than an "inaccurately precise" approach - that is to say, the economic forecasts are considered in broad terms of general rates of growth over longer periods that are considered realistic, rather than detailed rates of growth per year which would inevitably not be accurate.

It is interesting to note that the CBCG puts Montenegro and Serbia at the same level in terms of GDP per capita at PPS. In 2006, both countries were estimated to be at 33 percent of the level of the EU27.

[1] Louis Berger SAS (2008) Technical Memorandum no. 13A, General Traffic Forecast - Revision
[2] http://www.imf.org/external/pubs/ft/scr/2009/cr0988.pdf

[3] CBCG (2008) Chief Economist Annual Report 2007

Nevertheless, this does not necessarily imply that the toll rates per kilometre that could be supported would be the same. The actual rate that drivers are prepared to pay depends on the perceived benefits, and these vary with local conditions. Benefits in terms of time and accident cost savings may be very much higher in the mountainous environment of Montenegro compared with Serbia. In addition, the absence of suitable alternative routes makes a new Motorway very attractive due to significant time savings. This is clearly demonstrated by the relatively high tolls that drivers are prepared to pay to use the Sozina tunnel. For example, the toll charged for cars at Sozina is €2.5 which equates to about €0.77 per Km whilst the toll charged for the largest trucks is €18 which equates to about €4.2 per Km.

A "willingness to pay" survey was carried out during the course of the current study and is reported separately. For completeness, a brief summary of the willingness to pay (or stated preference survey) is included below.

A Stated Preference (SP) survey was carried out to provide values of time for drivers of cars and freight vehicles within the framework of the Bar – Boljare Motorway Project. Results of this survey can be found in the separate SP report, but the main conclusions are presented below.

Time and cost of travel are highly correlated in reality. Furthermore, the new motorway alternative which could be chosen does not yet exist. Therefore, computer assisted interviews were conducted with drivers travelling along the Bar – Boljare corridor. Assuming a hypothetical choice situation, drivers were asked to choose between the actual mountainous route and the proposed new motorway. Travel times were related to the actual trip of the interviewees. Using several different choice situations, travel times and toll levels were varied systematically between 6 and 12 eurocents per km for car drivers and up to 20 eurocents per km for drivers of freight vehicles.

In December 2008, 376 valid interviews were conducted on the Bar – Boljare corridor, north and south of Podgorica. Since the share of cars exceeds the share of freight vehicles interviewers explicitly tried to stop drivers of light goods vehicles (LGV ≤ 3.5 tons maximum gross weight) and heavy goods vehicles (HGV ≥ 7.5 tons) in order to allow for estimation of cost functions for both vehicle groups.

Almost all car trips (86%) and LGV trips (88%) had their origin and destination within Montenegro. Around 50% of the trips were lasting for less than 90 minutes and 120 minutes, respectively. Only HGV showed 50% of trips lasting longer than six hours. International traffic was travelling mainly between Montenegro and Serbia. Based on the collected information, the average speed was calculated to be around 60 km/h for cars, but only 46 km/h for LGV and HGV.

Most of the drivers of freight vehicles were in charge to decide whether to use a tolled motorway or not. Three quarters and two third of the drivers of LGV and HGV, respectively, stated that they were in charge to make that decision. Those who worked on their own account usually also owned the vehicle they drove whereas those who decided on behalf of their company usually did not own the vehicle they drove.

The willingness to pay for savings in travel time is almost 4 euro/h for drivers of cars, around 9.5 euro/h for drivers of LGV, and 16 euro for drivers of HGV[4]. Though, for all three groups there is a willingness to pay for the motorway for other reasons, presumably for gains in safety. Almost all drivers agreed with the statement that 'driving on the motorway would be much safer compared with the mountainous road'. Further, almost all of these drivers agreed with the statement that 'the gain in safety would be almost completely due to avoiding some dangerous sections of the existing roads'.

The willingness to pay for the motorway is around 7 euro for drivers of cars and around 6 euro for drivers of LGV. For drivers of HGV the willingness to pay for the motorway is around 13 euros. Sensitivity analysis showed that drivers of larger vehicles were often prepared to pay more than 20 cent per km regardless of savings in travel time. Therefore, the high willingness to pay for the motorway itself partly accounts for savings in travel time of the large vehicles.

The calculation of market shares of the motorway were demonstrated for cars, LGV, and HGV for different distances of trips. Results showed quite an elastic demand of cars and LGV whereas demand of HGV seemed to be rather price inelastic.

[4] This does not directly correspond to values of times and cannot be used directly in the traffic model.

Most of the drivers disagreed with the statement 'the gains in safety would only occur in winter'. Therefore, the results can be assumed to have no seasonal bias.

Further details of the SP survey can be found in the SP survey report.

In the traffic model, traffic to and from external zones is predominantly traffic to and from Serbia. The IMF forecast of GDP for Serbia to 2014 shown in Table 2.5 has therefore been used for external zones. Beyond 2014, forecasts used in recent traffic studies in Serbia have been used, specifically a GDP forecast of 5 percent per year to 2020 and 4 percent thereafter (EPTISA). The resulting rates for external zones for the time periods used in the current review are shown in Table 2.6.

Table 2.5 GDP / capita forecast annual growth rates for Serbia

Year	**Percent per year**
2008	5.40*
2009	-2.00
2010	0.00
2011	3.00
2012	5.00
2013	5.50
2014	5.50

** Actual data*
Source: IMF

Table 2.6 GDP / capita annual growth rates for external zones

Period	**Percent per year**
2007 - 2016	3.57
2017 - 2026	4.4
2027 - 2036	4.0
2037 - 2046	4.0

Source: IMF, EPTISA and Consultant's analysis

2.1.3 Differential rates of economic development

<u>Regional variation</u>

It is understood that LB applied uniform growth to traffic to and from all zones in the traffic model. This would appear to be confirmed by the following statement:

"It is important to emphasise here that the applied 'uniform growth' of traffic in zones (municipalities) of northern part of Montenegro as well as in zones (municipalities) of southern coastal area assumes basically the faster starting development of northern Montenegrin municipalities and in the future equalisation with development speed in other municipalities, which is also one of the basic aims of the Physical Plan of Montenegro." (Final Report Volume II, p.45)

In reality, it is likely that the rate of economic growth will vary by region. LB addressed this issue in the revised Final Report for the Bar - Boljare Motorway, but the results of the analysis would not have been carried through to the LB traffic model.

One of the objectives of the Physical Plan of Montenegro is to encourage growth in less developed regions. Nevertheless, it may be expected that regional disparities will remain. It is beyond the scope of the current review to do a full analysis of regional disparities, but a review of recent documents facilitates the making of some informed assumptions.

The country can be divided into three geographic regions as follows[5]:

- The southern region - the Mediterranean zone - is the most developed region. It covers 11.5 percent of the territory, has 23.4 percent of the total population and contributes 26.5 percent of the domestic product. The region has excellent conditions for tourism and is also important for the shipping industry and agriculture. The poverty rate is 8.8 percent.

- The central region comprises the municipalities of Danilovgrad, Nikšić, Podgorica and Cetinje. The region covers 35.5 percent of territory, has 45.1 percent of the population and contributes 55.5 percent of the domestic product. In terms of economics, this is the most important region, where the greatest part of domestic product is created by electricity generation, the construction industry, transport and storage, commerce and catering, tourism and agriculture. This region contains 22.4 percent of cultivable land, 25.5 percent of the timber mass and 22.6 percent of the cattle stock, as well as abundant bauxite deposits and a part of the hydro potential. The poverty rate is 10.8 percent.

- The northern region is mountainous and comprises the following municipalities: Andrijevica, Bijelo Polje, Žabljak, Berane, Kolašin, Mojkovac, Plav, Plužine, Pljevlja, Rožaje and Šavnik. The region covers 53 percent of the total territory and has 31.5 percent of the population, but generates only 18 percent of the domestic product. The region has the prevailing part of the total disposable hydro potential, all of the coal reserves processed by the thermal power plant in Pljevlja, 67 percent of the cultivatable land, 71 percent of the total timber mass, 70 percent of the cattle stock and almost all the lead and zinc reserves. It also has resources for the development of winter sports and eco-tourism. However, it is less developed in all aspects than the central and southern regions. This is evident in the domestic product per capita, the rate of unemployment and the poverty rate, which amounts to 19.3 percent.

In the current review, the capital area is considered separately from the central region. As is frequently the case, the capital area reveals a rate of growth and level of investment greater than that in other regions. Specific developments and special development zones (such as the port of Bar) are also considered separately.

The Physical Plan of Montenegro has been updated and renamed the Spatial Plan. It is a general objective of the Spatial Plan to mitigate regional disparities in economic and social development. The concept of the Spatial Plan is shown in Figure 2.1. It is built on a series of:

- Development corridors: areas along which major development activities are focussed. The first of these corridors is defined as Bar - Podgorica - Matesevo - Andrijevica - Berane - Boljare.

- Development zones: areas of interlinked cities and settlements of complementary activities. No development zones are identified in the corridor Bar - Boljare.

- Cross-border development zones: communities with similar problems and potentials to communities across the border. The Plan specifically identifies Berane and Andrijevica in the first zone, Bijelo Polje in the second zone and the Skadar Lake area (including Podgorica and Bar) in the seventh zone.

A Touristic Master Plan for Montenegro (2001) sets out a vision for the development of the tourism industry to 2020. The strategic aim of the plan is that in the summer half-year Montenegro will become a high quality coastal destination, while in winter it will be a niche provider with special products e.g. for winter sports.

The 26,000 hotel beds available in 2001 were to be increased to 50,000 by 2010 and 100,000 by 2020. (By August 2007, the number had reached 31,500.) It was aimed to increase total overnight stays from 3.69m in 2002 to 15.7m in 2010 and 25.9 in 2020. (By 2006, the number had reached 5.94m.)

[5] SEER (2006) Reaching balanced regional development in Montenegro: problems and solutions

These may be seen as maximum values if all necessary investments to facilitate them (including for example the Bar - Boljare motorway) are put in place.

Figure 2.1 Spatial Plan of Montenegro

Source: Spatial Plan of Montenegro until 2020, p.149

<u>The port of Bar</u>

The development of the port of Bar is a potential generator of traffic for the proposed motorway. The port has therefore been considered separately in this review.

The port of Bar currently handles about 2m tonnes of freight per year, an amount that has remained more or less constant during the period 2003 to 2007. In 2007 approximately 12 percent of freight was containerised; container traffic increased from 8,633 TEU in 2003 to 27,095 in 2007. RO-RO traffic constitutes about 4 percent of total freight traffic. In 2006, about 80,000 passengers used the port (Table 2.7).

Table 2.7 Port of Bar traffic 2003 - 2007

	Units	2003	2004	2005	2006	2007
passengers	‘000	n/a	n/a	66	80	n/a
freight loaded	mln. tonnes	n/a	n/a	1.24	1.06	n/a
freight unloaded	mln. tonnes	n/a	n/a	0.92	1.15	n/a
total freight	mln. tonnes	1.92	1.95	2.16	2.21	2.18
Of which:						
liquid bulk	mln. tonnes	0.37	0.46	0.39	0.39	0.45
dry bulk	mln. tonnes	1.03	0.98	1.04	0.79	0.54
general cargo	mln. tonnes	0.52	0.51	0.73	1.03	1.19
container traffic	TEU	8,633	11,434	12,258	17,854	27,095
container traffic	mln. tonnes	0.068	0.085	0.094	0.147	0.264
RO-RO traffic	mln. tonnes	n/a	n/a	0.08	0.09	n/a

Source: SEETO, MTMAT

The current capacity of the port is about 4.5m tonnes per year. However, it is proposed to restructure the organisation of the port, leading to a significant improvement in efficiency, and to invest in equipment and infrastructure. This is expected to result in an increase in capacity to about 10m tonnes per year. For such an increase in traffic to be achieved, investment would also need to be made in the road and / or rail links to the port. The Bar - Boljare motorway would be essential for the further development of the port. Serbian authorities[6] have indicated that their principal seaborne commerce would be transferred from Thessaloniki to Bar, once the complete motorway link from Belgrade to Bar is completed. Nevertheless, such a comment must be treated with a certain amount of caution, since the increasingly privatised commercial sector will be free to choose whichever port offers the most appropriate service. In parallel, upgraded rail infrastructure would influence the proportion of traffic using rail as opposed to road. Assuming necessary investments are made, full capacity of the port might be reached by 2020 .

The LB study identified about 180 truck journeys per day between the port of Bar and the border with Serbia. Assuming full development of the port, from the current 2.1m tonnes pa to 10m tonnes pa, a quadrupling of the number of trucks to 720 per day could be expected by 2020, assuming the modal split between road and rail remains constant.

Table 2.8 Volumes of trucks to / from Bar by corridor section (AADT)

Section	Existing	Growth	Total
Bijelo Polje - Serbia	180	540	720
Berane - Bijelo Polje	230	690	920
Andrijevica - Berane	310	930	1240
Kolašin - Andrijevica	330	990	1320
Podgorica - Kolašin	330	990	1320
Bar - Podgorica	540	1620	2160

Source: LB surveys and Consultant’s analysis

In conclusion, the development of the port will be facilitated by the construction of the motorway. The port of Bar may be expected to have above average growth since investment in port infrastructure is expected to lead to a step-change in tonnage through the port. While the growth of general traffic will not be significantly more than other coastal zones, the growth of truck traffic will be significantly higher as shown in the table above. This is considered explicitly in the traffic model.

Development of the railway

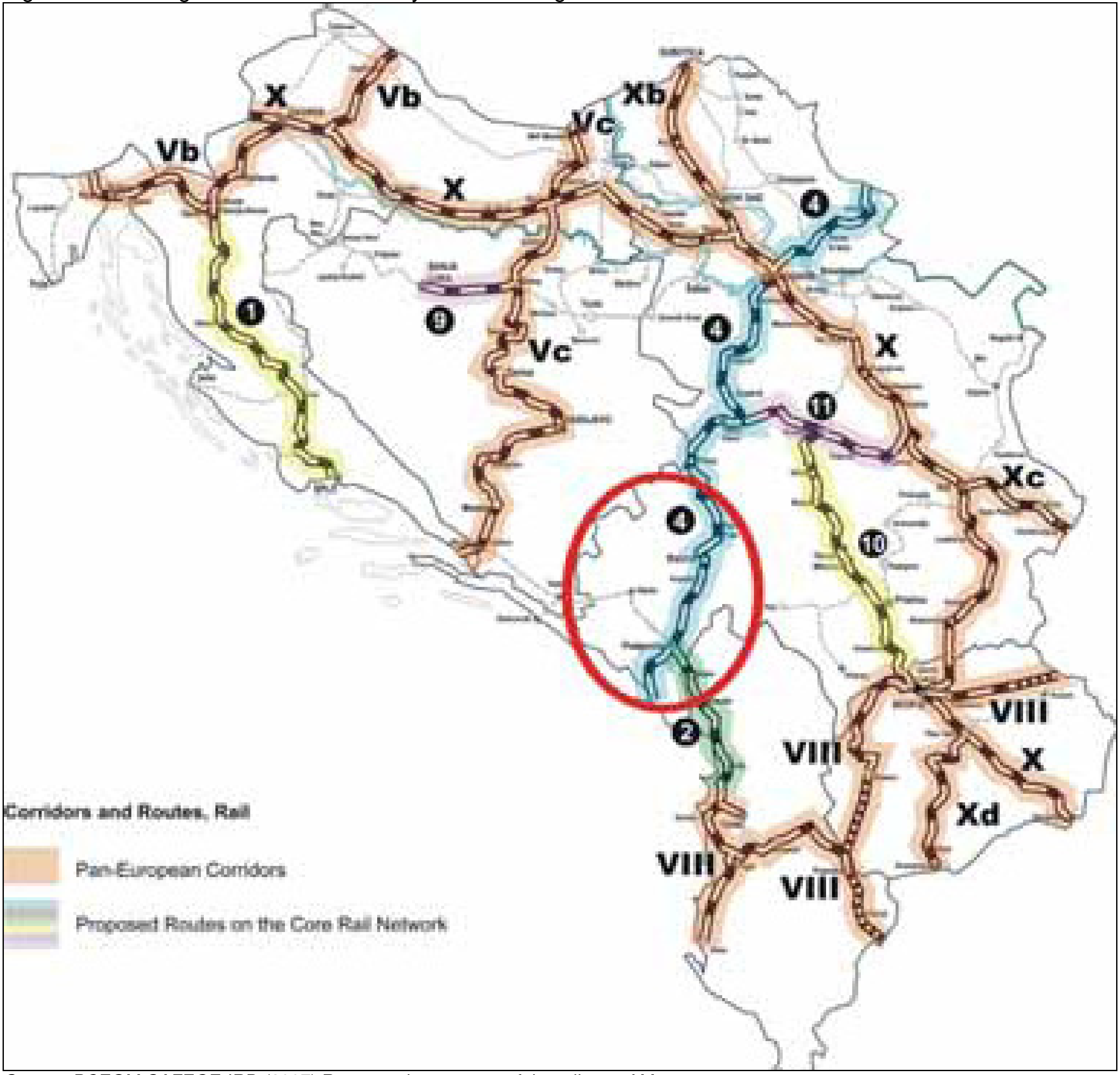
Another potential impact on road traffic in the Bar - Boljare corridor is proposed investment in the railway.

The regional context of railways in Montenegro is shown in Figure 2.2. The backbone of the railway network in Montenegro runs from the port of Bar, through Podgorica to Dobrakovo on the Serbian

[6] Serbian Infrastructure Minister Velemir Ilic, announcement 19 March 2008.

border, ultimately providing a link to Belgrade and Budapest. In addition, there are two branch lines from Podgorica: one to Niksic and one to Tuzi on the Albanian border that links ultimately with Tirana.

Figure 2.2 The regional context of railways in Montenegro



Source: BCEOM-SAFEGE-IRD (2007) Restructuring strategy of the railway of Montenegro

The single track line from Bar via Podgorica to Dobrakovo was completed in 1979 and is 167km long. It is fully electrified and about one third of the route is in tunnel or on viaduct. It is used for the transport of freight and passengers. The total average speed of trains is reduced from a design speed of 70km/hr to 55km/hr due to the condition of the infrastructure. A first stage of rehabilitation was carried out between 2003 and 2007 with a loan of EUR 15m from the EIB. A second stage is planned to be completed by 2012 using a loan of EUR 15m from the EIB, a loan of EUR 34m from the EBRD (EUR 34m) and a grant of EUR 3m from the EAR.

The number of trains per day varies significantly during the year. During the summer season 2008 there were 3 pairs of international trains operating between Bar and Belgrade, 2 pairs of long distance trains operating between Bar and Bijelo Polje and 5 pairs of local trains operating between Bar and Podgorica. The number of freight trains varies between 5 and 15 per day.

The 57km single track line from Podgorica to Niksic was originally built in 1948 as a narrow gauge line but was upgraded to standard gauge in 1965. Since 1992 it has been used solely for freight traffic, mainly carrying bauxite from the Niksic mine to the Podgorica aluminium plant. However, the line is currently being reconstructed and electrified and is expected to begin offering passenger services in 2009.

The single track line from Podgorica to the Albanian border carries only freight traffic at present, although there are plans to reconstruct and introduce passenger services in the future.

Overall, the railways carried 1.76m tonnes and 183m tonne kilometres of freight in 2007, of which 67.6 percent was international freight[7]. Tonnes of freight carried increased by 6 percent compared with 2006. However, this compares with 4.5m tonnes in 1989.

During the same period 1.2m passengers were carried a total of 135m passenger kilometres, an increase of 13 percent compared with 2006 in terms of passengers and 25 percent in terms of passenger kilometres[8]. This represents about 40 percent of the passengers carried in 1989. International passengers constitute 57 percent of the total.

Restructuring of the railways began in 2005. Separate infrastructure and operating companies were established at the beginning of 2006 under a holding company. However, the railway still operates essentially as a single organisation. The process towards full restructuring is ongoing and an action plan for the restructuring and privatisation of the railways has recently been drawn up.

Future plans include:

- completion of the reconstruction of the line from Bar to Bijelo Polje
- completion of the reconstruction and electrification of the line Podgorica - Niksic
- construction of terminals for combined transport at Bar, Podgorica and Bijelo Polje
- rehabilitation of the line Podgorica - Tuzi.

The experience of railways in other countries of central and eastern Europe suggests that the levels and patterns of traffic observed before 1989 will not be regained in the foreseeable future.

With regard to the transport of freight, the nature and patterns of transport have changed irrevocably following the change from a controlled to a free-market economy and following changes in global trends. In particular, the long distance movements of bulk commodities carried by rail at low freight rates across the region will not return.

The patterns and nature of passenger transport have also changed. While travel in general has increased, rail now faces much more competition from private cars and cheap airlines. While these in turn may be significantly affected by the price of oil in the future, it has been observed that congestion and travel cost must reach very high levels before travellers can be persuaded to switch back to rail from other modes. The potential impact of the railway on the proposed motorway is discussed in Section 7.6 of the Traffic and Tolling Report dated June 2009..

Summary of regional variation in economic growth.

The traffic zones have been categorised according to the four regions identified above and are shown in Table 2.9. The different rates of growth of GDP were selected on the basis of the highest and lowest regional rates compared with the average observed between 1998 and 2001 in Romania and Bulgaria[9]. From this table it can be seen that Podgorica is assumed to experience economic growth 30 percent above the average for the country as a whole, while the coastal region is assumed to have growth 15 percent above the average. The central region is assumed to grow at the average rate for the country as a whole and the northern region is assumed to grow at a slower rate.

[7] UIC
[8] CER
[9] Statistics in Focus, Regional Gross Domestic Product in the Candidate Countries 1998 and 2001, Eurostat

Table 2.9 Assumed regional differentials in economic development: percentage growth in relation to the national average

-15%	0%	+15%	+30%
Northern region: • Pluzine • Savnik • Kolašin • Andrijevica • Plav • Žabljak • Mojkovac • Berane • Rozaje • Pljevlja • Bijelo Polje	Central region: • Niksic • Danilovgrad	Coastal region: • Herceg Novi • Tivat • Kotor • Budva • Bar • Ulcinj • Cetinje	Capital area: • Podgorica

Source: Consultant's analysis

2.1.4 Income elasticity of demand

Economic growth tends to lead to increased travel and transport of goods. In a more rapidly growing economy, a greater proportion of the population is likely to be working, has more disposable income and more products are produced which must be transported and for which raw materials must be supplied.

Growth in real income may result in additional passenger trips being made, given that trips have a positive elasticity in relation to income. This is because once all essential expenditure is taken into account, any additional income can be regarded as an increase in disposable income. However, increased disposable income may also be used for moving up to a more comfortable mode of transport, rather than extra trips. This could mean, for example, investing in a private car.

Regional experience suggests that even during times of economic turmoil, passenger car traffic continues to grow. However, political upheaval and military action may result in a destruction of the economy and a significant decline in traffic volumes.

LB assumed an income elasticity of demand of 1.5 in 2007 for all traffic, declining to 1.3 by 2017. These elasticities may be regarded as rather high. While it is true that high elasticities have been observed for short periods in neighbouring countries as they entered periods of change, a more conservative elasticity of 1.2 has been assumed in this report since this elasticity has typically been found to be appropriate for passenger cars in the central and east European region. Analyses of freight traffic in Europe have shown that on average freight traffic can be assumed to grow directly with GDP per capita (i.e. with an elasticity of 1.0). These rates are supported by an analysis of growth in GDP and corresponding growth in passenger and freight transport based on IRF World Road Statistics for the UK, France and Germany for the period 1970 to 1990, although it can be argued that this elasticity may be higher in the developing market context of Montenegro.

2.1.5 Summary of inputs for forecasting

In summary, the factors and elasticities set out below were used to produce forecasts of future travel demand.

Traffic is forecast to grow in line with changes in population. Population forecasts by zone are shown in Table 2.10.

Table 2.10 Revised population forecast by municipality based on Spatial Plan

	2003	2007	2016	2021	2026	2036
Andrijevica	5785	5,789	5,797	5,802	5904	6008
Bar	40,037	40,822	42,644	43,692	44462	45246
Berane	35068	36,119	38,601	40,053	40759	41477
BijeloPolje	50,284	51,535	54,466	56,166	57156	58163
Budva	15,909	16,366	17,441	18,069	18387	18711
Danilovgrad	16,523	16,588	16,736	16,819	17115	17417
Zabljak	4,204	4,187	4,150	4,129	4202	4276
Kolasin	9,949	9,911	9,825	9,778	9950	10126
Kotor	22,947	23,116	23,502	23,719	24137	24562
Mojkovac	10,066	10,236	10,628	10,853	11044	11239
Niksic	75,282	76,892	80,641	82,802	84261	85746
Plav	13,805	14,187	15,085	15,609	15884	16164
Pluzine	4,272	4,257	4,222	4,203	4277	4352
Pljevlja	35,806	36,072	36,678	37,019	37671	38335
Podgorica	169,132	175,155	189,501	197,973	201462	205012
Rozaje	22,693	24,003	27,233	29,212	29727	30251
Tivat	13,630	13,789	14,152	14,358	14611	14869
Ulcinj	20,290	20,658	21,511	22,000	22388	22782
HercegNovi	33,034	33,264	33,788	34,083	34684	35295
Cetinje	18,482	18,428	18,307	18,240	18561	18889
Savnik	2,947	2,911	2,831	2,787	2836	2886
Montenegro	620,145	634,284	667,741	687,366	699,479	711,806

Source: Spatial Plan of Montenegro until 2020, Table 11, and Consultant's analysis

Population in external zones is assumed to remain constant.

Traffic is forecast to grow as GDP increases. Growth in GDP is reviewed in section 2.2.2 above and is forecast to increase as shown in Table 2.11.

Table 2.11 Summary of GDP / capita forecasts (percent per annum)

Period	Montenegro	External zones
2007 - 2016	3.98	3.57
2017 - 2026	4.5	4.4
2027 - 2036	2.5	4.0
2037 - 2046	2.4	4.0

Source: Consultant's analysis

After applying these regional factors in the traffic model, the overall growth has been adjusted to a control total based on the forecast of GDP at the national level.

An elasticity of 1.2 relative to growth in GDP was assumed for passenger traffic and of 1.0 for freight traffic.

3. Economic evaluation

3.1 Introduction

The cost-benefit analysis considers the economic viability of the operation of the transport system from the point of view of the Montenegrin economy.

Economic evaluations of the proposed investments were carried out using normal cost benefit techniques. The procedures are consistent with the guidelines set out in the following documents:

the updated

- EC guide to cost-benefit analysis[10]
- the TINA guide to cost-benefit analysis[11]
- the EC guide to cost-benefit analysis for Cohesion Fund projects to be implemented during the period 2007 to 2013[12], and
- the recommendations of HEATCO[13].

3.2 Evaluation Methodology

The following sections present the evaluation methodology, a summary of the input data and the results that were obtained.

3.2.1 General approach

The economic evaluation compares a "Do Something" (DS) option against a "Do Minimum" (DM) option.

The DM option is the situation in which no investment is made, other than that necessary to maintain the existing infrastructure in its existing condition (hence the terminology "Do Minimum" rather than "Do Nothing"). Thus, the DM option represents the situation in which no project is implemented.

Conversely, the DS option represents the situation in which a project is implemented e.g. the construction of a motorway.

The economic evaluation compares, on the one hand:

- the additional economic costs incurred by Montenegrin society compared with the economic costs of the DM option

and on the other hand:

- the economic benefits that infrastructure users (i.e. car and bus passengers, freight transport companies) gain from using the project compared with the DM option

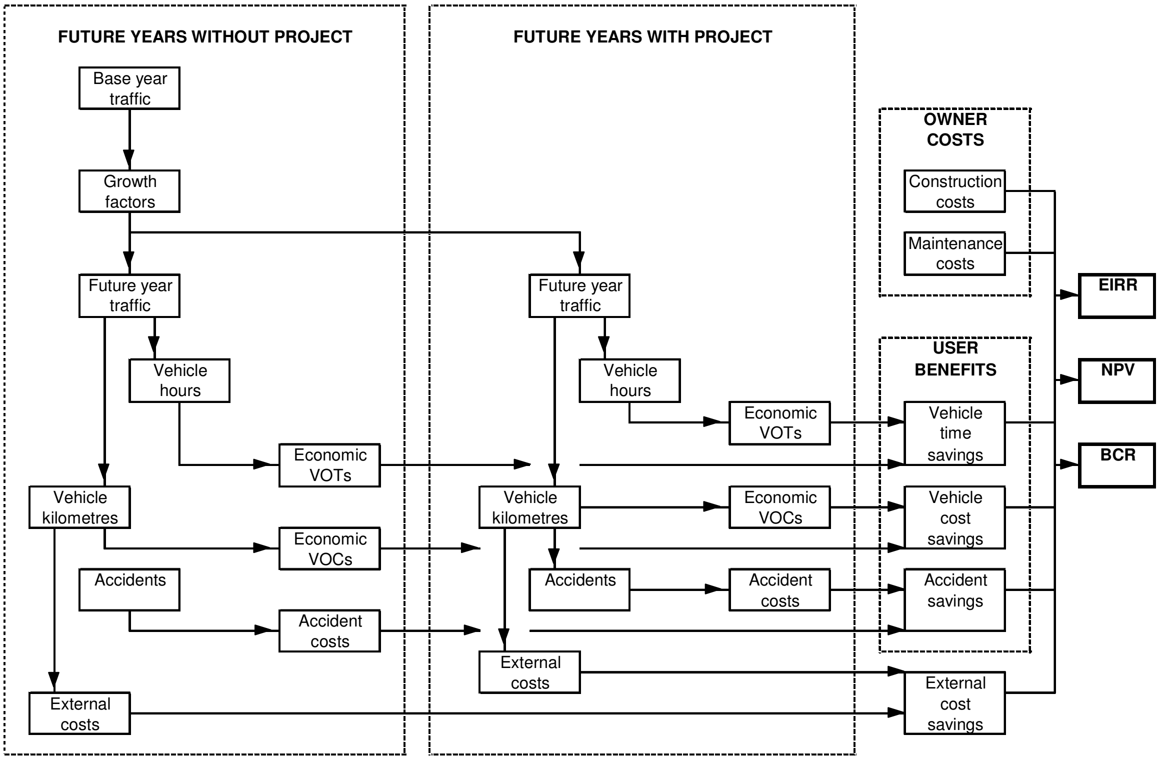
and in addition:

[10] EC Evaluation Unit DG Regional Policy "Guide to Cost Benefit of Investment Projects"
[11] TINA (1999) "Socio-Economic Cost Benefit Analysis in the context of Project Appraisals for developing a Trans-European Transport Network"
[12] EC "Guidance on the methodology for carrying out Cost-Benefit Analysis", a methodological working document for the New Programming period 2007-2013
[13] EC (2006) Developing Harmonised European Approaches for Transport Costing and Project Assessment

- external effects.

A schematic representation of the approach is shown in Figure 3.1.

Figure 3.1 Approach to economic evaluation



The economic **cost** of a project is the difference between the total economic **investment cost** of the DS project incurred by Montenegrin society and the economic investment cost necessary in the DM. There may also be additional **maintenance costs**, and infrastructure that has a lifespan greater than the evaluation period will have a **residual value**.

Do Something investment cost maintenance cost residual value	-	**Do Minimum** investment cost maintenance cost residual value	=	**Do Something** net investment cost net maintenance cost net residual value

The economic **benefits** come from various savings in costs that infrastructure users may enjoy as a result of the construction of the project. In the following diagram, the example user benefits come from savings in vehicle operating costs, travel time and accidents. Additional benefits come from savings in external costs such as noise reduction and climate change. There most likely will be additional benefits associated with the development impact that the motorway is expected to have on the economy of Montenegro; however, such additional benefits were not quantified in this report.

Do Something vehicle operation travel time accidents external effects	-	**Do Minimum** vehicle operation travel time accidents external effects	=	**Do Something** Changes in cost of: vehicle operation travel time accidents external effects

The economic evaluation compares the costs and the benefits to establish whether or not the project is worthwhile i.e. whether or not the benefits outweigh the costs.

Costs (to society)	**?** **<>**	**Benefits** (to users)

Economic costs and benefits are defined as resource costs i.e. all costs and benefits are expressed in monetary units net of all taxes, duties and transfer payments (fiscal corrections). On this basis passenger fares, freight transport charges, subsidies and taxes are excluded from the economic analysis.

Primary economic benefits relate to benefits that accrue directly to the project and the associated transport sector. Comparing the DS option against the DM option, the following primary economic benefits are considered:

- savings in road vehicle operating and maintenance costs
- value of time savings of passengers
- value of tonne / hour savings of freight
- savings in road accident costs
- value of benefits to generated traffic (if any).

In addition, some secondary economic benefits are considered. Secondary benefits are benefits that result from the implementation of the project but are external to the associated transport sector. The external costs considered include:

- noise costs
- pollution costs
- climate change costs.

Benefits come about through the effects of reductions in the amount of road traffic noise, air pollution due to road traffic and climate change due to road traffic.

The benefits are calculated separately for **existing traffic** and **generated traffic,** with benefits to generated traffic being valued at half of those attributable to existing traffic, as dictated by consumer surplus theory and the 'rule of a half'. (A simplified explanation of this is set out in the footnote below[14].)

3.2.2 Evaluation indicators

The economic evaluation is based on a cash flow analysis of the economic costs and benefits of the project over a 30 year evaluation period after project opening. The outputs are the following economic indicators:

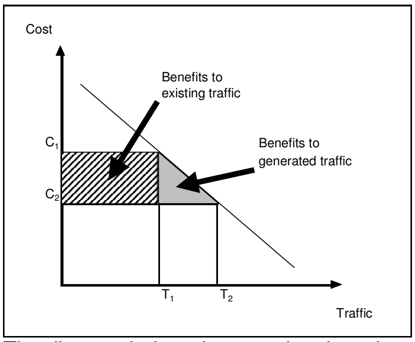
- economic internal rate of return (EIRR)
- net present value (NPV)
- benefit / cost ratio (BCR).

For a project to be considered economically viable, the following criteria should be met:

- EIRR greater than the discount rate (the Consultant uses an 8% discount rate in this report)
- NPV greater than €0.00
- BCR greater than 1.

When evaluating several projects the NPV should be determined first. All projects with a positive NPV should be retained as they are all, in principle, worthwhile. However, NPV tends to favour large projects, so the retained projects should then be ranked on the basis of their BCRs. The same ranking may be produced on the basis of EIRR, which has the advantage that it does not depend on a predetermined discount rate.

14



The diagram below shows a situation where demand (e.g. road traffic) increases as cost (e.g. travel cost or journey time) decreases. At cost C_1 (Do Minimum), the volume of traffic is T_1. If the cost decreases to C_2 (with project), traffic increases to T_2 i.e. there is **generated** traffic of (T_2 - T_1).

The value of benefits to **existing** traffic is indicated by the shaded rectangle and is calculated by multiplying the change in cost by the volume of traffic i.e. (C_1 - C_2) * T_1.

The value of benefits to **generated** traffic is indicated by the shaded triangle and is calculated by multiplying the change in cost by the change in traffic volume and taking 50% of the result i.e. ((C_1 - C_2) * (T_2 - T_1)) / 2.

3.3 Project Costs

3.3.1 Investment costs

The construction costs used in the evaluation are based on the revised cost estimates described in the Report on Engineering Studies. They are summarised in Table 3.1 for each of the project scenarios tested in the traffic model. The table also shows the motorway sections included in each scenario. It is worth noting that the cost estimates shown below are based on a comparative analysis of several other road projects in Eastern Europe and not on the Bill of Quantities for the Project. The cost estimates also include a 20% cost optimism bias. The cost estimate without the 20% optimism bias is shown in the table below for reference purposes. The construction cost estimates include the capital cost of construction of the toll system.

Table 3.1 Scenario definitions and project construction costs (financial costs at 2008 prices)

	Djurmani - Virpazar	Virpazar - Smokovac	Smokovac - Matesevo	Matesevo - Berane	Berane - Boljare	Cost exc. 20% Optimism Bias (EURm)	Cost inc. 20% Optimism Bias (EURm)
DM							0.0
SC1						840	1008.7
SC2						345	413.5
SC3						178	213.6
SC4						455	545.6
SC5						481	577.6
SC6						1185	1422.3
SC7						1363	1635.9
SC8						1820	2181.5
SC9						2299	2759.1
SC10						523	627.2

Source: LB, consultant's analysis

Financial costs were adjusted to economic costs by applying a factor of 0.8, as used by LB and by SW for the Belgrade Bypass study. The adjustment factor is based on an analysis of current taxes and previous projects in the region. The costs were also discounted back to 2007 in order to be consistent with all other cost data.

The above costs do not include the costs of land acquisition. An estimate of EUR 25m was provided by the Government of Montenegro for the section Smokovac - Matesevo and this was applied pro rata to other sections. The resulting estimates of the costs of land acquisition are shown in Table 3.2. Once detailed land expropriation plans and Resettlement Plans are drawn up, the land and social costs for the Smokovac-Matesevo section and other sections will be known with more accuracy.

Table 3.2 Estimated cost of land acquisition (financial costs at 2007 prices)

Scenario	Section	Distance (km)	EURm
SC1	Smokovac - Matesevo	43.5	25.0
SC2	Virpazar - Smokovac	38.2	22.0
SC3	Djurmani - Virpazar	11.7	6.7
SC4	Matesevo - Berane	34.4	19.7
SC5	Berane - Boljare	41.3	23.7
SC6	Virpazar - Matesevo	81.7	47.0
SC7	Djurmani - Matesevo	93.4	53.7
SC8	Djurmani - Berane	127.8	73.4
SC9	Djurmani - Boljare (Total)	169.1	97.2
SC10	Djurmani - Smokovac	49.9	28.7

Source: Consultant's analysis

The initial investment programmes assumed for each scenario are shown in Table 3.3 in terms of the number of years required for construction and the first year of operation. For simplicity, it is assumed that 5 percent of the total cost comprises design and land acquisition and is incurred prior to the commencement of construction. The remaining investment is assumed to be split equally per year during the investment period.

Table 3.3 Assumed investment programmes

Scenario	Section	Construction years	First year of operation
SC1	Smokovac - Matesevo	4	2014
SC2	Virpazar - Smokovac	4	2015
SC3	Djurmani - Virpazar	4	2016
SC4	Matesevo - Berane	4	2015
SC5	Berane - Boljare	4	2016
SC6	Virpazar - Matesevo	6	2015
SC7	Djurmani - Matesevo	7	2016
SC8	Djurmani - Berane	7	2016
SC9	Djurmani - Boljare (Total)	7	2016
SC10	Djurmani - Smokovac	4	2016

Source: Consultant's analysis

3.3.2 Residual value

The revised evaluations also include estimates of the residual value of the infrastructure at the end of the 30 year evaluation period. In the cost-benefit analysis the capital cost of the infrastructure is reduced by the net present value of the residual value of the infrastructure. In the LB study a constant rate of 33 percent appears to have been used.

In the current review the residual was estimated by:

- determining the fixed lifetime of the infrastructure
- determining a depreciation profile.

A range of recommended lifetimes of different elements of infrastructure is provided in the HEATCO documentation. In the current review it is assumed that tunnels and bridges have a lifetime of 75 years while the roadway has a lifetime of 20 years. These lifetimes assume that appropriate routine and periodic maintenance are carried out.

A summary of the residual values of each scenario is shown in Table 3.4. The overall residual value was estimated to be 33.4 percent of the total investment cost.

Table 3.4 Project scenario residual values (financial values at 2008 prices)

Scenario	Section	EURm	% of total
SC1	Smokovac - Matesevo	402.7	39.0
SC2	Virpazar - Smokovac	162.4	37.3
SC3	Djurmani - Virpazar	115.8	52.6
SC4	Matesevo - Berane	162.1	28.7
SC5	Berane - Boljare	110.4	18.4
SC6	Virpazar - Matesevo	565.1	38.5
SC7	Djurmani - Matesevo	680.9	40.3
SC8	Djurmani - Berane	843.0	37.4
SC9	Djurmani - Boljare (Total)	953.4	33.4
SC10	Djurmani - Smokovac	278.2	42.4

Source: Consultant's analysis

3.3.3 Operation and maintenance costs

The operation and maintenance (O&M) costs used in the LB study appear to be very low, at less than a total of 3 percent of the construction cost over 20 years. A rule of thumb suggests that a more usual amount would be an average of 1 percent of the construction cost per annum i.e. 30 percent of the construction cost over 30 years.

In the current review, O&M costs have been based on those used in the Slovak Republic for motorways in mountainous terrain[15]. Research in the Czech and Slovak Republics found the following average O&M costs in the period 2000 - 2003:

- EUR 30,000 per kilometre of D2 motorway per year for routine maintenance of the pavement
- EUR 350,000 per kilometre of D2 motorway for periodic maintenance of the pavement, incurred every 10 years
- EUR 2,004,000 per kilometre of D2 motorway tunnel for periodic maintenance of tunnels, incurred every 10 years.

Converted to 2007 costs per kilometre these become:

- EUR 37,500 per kilometre for the routine maintenance of the pavement per year
- EUR 437,500 per kilometre for the periodic maintenance of the pavement every 10 years
- EUR 2,550,000 per kilometre of tunnel for the periodic maintenance of tunnels every 10 years.

These rates result in O&M costs that range from 29.1 percent of the construction cost to 44.7 percent, as shown in Table 3.5. The overall rate for the whole motorway from Djurmani to Boljare is 33.6 percent, very close to the rule of thumb rate of 1 percent per year. The O&M cost profiles for the individual sections (SC1 - SC5) are included in Appendix 1.

[15] GOPA (2004) Preparation of Project Pipeline

Table 3.5 O&M costs over 30 years as percentage of construction costs (economic, excluding land acquisition)

Scenario	Section	%
SC1	Smokovac - Matesevo	31.9
SC2	Virpazar - Smokovac	42.2
SC3	Djurmani - Virpazar	44.7
SC4	Matesevo - Berane	30.7
SC5	Berane - Boljare	29.1
SC6	Virpazar - Matesevo	34.9
SC7	Djurmani - Matesevo	36.2
SC8	Djurmani - Berane	34.8
SC9	Djurmani - Boljare (Total)	33.6
SC10	Djurmani - Smokovac	43.1

Source: Consultant's analysis

Economic evaluations of scenarios SC1 and SC9 were also carried under the assumption that tolls will be charged. In these scenarios, the O&M costs of the toll plazas were also included. These were calculated on the basis of EUR 0.205m per year for operation of each plaza and EUR 0.035m per year for the maintenance of each plaza. It was assumed that SC1 will have two plazas and SC9 will have 13.

3.4.1 Vehicle Operating Costs

Benefits from vehicle operating costs (VOCs) result from savings due to the lower costs of driving a vehicle along the new infrastructure compared with the old infrastructure. Lower costs may result from a shorter route, a better surface quality, a more consistent speed, less stopping and starting etc. (If the costs of driving on the new infrastructure are higher, for example because the route is longer, then the VOC benefits may in fact be negative.)

VOCs include such elements as the cost of:

- fuel
- tyres
- lubricants
- maintenance (parts and labour)
- crew (salaries of drivers and other staff in the case of commercial vehicles)
- depreciation and interest charges
- overheads.

Unit VOCs were calculated using HDM-4 by vehicle type, road category, terrain type and speed.

The vehicle types modelled were:

- cars
- light commercial vehicles (vans, minibuses and light trucks)
- heavy commercial vehicles (medium trucks, heavy trucks and buses).

The characteristics of these vehicle types as defined for HDM-4 were based on the LB study and are shown in Table 3.6.

Table 3.6 Vehicle fleet characteristics (economic costs)

	Passenger car	Light commercial vehicle	Heavy commercial vehicle
Economic unit costs			
New vehicle cost (EUR / veh.)	11,200	21,100	84,000
Fuel cost (EUR / litre)	0.40	0.47	0.47
Lubricant cost (EUR / litre)	5.98	5.98	5.98
New tyre cost (EUR / tyre)	78	96	250
Number of tyres	4	6	8
Maintenance labour cost (EUR / hr)	6.00	6.30	9.00
Crew cost (EUR / hour)	0.00	4.50	4.50
Annual overhead (EUR)	170	300	884
Interest rate (%)	8	8	8
Utilisation			
Kms driven per year	16,000	35,000	54,000
Annual work hours	500	1,100	1,500
Service life (years)	12	12	13
Private use (%)	80	0	0
Unladen vehicle weight (tonnes)	1.1	3.0	16.0

Source: LB

It should be noted that the costs in Table 3.6 are economic costs that exclude taxes and duties.
For example, for fuel with an economic cost of about €0.40/litre, the pump price of about €0.95/litre is based on a cost per barrel of crude oil of USD 72 plus a manufacturing cost of 27.75 percent, excise duty of EUR 0.36 per litre, plus an inland distribution cost and retailer margin of EUR 0.055. In addition, VAT (18%) must be added to the total.

Similarly, for fuel with an economic cost of about €0.85/litre, a pump price of about €1.5/litre is based on a cost per barrel of crude oil of USD 150.

Roads were categorised into three types:

- D2 motorway standard (dual 2-lane, 100 km/h, IRI 2)
- main road (single carriageway 2-lane, 80 km/h, IRI 3)
- regional road (single carriageway 2-lane, 60 km/h, IRI 5).

Three terrain types were defined:

- flat
- rolling
- mountainous.

For each vehicle category, road type and terrain type, VOCs were calculated for speeds of 10, 30, 50, 70, 90 and 110 km/h.

The analysis showed that the VOCs for cars fell within a very narrow range of 0.14c - 0.16c per kilometre for all speeds, types of road and types of terrain, except at very low speeds on single carriageway roads.

For LCVs, no significant difference in VOC was found for different terrain types, but VOCs were found to change with speed.

For HCVs, VOCs were found to depend both on speed and terrain type.

Bearing in mind the inherent uncertainty in the other elements of traffic modelling and forecasting that feed into the economic evaluation, the detailed HDM-4 outputs were consolidated into the VOC unit values shown in Table 3.7.

Table 3.7 Consolidated VOC unit values (EUR/km)

Cars (all terrain types)

	0 - 20 km/h	20.1 - 40 km/h	40.1 - 80 km/h	> 80 km/h
Motorway	0.16	0.16	0.14	0.15
Main road	0.17	0.16	0.14	0.15
Regional road	0.19	0.16	0.15	0.15

LCVs (all terrain types)

	0 - 20 km/h	20.1 - 40 km/h	40.1 - 80 km/h	> 80 km/h
Motorway	0.33	0.33	0.29	0.29
Main road	0.39	0.34	0.29	0.29
Regional road	0.45	0.36	0.31	0.31

HCVs (flat terrain)

	0 - 20 km/h	20.1 - 40 km/h	40.1 - 80 km/h	> 80 km/h
Motorway	0.81	0.81	0.75	0.77
Main road	0.90	0.82	0.76	0.77
Regional road	1.05	0.89	0.83	0.83

HCVs (rolling terrain)

	0 - 20 km/h	20.1 - 40 km/h	40.1 - 80 km/h	> 80 km/h
Motorway	0.83	0.83	0.75	0.77
Main road	0.92	0.83	0.77	0.77
Regional road	1.07	0.91	0.85	0.85

HCVs (mountainous terrain)

	0 - 20 km/h	20.1 - 40 km/h	40.1 - 80 km/h	> 80 km/h
Motorway	0.88	0.88	0.83	0.83
Main road	0.96	0.88	0.84	0.84
Regional road	1.11	0.96	0.92	0.92

Source: Consultant's analysis

3.4.2 Value of time

The unit values of time (VOTs) represent the cost to the economy of spending an hour of time travelling. The values were derived following advice such as that contained in the TINA and HEATCO documentation.[16]

The value of working time is assumed to be directly related to the hourly wage rate. This assumes that wage rates are a measure of the value of the output produced in one hour and all savings in working time can be used for the production of additional output by the employee. In order to obtain values per vehicle, the VOTs are associated with average passenger occupancies for each type of vehicle or mode.

For trips made on business in working time, the value per person was set to the 2007 average gross monthly salary of EUR 497[17] plus employers' overheads of 65 percent (based on the percent estimated by the Highway Institute in Serbia) i.e. EUR 820. This is equivalent to EUR 5.12 per hour. This could be seen as a conservative assumption because road users on business trips in a transitional economy like that of Montenegro might have higher-than-average salaries or income.

For other trips (i.e. trips made in non-productive time), a value per person of 30 percent of the average net 2007 income of EUR 338[18] per month was used. This is equivalent to EUR 0.63 per hour. It may be noted that non-work time includes travelling between the usual place of work and home (commuting).

The traffic surveys carried out by LB showed that 9.1 percent of private cars were being used for business trips. The surveys also showed that the average occupancy of private cars was 2.14. The average value of time for all passengers was therefore calculated to be EUR 1.04 per person and EUR 2.23 per passenger car.

It might be argued that these values should be increased to take into account the fact that an estimated 15 to 30 percent of the economy is operating in the so-called "informal" sector. However, the above values are based on wage rates, rather than absolute total values of wages earned (whether in the formal or informal sectors). Thus, if it is assumed that earning rates in the informal sector are similar to wage rates in the formal sector, then the above VOTs are still appropriate.

No explicit VOTs have been included for drivers of commercial vehicles since crew costs are included in the VOCs. However, a time cost was included for the transport of freight based on the value of the locked-up capital of the freight being transported.

On average, products transported by road in CEEC have a value of EUR 2300 per tonne[19]. At 10 percent interest, this suggests that road freight has a VOT of about EUR 26.25 per 1000 tonne hours[20].

A summary of the values used is shown in Table 3.8.

---

[16] During the course of the current study, a "willingness to pay" survey was carried out that included an assessment of the value that drivers of vehicles place on time. However, this is a behavioural value that contributes to the route choice decision making of drivers and is not used in the economics.
[17] http://www.monstat.cg.yu/EngMeniGodisnjiPodaci.htm
[18] Statistical Yearbook of Montenegro
[19] Source: www.euractiv.com/en/enlargement/expansion-logistics-sector-ceec/article-135995
[20] At 10 percent interest, assume EUR 230 would be paid on the capital sum of EUR 2300 in a year, the average value of a tonne of road freight. If the freight is delayed for a day, it may be assumed that this is equivalent to EUR 230 / 365 = EUR 0.63 per tonne in interest that must be paid. The amount per hour would be EUR 0.63 / 24 = EUR 0.02625.

Table 3.8 Summary of values of time for 2007 (per hour)

Vehicle type	Occupancy	EUR	EUR / vehicle
Car	2.14 persons	1.04 / person	2.23
LCV	3.6 tonnes	0.02625 / tonne	0.095
HCV	12.5 tonnes	0.02625 / tonne	0.328

Source: LB, Consultant's analysis

Future VOTs are increased in line with forecast growth in GDP using an elasticity of 0.7 (as recommended by HEATCO). Assumed growth in GDP as set out in section 2.2.2 of this report, and with an elasticity of 0.7 applied, is shown in Table 3.9.

Table 3.9 VOT growth factors 2007 - 2046 (percent per year)

Year	%
2007 - 2016	2.8%
2017 - 2026	3.2%
2027 - 2036	1.8%
2037 - 2046	1.7%

Source: Consultant's analysis

3.4.3 Accident rates and costs

It may be expected that construction of the Bar - Boljare will lead to changes in the numbers and severity of accidents. The new road will be of a higher standard than the existing road, thus reducing the potential for accidents. Conversely, higher standards may encourage higher speeds that could potentially result in greater numbers of accidents or more serious accidents. The accident cost savings are an attempt to put a monetary value on benefits that result from an investment due to changes in accident numbers and/or severity.

The derivation of accident rates and costs is based on an analysis carried out for a related road corridor in Serbia in 2007 by EPTISA[21]. This is judged to be appropriate for the current study due to the fact that the two projects are closely related and that both countries are at a similar level of economic development.

Accident impacts fall into the following categories in accordance with EU definitions (e.g. EUNET, HEATCO):

- Fatality: death arising from an accident within 30 days.
- Serious injury: casualties that require hospital treatment and have lasting injuries, but the victim does not die with 30 days.
- Slight injury: casualties whose injuries do not require hospital treatment or, if they do, the effect of the injury quickly subsides.
- Damage-only accident: accident without casualties.

Under-reporting of road accidents is a well recognised problem in official road accident statistics. This is particularly true of damage-only accidents, but may also occur because of poor reporting, recording and coordinating of data. HEATCO recommends applying correction factors for unreported accidents. Table 3.10 shows suggested European average values for road accidents. It should be noted that under-reporting may be higher in Montenegro than the European average, meaning that the potential benefits of the motorway may be even higher.

[21] EPTISA (2008) Feasibility Study for Road "Novi Sad - Sabac - Loznica - Pozega"

Table 3.10 Recommended European average correction values for under-reporting of road accidents

	Fatality	Serious injury	Slight injury	Damage only
Average	1.02	1.50	3.00	6.00
Car	1.02	1.25	2.00	3.50
Motorcycle	1.02	1.55	3.20	6.50
Bicycle	1.02	2.75	8.00	18.50
Pedestrian	1.02	1.35	2.40	4.50

Source: HEATCO

The correction factor of 1.02 for fatalities takes into account the fact that a few victims die after the recording period of 30 days.

The valuation of an accident can be divided into:

- direct economic costs (medical and rehabilitation costs, legal costs, emergency services and property damage cost)
- indirect economic costs (lost production)
- value of safety per se (pain, grief and suffering).

The value of casualties avoided in Montenegro has been calculated based on work carried out by the Faculty of Transport and Traffic Engineering at the University of Belgrade. This work used data obtained from research carried out by insurance companies in Serbia.

The estimated total direct and indirect costs per accident and per casualty are shown in Table 3.11 for 2003. Estimated values are also shown for 2007, derived by increasing the 2003 values in line with growth in GDP per capita at PPP (a growth factor of 1.427).

Table 3.11 Estimated direct and indirect costs of accidents and casualties 2003 and 2007 (EUR)

Year	Total cost per type of accident				Cost per casualty		
	Damage only acc.	Slight injury acc.	Serious injury acc.	Fatal accident	Slight injury	Serious injury	Fatality
2003	980	1103	5300	45770	805	3869	41609
2007	1398	1574	7563	65314	1149	5521	59376

Source: Faculty of Transport and Traffic Engineering at the University of Belgrade and Consultant's analysis

The per casualty values can be compared with HEATCO (HEATCO Table 5.2). The HEATCO values for direct plus indirect costs in 2002 for Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia are shown in Table 3.12.

An analysis of the HEATCO values for direct plus indirect costs suggests that the values that might have been expected for Montenegro would be of the order of magnitude EUR 100 for slight accidents, EUR 2,500 for serious accidents and 15,000 for fatalities (2002 factor prices).

Table 3.12 Range of direct and indirect accident costs in neighbouring countries and expected costs in Montenegro (EUR 2002 per casualty)

	Slight	Serious	Fatal
Neighbouring countries	200-400	5,000-9,000	25,000-70,000
Expected in Serbia	100	2,500	15,000

Source: Consultant's analysis based on HEATCO

In summary, therefore, it may be stated that the costs per casualty shown in Table 3.11 are much higher than the expected values based on HEATCO for slight injury casualties and fatal casualties.

An analysis of the HEATCO values of safety per se for the same countries suggests that the values that might be expected for Montenegro would be of the order of magnitude EUR 1,500 for slight accidents, EUR 19,000 for serious accidents and EUR 150,000 for fatalities (2002 factor prices), as shown in Table 3.13.

Table 3.13 Expected value of safety per se in Montenegro (EUR 2002 per casualty)

Slight	Serious	Fatal
1,500	19,000	150,000

Source: Consultant's analysis based on HEATCO

Since the values of safety per se are of a much greater magnitude than the direct and indirect costs, they overshadow the differences observed between the values shown in Table 3.11 and those based on HEATCO.

In summary, the values that might be expected, based on HEATCO, could be as shown in Table 3.14.

Table 3.14 Expected accident costs based on HEATCO (EUR 2002 per casualty)

	Slight	Serious	Fatal
Direct & indirect	100	2,500	15,000
Value of safety per se	1,500	19,000	150,000
Total	1,600	21,500	165,000

Source: Consultant's analysis based on HEATCO

These are shown inflated to 2007 in Table 3.15.

Table 3.15 Expected accident costs based on HEATCO (EUR 2007 per casualty)

	Slight	Serious	Fatal
Direct & indirect	150	3,750	22,500
Value of safety per se	2,250	28,500	225,000
Total	2,400	32,250	247,500

Source: Consultant's analysis based on HEATCO

For the purposes of the current study, the total cost per casualty has been based on the sum of the direct and indirect costs as estimated by the research of Serbian insurance companies, plus the value of safety per se from HEATCO. The resulting rounded costs are shown in Table 3.16. For future years, these values are increased over time in line with growth in GDP, as recommended by HEATCO.

Table 3.16 Estimated cost per casualty 2007 (rounded EUR)

	Damage only	Slight	Serious	Fatal
Direct & indirect	1,400	800	4,000	42,000
Value of safety per se	n/a	2,250	28,500	225,000
Total	1,400	3,050	32,500	267,000

Source: Faculty of Transport and Traffic Engineering at the University of Belgrade, HEATCO and Consultant's analysis

These costs are compared with the costs used by LB in Table 3.17 below.

Table 3.17 Comparison of LB accident costs with those based on EPTISA (EUR per casualty)

	Damage only	Slight	Serious	Fatal
LB	n/a	3,000	45,000	157,000
EPTSA	1,400	3,050	32,500	267,000

Source: LB, EPTISA

Casualty rates by type of road were derived based on accident data in the study area from the years 2002 to 2006. These are shown in Table 3.18.

Table 3.18 Accident rates by type of road (casualties per million veh.kms)

	Expressway	Main road	Regional road	Motorway
Fatalities	0.030	0.060	0.060	0.030
Serious injuries	0.085	0.170	0.170	0.085
Slight injuries	0.155	0.310	0.310	0.155
Damage only	0.325	0.650	0.650	0.325

Source: Faculty of Transport and Traffic Engineering at the University of Belgrade and Consultant's analysis

These rates are compared with the rates used by LB in Table 3.19 below. It may be noted that the unit rates quoted by LB appear to have been labelled incorrectly per million vehicle kilometres when they appear to relate to 100m vehicle kilometres.

Table 3.19 Comparison of LB accident rates with those based on EPTISA (casualties per million veh.kms)

	Casualty type	Motorway	Main road
LB	Fatal	0.02	0.06
	Non-fatal	0.40	1.20
EPTISA	Fatal	0.03	0.06
	Non-fatal	0.24	0.48

Source: LB, EPTISA

Compared with EPTISA, LB has a much lower cost for fatal casualties, a higher cost for victims of serious injuries and a similar cost for slightly injured casualties. LB does not place a cost on damage only accidents.

In terms of accident rates, LB has lower fatality rates on motorways but higher non-fatal casualty rates. On other roads, LB has similar fatality rates to EPTISA but much higher non-fatal casualty rates.

The overall effect is that the LB study estimates benefits due to accidents at about double the rate of EPTISAThis is taken into account in the current study by including a doubling of accident benefits in the sensitivity analysis.

3.4.4 External costs

External costs considered in this report are environmental costs. They include:

- noise
- air pollution
- climate change.

Such costs were not included in the evaluations carried out by LB.

External costs are valued on the basis of their impacts, rather than their environmental burden. Two approaches were identified, one set out in the HEATCO documentation and one specified by INFRAS/IWW[22]. However, the approach recommended by HEATCO requires more extensive data that was not available for the current study and the INFRAS/IWW approach was therefore adopted.

The analysis is based on that carried out by EPTISA in 2007 for the study of a related road corridor in Serbia. Since most of the underlying data relates to what was previously Serbia and Montenegro, and since both independent countries are at a similar level of economic development, this approach was judged to be appropriate.

External costs are calculated on the basis of passenger kilometres and tonne kilometres. Thus, a project that results in reduced passenger and tonne kilometres compared with the do minimum situation will also result in reduced external costs. Conversely, a project that results in increased passenger and tonne kilometres will result in increased external costs.

<u>Noise</u>

Damage due to noise is assumed to affect land values and human health. The valuation is based on a willingness to pay for silent space above 55 dB(A).

The INFRAS/IWW study presents specific values by means of transport for EU15+2 countries (i.e. EU15 plus Norway and Switzerland), as shown in Table 3.20. To be applicable in Montenegro, these

[22] INFRAS/IWW (2004) External Costs of Transport, Update Study

were converted to appropriate values based on relative GDP at PPS and increased over time in line with GDP.

Table 3.20 Noise: 2000 factor costs

Passenger modes (EUR/1000 pass.km)	Freight modes (EUR/1000 tonne.km)	
Car	**LCV**	**HCV**
5.2	32.4	4.9

Source: INFRAS/IWW

Air pollution

Damage due to air pollution includes damage to human health and material damage to buildings, crops and forests.

The INFRAS/IWW study presents specific values by means of transport for EU15+2 countries, as shown in Table 3.21. Once again, to be applicable in Montenegro, these were converted to appropriate values based on relative GDP at PPS and increased over time in line with GDP.

Table 3.21 Air pollution: 2000 factor costs

Passenger modes (EUR/1000 pass.km)	Freight modes (EUR/1000 tonne.km)	
Car	**LCV**	**HCV**
12.7	86.9	38.3

Source: INFRAS/IWW

Climate change

Climate change damage relates to global warming and is based on a unit cost value of EUR 135 per tonne of carbon dioxide.

The INFRAS/IWW study presents specific values by means of transport for EU15+2 countries, as shown in Table 3.22. The values should not be PPS adjusted as the effect is global.

Table 3.22 Climate change: 2000 factor costs

Passenger modes (EUR/1000 pass.km)	Freight modes (EUR/1000 tonne.km)	
Car	**LCV**	**HCV**
17.6	57.4	12.8

Source: INFRAS/IWW

Aggregate external costs

The values set out in Tables 3.20 - 3.22 above were converted to 2007 values appropriate for Montenegro in two stages.

First, a factor of 1.20 was applied. This is the estimated growth in GDP per capita at PPS in the EU15+2 between 2000 and 2007, based on data presented in the EUROSTAT Yearbook.

Then, an adjustment factor of 0.20 was applied to the noise and air pollution costs, derived in relation to the relative GDP per capita at PPS in Montenegro in 2007 (estimated to be EUR 5,300) compared with the EU15+2 (estimated to be EUR 26,500). This factor was not applied to the climate change costs as the effect of climate change is assumed to be global rather than local. The adjusted values are shown in Table 3.23. These are the values that are applied to the passenger and tonne kilometres for the do minimum and do something situations in the economic evaluations.

Table 3.23 Aggregate external costs: 2007 factor costs

Passenger modes (EUR/1000 pass.km)	**Freight modes (EUR/1000 tonne.km)**	
Car	**LCV**	**HCV**
25.4	97.5	25.7

Source: INFRAS/IWW and Consultant's estimate

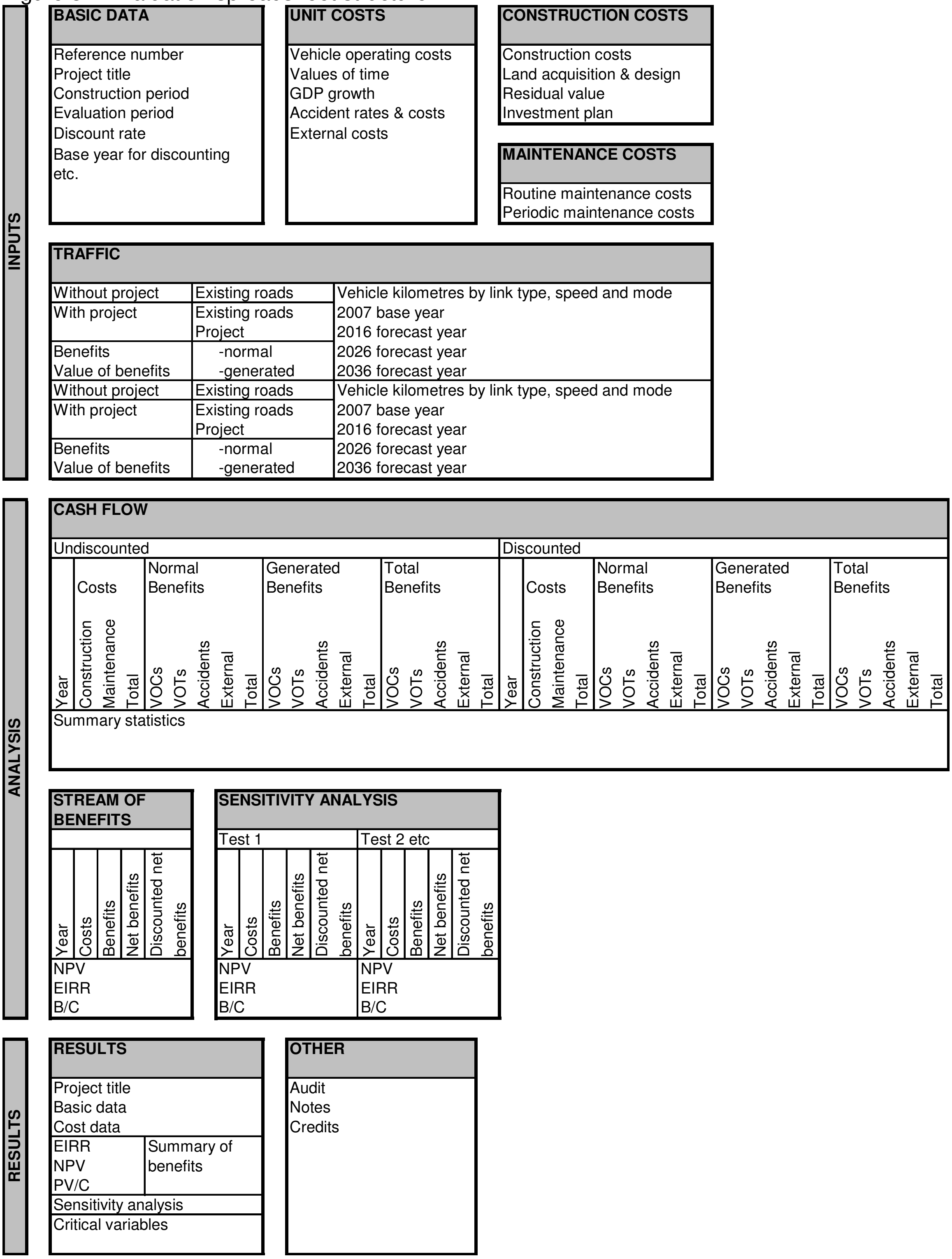
3.5 Evaluation procedures

A series of standardised spreadsheets was set up to carry out the economic evaluations. They are highly structured and incorporate a consistent and intuitive logical progression. The spreadsheets are designed to allow alternative scenarios and alternative variants to be tested, as well as making provision for sensitivity tests.

A diagram of the structure of the evaluation spreadsheets is shown in Figure 3.2. The sheets are grouped into inputs, analysis and results. Additional sheets incorporate space for an audit, in order to check that actual results are consistent with expected results, and space for comments and notes.

The spreadsheets are colour coded throughout to indicate user inputs, values transferred from one sheet to another and calculated values.

Figure 3.2 Evaluation spreadsheet structure



Source: Consultant's analysis

Inputs

The inputs are divided into those that are project specific (project title, traffic data, construction cost etc.) and those that are constant for all projects (unit costs, GDP growth rates etc.).

The first group of inputs is made up of **basic data** about the project. This includes a project identification code and title, information on the year in which construction is expected to commence and the construction period in years. The base year for costs and for discounting is set to 2007. The evaluation period is set to 30 years starting from the year of opening. The discount rate is set at 8 percent[23]. The spreadsheet handles any construction period up to the year 2016 and sets up the subsequent evaluation period accordingly.

The second group of inputs (**unit costs**) comprises VOCs, VOTs, GDP growth, accident rates and costs and external costs.

The third group of inputs consists of the **construction** costs of the project. The construction cost of each option is entered inclusive of taxes and duties, at 2008 prices, along with a financial / economic cost conversion rate and a 2008 to 2007 discount factor. An investment plan is also specified which shows the proportion of the total construction cost incurred in each year of the construction period. The residual value of the infrastructure is also entered here.

Maintenance costs are entered in terms of cost per kilometre per year of routine maintenance and periodic maintenance. The length of tunnel and costs of tunnel maintenance are also entered. For scenarios that incorporate the charging of tolls, the cost of operation and maintenance of the toll collection system is also added.

The final group of inputs consists of the **traffic** data. This is input for the DM and DS situations by vehicle type, road type, terrain type and speed in terms of vehicle kilometres and vehicle hours for the years 2007, 2016, 2026 and 2036 for both normal and generated traffic.

Analysis

A **cash flow** sheet provides tables of all costs and benefits by year, during the 30 year evaluation period of the project. Data for years which are not modelled explicitly (as described above) are interpolated. Benefits for years beyond the last year for which traffic is modelled explicitly (i.e. beyond 2036) are held constant. (It may be noted, however, that the unit values of the benefits for which the value increases with time continue to increase.) Summary statistics are produced in the form of total and proportionate benefits from different sources (VOCs, VOTs, accidents and external, normal and generated traffic). The sheet includes both undiscounted and discounted cash flow tables.

In the **stream of benefits** sheet, the total costs to society are subtracted from the total user benefits for each year during the period of evaluation, to produce the net benefits. These are then discounted back to 2007 (using a discount rate of 8 percent) to produce the NPV. The EIRR and BCR are also calculated on this sheet.

The final analysis sheet calculates the results of a series of **sensitivity** tests. These follow the same format as the calculation made on the **stream of benefits**. Sensitivity tests are carried out to assess the impact of various elements of the analysis on the results. These include variations in:

- construction costs (-20/+50 percent)
- maintenance costs (+/- 30 percent)
- VOC savings (+/- 50 percent)
- time benefits (+/- 50 percent)
- accidents (increased by a factor of two)
- external costs (increased by a factor of two).

[23] EC DG Regional Policy guidelines suggest that a 5 percent discount rate is appropriate for EU countries. A higher rate of 8 percent acknowledges the greater risk on capital that may be incurred in Serbia. Meanwhile, institutions such as the World Bank and EBRD may adopt a rate of 10 percent or more. Since it is not known which institutions will finance projects of the current study, it is suggested that 8 percent represents a reasonable compromise discount rate.

Further tests consider the effect of excluding the residual value of the project and of excluding benefits due to generated traffic. A final test sets the discount rate equal to the EIRR to demonstrate the internal integrity of the evaluation procedures.

Critical variables are defined as those variables for which a one percent variation gives rise to a corresponding variation of one percent or more in the NPV. The sensitivity analysis identifies whether or not a variable is critical.

Results

A **results** sheet summarises the basic data relating to the project and presents the key economic results: EIRR, NPV and BCR. It also presents the results of sensitivity tests and a summary of the relative importance of the various categories of benefits. An example is shown in Figure 3.3.

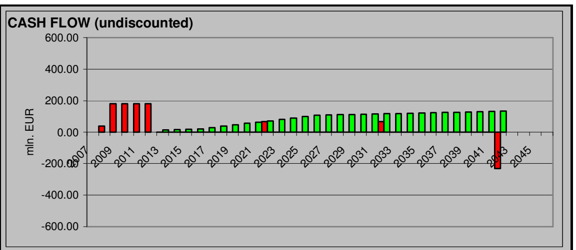
The figure includes a graphic representation of the undiscounted cash flow. In this graph, costs are shown in red and benefits are shown in green. The construction costs can be seen in red at the beginning of the evaluation period, followed by a generally increasing profile of benefits in green. These are interspersed with periodic maintenance costs that can be seen at ten year intervals and the residual value of the project that appears as a negative cost at the end of the evaluation period. (Routine maintenance costs are also present but are generally too small to appear on this graph.)

Figure 3.3 Sample economic evaluation results sheet

Bar - Boljare: Smokovac - Matesevo

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2009
Construction period	years	4
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	760.80
Residual value	EUR mln	-296.71
Total O&M costs over evaluation period	EUR mln	242.47

BENEFITS (undiscounted)

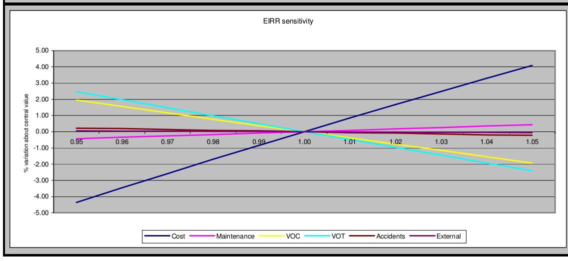
	EUR mln	
Road VOC benefits	1023.7	38.0%
Road VOT benefits	1491.8	55.4%
Accident benefits	139.6	5.2%
External benefits	36.0	1.3%
TOTAL	2691.1	100.0%

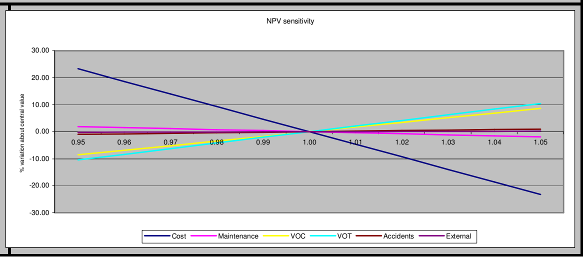
ECONOMIC INDICATORS

EIRR		6.59%
NPV	EUR mln	-122.40
BCR		0.79

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		7.89%	4.50%	6.42%	6.77%	7.81%	5.24%	8.06%	4.78%	6.89%	6.65%	5.16%	6.27%	6.59%
NPV	EUR mln	-8.54	-407.04	-136.38	-108.41	-17.80	-226.99	5.69	-250.48	-98.56	-118.08	-244.58	-142.46	0.00
BCR		0.98	0.52	0.76	0.81	0.97	0.60	1.01	0.56	0.83	0.79	0.57	0.76	1.00
Critical?		Y		N		Y		Y		N	N			





Source: Consultant's analysis

3.6 Economic evaluation results

As outlined previously, a project may be considered viable on economic grounds if it has an EIRR of at least the discount rate - in this case 8 percent - an NPV greater than €0.00 and a BCR greater than 1.00. Different financing agencies may have different absolute requirements for assessing the economic viability of projects. For example, the European Union uses a rule of thumb according to which projects with EIRR of above 5% are generally considered to qualify for financial support. On the other hand, the World Bank and the International Finance Corporation often use a discount rate of 10% to assess project NPV.

3.6.1 Evaluation of scenarios without tolls

The results of the economic evaluations of scenarios without tolls are set out in Table 3.24. Scenarios SC1 to SC5 relate to the construction of individual sections of motorway in isolation from other sections while scenarios SC6 to SC10 relate to combinations of individual sections.

Table 3.24 Economic evaluation results (no toll)

Scenario	Section	EIRR (%)	NPV (EURm)	B/C
SC1	Smokovac - Matesevo	6.59	-122.40	0.79
SC2	Virpazar - Smokovac	14.57	299.29	2.45
SC3	Djurmani - Virpazar	17.45	204.64	3.15
SC4	Matesevo - Berane	3.97	-145.00	0.46
SC5	Berane - Boljare	9.34	55.47	1.21
SC6	Virpazar - Matesevo	7.89	-13.78	0.98
SC7	Djurmani - Matesevo	8.37	56.51	1.06
SC8	Djurmani - Berane	6.76	-223.24	0.81
SC9	Djurmani - Boljare (Total)	6.87	-242.96	0.83
SC10	Djurmani - Smokovac	13.88	375.71	2.25

Source: Consultant's analysis

This table shows that the scenarios for the southern sections (SC2, SC3 and SC10) appear to be the most beneficial because this is where the travel demand is highest in Montenegro.

While the EIRR for scenario SC1 is not as high as some of the other sections, this is due to relatively high construction costs.

Scenario SC4 has a relatively low EIRR because the existing road still provides an attractive alternative for road users wishing to travel to the North West of Montenegro.

Scenario SC5 has a relatively high EIRR due to the significant time savings that arise through using the Motorway in comparison with the existing road network.

Scenarios SC6, SC7 and SC8 represent combinations of Motorway sections where travel demand is reasonably high but construction costs are also reasonably high resulting in EIRR's that fall between the higher and lower values.

Scenario SC9 (whole Motorway) has relatively high costs with different traffic volumes along each section resulting in EIRR value between the higher and lower values.

Table 3.24 lists EIRRs, NPVs and B/Cs for each section separately and for each combination of the sections under the assumptions set out in this report. The benefits of the combined scenarios SC6 - SC10 may be slightly underestimated, since benefits only accrue once the whole section under evaluation is open to traffic. The table shows that scenarios SC2, SC3 SC5, SC7 and SC10 are above the threshold values of the various economic indicators, whereas scenarios SC1, SC4, SC6, SC8 and SC9 are below.

In general, it is the construction costs, VOC benefits and VOT benefits that contribute most to the costs and benefits. The sources of benefits for each scenario are shown in Table 3.25. Overall (with the exception of SC4), benefits from savings in VOCs constitute from 25 to 40 percent of the total, savings in VOTs 50 to 80 percent, accident savings up to about 12 percent and external costs less than 2 percent.

Table 3.25 Source of benefits for each scenario without toll (%)

Scenario		VOC	VOT	Accidents	External
SC1	Smokovac - Matesevo	38.0	55.4	5.2	1.3
SC2	Virpazar - Smokovac	33.1	56.0	9.2	1.7
SC3	Djurmani - Virpazar	26.6	81.3	-7.9	0.0
SC4	Matesevo - Berane	6.5	106.3	-8.7	-4.1
SC5	Berane - Boljare	29.3	66.3	2.8	1.6
SC6	Virpazar - Matesevo	38.3	49.4	11.0	1.2
SC7	Djurmani - Matesevo	38.5	52.6	8.3	0.5
SC8	Djurmani - Berane	38.6	52.8	9.0	-0.4
SC9	Djurmani - Boljare (Total)	38.7	49.8	11.6	-0.1
SC10	Djurmani - Smokovac	34.9	59.0	5.5	0.6

Source: Consultant's analysis

3.6.2 Evaluation of scenarios with tolls

The traffic model was rerun for SC1 (Smokovac - Matesevo) and SC9 (Djurmani - Boljare) under the assumption that the optimum tolls identified in the traffic study would be charged (SC1T and SC9T): The traffic model was run using different toll rates between 0 and 30€/km to determine the optimum rate as follows ;

- EUR 0.13 / km for cars
- EUR 0.18 / km for LCVs
- EUR 0.30 / km for HCVs.

The existing toll rates for the Sozina tunnel would be maintained:

- EUR 0.77 / km for cars
- EUR 1.49 / km for LCVs
- EUR 3.14 / km for HCVs.

The charging of tolls results in less traffic using the motorway. It also requires the addition of the O&M costs of the toll plazas, as set out in section 3.3.3. The results of the economic evaluation of SC1T and SC9T are shown in Table 3.26. The EIRR for the section between Smokovac and Matesevo falls slightly to 6.5 percent, while the EIRR for the whole of the motorway between Djurmani and Boljare is 5.8 percent.

Table 3.26 Economic evaluation results (with toll) using an 8% discount rate

Scenario	Section	EIRR (%)	NPV (EURm)	B/C
SC1T	Smokovac - Matesevo	6.45	-134.65	0.76
SC9T	Djurmani - Boljare (Total)	5.78	-457.00	0.68

Source: Consultant's analysis

3.6.3 Sensitivity analysis and risk assessment

<u>Sensitivity analysis of economic evaluation variables</u>

The sensitivity tests outlined in section 3.5 were run for every scenario. The EIRR for each test and each scenario is shown in Table 3.27. The detailed results are included in the economic evaluation summary sheets in Annex 2.

Table 3.27 Sensitivity analysis: EIRR (%)

Scenario		**Base**	**Constr. costs**		**O&M costs**		**VOC**		**VOT**		**Acc.**	**Ext.**	**Gen.**	**Resid.**
			-20%	**+50%**	**+30%**	**-30%**	**+50%**	**-50%**	**+50%**	**-50%**	**+100%**	**+100%**	**0%**	**0%**
No toll														
SC1	Smokovac - Matesevo	6.59	7.89	4.50	6.42	6.77	7.81	5.24	8.06	4.78	6.89	6.65	5.16	6.27
SC2	Virpazar - Smokovac	14.57	16.53	11.36	14.44	14.70	16.13	12.82	16.71	11.98	15.36	14.68	12.13	14.53
SC3	Djurmani - Virpazar	17.45	19.83	13.62	17.35	17.56	19.22	15.54	20.88	12.97	16.69	17.43	14.03	17.42
SC4	Matesevo - Berane	3.97	5.05	2.18	3.74	4.19	4.18	3.75	6.38	0.00	3.49	3.74	0.00	3.49
SC5	Berane - Boljare	9.34	11.06	6.56	9.20	9.49	10.70	7.88	11.47	6.59	9.54	9.44	7.54	9.26
SC6	Virpazar - Matesevo	7.89	9.26	5.66	7.75	8.04	9.16	6.46	9.24	6.26	8.56	7.97	6.69	7.70
SC7	Djurmani - Matesevo	8.37	9.76	6.10	8.24	8.50	9.67	6.90	9.80	6.61	8.88	8.41	7.15	8.20
SC8	Djurmani - Berane	6.76	8.04	4.67	6.59	6.92	7.94	5.41	8.14	5.06	7.28	6.74	5.64	6.50
SC9	Djurmani - Boljare	6.87	8.21	4.69	6.70	7.03	8.14	5.44	8.22	5.23	7.55	6.87	5.78	6.64
SC10	Djurmani - Smokovac	13.88	15.83	10.72	13.76	14.00	15.58	11.99	16.03	11.24	14.36	13.93	11.74	13.83
With toll														
SC1T	Smokovac - Matesevo	6.45	7.72	4.38	6.26	6.63	7.54	5.24	8.05	4.43	6.66	6.51	5.00	6.12
SC9T	Djurmani - Boljare	5.78	7.01	3.79	5.57	5.99	6.92	4.50	7.24	3.96	6.13	5.81	4.88	5.47

Source: Consultant's analysis

For scenarios SC6 and SC7 construction costs, maintenance costs, VOCs, VOTs and accident costs are identified as critical (i.e. a 1 percent variation gives rise to a corresponding variation of 1 percent or more in the NPV). For scenarios SC1, SC1T, SC5, SC8 and SC9, construction costs, VOCs and VOTs are identified as critical. For SC4 and SC9T, construction costs and VOTs are identified as critical. For SC3 and SC10, VOTs are identified as critical. For SC2, no variables are identified as critical.

The switching values of the critical variables in scenarios SC1 and SC9 with and without tolls have been calculated. Table 3.28 shows the factor that would have to be applied to a critical variable for negative NPV projects to become positive NPV projects and vice versa.

Table 3.28 Factors to be applied to critical variables to achieve NPV = EUR 0.0m using 8% discount rate

Scenario	**Section**	**Construction cost**	**VOC**	**VOT**
SC1	Smokovac - Matesevo	0.785	1.585	1.478
SC1T	Smokovac - Matesevo	0.763	1.726	1.483
SC9	Djurmani - Boljare (Total)	0.828	1.441	1.413
SC9T	Djurmani - Boljare (Total)	0.677	(2.022)*	1.803

** Not critical*
Source: Consultant's analysis

The table shows, for example, that for SC1 to no longer to have a negative NPV under the current assumptions, construction costs would have to be decreased by 21.5 percent, VOC savings increased by 58.5 percent or VOT savings increased by 47.8 percent. Clearly, this could also be achieved through a combination of changes in each of the critical variables.

<u>Additional sensitivity tests</u>

Additional sensitivity tests were carried out relating to changes external to economic evaluation. These required changes to be made to the traffic model and hence to the traffic data input to the economics.

Pessimistic growth forecast

In 2007 the IMF produced alternative forecasts of GDP growth for Montenegro (Table 3.29).

Table 3.29 The IMF scenarios for economic growth (% per year)

	Baseline	**Backtracking**	**Reform**
2008	7.2	6.0	7.5
2009	5.5	4.5	6.6
2010	5.0	4.0	6.5
2011	4.8	3.5	6.5
2012	4.6	3.0	6.5
2013	4.5	3.1	6.5
2014	4.5	3.2	6.5
2015	4.5	3.3	6.6

Source: CBCG Chief Economist Annual Report 2007, p.16

Although the middle (baseline) forecast has now been adjusted downwards in the context of the current economic climate, it may be assumed that the relationship between the middle and low (backtracking) forecasts still holds. Based on this data, it has been assumed in the pessimistic forecast used in the current study that growth in GDP is about one percentage point lower. The resulting growth rates in terms of percent per annum are shown in Table 3.30.

Table 3.30 Summary of pessimistic GDP / capita forecasts (percent per annum)

Period	Montenegro	External zones
2007 - 2016	2.98	2.57
2017 - 2026	3.5	3.4
2027 - 2036	1.5	3.0
2037 - 2046	1.4	3.0

Source: Consultant's analysis

Applying these lower growth rates to both the forecasts of traffic and increases in VOTs results in the EIRRs shown in Table 3.31.

Table 3.31 Pessimistic growth forecast: EIRR (%)

Scenario	Section	Base	Pessimistic growth
SC1	Smokovac - Matesevo	6.59	4.50
SC2	Virpazar - Smokovac	14.57	11.75
SC3	Djurmani - Virpazar	17.45	15.17
SC4	Matesevo - Berane	3.97	0.00
SC5	Berane - Boljare	9.34	6.92
SC6	Virpazar - Matesevo	7.89	5.79
SC7	Djurmani - Matesevo	8.37	6.53
SC8	Djurmani - Berane	6.76	4.90
SC9	Djurmani - Boljare	6.87	4.88
SC10	Djurmani - Smokovac	13.88	11.70

Source: Consultant's analysis

Scenario SC9x

Scenario SC9x relates to the whole of the motorway from Djurmani to Boljare. It is the same as the base scenario SC9, except that it is assumed that the motorway does not continue into Serbia from Boljare. In this case, the EIRR reduces from 6.87 percent to 6.03 percent. This is because the Northern section of the Motorway is used only by local traffic whilst strategic traffic continues to use the existing road network.

Scenarios SC1y, SC6y, SC7y and SC9y

These scenarios exclude the additional traffic assumed to result from the possible expansion of the Port of Bar. This results in lower EIRRs as shown in Table 3.32 due to lower volumes of freight traffic, hence less benefits.

Scenarios SC1z, SC6z, SC7z and SC9z

These scenarios include the additional traffic that had been assumed to switch from road to rail and use the proposed motorway. This results in higher EIRRs as shown in Table 3.32.

Table 3.32 Additional sensitivity tests: EIRR (%)

Scenario	Section	Base	x (exc. m'way in Serbia)	y (exc. dev. of Port of Bar)	z (exc. switch to railway)
SC1	Smokovac - Matesevo	6.59	n/a	5.87	6.70
SC6	Virpazar - Matesevo	7.89	n/a	7.41	8.05
SC7	Djurmani - Matesevo	8.37	n/a	7.89	8.51
SC9	Djurmani - Boljare (Total)	6.87	6.03	6.30	7.02

Source: Consultant's analysis

Risk assessment

A risk assessment consists of studying the probability that a project will achieve a satisfactory performance, for example in terms of an NPV (EUR 0.0m). A risk analysis has been carried out for the section Smokovac - Matesevo and for the full length of the motorway with and without tolls.

The distribution of costs is assumed to be triangular, possibly varying by up to -20 percent or +50 percent, as specified for the sensitivity analysis. A triangular distribution is also assumed for benefits, plus or minus 30 percent.

In a monte carlo simulation, 5000 combinations of randomly varied costs and benefits were tested. The cost and benefit distributions for SC1, and resulting NPV distribution, are shown in Figure 3.4. The figure also shows the probability and cumulative probability distributions of NPV. The analysis shows that the probability that the NPV of SC1 is less than EUR 0.0m is 93 percent.

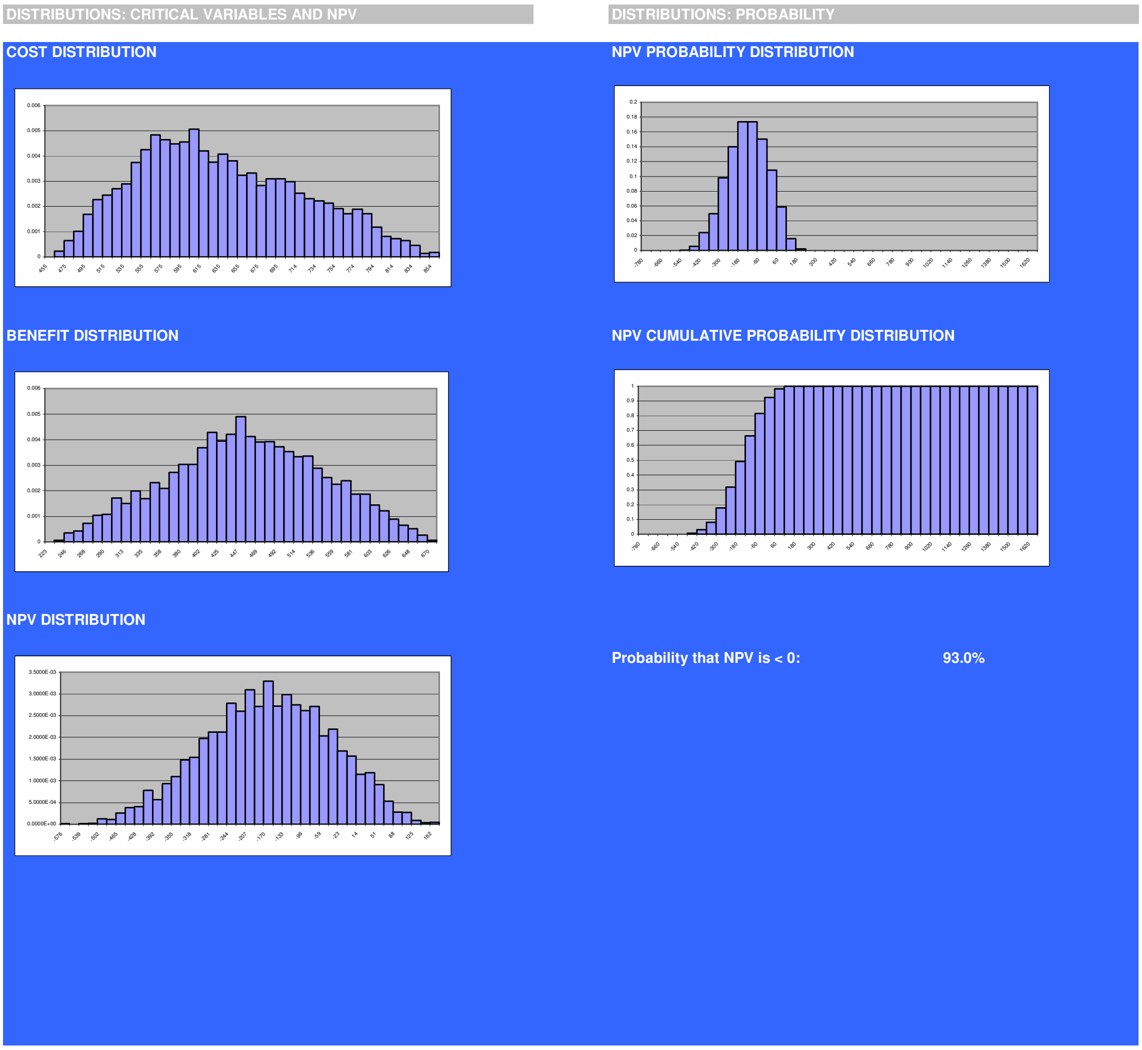
A similar analysis was carried out for SC1T and for the full motorway. The results are shown in Table 3.33.

Table 3.33 Probability that NPV is less than EUR 0.0m by scenario

Scenario	**Section**	**Probability**
SC1	Smokovac - Matesevo	93%
SC1T	Smokovac - Matesevo	94%
SC9	Djurmani - Boljare (Total)	88%
SC9T	Djurmani - Boljare (Total)	99%

Source: Consultant's analysis

Figure 3.4 Risk analysis SC1



Source: Consultant's analysis

4. Conclusions

The Bar - Boljare motorway has a clear strategic role to play in the regional highway network. It will link the capital of a country in the region and a major tourist destination with other regional capitals and economic centres, providing the infrastructure for fast, safe and reliable travel.

In terms of economic analysis, the priority section between Smokovac and Matesevo has an EIRR of 6.6 percent under the assumptions of the current review. If tolls are charged, then it is likely that less traffic will use the facility, reducing the EIRR for this section to 6.5 percent.

Construction of the whole length of motorway from Djurmani to Boljare results in an EIRR of 6.9 percent when considered as a single project under the assumptions of the current review, or 5.8 percent if tolls are charged.

Table 3.27 shows the results in terms of EIRR of different sensitivity analyses for the Project.

The Consultant believes that the most direct way of improving the economic viability of the Project, when considering only the Smokovac-Matesevo section, is by reducing the construction cost. This could be achieved by phasing the construction from a two lane motorway to a four lane motorway, either for the entire length of the road or for tunnels and or bridges/viaducts only. As an initial estimate, the Consultant believes that the Project cost would fall by about 20 percent if construction of some or all parts of the motorway was phased. This would have the most direct positive effect on the EIRR of the Project.

Finally, it is important to note that the current report is based on an economic evaluation of the road project assessing project benefits solely in terms of VOC, VOT, reduction in the number of accidents, and environmental impacts. A project-based economic evaluation enables a given project to be compared with other potential projects using a common benchmark of comparison. This is not a study of potential regional development or socio-economic benefits arising from the road, including benefits such as reduction in costs to the economy due to the uninterrupted traffic flow between the north and south of the country, and additional economic opportunities arising out of the Project and accruing to the citizens of Montenegro. The EIRR of the Project, both for the Smokovac-Matesevo section and the entire motorway may be shown to be higher if such aspects were taken into consideration.

Appendix 1: O&M costs

SC1 Smokovac - Matesevo without toll

MAINTENANCE

Length:	43.5	km	Routine:	0.0375	EURm/km	Periodic:	0.04375 EURm/km
Tunnel:	17.835	km					0.255 EURm/km

year no.	year	Routine EUR mln	Periodic EUR mln	Total EUR mln		Year	Total EUR mln
						2007	0.000
						2008	0.000
						2009	0.000
						2010	0.000
						2011	0.000
						2012	0.000
1	2013	1.631	0.000	1.631		2013	1.631
2	2014	1.631	0.000	1.631		2014	1.631
3	2015	1.631	0.000	1.631		2015	1.631
4	2016	1.631	0.000	1.631		2016	1.631
5	2017	1.631	0.000	1.631		2017	1.631
6	2018	1.631	0.000	1.631		2018	1.631
7	2019	1.631	0.000	1.631		2019	1.631
8	2020	1.631	0.000	1.631		2020	1.631
9	2021	1.631	0.000	1.631		2021	1.631
10	2022	1.631	64.511	66.142		2022	66.142
11	2023	1.631	0.000	1.631		2023	1.631
12	2024	1.631	0.000	1.631		2024	1.631
13	2025	1.631	0.000	1.631		2025	1.631
14	2026	1.631	0.000	1.631		2026	1.631
15	2027	1.631	0.000	1.631		2027	1.631
16	2028	1.631	0.000	1.631		2028	1.631
17	2029	1.631	0.000	1.631		2029	1.631
18	2030	1.631	0.000	1.631		2030	1.631
19	2031	1.631	0.000	1.631		2031	1.631
20	2032	1.631	64.511	66.142		2032	66.142
21	2033	1.631	0.000	1.631		2033	1.631
22	2034	1.631	0.000	1.631		2034	1.631
23	2035	1.631	0.000	1.631		2035	1.631
24	2036	1.631	0.000	1.631		2036	1.631
25	2037	1.631	0.000	1.631		2037	1.631
26	2038	1.631	0.000	1.631		2038	1.631
27	2039	1.631	0.000	1.631		2039	1.631
28	2040	1.631	0.000	1.631		2040	1.631
29	2041	1.631	0.000	1.631		2041	1.631
30	2042	1.631	64.511	66.142		2042	66.142
Total				242.469			

Verification:
Total maintenance cost OK

SC2 Virpazar - Smokovac without toll

MAINTENANCE

Length:	38.231	km	Routine:	0.0375	EURm/km	Periodic:	0.04375	EURm/km
Tunnel:	5.510	km					0.255	EURm/km

year no.	year	Routine EUR mln	Periodic EUR mln	Total EUR mln
1	2015	1.434	0.000	1.434
2	2016	1.434	0.000	1.434
3	2017	1.434	0.000	1.434
4	2018	1.434	0.000	1.434
5	2019	1.434	0.000	1.434
6	2020	1.434	0.000	1.434
7	2021	1.434	0.000	1.434
8	2022	1.434	0.000	1.434
9	2023	1.434	0.000	1.434
10	2024	1.434	30.777	32.210
11	2025	1.434	0.000	1.434
12	2026	1.434	0.000	1.434
13	2027	1.434	0.000	1.434
14	2028	1.434	0.000	1.434
15	2029	1.434	0.000	1.434
16	2030	1.434	0.000	1.434
17	2031	1.434	0.000	1.434
18	2032	1.434	0.000	1.434
19	2033	1.434	0.000	1.434
20	2034	1.434	30.777	32.210
21	2035	1.434	0.000	1.434
22	2036	1.434	0.000	1.434
23	2037	1.434	0.000	1.434
24	2038	1.434	0.000	1.434
25	2039	1.434	0.000	1.434
26	2040	1.434	0.000	1.434
27	2041	1.434	0.000	1.434
28	2042	1.434	0.000	1.434
29	2043	1.434	0.000	1.434
30	2044	1.434	30.777	32.210
Total				135.340

Verification:
Total maintenance cost OK

Year	Total EUR mln
2007	0.000
2008	0.000
2009	0.000
2010	0.000
2011	0.000
2012	0.000
2013	0.000
2014	0.000
2015	1.434
2016	1.434
2017	1.434
2018	1.434
2019	1.434
2020	1.434
2021	1.434
2022	1.434
2023	1.434
2024	32.210
2025	1.434
2026	1.434
2027	1.434
2028	1.434
2029	1.434
2030	1.434
2031	1.434
2032	1.434
2033	1.434
2034	32.210
2035	1.434
2036	1.434
2037	1.434
2038	1.434
2039	1.434
2040	1.434
2041	1.434
2042	1.434
2043	1.434
2044	32.210

SC3 Djurmani - Virpazar without toll

MAINTENANCE

Length:	11.7	km	Routine:	0.0375 EURm/km	Periodic:	0.04375 EURm/km
Tunnel:	5.750	km				0.255 EURm/km

year no.	year	Routine EUR mln	Periodic EUR mln	Total EUR mln
1	2016	0.439	0.000	0.439
2	2017	0.439	0.000	0.439
3	2018	0.439	0.000	0.439
4	2019	0.439	0.000	0.439
5	2020	0.439	0.000	0.439
6	2021	0.439	0.000	0.439
7	2022	0.439	0.000	0.439
8	2023	0.439	0.000	0.439
9	2024	0.439	0.000	0.439
10	2025	0.439	19.781	20.220
11	2026	0.439	0.000	0.439
12	2027	0.439	0.000	0.439
13	2028	0.439	0.000	0.439
14	2029	0.439	0.000	0.439
15	2030	0.439	0.000	0.439
16	2031	0.439	0.000	0.439
17	2032	0.439	0.000	0.439
18	2033	0.439	0.000	0.439
19	2034	0.439	0.000	0.439
20	2035	0.439	19.781	20.220
21	2036	0.439	0.000	0.439
22	2037	0.439	0.000	0.439
23	2038	0.439	0.000	0.439
24	2039	0.439	0.000	0.439
25	2040	0.439	0.000	0.439
26	2041	0.439	0.000	0.439
27	2042	0.439	0.000	0.439
28	2043	0.439	0.000	0.439
29	2044	0.439	0.000	0.439
30	2045	0.439	19.781	20.220
Total				72.506

Year	Total EUR mln
2007	0.000
2008	0.000
2009	0.000
2010	0.000
2011	0.000
2012	0.000
2013	0.000
2014	0.000
2015	0.000
2016	0.439
2017	0.439
2018	0.439
2019	0.439
2020	0.439
2021	0.439
2022	0.439
2023	0.439
2024	0.439
2025	20.220
2026	0.439
2027	0.439
2028	0.439
2029	0.439
2030	0.439
2031	0.439
2032	0.439
2033	0.439
2034	0.439
2035	20.220
2036	0.439
2037	0.439
2038	0.439
2039	0.439
2040	0.439
2041	0.439
2042	0.439
2043	0.439
2044	0.439
2045	20.220

Verification:
Total maintenance cost OK

SC4 Matesevo - Berane without toll

MAINTENANCE

Length:	34.352	km	Routine:	0.0375 EURm/km	Periodic:	0.04375 EURm/km
Tunnel:	5.735	km				0.255 EURm/km

year no.	year	Routine EUR mln	Periodic EUR mln	Total EUR mln
1	2015	1.288	0.000	1.288
2	2016	1.288	0.000	1.288
3	2017	1.288	0.000	1.288
4	2018	1.288	0.000	1.288
5	2019	1.288	0.000	1.288
6	2020	1.288	0.000	1.288
7	2021	1.288	0.000	1.288
8	2022	1.288	0.000	1.288
9	2023	1.288	0.000	1.288
10	2024	1.288	29.653	30.941
11	2025	1.288	0.000	1.288
12	2026	1.288	0.000	1.288
13	2027	1.288	0.000	1.288
14	2028	1.288	0.000	1.288
15	2029	1.288	0.000	1.288
16	2030	1.288	0.000	1.288
17	2031	1.288	0.000	1.288
18	2032	1.288	0.000	1.288
19	2033	1.288	0.000	1.288
20	2034	1.288	29.653	30.941
21	2035	1.288	0.000	1.288
22	2036	1.288	0.000	1.288
23	2037	1.288	0.000	1.288
24	2038	1.288	0.000	1.288
25	2039	1.288	0.000	1.288
26	2040	1.288	0.000	1.288
27	2041	1.288	0.000	1.288
28	2042	1.288	0.000	1.288
29	2043	1.288	0.000	1.288
30	2044	1.288	29.653	30.941
Total				127.606

Verification:
Total maintenance cost OK

Year	Total EUR mln
2007	0.000
2008	0.000
2009	0.000
2010	0.000
2011	0.000
2012	0.000
2013	0.000
2014	0.000
2015	1.288
2016	1.288
2017	1.288
2018	1.288
2019	1.288
2020	1.288
2021	1.288
2022	1.288
2023	1.288
2024	30.941
2025	1.288
2026	1.288
2027	1.288
2028	1.288
2029	1.288
2030	1.288
2031	1.288
2032	1.288
2033	1.288
2034	30.941
2035	1.288
2036	1.288
2037	1.288
2038	1.288
2039	1.288
2040	1.288
2041	1.288
2042	1.288
2043	1.288
2044	30.941

SC5 Berane - Boljare without toll

MAINTENANCE

Length:	41.3 km	Routine:	0.0375 EURm/km	Periodic:	0.04375 EURm/km
Tunnel:	3.690 km				0.255 EURm/km

year no.	year	Routine EUR mln	Periodic EUR mln	Total EUR mln
1	2016	1.549	0.000	1.549
2	2017	1.549	0.000	1.549
3	2018	1.549	0.000	1.549
4	2019	1.549	0.000	1.549
5	2020	1.549	0.000	1.549
6	2021	1.549	0.000	1.549
7	2022	1.549	0.000	1.549
8	2023	1.549	0.000	1.549
9	2024	1.549	0.000	1.549
10	2025	1.549	27.478	29.027
11	2026	1.549	0.000	1.549
12	2027	1.549	0.000	1.549
13	2028	1.549	0.000	1.549
14	2029	1.549	0.000	1.549
15	2030	1.549	0.000	1.549
16	2031	1.549	0.000	1.549
17	2032	1.549	0.000	1.549
18	2033	1.549	0.000	1.549
19	2034	1.549	0.000	1.549
20	2035	1.549	27.478	29.027
21	2036	1.549	0.000	1.549
22	2037	1.549	0.000	1.549
23	2038	1.549	0.000	1.549
24	2039	1.549	0.000	1.549
25	2040	1.549	0.000	1.549
26	2041	1.549	0.000	1.549
27	2042	1.549	0.000	1.549
28	2043	1.549	0.000	1.549
29	2044	1.549	0.000	1.549
30	2045	1.549	27.478	29.027
Total				128.897

Verification:
Total maintenance cost OK

Year	Total EUR mln
2007	0.000
2008	0.000
2009	0.000
2010	0.000
2011	0.000
2012	0.000
2013	0.000
2014	0.000
2015	0.000
2016	1.549
2017	1.549
2018	1.549
2019	1.549
2020	1.549
2021	1.549
2022	1.549
2023	1.549
2024	1.549
2025	29.027
2026	1.549
2027	1.549
2028	1.549
2029	1.549
2030	1.549
2031	1.549
2032	1.549
2033	1.549
2034	1.549
2035	29.027
2036	1.549
2037	1.549
2038	1.549
2039	1.549
2040	1.549
2041	1.549
2042	1.549
2043	1.549
2044	1.549
2045	29.027

SC1 Smokovac - Matesevo with toll

MAINTENANCE

Length:	43.5	km	Routine:	0.0375	EURm/km	Periodic:	0.04375 EURm/km
Tunnel:	17.835	km					0.255 EURm/km
Plazas:	2		Operation:	0.205	EURm/plaza	Maint:	0.035 EURm/plaz

year no.	year	Routine EUR mln	Periodic EUR mln	Toll Operation	Toll Maint	Total EUR mln
1	2013	1.631	0.000	0.410	0.07	2.111
2	2014	1.631	0.000	0.410	0.07	2.111
3	2015	1.631	0.000	0.410	0.07	2.111
4	2016	1.631	0.000	0.410	0.07	2.111
5	2017	1.631	0.000	0.410	0.07	2.111
6	2018	1.631	0.000	0.410	0.07	2.111
7	2019	1.631	0.000	0.410	0.07	2.111
8	2020	1.631	0.000	0.410	0.07	2.111
9	2021	1.631	0.000	0.410	0.07	2.111
10	2022	1.631	64.511	0.410	0.07	66.622
11	2023	1.631	0.000	0.410	0.07	2.111
12	2024	1.631	0.000	0.410	0.07	2.111
13	2025	1.631	0.000	0.410	0.07	2.111
14	2026	1.631	0.000	0.410	0.07	2.111
15	2027	1.631	0.000	0.410	0.07	2.111
16	2028	1.631	0.000	0.410	0.07	2.111
17	2029	1.631	0.000	0.410	0.07	2.111
18	2030	1.631	0.000	0.410	0.07	2.111
19	2031	1.631	0.000	0.410	0.07	2.111
20	2032	1.631	64.511	0.410	0.07	66.622
21	2033	1.631	0.000	0.410	0.07	2.111
22	2034	1.631	0.000	0.410	0.07	2.111
23	2035	1.631	0.000	0.410	0.07	2.111
24	2036	1.631	0.000	0.410	0.07	2.111
25	2037	1.631	0.000	0.410	0.07	2.111
26	2038	1.631	0.000	0.410	0.07	2.111
27	2039	1.631	0.000	0.410	0.07	2.111
28	2040	1.631	0.000	0.410	0.07	2.111
29	2041	1.631	0.000	0.410	0.07	2.111
30	2042	1.631	64.511	0.410	0.07	66.622
Total						256.869

Year	Total EUR mln
2007	0.000
2008	0.000
2009	0.000
2010	0.000
2011	0.000
2012	0.000
2013	2.111
2014	2.111
2015	2.111
2016	2.111
2017	2.111
2018	2.111
2019	2.111
2020	2.111
2021	2.111
2022	66.622
2023	2.111
2024	2.111
2025	2.111
2026	2.111
2027	2.111
2028	2.111
2029	2.111
2030	2.111
2031	2.111
2032	66.622
2033	2.111
2034	2.111
2035	2.111
2036	2.111
2037	2.111
2038	2.111
2039	2.111
2040	2.111
2041	2.111
2042	66.622

Verification:
Total maintenance cost OK

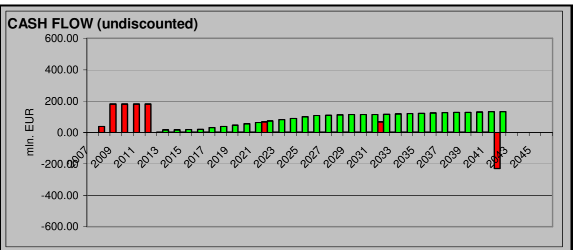
Appendix 2. Economic evaluation results

Figure A2.1 Economic evaluation results: SC1 Smokovac - Matesevo (no toll)

Bar - Boljare: Smokovac - Matesevo

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2009
Construction period	years	4
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	760.80
Residual value	EUR mln	-296.71
Total O&M costs over evaluation period	EUR mln	242.47

BENEFITS (undiscounted)

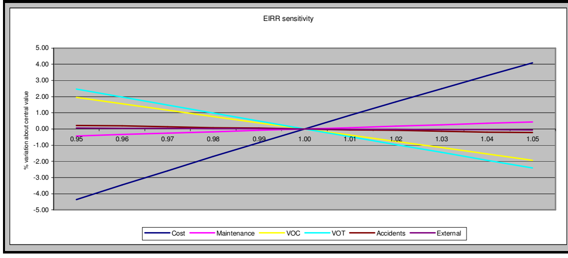
	EUR mln	
Road VOC benefits	1023.7	38.0%
Road VOT benefits	1491.8	55.4%
Accident benefits	139.6	5.2%
External benefits	36.0	1.3%
TOTAL	2691.1	100.0%

ECONOMIC INDICATORS

EIRR		6.59%
NPV	EUR mln	-122.40
BCR		0.79

SENSITIVITY ANALYSIS

		Construction costs -20%	Construction costs +50%	Maintenance costs +30%	Maintenance costs -30%	VOC +50%	VOC -50%	VOT +50%	VOT -50%	Accidents +100%	External +100%	Generated 0%	Residual 0%	Disc. rate = EIRR
EIRR		7.89%	4.50%	6.42%	6.77%	7.81%	5.24%	8.06%	4.78%	6.89%	6.65%	5.16%	6.27%	6.59%
NPV	EUR mln	-8.54	-407.04	-136.38	-108.41	-17.80	-226.99	5.69	-250.48	-98.56	-118.08	-244.58	-142.46	0.00
BCR		0.98	0.52	0.76	0.81	0.97	0.60	1.01	0.56	0.83	0.79	0.57	0.76	1.00
Critical?		Y		N		Y		Y		N	N			



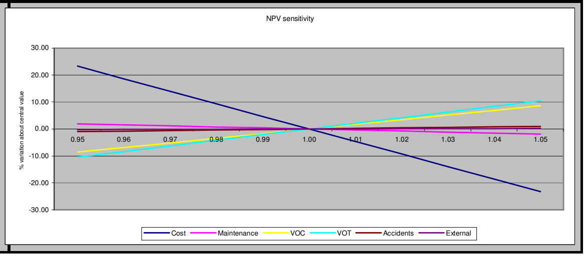
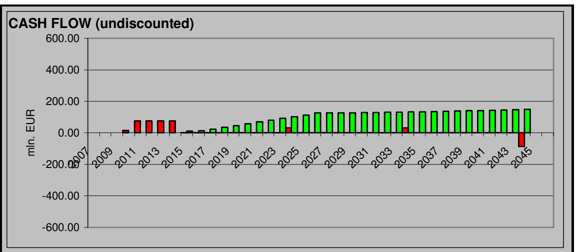


Figure A2.2 Economic evaluation results: SC2 Virpazar - Smokovac (no toll)

Bar - Boljare: Virpazar - Smokovac

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2011
Construction period	years	4
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	320.53
Residual value	EUR mln	-119.56
Total O&M costs over evaluation period	EUR mln	135.34

BENEFITS (undiscounted)

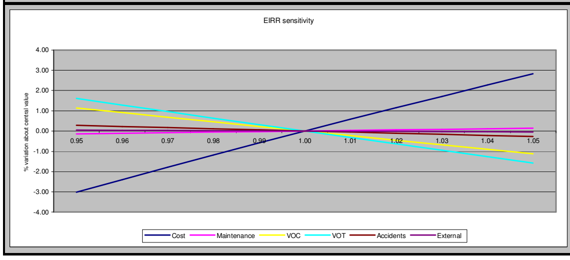
	EUR mln	
Road VOC benefits	1063.6	33.1%
Road VOT benefits	1800.2	56.0%
Accident benefits	296.0	9.2%
External benefits	54.8	1.7%
TOTAL	3214.7	100.0%

ECONOMIC INDICATORS

EIRR		14.57%
NPV	EUR mln	299.29
BCR		2.45

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		16.53%	11.36%	14.44%	14.70%	16.13%	12.82%	16.71%	11.98%	15.36%	14.68%	12.13%	14.53%	14.57%
NPV	EUR mln	340.48	196.32	292.28	306.30	393.84	204.73	440.45	158.12	347.95	307.79	188.50	292.35	0.00
BCR		3.07	1.64	2.42	2.49	2.91	1.99	3.14	1.77	2.69	2.49	1.92	2.37	1.00
Critical?		N		N		N		N		N	N			



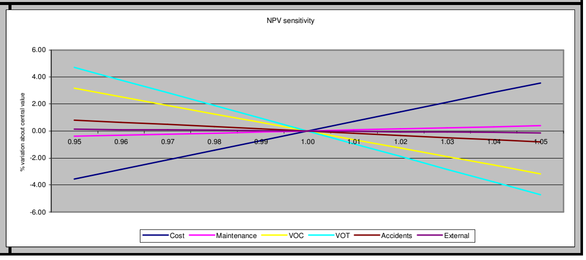
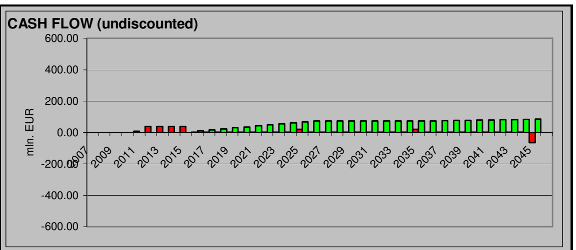


Figure A2.3 Economic evaluation results: SC3 Djurmani - Virpazar (no toll)

Bar - Boljare: Djurmani - Virpazar

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2012
Construction period	years	4
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	162.14
Residual value	EUR mln	-85.29
Total O&M costs over evaluation period	EUR mln	72.51

BENEFITS (undiscounted)

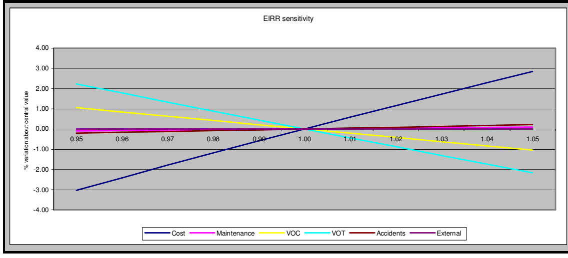
	EUR mln	
Road VOC benefits	510.1	26.6%
Road VOT benefits	1560.8	81.3%
Accident benefits	-151.2	-7.9%
External benefits	0.2	0.0%
TOTAL	1919.9	100.0%

ECONOMIC INDICATORS

EIRR		17.45%
NPV	EUR mln	204.64
BCR		3.15

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		19.83%	13.62%	17.35%	17.56%	19.22%	15.54%	20.88%	12.97%	16.69%	17.43%	14.03%	17.42%	17.45%
NPV	EUR mln	223.67	157.08	201.35	207.93	252.93	156.35	322.55	86.73	182.61	205.03	129.20	200.06	0.00
BCR		3.94	2.10	3.12	3.19	3.66	2.64	4.39	1.91	2.92	3.16	2.36	3.01	1.00
Critical?		N		N		N		Y		N	N			



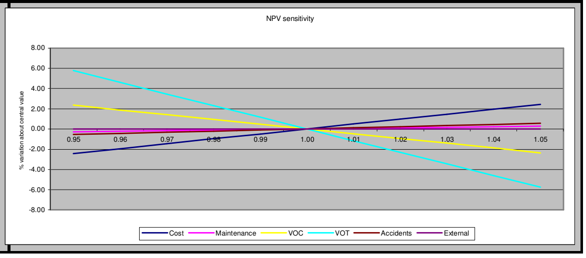


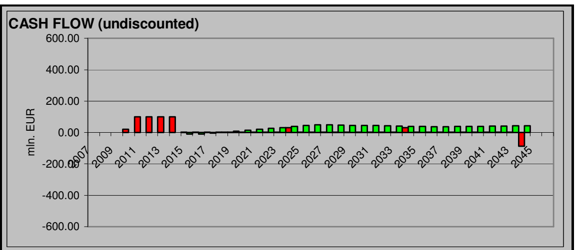
Figure A2.4 Economic evaluation results: SC4 Matesevo - Berane (no toll)

Bar - Boljare: Matesevo - Berane

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2011
Construction period	years	4
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007

CASH FLOW (undiscounted)



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	416.13
Residual value	EUR mln	-119.43
Total O&M costs over evaluation period	EUR mln	127.61

BENEFITS (undiscounted)

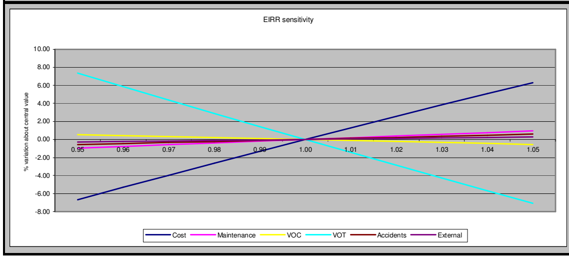
	EUR mln	
Road VOC benefits	61.7	6.5%
Road VOT benefits	1011.4	106.3%
Accident benefits	-82.7	-8.7%
External benefits	-39.2	-4.1%
TOTAL	951.2	100.0%

ECONOMIC INDICATORS

EIRR		3.97%
NPV	EUR mln	-145.00
BCR		0.46

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		5.05%	2.18%	3.74%	4.19%	4.18%	3.75%	6.38%	0.00%	3.49%	3.74%	0.00%	3.49%	3.97%
NPV	EUR mln	-91.11	-279.72	-151.57	-138.42	-139.57	-150.42	-67.60	-222.39	-157.76	-151.50	-212.38	-151.92	0.00
BCR		0.58	0.31	0.44	0.49	0.48	0.44	0.75	0.17	0.41	0.44	0.21	0.45	100.00%
Critical?		Y		N		N		Y		N	N			



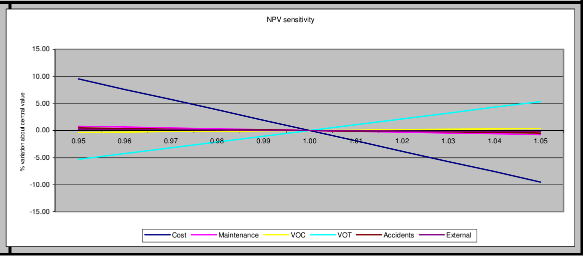
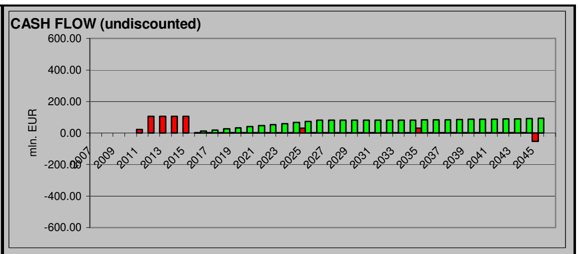


Figure A2.5 Economic evaluation results: SC5 Berane - Boljare (no toll)

Bar - Boljare: Berane - Boljare

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2012
Construction period	years	4
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	442.56
Residual value	EUR mln	-81.43
Total O&M costs over evaluation period	EUR mln	128.90

BENEFITS (undiscounted)

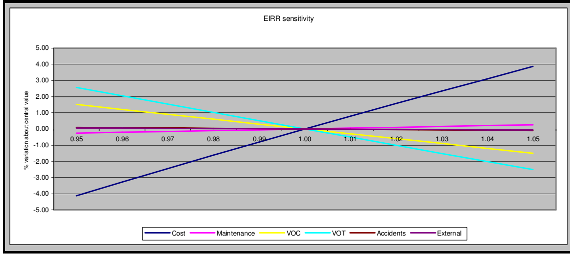
	EUR mln	
Road VOC benefits	621.3	29.3%
Road VOT benefits	1403.4	66.3%
Accident benefits	58.9	2.8%
External benefits	34.6	1.6%
TOTAL	2118.2	100.0%

ECONOMIC INDICATORS

EIRR		9.34%
NPV	EUR mln	55.47
BCR		1.21

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		11.06%	6.56%	9.20%	9.49%	10.70%	7.88%	11.47%	6.59%	9.54%	9.44%	7.54%	9.26%	9.34%
NPV	EUR mln	109.03	-78.42	49.18	61.76	115.72	-4.78	160.60	-49.66	64.24	60.14	-19.33	51.10	0.00
BCR		1.51	0.80	1.18	1.23	1.43	0.98	1.60	0.81	1.24	1.22	0.93	1.19	1.00
Critical?		Y		N		Y		Y		N	N			



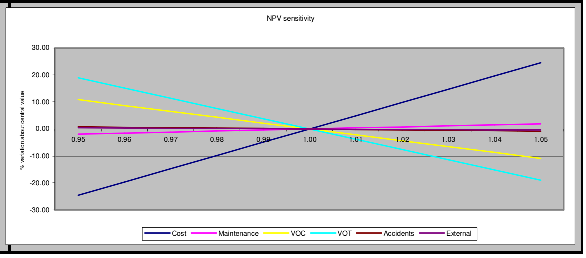
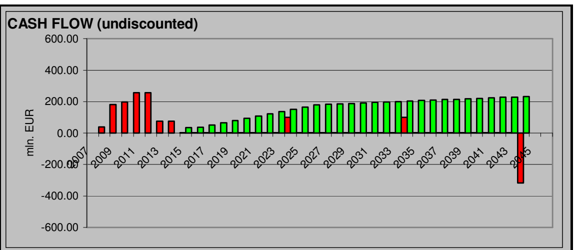


Figure A2.6 Economic evaluation results: SC6 Virpazar - Matesevo (no toll)

Bar - Boljare: Virpazar - Matesevo

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2009
Construction period	years	6
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	1081.40
Residual value	EUR mln	-416.34
Total O&M costs over evaluation period	EUR mln	377.81

ECONOMIC INDICATORS

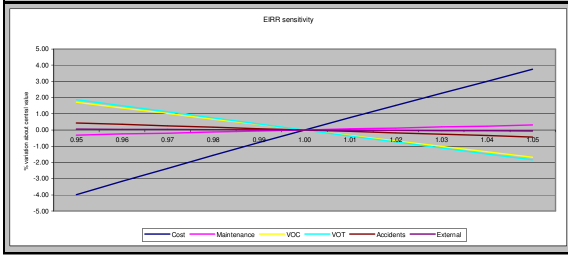
EIRR		7.89%
NPV	EUR mln	-13.78
BCR		0.98

BENEFITS (undiscounted)

	EUR mln	
Road VOC benefits	1894.7	38.3%
Road VOT benefits	2444.1	49.4%
Accident benefits	544.1	11.0%
External benefits	60.7	1.2%
TOTAL	4943.7	100.0%

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		9.26%	5.66%	7.75%	8.04%	9.16%	6.46%	9.24%	6.26%	8.56%	7.97%	6.69%	7.70%	7.89%
NPV	EUR mln	141.85	-402.86	-32.78	5.22	160.06	-187.62	176.49	-204.05	75.96	-4.02	-168.38	-37.92	0.00
BCR		1.23	0.65	0.96	1.01	1.21	0.76	1.23	0.74	1.10	0.99	0.78	0.95	1.00
Critical?		Y		Y		Y		Y		Y	N			



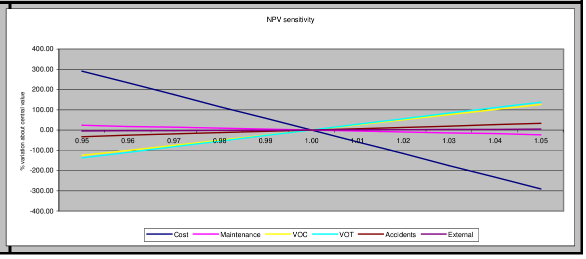


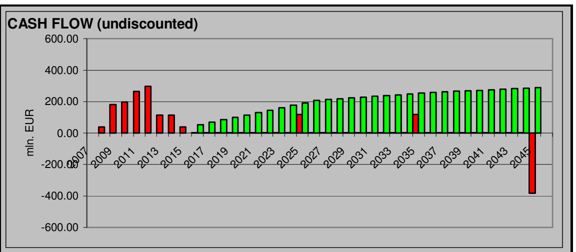
Figure A2.7 Economic evaluation results: SC7 Djurmani - Matesevo (no toll)

Bar - Boljare: Djurmani - Matesevo

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2009
Construction period	years	7
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007

CASH FLOW (undiscounted)



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	1243.55
Residual value	EUR mln	-501.15
Total O&M costs over evaluation period	EUR mln	450.31

BENEFITS (undiscounted)

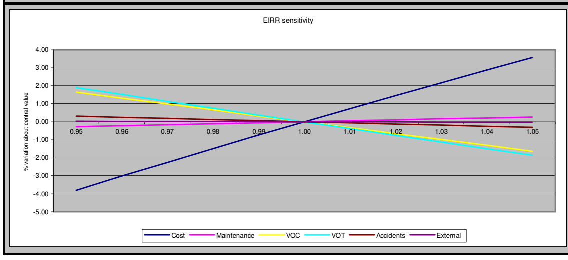
	EUR mln	
Road VOC benefits	2412.2	38.5%
Road VOT benefits	3294.5	52.6%
Accident benefits	521.1	8.3%
External benefits	33.9	0.5%
TOTAL	6261.8	100.0%

ECONOMIC INDICATORS

EIRR		8.37%
NPV	EUR mln	56.51
BCR		1.06

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		9.76%	6.10%	8.24%	8.50%	9.67%	6.90%	9.80%	6.61%	8.88%	8.41%	7.15%	8.20%	8.37%
NPV	EUR mln	231.53	-381.03	35.63	77.40	269.21	-156.18	300.95	-187.93	137.53	62.44	-125.97	29.60	0.00
BCR		1.33	0.71	1.04	1.09	1.31	0.82	1.34	0.79	1.16	1.07	0.86	1.03	1.00
Critical?		Y		Y		Y		Y		Y	N			



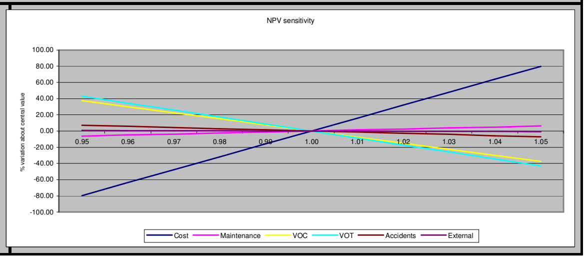
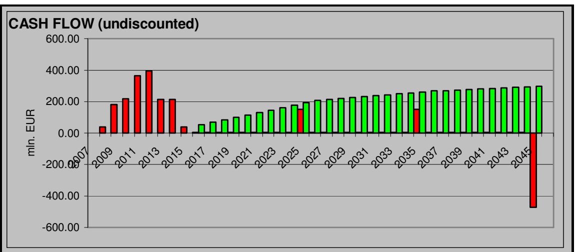


Figure A2.8 Economic evaluation results: SC8 Djurmani - Berane (no toll)

Bar - Boljare: Djurmani - Berane

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2009
Construction period	years	7
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	1659.68
Residual value	EUR mln	-620.72
Total O&M costs over 20 evaluation period	EUR mln	577.91

BENEFITS (undiscounted)

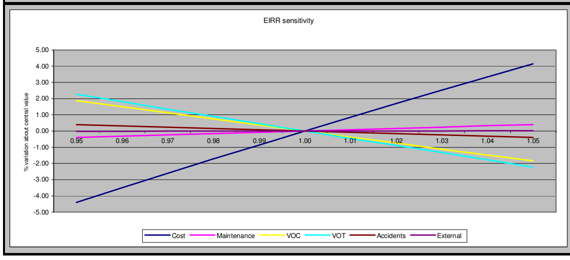
	EUR mln	
Road VOC benefits	2459.5	38.6%
Road VOT benefits	3369.0	52.8%
Accident benefits	575.2	9.0%
External benefits	-23.9	-0.4%
TOTAL	6379.8	100.0%

ECONOMIC INDICATORS

EIRR		6.76%
NPV	EUR mln	-223.24
BCR		0.81

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		8.04%	4.67%	6.59%	6.92%	7.94%	5.41%	8.14%	5.06%	7.28%	6.74%	5.64%	6.50%	6.76%
NPV	EUR mln	5.78	-795.76	-250.21	-196.26	-10.47	-436.00	26.82	-473.29	-134.19	-226.20	-415.67	-256.56	0.00
BCR		1.01	0.54	0.78	0.83	0.99	0.62	1.02	0.59	0.88	0.80	0.64	0.78	1.00
Critical?		Y		N		Y		Y		N	N			



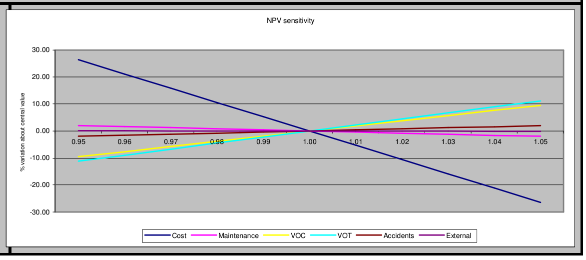
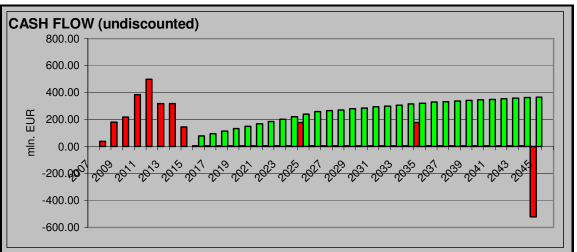


Figure A2.9 Economic evaluation results: SC9 Djurmani - Boljare (no toll)

Bar - Boljare: Djurmani - Boljare

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2009
Construction period	years	7
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	2102.24
Residual value	EUR mln	-702.15
Total O&M costs over evaluation period	EUR mln	706.81

BENEFITS (undiscounted)

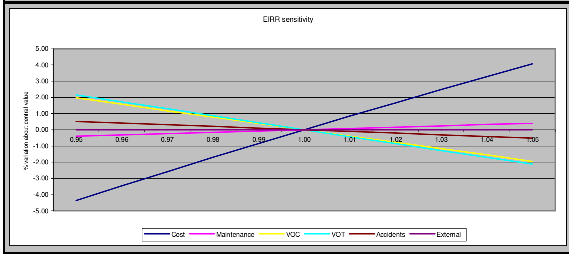
	EUR mln	
Road VOC benefits	3082.1	38.7%
Road VOT benefits	3962.6	49.8%
Accident benefits	922.0	11.6%
External benefits	-7.7	-0.1%
TOTAL	7959.0	100.0%

ECONOMIC INDICATORS

EIRR		6.87%
NPV	EUR mln	-242.96
BCR		0.83

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		8.21%	4.69%	6.70%	7.03%	8.14%	5.44%	8.22%	5.23%	7.55%	6.87%	5.78%	6.64%	6.87%
NPV	EUR mln	39.61	-949.40	-276.22	-209.70	32.71	-518.63	51.20	-537.13	-101.38	-243.45	-472.98	-280.66	0.00
BCR		1.04	0.55	0.80	0.85	1.02	0.63	1.04	0.62	0.93	0.83	0.67	0.81	1.00
Critical?		Y		N		Y		Y		N	N			



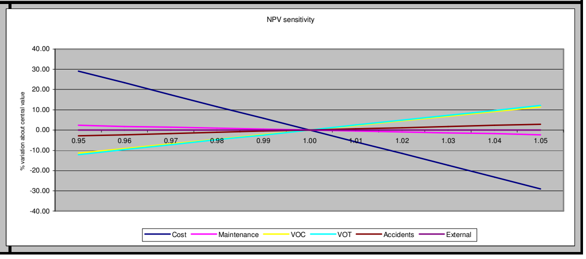


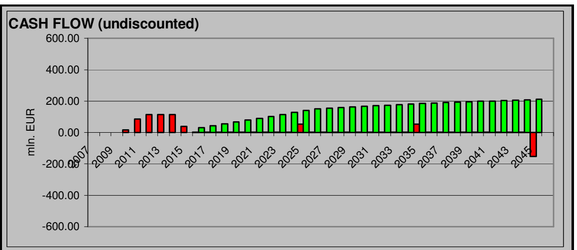
Figure A2.10 Economic evaluation results: SC10 Djurmani - Smokovac (no toll)

Bar - Boljare: Djurmani - Smokovac

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2011
Construction period	years	5
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007

CASH FLOW (undiscounted)



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	482.74
Residual value	EUR mln	-204.68
Total O&M costs over evaluation period	EUR mln	207.84

BENEFITS (undiscounted)

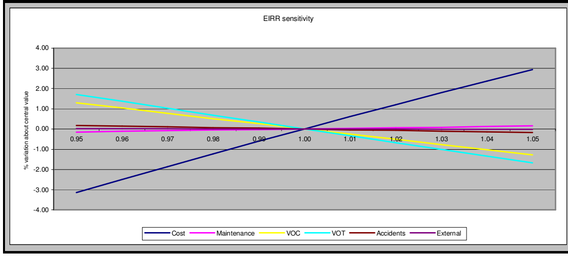
	EUR mln	
Road VOC benefits	1574.3	34.9%
Road VOT benefits	2662.1	59.0%
Accident benefits	249.0	5.5%
External benefits	26.3	0.6%
TOTAL	4511.7	100.0%

ECONOMIC INDICATORS

EIRR		13.88%
NPV	EUR mln	375.71
BCR		2.25

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		15.83%	10.72%	13.76%	14.00%	15.58%	11.99%	16.03%	11.24%	14.36%	13.93%	11.74%	13.83%	13.88%
NPV	EUR mln	436.04	224.89	365.93	385.50	512.14	239.28	572.25	179.18	415.15	380.31	235.49	364.72	0.00
BCR		2.81	1.50	2.21	2.28	2.70	1.79	2.90	1.59	2.38	2.26	1.78	2.17	1.00
Critical?		N		N		N		Y		N	N			



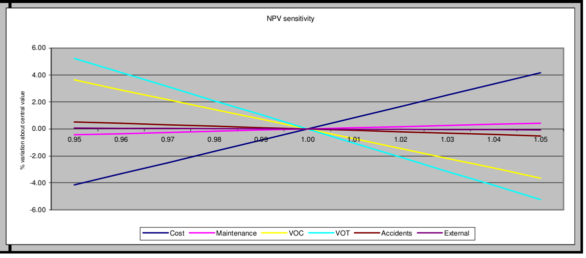
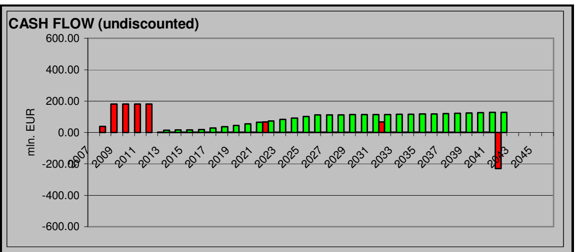


Figure A2.11 Economic evaluation results: SC1 Smokovac - Matesevo (with toll)

Bar - Boljare: Smokovac - Matesevo

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2009
Construction period	years	4
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	760.80
Residual value	EUR mln	-296.71
Total O&M costs over evaluation period	EUR mln	256.87

BENEFITS (undiscounted)

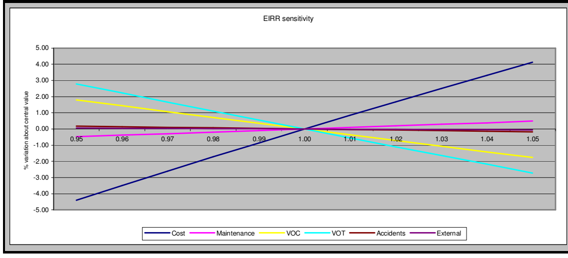
	EUR mln	
Road VOC benefits	900.3	34.1%
Road VOT benefits	1606.7	60.8%
Accident benefits	101.7	3.8%
External benefits	35.0	1.3%
TOTAL	2643.7	100.0%

ECONOMIC INDICATORS

EIRR		6.45%
NPV	EUR mln	-134.65
BCR		0.76

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		7.72%	4.38%	6.26%	6.63%	7.54%	5.24%	8.05%	4.43%	6.66%	6.51%	5.00%	6.12%	6.45%
NPV	EUR mln	-20.79	-419.30	-149.74	-119.56	-41.93	-227.37	4.78	-274.08	-118.29	-130.37	-258.20	-154.72	0.00
BCR		0.95	0.51	0.74	0.79	0.93	0.60	1.01	0.52	0.79	0.77	0.55	0.74	1.00
Critical?		Y		N		Y		Y		N	N			



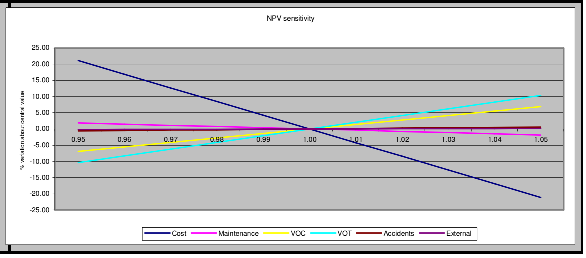
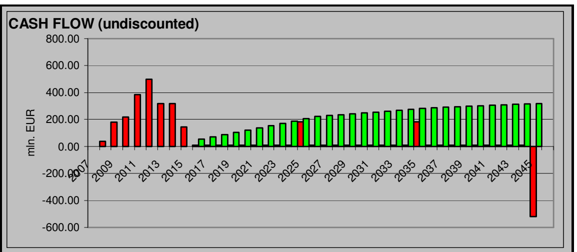


Figure A2.12 Economic evaluation results: SC9 Djurmani - Boljare (with toll)

Bar - Boljare: Djurmani - Boljare

Economic Evaluation

Macroeconomic scenario (L/M/H)		Realistic
Base year for costs	Year	2007
Year of beginning of construction	Year	2009
Construction period	years	7
Evaluation period	years	30
Discount rate	%	8
Base year for discounting	Year	2007



COSTS (undiscounted)

Total construction cost (exc. taxes)	EUR mln	2102.24
Residual value	EUR mln	-702.15
Total O&M costs over evaluation period	EUR mln	800.41

BENEFITS (undiscounted)

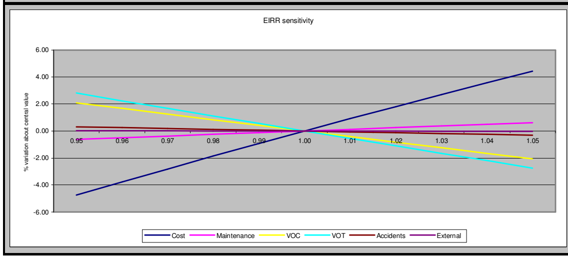
	EUR mln	
Road VOC benefits	2563.8	37.4%
Road VOT benefits	3849.8	56.1%
Accident benefits	422.0	6.2%
External benefits	24.8	0.4%
TOTAL	6860.4	100.0%

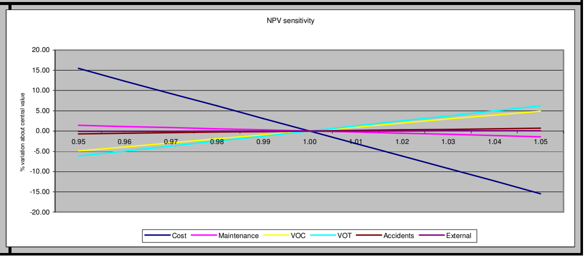
ECONOMIC INDICATORS

EIRR		5.78%
NPV	EUR mln	-457.00
BCR		0.68

SENSITIVITY ANALYSIS

		Construction costs		Maintenance costs		VOC		VOT		Accidents	External	Generated	Residual	Disc. rate
		-20%	+50%	+30%	-30%	+50%	-50%	+50%	-50%	+100%	+100%	0%	0%	= EIRR
EIRR		7.01%	3.79%	5.57%	5.99%	6.92%	4.50%	7.24%	3.96%	6.13%	5.81%	4.88%	5.47%	5.78%
NPV	EUR mln	-174.43	-1163.44	-495.95	-418.05	-233.35	-680.65	-172.43	-741.57	-393.31	-451.42	-640.25	-494.70	0.00
BCR		0.85	0.45	0.65	0.70	0.83	0.52	0.88	0.48	0.72	0.68	0.55	0.66	1.00
Critical?		Y		N		N		Y		N	N			





Revision Schedule

Bar – Boljare Motorway, Montenegro – Traffic Study Report
June 2009

Rev	Date	Details	Prepared by	Reviewed by	Approved by
01	20/10/2008	Final draft	**Philippe Perret** Senior transport planner	**Dave Gardner** Technical director	**Simon Roberts** Technical director
02	26/11/2008	Includes IFC comments	**Philippe Perret** Senior transport planner	**Dave Gardner** Technical director	**Martin Edge** Director
03	04/02/2009	Includes WTP results	**Philippe Perret** Principal transport planner	**Simon Roberts** Technical director	**Martin Edge** Director
04	11/06/2009	Adjusted for new GDP	**Mattias Stridh** Transport planner	**Philippe Perret** Principal transport planner	**Simon Roberts** Technical director

Scott Wilson
Scott House
Alencon Link
Basingstoke
Hampshire
RG21 7PP
UK
Tel +44 (0) 1256 310200
Fax +44 (0) 1256 310201

www.scottwilson.com

Table of Contents

List of Tables

List of Figures

1 INTRODUCTION

The Government of Montenegro (GOM) is planning to proceed with the construction of the Bar – Boljare motorway. The International Finance Corporation (IFC) has been appointed to act as a lead advisor in the structuring and implementing of a public-private partnership (PPP) for the design, financing, construction, operation and maintenance. IFC has in turn contracted Scott Wilson (SW).

The objectives of the study are to review and update work carried out by Louis Berger SAS (LB) for the *Feasibility Study for Two Highways in Montenegro*. This report focuses on the development of the revised traffic model.

This is revision version 04 of the Bar – Boljare Traffic Study Report, which presents results from model runs with revised GDP forecasts. The report has also been updated in order to reflect comments from IFC (revision version 02) as well as the results from the WTP survey (revision version 03).

1.1 Strategic context

In 2007-2008 LB carried out the *Feasibility Study for Two Highways in Montenegro*. One of the two highways is the proposed motorway from Bar to Boljare. The motorway would run from the Montenegrin coast near the port of Bar to the capital Podgorica and on to the Serbian border. At the border it would link up with the proposed Serbian motorway to Belgrade. It would also connect with routes to the regional capital cities of Sarajevo in Bosnia and Herzegovina, Tirana in Albania, Pristina in Kosovo and Skopje in the Former Yugoslav Republic of Macedonia. While the motorway does not form part of the European network of corridors, it is part of the core network of links (Figure 1.1). The motorway therefore has a clear strategic role to play in the region.

Figure 1-1: Strategic road links in south east Europe

Source: SEETO

However, the viability of the road does depend to a large extent on the construction of the continuation on the Serbian side of the border. Construction of this motorway was originally due to begin in 2008 but we understand that this may now be delayed.

In Montenegro the motorway is divided into five sections:

- The coast (Djurmani) - Virpazar
- Virpazar - Smokovac
- Smokovac - Matesevo
- Matesevo - Berane
- Berane - Boljare.

It is the intention of the GOM that the section north of Podgorica from Smokovac to Matesevo should be constructed first, followed shortly after by the remaining sections.

Louis Berger have produced a number of reports and memoranda for their study, these were used as supporting information as LB have carried out considerable research for the *Feasibility Study for Two Highways in Montenegro*.

Other consultants have also carried out studies in the region over the last few years. Access to the reports of the following studies was provided:

- *Ecorys study*;
- *BCEOM COWI study*;
- *The Spatial Plan of Montenegro until 2020*.

1.2 Structure of the report

The report discusses the traffic surveys that were carried out and the development of the traffic model, including its calibration. This report also focuses on the analysis of the future year assignments and gives conclusions and recommendations.

The remainder of this report will be structured as follows:

- Section 2 reviews the various types of traffic surveys that were undertaken by LB and SW;
- Section 3 describes the development of the model highway networks;
- Section 4 describes the development of the model trip matrices;
- Section 5 discusses the procedures by which the base year models were calibrated and presents the results of a comparison of observed against modelled data for a variety of link flows;
- Section 6 details the development of the forecast year highway networks;
- Section 7 describes the development of the forecast year matrices;
- Section 8 describes the future year assignment process and results;
- Section 9 discusses the sensitivity tests carried out;
- Section 10 presents the toll optimisation; and
- Section 11 provides a summary and conclusions.

2 TRAFFIC SURVEYS

This chapter presents the methodology used for the traffic surveys carried out as part of the Bar – Boljare study. This includes both the initial set of surveys carried by LB and the additional data collection exercise carried out by SW. It then presents some of the main findings from the analysis of the survey outputs.

2.1 Initial data collection

Road Side Interviews (RSI) were carried out by Louis Berger at 16 locations, covering all Montenegrin strategic corridors and the main roads in Montenegro The purpose of these surveys was to provide specific information on the type of trips using the highway network around Montenegro, especially with regard to the origin and destinations of those trips. This data was then used as a key component in the development of trip matrices for the Bar – Boljare model.

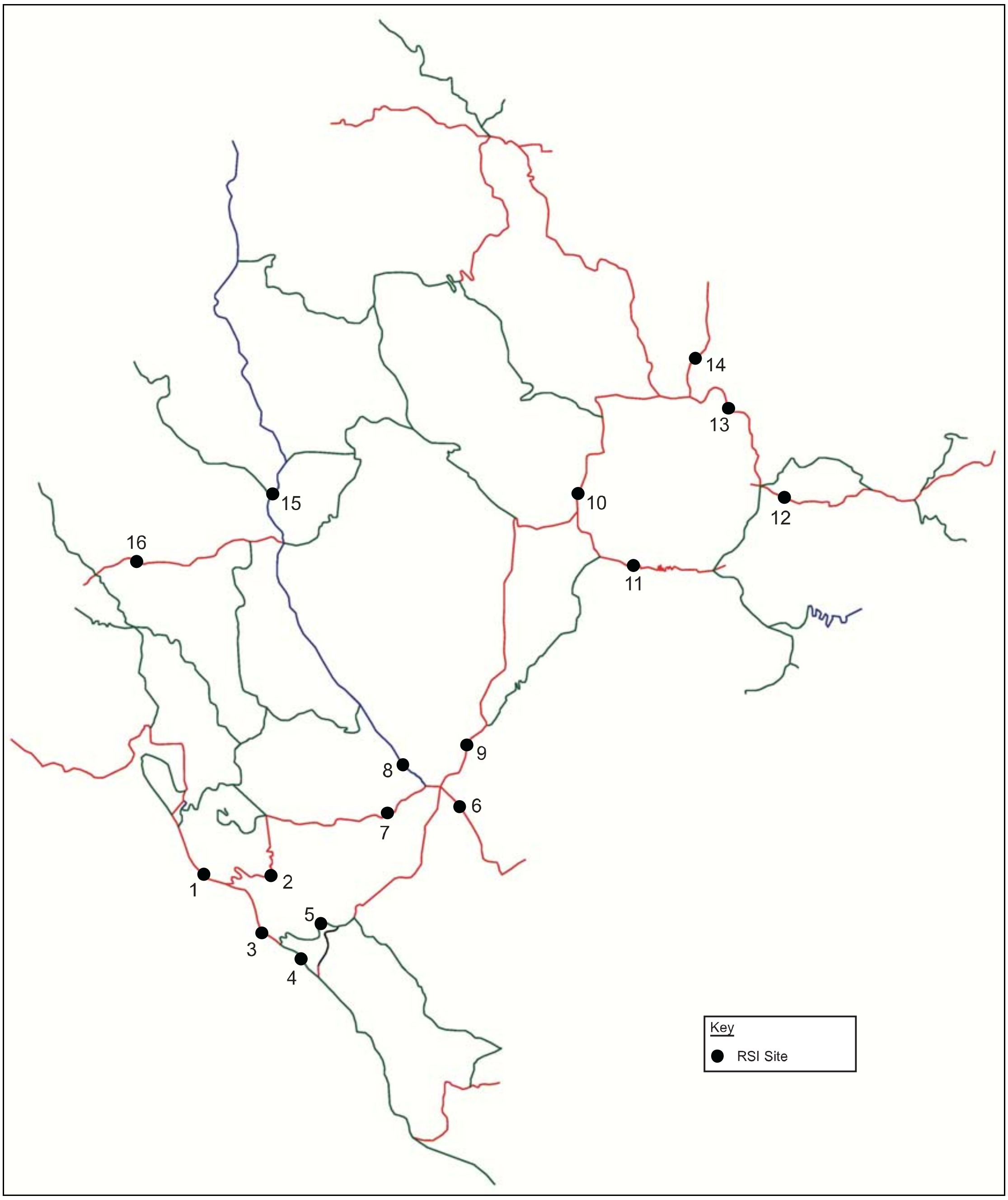
During the RSI surveys, a sample of vehicles was stopped on the roadside, and the vehicle driver asked certain questions pertinent to his trip. This sample is then expanded into the total flow using traffic counts that are conducted simultaneously.

The surveys were carried out end of October 2007. The locations of the RSI's are illustrated in Figure 2.1 and are as follows:

- Station 1: Between Budva and Tivat
- Station 2: Between Budva and Cetinje
- Station 3: Between Budva and Petrovac
- Station 4: Between Petrovac and Bar
- Station 5: Old road between Virpazar and Petrovac
- Station 6: Between Podgorica and Tuzi
- Station 7: Between Podgorica and Cetinje
- Station 8: Between Podgorica and Danilovgrad
- Station 9: Between Podgorica and Bioče
- Station 10: Between Crkvine and Kolasin
- Station 11: Between Matesevo and Kraljske Bare
- Station 12: Between Berane and Rožaje

- Station 13: Interchange "Ribarevina"
- Station 14: Between B. Polje and Barski most
- Station 15: Between Niksic and Jasenovo Polje
- Station 16: Between Vilusi and Klobuk

Figure 2-1: Location of LB traffic surveys



Source: LB

The RSI's were carried out by Louis Berger for a single day over a twelve hour period between 07:00 and 19:00, for both directions of traffic. During the interviews, the following data was collected:

- The vehicle classification: passenger car, light goods vehicle (LGV), medium or heavy goods vehicle (MGV, HGV), bus, or articulated lorry (artic);
- The number of occupants in the vehicle;
- Location where vehicle was registered;
- The origin and destination (OD) of the trip. municipality in Montenegro or country outside Montenegro
- The trip origin purpose: home, work education, tourism (short and long), shopping or visiting friends or personal trips, others;
- The trip destination purpose: home, work education, tourism (short and long), shopping or visiting friends or personal trips, others; and
- Frequency of trip.

In addition to the RSI surveys, Manual Classified Counts (MCC's) were undertaken at each of the RSI stations, for the duration of the survey for 24 hours. The purpose of the MCC's was to allow the sample of traffic surveyed during the RSI's to be expanded to the total flow. This expansion is carried out by vehicle type, at that specific location.

Traffic Counts were undertaken at all locations for a period of one week, inclusive of the survey day for twelve hours each day. This was to determine average weekly flows for the RSI locations, and allow for any variations in traffic flows that may have occurred during the day of the RSI. Such variation can potentially take place if the RSI itself causes traffic disruption and diversion from the site.

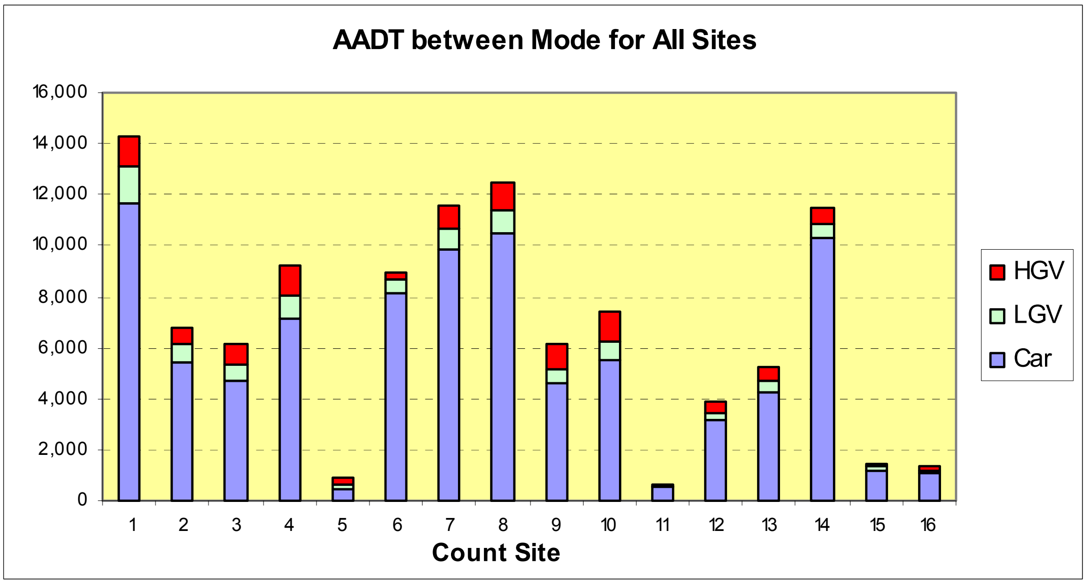
2.2 Traffic volumes

Considerable information has been collected through the RSI, MCC and traffic count surveys. Figure 3.2 illustrates the AADT traffic volumes, at the 16 RSI sites, by type of vehicle, as obtained from the MCC (converted to AADT). The figures demonstrate a number of facts:

- The busiest site is on the coast between Budva and Tivat;
- Sites 7 and 8 to the west of Podgorica are also experiencing relatively high AADT;
- Site 14 near the Serbian border, on our corridor of interest, is showing AADT of about 11,000 vehicles a day[1];
- Sites 15 and 16,west of Niksic, site 12 close to Andrijevica and site 5, the old road to Bar (replaced by the Sozina tunnel) are showing very low AADT; and
- Car traffic makes a high proportion of the flow.

[1] A high proportion of local traffic is included in this figure, hence requiring adjustment before carrying out calibration, see chapter 5.

Figure 2-2: Observed AADT at LB traffic survey locations



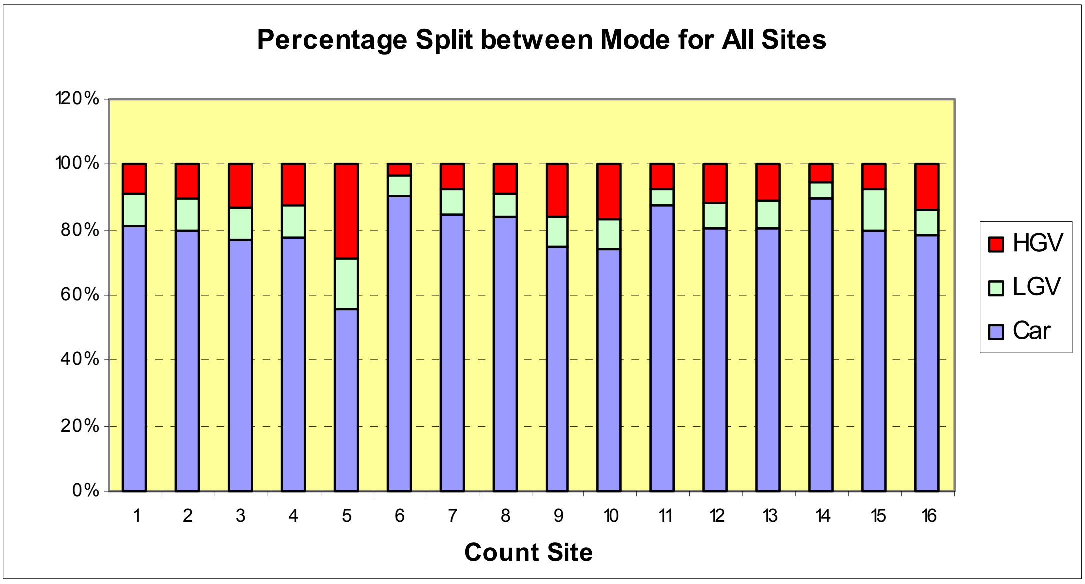
Source: LB and consultant's analysis

Figure 3.3 shows the percentage mode split for all sites. Three categories have been considered combining the various modes as follows:

- Passenger car;
- LGV: Van + Minibus + Light truck;
- HGV: Bus + Medium truck + Heavy truck and heavy truck with trailer.

It shows that on average cars form about 80% of the traffic. There also tend to be more heavy goods vehicles (HGV) than light goods vehicles (LGV).

Figure 2-3: Observed mode split at LB traffic survey locations



Source: LB and consultant's analysis

Further analysis of the MCC and traffic count results can be found in **Appendix 1**. This includes the daily and weekly variations per site. Weekly profiles are relatively flat for most sites. Exceptions are sites 4 and 5 near the coast, sites 15 and 16 west of Niksic and sites 12 and 13 in the mountains. On the Bar – Boljare corridor (sites 14, 10, 9 and 4 north to south), weekly profiles are relatively flat. Daily profiles are usually similar across all sites showing low levels of traffic until 7:00 AM and showing peaks between 12:00 and 18:00.

2.3 Additional data collection

All the MCC and traffic count data collected together with the processed RSI data per site was made available for Scott Wilson as part of this study. Historic traffic count data for numerous links across Montenegro as collected by the Crnagoraput Company and data for the Sozina tunnel crossing was also made available for use in the study.

The locations of the 16 RSI sites were judged adequate for the study as they capture most of the strategic long distance trips. No data had been collected about the type of freight but this data gap can be covered from knowledge gained from the haulage industry. It was considered that there was no need to arrange for further RSI as this would not add value to the origin-destination information already available.

However, based on the IFC recommendation note and Scott Wilson's own review of the Louis Berger traffic study, it was proposed to carry out additional traffic counts in order to obtain greater confidence in the existing traffic counts. The aim was to ascertain if the LB counts are reasonable. It was not intended to use these counts in the model development, at least at an initial stage. Should the new surveys return results that are not in line with expectations consideration would be given to recalibrating the traffic model based on the new counts before rerunning the traffic forecasts.

It was proposed to conduct additional traffic counts at locations directly related to the Bar – Boljare motorway project and hence on the Bar – Boljare existing road corridor. Furthermore, to minimise the risks of incompatibility of information or incorrect conversion through various factors (daily, weekly, monthly and annual distribution factors), we proposed to carry out these additional counts:

- At the same time of the year as the period used for LB study, i.e. October;
- At the same locations, if possible, as the count carried out for the LB study.

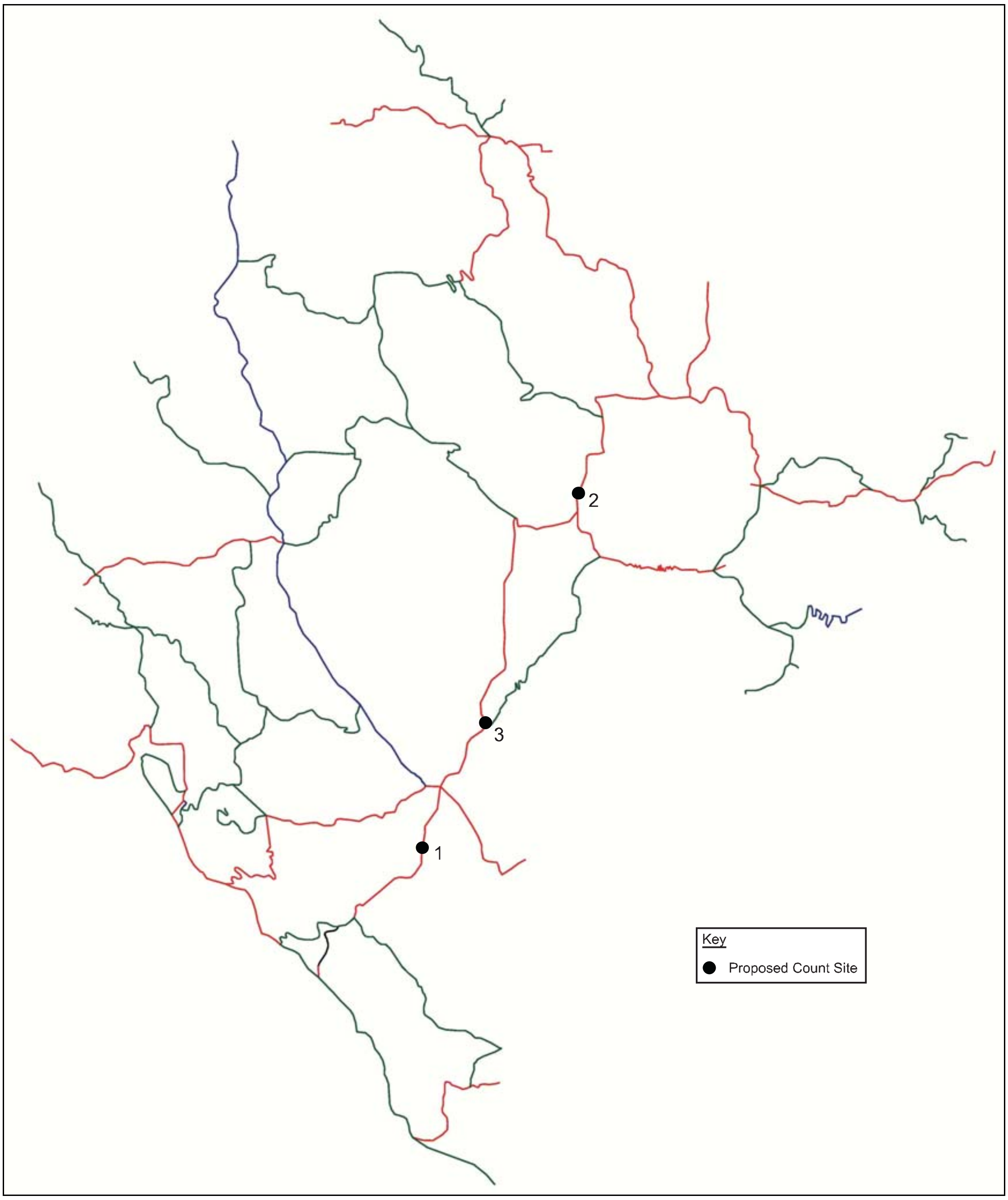
Three sets of traffic counts have been identified as crucial and the locations of these are:

- 1. A new set between Podgorica and Golubovci;
- 2. A new set between Kolasin and Mojkovac;
- 3. At the Bioče location.

These three locations are indicated on the map in Figure 3.5. The exact locations have been chosen with the following issues in mind:

- Safety - location to be on site with high visibility, and an available lay-by, to avoid risks to the survey team;
- Count accuracy - the location of the count site should be away from village centres or large settlements, as the results could be distorted by local traffic (the primary interest being long distance traffic).

Figure 2-4: Location of additional traffic counts conducted by SW



Source: consultant's analysis

The LB study traffic counts were carried out on the week commencing the 23rd of October 2007. As a result the optimal time to carry out the additional surveys was identified to be the week starting Sunday the 26th of October 2008. Two types of data collection exercise were carried out:

- Manual Classified Counts (MCC); and
- Automated Traffic Counts (ATC).

The MCC were carried out for one full day (24 hours) on a weekday of the week noted above. The classification of vehicles used was:

- Passenger car;
- Van + minibus;
- Bus;
- Light truck;
- Medium truck; and
- Heavy truck and heavy truck with trailer.

The MCC surveys have been carried out using video camera equipment. At each site, the road was filmed for 24 consecutive hours and the video analysed at a later stage. This method has a benefit of providing robust results that can be checked if necessary.

The ATC were carried out using automatic counters for one week. This provided the definition of an average weekday and removed the human factor to be considered when looking at the result of counts carried out manually. A security company was commissioned to look after the equipment to ensure that it is not stolen and so that they could report failure of the counting system immediately in case of problem.

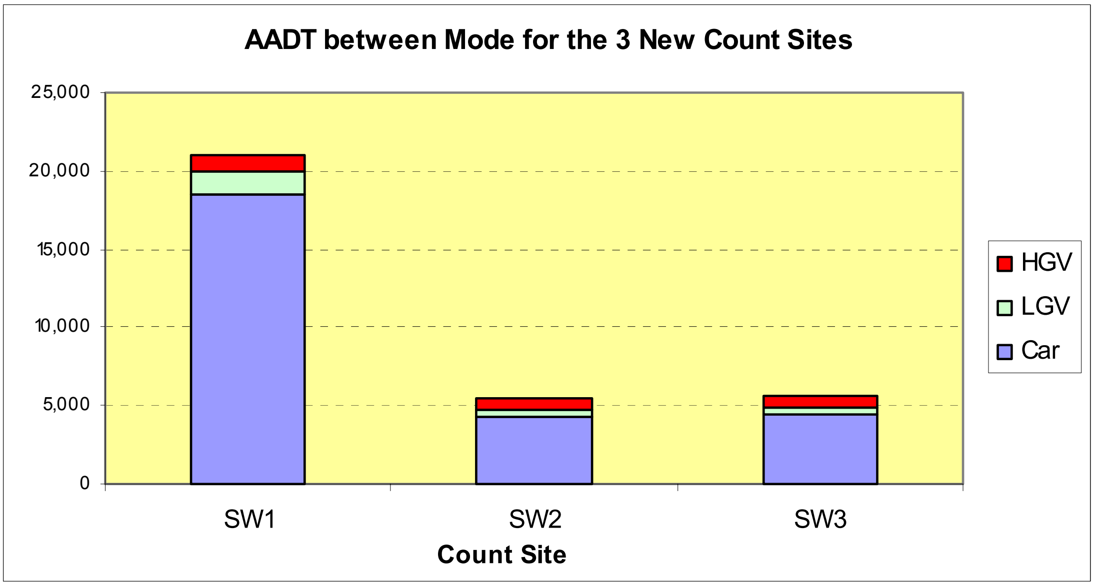
The work was carried using a traffic survey company based in the UK. They are experts in traffic data collection and have experience of data collection in Eastern Europe.

Figures 3.6 and 3.7 show the AADT levels (adjusted to 2007) and the percentage mode split at the three locations where new counts have been carried out. These results allow two conclusions to be drawn:

- The section between Podgorica and Golubovci (site SW1) is heavily trafficked. This is to be expected as Golubovci is part of the Podgorica municipality and the there is no clear boundary between the two as they form a single large conurbation. Enquiries with local users confirmed that this section of the existing road is used extensively for short distance trip including commuters and shopping trips from/to Podgorica to Golubovci; and
- The mode split for sites SW2 and SW3 is in line with other sites while the mode split for site SW1 shows a high proportion of car. This confirms the hypothesis noted above that this section is used for short distance trips by locals.

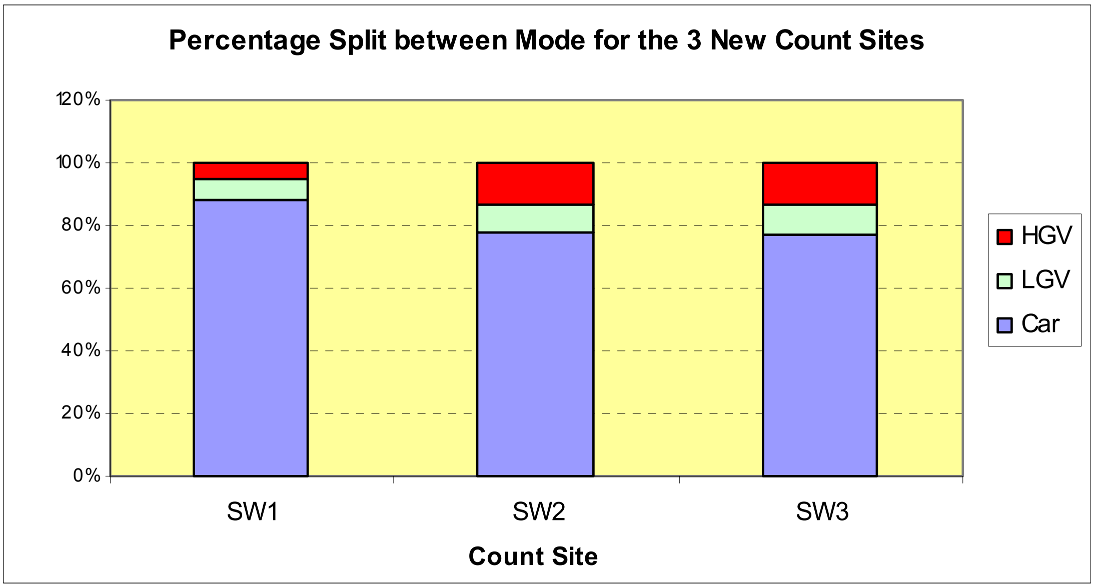
Further analysis of the MCC and traffic count results can be found in **Appendix 1**.

Figure 2-5: Observed AADT at SW traffic count locations



Source: consultant’s analysis

Figure 2-6: Observed mode split at SW traffic survey locations



Source: consultant’s analysis

One of the purposes of carrying out new traffic counts was to confirm that the data collection exercise carried out by LB was correct. The SW3 count carried out at the Bioce location was in fact at the same location as site 9 from LB.

Table 2.1 shows a comparison between LB's site 9 results and SW's site 3 results corrected to 2007 AADT levels and mode split. The AADT levels are slightly lower for the SW counts but the difference is not significant considering normal day to day variations in traffic flow and the factoring to bring the SW counts from 2008 to 2007. More interestingly, the mode split appears to be similar for both counts with only a slightly lower proportion of HGVs for the SW count.

Table 2.1: Comparison between LB and SW counts

Comparison between same location site (Bioce)				
	AADT flow		Mode split	
Mode	RSI 9	SW3	RSI 9	SW3
Car	4,600	4,385	75%	77%
LGV	573	570	9%	10%
HGV	978	740	16%	13%
Total	**6,151**	**5,695**	**100%**	**100%**

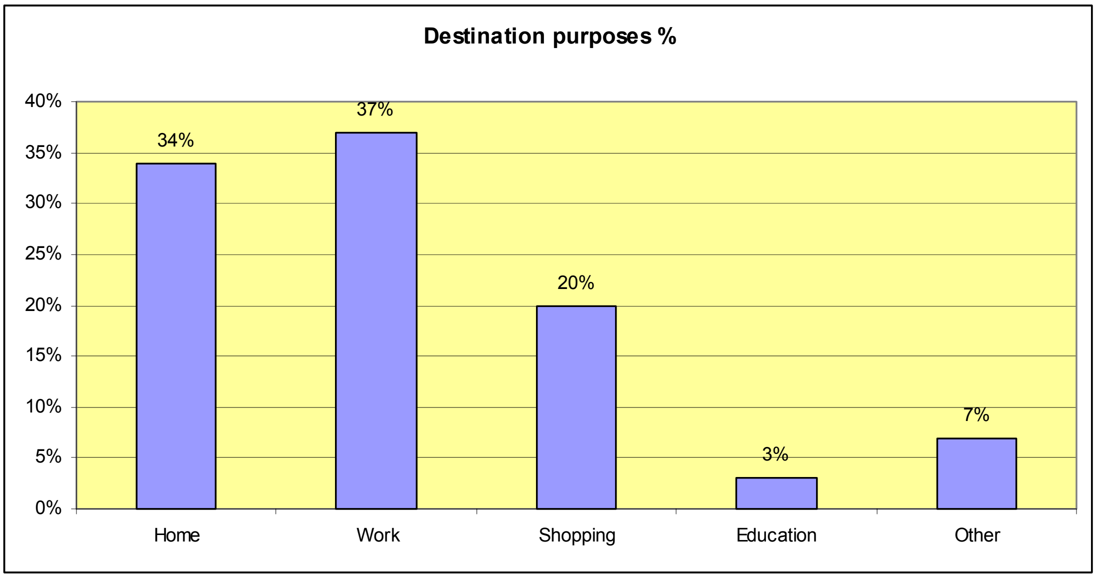
Source: consultant's analysis

The above suggests that the survey data obtained by LB is sufficiently robust to be used as part of the Bar – Boljare motorway traffic study. A conservative approach was chosen, and for the rest of the study, where counts have been redone, the most recent counts were used as they correspond to the lowest AADT avoiding overestimation of the forecast potential Bar – Boljare motorway traffic.

2.4 RSI data analysis

Figure 3.4 shows the overall purpose split for all sites combined. It shows that strategic movements in Montenegro are highly work related. Purposes such as education are minor as the data as been collected away from urban centres.

Figure 2-7: Observed destination purpose split based on LB RSI surveys



Source: LB and consultant's analysis

Analysis of the RSI data showed that average occupancy is fairly stable throughout the day. The average value found was 2.14 occupants per car.

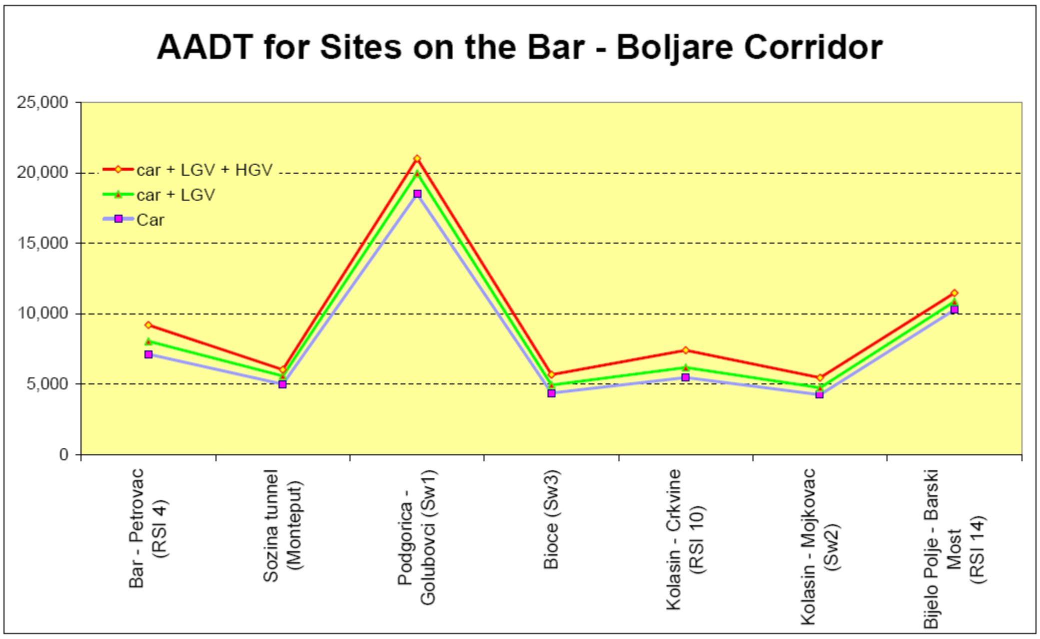
Further analysis of the RSI data, looking at major generators and key observed movements are detailed in chapter 6 of this report.

2.5 Bar – Boljare corridor

Figure 3.8 shows how observed traffic varies on the Bar – Boljare existing corridor using LB RSI sites 4, 10, 14; the SW count sites 1, 2 and 3 and the Sozina tunnel traffic data from the Monteput company. It shows that the highest levels of traffic are between Golubovci and Podgorica, as this is in an urban environment thus used by local and non strategic traffic. Traffic appears to be relatively high close to the Serbian border which is relatively unexpected and mainly due to the location of the survey site close to an urban centre[2]. On other sections of the corridor, traffic appears to be relatively constant and around 7,500 vehicles AADT.

[2] Hence requiring adjustment before carrying out calibration, see chapter 5.

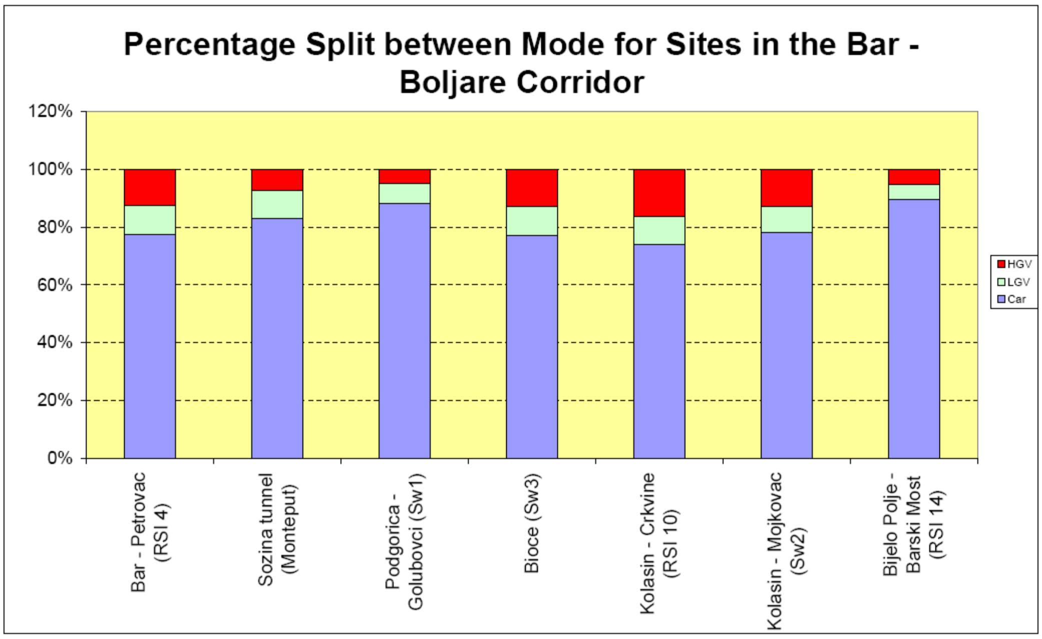
Figure 2-8: Observed AADT traffic survey locations on Bar – Boljare corridor



Source: LB and consultant's analysis

Figure 3.9 suggests a high proportion of goods vehicles on the corridor on the rural sections used by strategic long distance traffic. Within areas close to towns and cites (sites SW1 and RSI14) the proportion of good vehicles drops as the sections of roads are used by local traffic.

Figure 2-9: Observed mode split at traffic survey locations on Bar – Boljare corridor



Source: LB and consultant's analysis

2.6 Stated preference survey analysis

A Stated Preference (SP) survey was carried out to provide values of time of drivers of cars and freight vehicles within the framework of the Bar – Boljare Motorway Project. Results of this survey can be found in the SP report, but the main conclusions are presented below.

Time and cost of travel are highly correlated in reality. Furthermore, the new motorway alternative which could be chosen does not yet exist. Therefore, computer assisted interviews were conducted with drivers travelling along the Bar – Boljare corridor. Assuming a hypothetical choice situation, drivers were asked to choose between the actual mountainous route and the proposed new motorway. Travel times were related to the actual trip of the interviewees. Using several different choice situations, travel times and toll levels were varied systematically between 6 and 12 eurocents per km for car drivers and up to 20 eurocents per km for drivers of freight vehicles.

In December 2008, 376 valid interviews were conducted on the Bar – Boljare corridor, north and south of Podgorica. Since the share of cars exceeds the share of freight vehicles interviewers explicitly tried to stop drivers of light goods vehicles (LGV ≤ 3.5 tons maximum gross weight) and heavy goods vehicles (HGV ≥ 7.5 tons) in order to allow for estimation of cost functions for both vehicle groups.

Almost all car trips (86%) and LGV trips (88%) had their origin and destination within Montenegro. Around 50% of the trips were lasting for less than 90 minutes and 120 minutes, respectively. Only HGV showed 50% of trips lasting longer than six hours. International traffic was travelling mainly between Montenegro and Serbia. Based on the collected information, the average speed was calculated to be around 60 km/h for cars, but only 46 km/h for LGV and HGV.

Most of the drivers of freight vehicles were in charge to decide whether to use a tolled motorway or not. Three quarters and two third of the drivers of LGV and HGV, respectively, stated that they were in charge to make that decision. Those who worked on their own account usually also owned the vehicle they drove whereas those who decided on behalf of their company usually did not own the vehicle they drove.

The willingness to pay for savings in travel time is almost 4 euro/h for drivers of cars, around 9.5 euro/h for drivers of LGV, and 16 euro for drivers of HGV[3]. Though, for all three groups there is a willingness to pay for the motorway for other reasons, presumably for gains in safety. Almost all drivers agreed with the statement that ‘driving on the motorway would be much safer compared with the mountainous road’. Further, almost all of these drivers agreed with the statement that ‘the gain in safety would be almost completely due to avoiding some dangerous sections of the existing roads’.

The willingness to pay for the motorway is around 7 euro for drivers of cars and around 6 euro for drivers of LGV. For drivers of HGV the willingness to pay for the motorway is around 13 euros. Sensitivity analysis showed that drivers of larger vehicles were often prepared to pay more than 20 cent per km regardless of savings in travel time. Therefore, the high willingness to pay for the motorway itself partly accounts for savings in travel time of the large vehicles.

[3] This does not directly correspond to values of times and cannot be used directly in the traffic model.

The calculation of market shares of the motorway were demonstrated for cars, LGV, and HGV for different distances of trips. Results showed quite an elastic demand of cars and LGV whereas demand of HGV seemed to be rather price inelastic.

Most of the drivers disagreed with the statement ‘the gains in safety would only occur in winter’. Therefore, the results can be assumed to have no seasonal bias.

The utility functions, implied values of time (VOT) and vehicle operating costs (VOC) are discussed later on in this report. Further details of the SP survey can be found in the SP survey report.

2.7 Analysis of freight traffic

As part of the Stated Preference (SP) survey, data on carried commodities was collected for a period of two days. Table 2.2 provides a breakdown of the sample by group of commodity carried and types of freight vehicles. The commodity groups are defined according to the Nomenclatures NST R described in detail in **Appendix 2**.

Analysis of Table 2.2 shows that LGV are rather used for transports of agricultural goods and live animals while they are not used at all for crude minerals and building materials but rather for Manufactured Articles and Miscellaneous Goods.

HGV appear to be used for foodstuff and animal fodder, but otherwise there is no clear pattern suggesting that the transport industry is relying heavily on particular commodities.

Table 2.2: Distribution of Trips by Commodity Groups and Types of Vehicles

Commodity Groups	Vehicle		Total
	LGV ≤3.5 t	HGV ≥7.5 t	
Agricultural Products and Live Animals	3	5	8
	12%	6%	8%
Foodstuffs and Animal Fodder	5	28	33
	20%	35%	32%
Solid Mineral Fuels	0	1	1
	0%	1%	1%
Petroleum Products	0	4	4
	0%	5%	4%
Ores and Metal Waste	1	4	5
	4%	5%	5%
Metal Products	4	7	11
	16%	9%	11%
Crude and Manufactured Minerals, Building Material	0	14	14
	0%	18%	14%
Fertilizers	0	3	3
	0%	4%	3%
Chemicals	1	2	3
	4%	3%	3%
Machinery, Transport Equipment, manufactured Articles and Miscellaneous	11	11	22
	44%	14%	21%
Total	**25**	**79**	**104**
	100%	**100%**	**100%**

Source: Consultant's analysis

3 NETWORK BUILDING

This chapter details the development of the base year VISUM network.

The main characteristics of the VISUM model developed are presented below. The model covers Montenegro and with neighbouring countries treated as external zones. The main features of the model are:

- AADT[4] model;
- 21 internal zones, based on Montenegrin municipalities and 9 external zones, representing neighbouring countries;
- 100 nodes;
- 254 links, covering a network of 1,840 kilometres of main and regional roads;
- Three user classes, cars, light good vehicles and heavy good vehicles.

3.1 Zoning system

The zoning system used in the model is presented in Figure 3.1. The model includes 21 internal zones (within Montenegro) and 9 external zones. The zoning system used suits the needs of the model as the municipality level is the most disaggregated level at which socio-economic data can be obtained.

Detailed listing of the zoning system is given below, starting with the internal zones:

- 1. Herceg Novi
- 2. Tivat
- 3. Kotor
- 4. Budva
- 5. Bar
- 6. Ulcinj
- 7. Cetinje
- 8. Nikšić
- 9. Danilovgrad

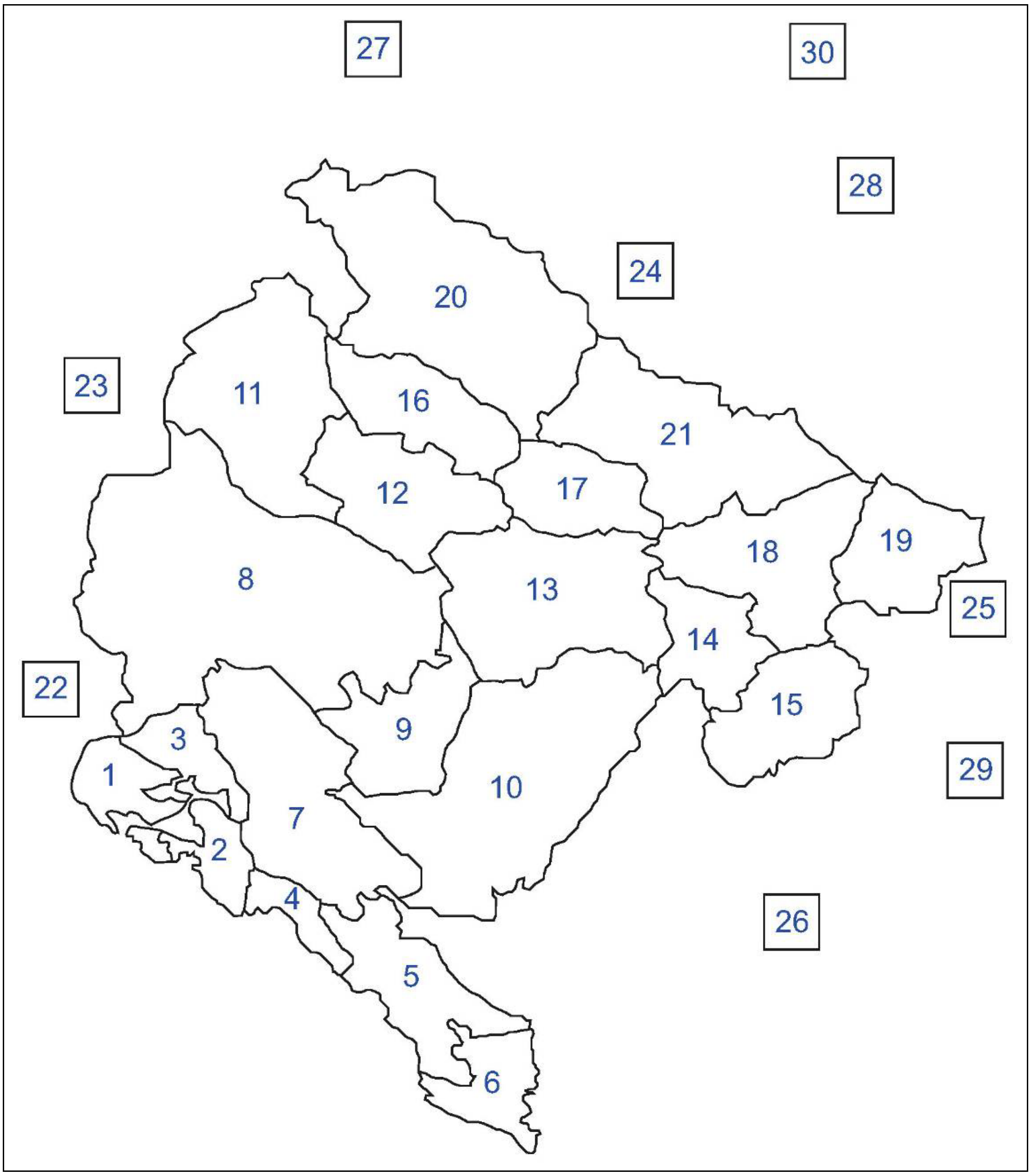
[4] Average Annual Daily Traffic

- 10. Podgorica
- 11. Plužine
- 12. Šavnik
- 13. Kolašin
- 14. Andrijevica
- 15. Plav
- 16. Žabljak
- 17. Mojkovac
- 18. Berane
- 19. Rožaje
- 20. Pljevlja
- 21. Bijelo Polje

Additionally, zones external to Montenegro:

- 22. Croatia
- 23. Bosnia and Herzegovina
- 24. Serbia (1)
- 25. Serbia (2)
- 26. Albania
- 27. Slovenia
- 28. Bulgaria and Romania
- 29. Macedonia
- 30. Europe and all other countries

Figure 3-1: Traffic model zoning system



Source: Consultant's analysis

3.2 Network

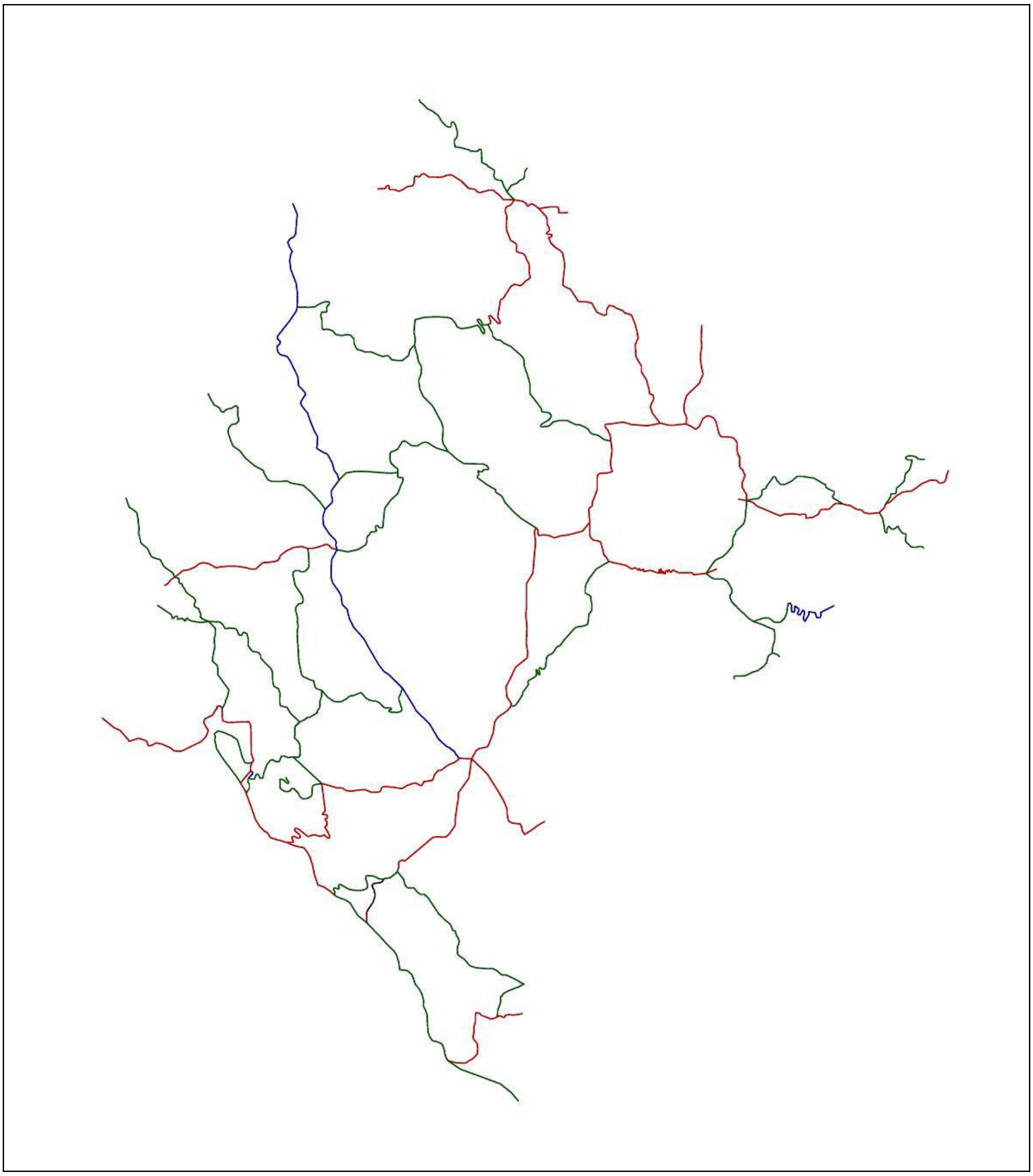
The existing road network of Montenegro has (based on the official report of the Crnagoraput Company which is in charge of road maintenance) 845 km of main and 963 km of regional roads, shown in Figure 3.2, while there are approximately 5,000 km of minor roads. The network coverage as currently used is sufficient for the purpose of the study which focuses on strategic movements around Montenegro only. The network has been checked for consistency and minor adjustments have been carried out. It should be noted that existing tolls at the Sozina tunnel location are included in the base year model.

The modelled VISUM network represents the main and regional road roads, as shown in Figure 3.3.

Figure 3-2: Montenegrin strategic road network

Source: Crnagoraput

Figure 3-3: traffic model representation of Montenegrin road network



Source: Consultant's analysis

The network characteristics coded for each link, per direction, include:

- Distance;
- Free flow speed;
- Capacity (in vehicles per day);

- Number of lanes; and
- Authorised vehicles classes.

The links are also associated with volume-delay curves to represent the reduction in speed as traffic volumes increase. Based on the above characteristics, the model uses the following curve to derive the loaded travel times:

$$T_{cur} = T_0 \times (1 + a \times SAT^b) \text{ with } SAT = \frac{q}{q_{\max} \times c}$$

Where T_{cur} is the expected travel time on the loaded section, T_0 is the travel time at free flow, q is the traffic volume on the section, q_{max} the capacity of the section and a, b, c calibration parameters.

The assignment is carried out using an incremental equilibrium, an approach suited to relatively low traffic levels. In the base year, the minimum path is based purely on time, and is:

$$imp = VOT \times T_{cur}$$

Where T_{cur} is the expected travel time on the loaded section, VOT the value of time and imp the impedance of the path.

Connectors are used to connect the zones to the network. In the model each zones tends to have several loading points depending on the direction of travel. A few connectors have been adjusted to improve the loading but overall the coding of the speed flow curves was considered adequate. The assignment method, using incremental equilibrium is the best approach considering the low levels of flow expected on some sections of the network.

3.3 User classes

Both the results from the SP survey and the network characteristics (including gradients: flat, rolling, mountainous) prompted the need three user classes as the vehicle operating costs would be different per vehicle type. The three categories have been considered combining the various modes as follows:

- Passenger car;
- LGV: Van + Minibus + Light truck;
- HGV: Bus + Medium truck + Heavy truck and heavy truck with trailer.

In order to accurately represent driving behaviours of the three categories included in the model, maximum travelling speeds have been capped for each user class:

- Passenger car – maximum 120 km/h
- LGV – maximum 100 km/h
- HGV – maximum 80 km/h

3.4 Impedance and generalised costs

Impedances are used in VISUM in order for the model to calculate the best route. The generalised costs for the impedance should be monetised. These were derived from the SP survey which produced perceived Value of Time (VOT) and Vehicle Operating Costs (VOC). These have been calculated for each user class. A slight adjustment to the SP values was carried out to convert the constant in a per km parameter. This was done assuming that the average travel time and distance were one hour and 60 kilometres respectively[5]. The VOT element as been adjusted to 2007 based on the GDP/capita growth of 5.4% with an elasticity of 0.7[6].

A summary of assignment parameters (EUR 2007 per vehicle) are given below:

- imp_{Cars} = (3.94 x hour) + (0.057 x km) – (0.119 x motorway km) + (toll rate x km)
- imp_{LGV} = (9.17 x hour) + (0.128 x km) – (0.103 x motorway km) + (toll rate x km)
- imp_{HGV} = (9.17 x hour) + (0.240 x km) – (0.103 x motorway km) + (toll rate x km)

[5] For cars 7.14/60 = 0.119. For LGV, 6.16/60 = 0.103. For HGV, distance constant borrowed from LGV, thus (16.27-9.52)/60 + 0.128 = 0.240
[6] See section 6.3 of this report.

4 MATRIX DEVELOPMENT

This section provides details of the RSI used to build the trip matrices for the study and describes the methodology adopted in combining these data sources to obtain the prior matrix used for the calibration of the traffic model.

No clear information was provided by Louis Berger on the development of the matrices. It was thus considered that the best option was to recreate the prior matrix from the individual RSI outputs.

The AADT trip matrices have been built for the following three user classes:

- UC1: Cars;
- UC2: LGVs; and
- UC3: HGVs.

4.1 AADT volumes calculations

Before carrying out the expansion of the RSI interview matrices, the AADT flows were derived for each site.

Four factors were calculated to convert the traffic counts to AADT flows:

- Daily traffic distribution factor (12h to 24h conversion);
- Weekly traffic distribution factor (day to average weekday factor for the counting week);
- Monthly traffic distribution factor (from an average weekday of counting week to average weekday of the month); and
- Annual traffic distribution factor (from the October month to average month).

The daily distribution factor was derived directly from the 12h and 24h counts carried out at all 16 site locations. Considering that for each site 24h data was available for only one day and considering the expected variation on a day-to-day basis of such ratio, it was decided to use an average based on all sites rather than using site specific ratios. Detailed calculations for this factor are shown below; the average was calculated as 1.34.

Table 4.1: Daily traffic distribution factor

Site	12-hour Count	24-hour Count	Ratio
1	8,348	11,280	1.35
2	4,080	5,447	1.34
3	3,898	4,767	1.22
4	4,375	6,818	1.56
5	477	597	1.25
6	6,402	7,727	1.21
7	6,719	8,743	1.30
8	6,758	8,789	1.30
9	3,296	4,580	1.39
10	4,356	6,211	1.43
11	251	394	1.57
12	1,835	2,892	1.58
13	3,387	4,152	1.23
14	6,523	8,766	1.34
15	663	898	1.35
16	563	804	1.43
Total	**61,931**	**82,865**	**1.34**

Source: LB and consultant's analysis

The weekly traffic distribution factor has been assumed to be 1.00 for all sites as the 12h counts collected for seven consecutive days were averaged to derive an average weekday 12h flow.

The monthly traffic distribution factor was calculated by looking at the number of each day of the week there was for the month of October 2007 and deriving a ratio between the weekday flow calculated above and the weighted average based on the number of each day of the week in the month. This ratio was calculated separately for each site and is around 1.00. A list showing the numbers of days of the week included in October 2007 is given below:

- Monday: 5
- Tuesday: 5
- Wednesday: 5
- Thursday: 4
- Friday: 4
- Saturday: 4
- Sunday: 4

The annual traffic distribution factor needs to be derived from long term traffic data. The use of border crossing data was considered but as only limited information was available the most robust set of traffic counts identified to derive the annual factor is from the Sozina tunnel company. The annual distribution (Table 4.2) shows a summer peak considerably more marked than is often seen in road networks but this unusually high variation does not invalidate the methodology.

Based on the Average Monthly traffic for year 2007, it was estimated that the average demand throughout the year corresponds to 1.33 times the demand observed in October.

Table 4.2: Annual traffic distribution factor

Month	Observed Average Daily Flow (veh)
January	3,634
February	3,765
March	4,132
April	4,907
May	5,305
June	7,534
July	11,797
August	11,702
September	6,202
October	4,616
November	4,404
December	4,485
Average	6,040
Ratio October to Average	**1.33**

Source: Monteput

Table 4.3 summarises the AADT calculations based on the above.

Table 4.3: Summary of AADT

Site	12-Hour Average	Weekly	Monthly	Annually	FACTORS			
					Daily	Weekly	Monthly	Annually
1	7,990	10,690	10,753	14,324	1.338	1.000	1.006	1.33
2	3,810	5,098	5,115	6,814	1.338	1.000	1.003	1.33
3	3,445	4,610	4,624	6,160	1.338	1.000	1.003	1.33
4	5,171	6,919	6,912	9,207	1.338	1.000	0.999	1.33
5	486	650	659	878	1.338	1.000	1.014	1.33
6	4,983	6,667	6,734	8,970	1.338	1.000	1.010	1.33
7	6,498	8,694	8,698	11,586	1.338	1.000	1.000	1.33
8	6,986	9,347	9,335	12,435	1.338	1.000	0.999	1.33
9	3,475	4,650	4,617	6,151	1.338	1.000	0.993	1.33
10	4,194	5,611	5,568	7,417	1.338	1.000	0.992	1.33
11	347	464	468	623	1.338	1.000	1.007	1.33
12	2,197	2,939	2,930	3,903	1.338	1.000	0.997	1.33
13	2,950	3,947	3,933	5,239	1.338	1.000	0.996	1.33
14	6,408	8,574	8,620	11,482	1.338	1.000	1.005	1.33
15	829	1,110	1,099	1,463	1.338	1.000	0.990	1.33
16	769	1,029	1,016	1,354	1.338	1.000	0.987	1.33
SW1	11,789	15,774	15,800	21,009	1.338	1.000	1.002	1.33
SW2	3,094	4,139	4,116	5,472	1.338	1.000	0.994	1.33
SW3	3,227	4,318	4,283	5,695	1.338	1.000	0.992	1.33

Source: Consultant's analysis

4.2 Road Side Interview data processing

The RSI data that was collected covers 16 sites around Montenegro as noted in chapter 2. At each of the 16 survey stations, the RSI data sample was expanded to the calculated AADT flow derived from the traffic counts, for the RSI site, by vehicle type. The table below shows that the percentage of traffic interviewed is reasonable at around 10%. Sites 11 and 14 show low returns, below 5% and more interviews would have improved these sites. Furthermore, the sample sizes in absolute terms appear to be very low at some sites such as for example sites 5, 11, 15 and 16.

Table 4.4: Percentage of interview at LB RSI sites

Site	Car		LGV		HGV		TOTAL		
	Interviewed	AADT	Interviewed	AADT	Interviewed	AADT	Interviewed	AADT	% Interviewed
1	1,312	11,233	233	1,995	128	1,096	1,673	14,324	11.7%
2	672	5,387	121	970	57	457	850	6,814	12.5%
3	575	4,852	81	684	74	624	730	6,160	11.9%
4	503	6,693	113	1,503	76	1,011	692	9,207	7.5%
5	79	588	13	97	26	193	118	878	13.4%
6	849	7,302	124	1,066	70	602	1,043	8,970	11.6%
7	973	9,968	110	1,127	48	492	1,131	11,586	9.8%
8	701	9,610	115	1,577	91	1,248	907	12,435	7.3%
9	346	4,231	59	721	98	1,198	503	6,151	8.2%
10	465	5,381	101	1,169	75	868	641	7,417	8.6%
11	18	534	2	59	1	30	21	623	3.4%
12	373	3,228	68	589	10	87	451	3,903	11.6%
13	331	4,357	55	724	12	158	398	5,239	7.6%
14	363	8,983	55	1,361	46	1,138	464	11,482	4.0%
15	97	1,154	19	226	7	83	123	1,463	8.4%
16	108	840	30	233	36	280	174	1,354	12.9%

Source: LB

In total 16 matrices per vehicle class have been created. Table 4.5 shows the matrix totals for each site for each vehicle class. It shows that for sites 6 and 14 there very high numbers of intrazonal trips suggesting that at these locations the road is not only used for strategic movements but also for local traffic. It should be note that this very local traffic is unlikely to use the proposed motorway, thus these calculated AADT flows have been adjusted for these sites before carrying out the calibration of the model[7].

[7] See chapter 5.

Table 4.5: RSI matrix totals

Site	Car		LGV		HGV		Total		
	Total Trips	Intrazonal Trips	Total Trips	Intrazonal Trips	Total Trips	Intrazonal Trips	Total Trips	Intrazonal Trips	% Intrazonal Trips
1	11,233	334	1,995	51	1,096	34	14,324	420	2.9%
2	5,387	168	970	16	457	16	6,814	200	2.9%
3	4,852	894	684	68	624	25	6,160	987	16.0%
4	6,693	1,756	1,503	279	1,011	93	9,207	2,129	23.1%
5	588	60	97	7	193	7	878	74	8.5%
6	7,302	5,831	1,066	748	602	327	8,970	6,906	77.0%
7	9,968	1,516	1,127	113	492	31	11,586	1,660	14.3%
8	9,610	219	1,577	27	1,248	14	12,435	260	2.1%
9	4,231	673	721	12	1,198	61	6,151	746	12.1%
10	5,381	1,007	1,169	116	868	58	7,417	1,180	15.9%
11	534	0	59	0	30	0	623	0	0.0%
12	3,228	545	589	17	87	17	3,903	580	14.9%
13	4,357	935	724	132	158	0	5,239	1,066	20.4%
14	8,983	6,360	1,361	866	1,138	322	11,482	7,547	65.7%
15	1,154	36	226	0	83	0	1,463	36	2.4%
16	1,285	440	357	131	428	71	2,070	642	31.0%
Total	**84,785**	**20,774**	**14,225**	**2,584**	**9,714**	**1,077**	**108,723**	**24,434**	**22.5%**

Source: Consultant's analysis

These 16 matrices were then combined for each vehicle class thus creating three RSI combined matrices.

As the RSIs form barriers across the network, it is possible to cross several RSI points to go from one origin to a destination thus introducing double counting when carrying out the surveys. Double counting was addressed by dividing the combined RSI matrix by the number of times an RSI point needs to be crossed to from one origin to one destination. For example, to travel from the Serbian border to Podgorica, there is a need to pass through 3 RSI sites: 14, 10 and 9. Hence the observed movements through the RSI needed to be divided by three. This double counting matrix is given in **Appendix 3**. Table 4.6 shows that the impact of double counting removal on the matrix totals.

Table 4.6: Impact of double counting removal

	RSI Combined Matrix	Post Double Counting Removal
Car	84,785	65,011
LGV	14,225	10,551
HGV	9,714	6,187

Source: Consultant's analysis

In total 16 matrices per vehicle class have been created. These 16 matrices were then combined for each vehicle class thus creating three RSI combined matrices.

Copies of the final prior matrix for each vehicle class are given in **Appendix 4** with and without intrazonals. These correspond to the corrected observed movements.

An analysis of these matrices suggests the following:

- These matrices have a high percentage of intrazonal trips (not assigned) as the zones cover large areas in the model. As an example, out of the 65,011 trips observed for car, 20,774 trips are intrazonal or about 30% (24% for LGVs and 17% for HGVs). This suggests that the Bar – Boljare corridor, in its current state, serves two purposes, it provides a strategic route for long distance traffic, but it is also used extensively by local traffic;
- The key trip generators for cars and LGVs are Podgorica (excluding intrazonals) followed by Budva and Niksic. LGV trips appear to be more sprayed across the matrix than for cars;
- HGV trips originating in Serbia and likely to use the Bar – Boljare motorway are relatively high, backing up the fact that the Bar to Boljare road is a strategic corridor as it stands.

5 CALIBRATION

This chapter presents the calibration exercise carried out to ensure good fit of the modelled flows to observed flows. Details about the calibration can be found in **Appendix 5** of this report.

5.1 Matrix estimation

The process of combining the trip matrices from the various sources, as discussed in section 4, produces what is called a 'prior' matrix. This is effectively a first estimate of what the matrix is likely to contain. The next step is to assign this prior matrix onto the coded network, and use Matrix Estimation (ME2) techniques to calibrate the matrix.

ME2 is required to ensure that the trip matrices are reproducing, within defined limits, a set of observed conditions, when they are assigned to the model networks. During matrix estimation, adjustments are made to the trip matrices to improve the degree of match between the observed and modelled data.

ME2 is undertaken with the TFLOWFUZZY module within VISUM. This module takes as inputs target traffic counts at various locations within the network. The module then seeks to undertake minimum revisions to the matrix so that it matches these user defined link flows as much as possible.

5.2 Calibration results

The two directional observed counts at the 16 RSI locations, SW count locations and at the Sozina tunnel were used as input controls for the ME2 procedure.

Due to the very high level of intrazonal traffic at some of the RSI sites, target flows needed to be adjusted as the purpose of the study is to focus on the traffic which may potentially transfer to the new Bar – Boljare motorway rather than to focus on localised (urban demand). If this adjustment is not carried out, the model is likely to overestimate the potential demand on the motorway. Sites 14 and 6 have been identified as sites needing adjustment as showing more than 50% intrazonals[8]. For these sites, the target flows were reduced, for each user class, in line with the percentage of intrazonal demand observed, as shown in Table 5.1.

[8] See table 4.5.

Table 5.1: Corrected observed flows (AADT)

Site	Car		LGV		HGV	
	Total Trips	Intrazonal Trips	Total Trips	Intrazonal Trips	Total Trips	Intrazonal Trips
6	7,302	5,831	1,066	748	602	327
new target demand flow	1,471		318		275	
14	8,983	6,360	1,361	866	1,138	322
new target demand flow	2,623		495		817	

The calibration results have been assessed by comparing the observed and modelled (assigned) flows at all of the locations used as input to the matrix estimation process. The main indicator for the goodness of fit is the GEH statistic, which is defined as[9]:

$$\text{GEH} = \sqrt{\frac{(\text{modelled flow - observed flow})^2}{0.5 \times (\text{observed flow} + \text{modelled flow})}}$$

Site SW1 has been excluded from calibration, as it showed that modelled results were still very far from observed only being at one third of the expected level. This was mainly due to the high level of local traffic recorded at site SW1[10] which cannot be represented at matrix level. It is clear that most of the traffic at site SW1 being very local, it cannot be considered as strategic and is unlikely to use the proposed new Bar – Boljare motorway. As no RSI were conducted at this site no proportion of local traffic could be identified to be removed to create the target flows for the matrix estimation.

5.3 Model calibration

A total of 17 points were chosen for ME2. All three user classes were subject to matrix estimation to improve the fit to observed counts.

It is generally considered acceptable that 85% of all links analysed should have a GEH value of five or less. Table 5.2 shows the results post matrix estimation excluding site SW1. The results show a high level of calibration has been achieved on the existing links, for both directions of movements for most sites. The mean GEH for the three user classes are all below two, and more than 85% of the links have GEH below five. Only sites 3 and 4, on the coast, show a GEH higher than five but this should not impact on the forecast results as these locations are not directly on the corridor of the Bar – Boljare motorway. Sites 14, SW2, SW3 and the Sozina tunnel show a good fit between observed and modelled flows, this is important at it is anticipated that traffic using the new Bar – Boljare motorway will largely reassign from that route.

[9] In fact it is a function of the square root of an average Chi Squared test.
[10] As presented in section 3.4 of this report.

Table 5.2: GEH using estimated matrix

	2 sites at 38% & 38%			MODELLED				OBSERVED				GEH			
Site	LINK	FROM	TO	SUM	CAR	LGV	HGV	SUM	CAR	LGV	HGV	SUM	CAR	LGV	HGV
1	7	112	113	7134	5622	551	960	7161	5616	548	997	0.3	0.1	0.1	1.2
1	7	113	112	7159	5645	557	956	7161	5616	548	997	0.0	0.4	0.4	1.3
2	125	185	195	3409	2726	469	214	3407	2694	485	228	0.0	0.6	0.7	0.9
2	125	195	185	3484	2776	474	233	3407	2694	485	228	1.3	1.6	0.5	0.3
3	100	194	195	3648	2801	470	377	3080	2426	342	312	9.8	7.3	6.4	3.5
3	100	195	194	3652	2810	470	372	3080	2426	342	312	9.9	7.5	6.4	3.2
4	136	194	204	3705	2810	470	426	4604	3346	752	506	13.9	9.7	11.4	3.7
4	136	204	194	3682	2801	470	411	4604	3346	752	506	14.3	9.8	11.4	4.4
6	33	149	151	1003	713	153	137	1033	736	159	138	0.9	0.9	0.5	0.1
6	33	151	149	978	706	150	122	1033	736	159	138	1.7	1.1	0.7	1.4
7	152	121	185	5804	4972	575	257	5793	4984	563	246	0.1	0.2	0.5	0.7
7	152	185	121	5730	4903	574	252	5793	4984	563	246	0.8	1.2	0.5	0.4
8	154	104	123	6205	4826	774	606	6217	4805	788	624	0.2	0.3	0.5	0.7
8	154	123	104	6302	4872	798	633	6217	4805	788	624	1.1	1.0	0.4	0.4
SW3	121	109	132	2901	2231	290	380	2848	2193	285	370	1.0	0.8	0.3	0.5
SW3	121	132	109	2914	2225	294	395	2848	2193	285	370	1.2	0.7	0.5	1.3
SW2	79	102	105	2688	2106	249	334	2736	2134	246	356	0.9	0.6	0.2	1.2
SW2	79	105	102	2729	2123	249	357	2736	2134	246	356	0.1	0.2	0.2	0.1
11	47	162	167	317	271	30	16	312	267	30	15	0.3	0.2	0.0	0.3
11	47	167	162	320	275	30	15	312	267	30	15	0.5	0.5	0.0	0.0
12	110	143	161	1935	1601	292	42	1951	1614	294	43	0.4	0.3	0.1	0.2
12	110	161	143	1936	1603	291	42	1951	1614	294	43	0.3	0.3	0.2	0.2
13	130	142	200	2614	2171	363	81	2620	2179	362	79	0.1	0.2	0.1	0.2
13	130	200	142	2619	2177	363	78	2620	2179	362	79	0.0	0.0	0.1	0.1
14	87	191	192	1971	1325	236	409	1967	1311	248	408	0.1	0.4	0.8	0.0
14	87	192	191	1986	1328	243	416	1967	1311	248	408	0.4	0.5	0.3	0.4
15	65	180	182	728	560	111	57	732	577	113	42	0.1	0.7	0.2	2.1
15	65	182	180	720	560	112	47	732	577	113	42	0.4	0.7	0.1	0.7
16	26	116	139	688	432	116	140	677	420	117	140	0.4	0.6	0.1	0.0
16	26	139	116	677	420	117	140	677	420	117	140	0.0	0.0	0.0	0.0
Sozina	147	203	208	2993	2472	285	237	3020	2508	288	224	0.5	0.7	0.2	0.9
Sozina	147	208	203	3028	2503	293	232	3020	2508	288	224	0.1	0.1	0.3	0.5
MEAN												**1.9**	**1.5**	**1.4**	**1.0**
Percentage of links with a GEH value of more than 5%												**13%**	**13%**	**13%**	**0%**

Source: Consultant's analysis

5.4 Regression analysis

In order to ensure that the integrity of the matrices has not been materially jeopardised due to the ME2 process, a regression analysis has been carried out for the three different user classes. The analysis compares the pre and post ME2 trips within the zones.

The R-squared values for the three user classes and a combined estimate are high. This confirms that the post estimation matrices have retained the characteristics of the relevant prior matrices and demonstrates that the matrices have not been adversely affected by the ME2 process. The R^2 values are:

- Car: 0.98;
- LGV: 0.92;

- HGV: 0.76; and
- All: 0.98.

5.5 Estimated matrices

As the calibration-validation process produced satisfactory results, the ‘estimated’ matrices are considered to be the base year matrices for cars, LGVs and HGVs and totals are as shown in Table 5.3. Copies of the final estimated matrix for each vehicle class are given in **Appendix 6** with and without intrazonals.

Table 5.3: Prior and estimated matrix totals

	Prior		Estimated	
	Total	Intrazonals	Total	Intrazonals
Car	65,005	20,773	82,654	26,412
LGV	10,551	2,584	11,187	2,736
HGV	6,185	1,077	8,045	1,401

Source: Consultant’s analysis

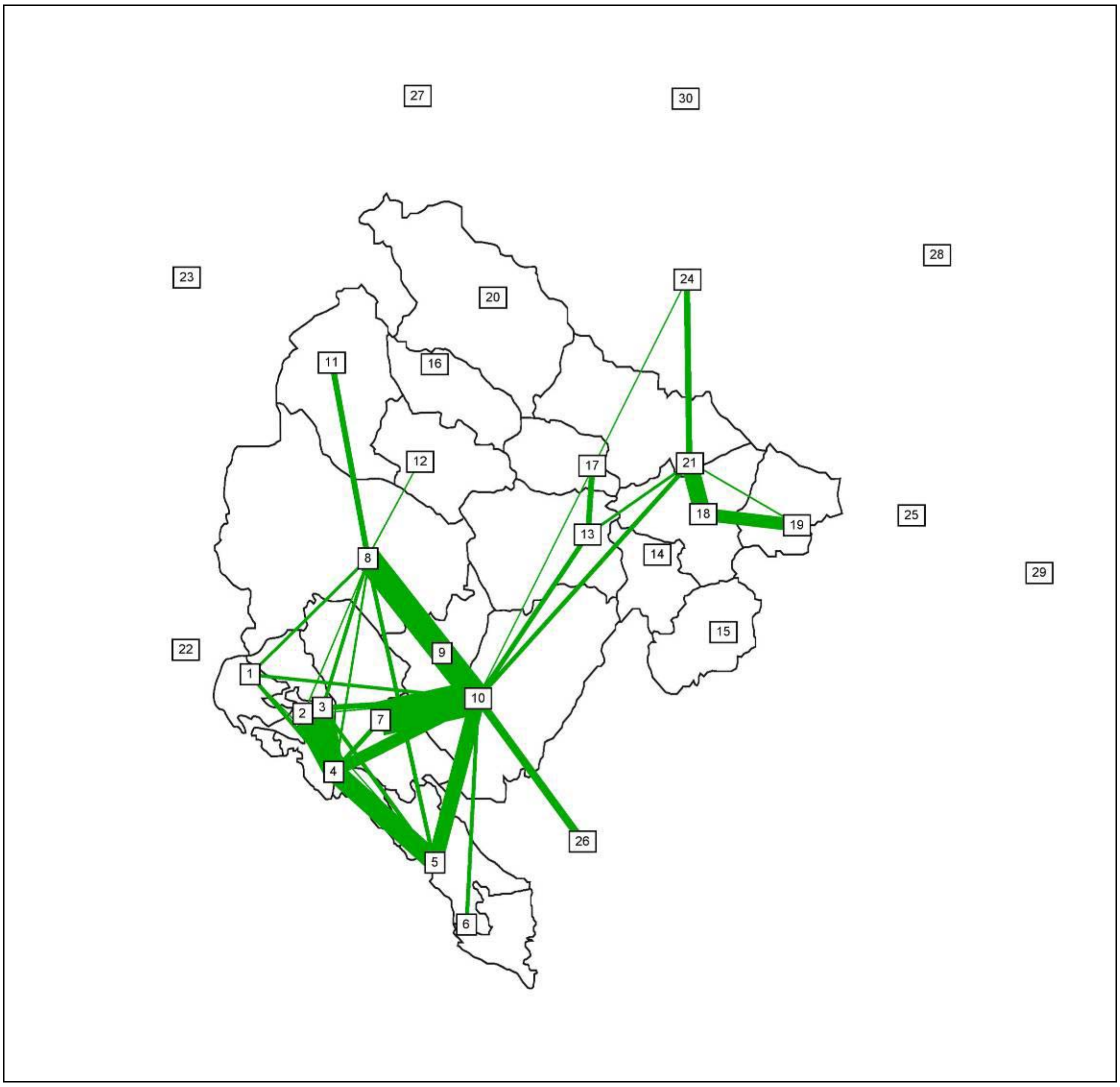
Table 5.3 shows that the prior demand tended to underestimate the expected demand and the matrix estimation adjusted this to the higher observed demand. This can be explained by the need for the demand to increase to match observed flows at the validation points as the intrazonal demand is not assigned.

5.6 Desire lines

Desires lines show the origin-destination movements spatially. The figures below show the main origin-destination movements, post matrix estimations for the three user classes. It should be noted that only the main movements are represented to avoid confusion, hence no representation does not necessarily mean no demand.

Figure 5.1 shows that there are three main poles of attraction for car are, Podgorica, the coast and the Montenegrin Serbian border. On the Bar – Boljare corridor, most of the demand is between Bar and Podgorica. The demand between Bijelo Polje – Berane – Rožaje is also relatively high. There are some movements between the coast and Serbia but these are relatively limited.

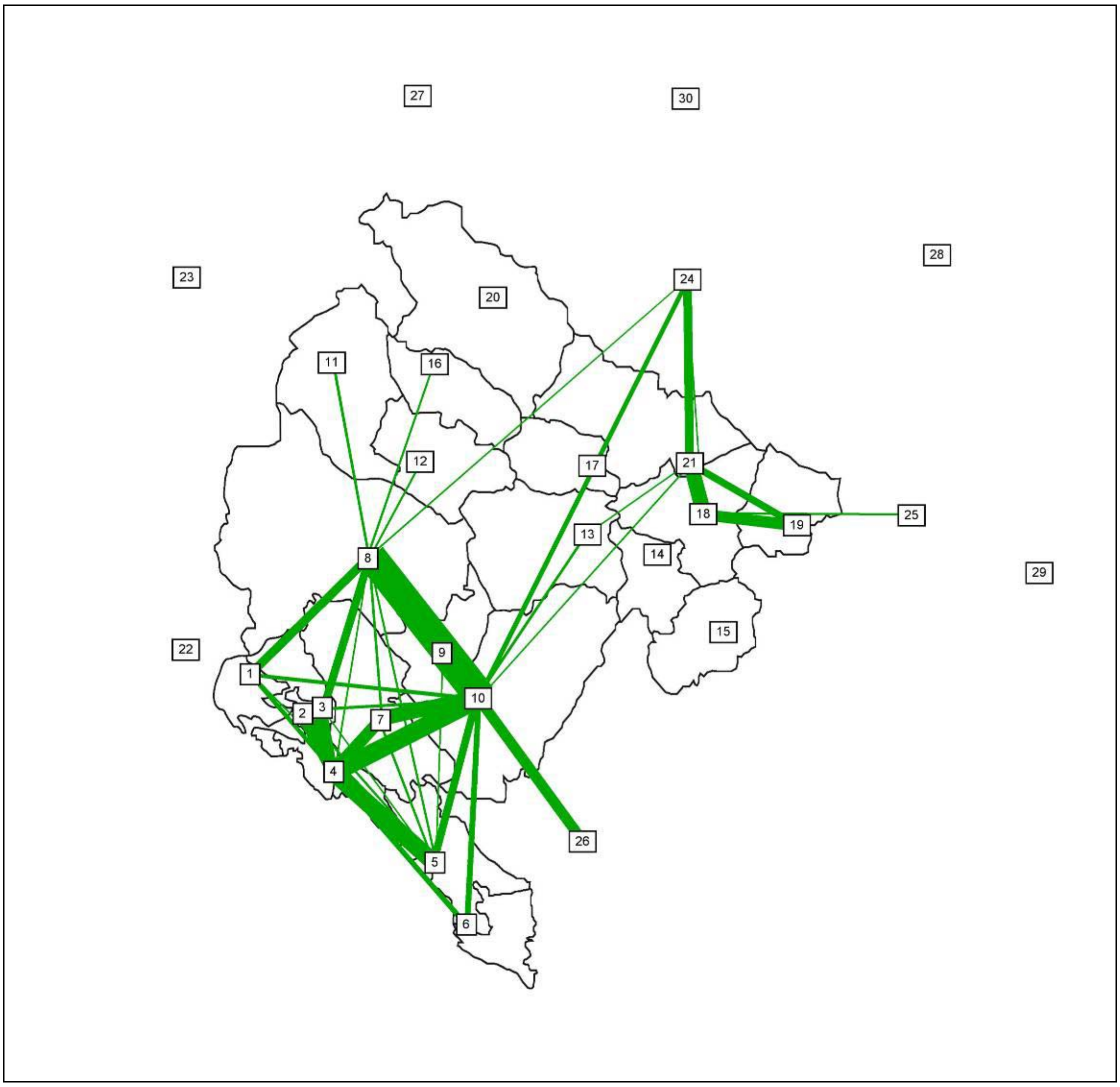
Figure 5-1: Desire lines for car demand



Source: Consultant's analysis

For LGVs, Figure 5.2, the desires lines show a relatively similar picture to cars. The demand is relatively more sprayed than for cars suggesting more long distance movements.

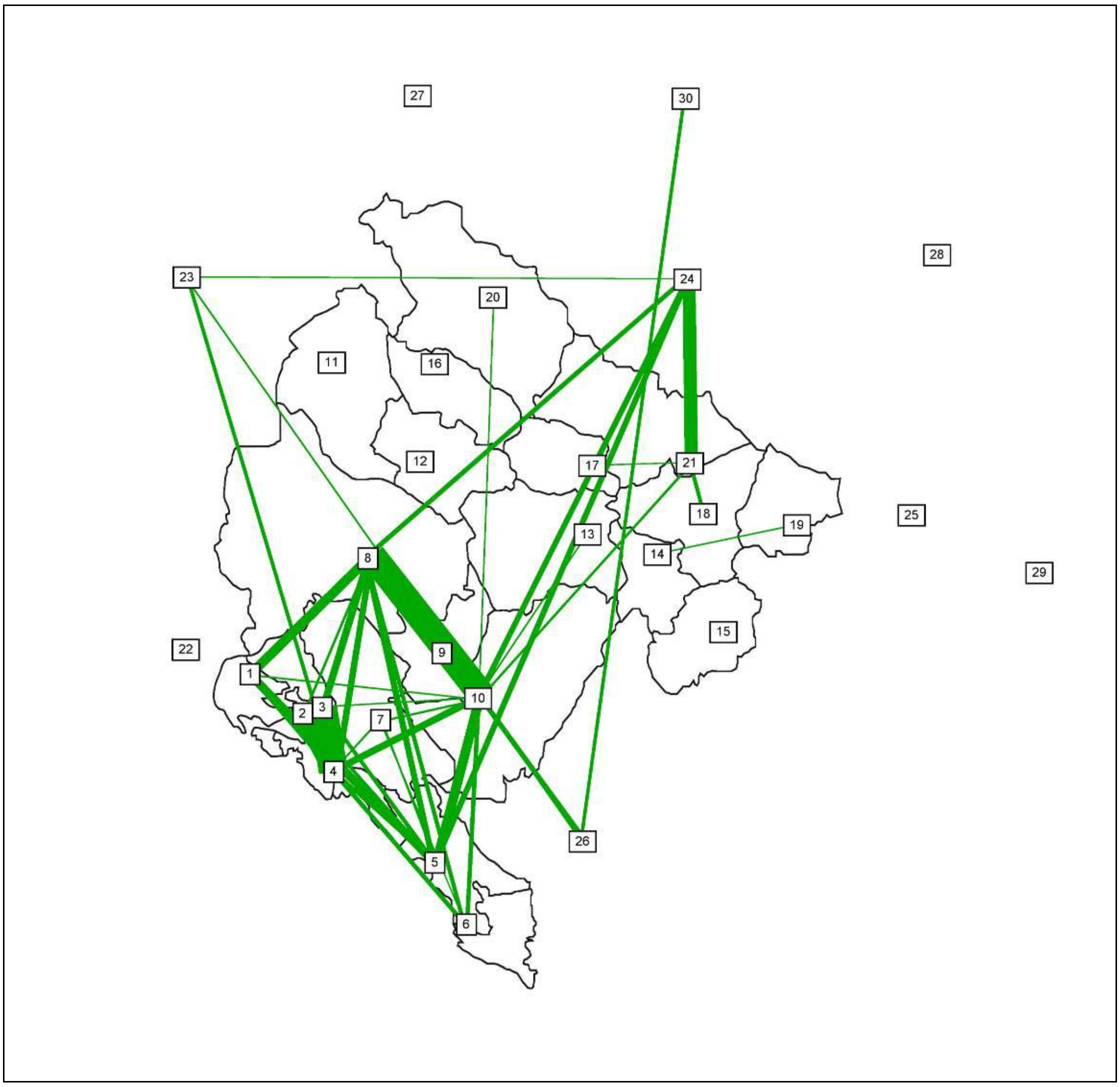
Figure 5-2: Desire lines for LGV demand



Source: Consultant's analysis

HGV desire lines, in Figure 5.3, are more scattered throughout the network and confirm the existence of relatively long distance traffic. The main poles of attraction remain Podgorica, Niksic, the coast, Serbia and to a lesser extent Albania. The Bar – Boljare corridor appears to be more vital for HGVs than cars and LGVs with a large demand from Serbia to the coastal regions.

Figure 5-3: Desire lines for HGV demand



Source: Consultant's analysis

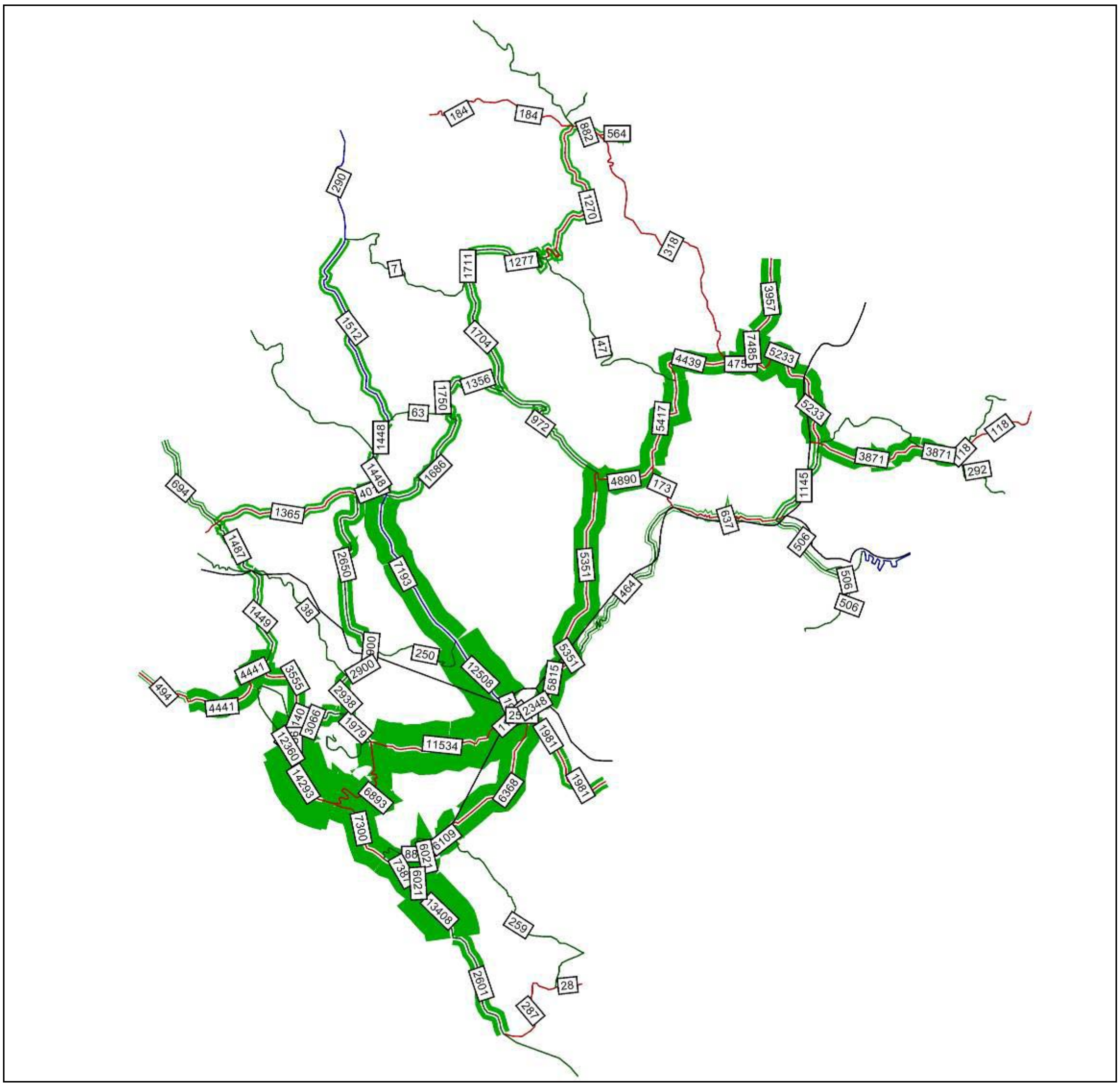
The above analysis demonstrates the strategic nature of the Bar – Boljare corridor. Three separate sections can clearly be identified:

- The Coast to Podgorica, with very high demand, especially from cars and LGVs using the section for short distance trips. HGVs also using this section but for more long distance strategic traffic;
- Long distance North-South movements, all using Podgorica to Kolasin, a section with a high proportion of HGVs;
- The northern sections to Serbia, with both relatively local traffic between the various urban areas of Bijelo Polje, Berane and Rožaje and more long distance strategic HGV traffic.

5.7 Assignment results

Figure 5.4 shows the assignment of the estimated matrix. This shows that matrix estimation as adjusted flows by increasing traffic levels on the Bar – Boljare corridor to match observed flows.

Figure 5-4: Assignment of estimated matrix

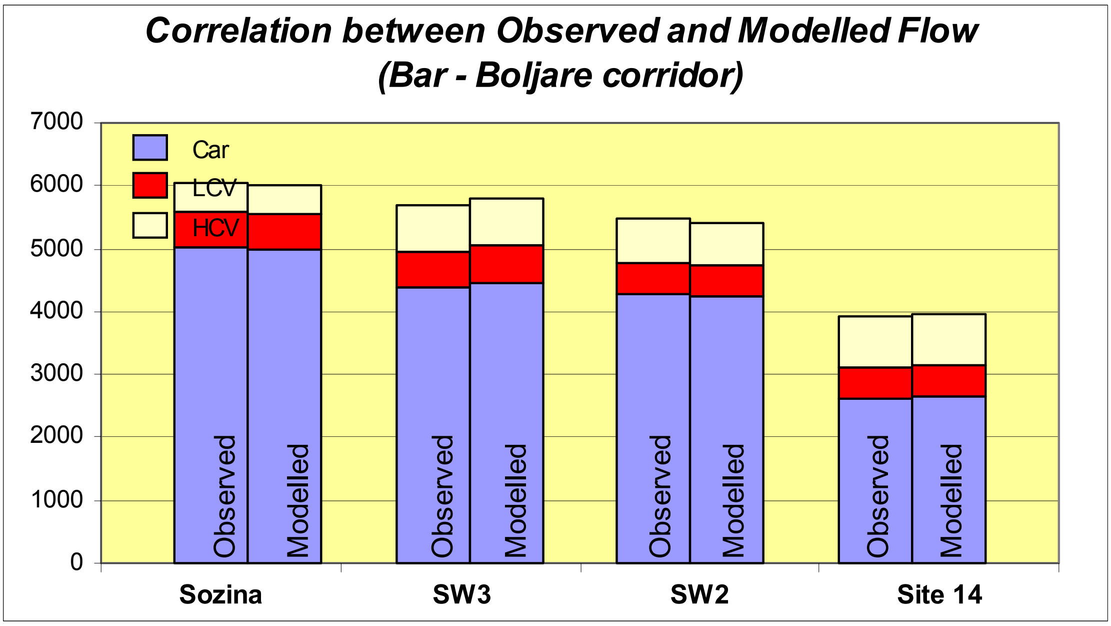


Source: Consultant's analysis

5.8 Focus on Bar – Boljare corridor

The focus on the study is on the Bar – Boljare corridor where the modelled flows for each user class must represent observed closely. Figure 5.5 demonstrates that, on the corridor, modelled flows matched closely with observed flows for all cars, LGVs and HGVs. It also shows that the volume of strategic traffic decreases continuously form the coast to the Serbian border.

Figure 5-5: Correlation between and modeled flow on Bar – Boljare corridor



Source: Consultant's analysis

5.9 Validation

No validation of the model has been carried out due to the lack of reliable count data. The only set available was from the Crnagoraput and collected on the main and regional roads for a single day (24 hours) in September 2007. This data was considered not to give sufficient information in terms of average annual flow (AADT) as this is only a "spot" count on a single day missing the weekly variation, monthly variation and annual variation and not robust enough to use for validation.

The lack of validation is not considered important because the counts used for calibration are well spread across the network. On the Bar – Boljare corridor specifically, the coverage of the calibration data provides a robust set of observed information for comparison with the modelled outputs.

6 FUTURE NETWORKS

Following the successful calibration and validation of the VISUM model highway network and of the base year trip matrices for the Bar – Boljare motorway study, future networks have been developed.

A number of scenarios have been developed in discussion with the transport economist. All scenarios have been run for the base year and the three forecast years 2016, 2026 and 2036.

A Do-Minimum (DM) scenario has been developed including the most likely developments outside the corridor of interest. Then, the Do-Something scenarios relating to the Bar – Boljare corridor, have been developed based on the DM, and have been assessed so as to fully understand the effects of introducing the differentiating elements of each scenario, for the proposed Bar – Boljare motorway.

Further details of the scenarios are presented in the following sections.

6.1 Do-Minimum network

The Do-Minimum supply assumptions remain constant for the three modelled years except where other road links are likely to be built in Montenegro during the period tested.

Focus has been given on information provided in the *Spatial Plan of Montenegro* until 2020. Based on this four schemes have been identified as major and will be included in the modelling. As no specific opening years are given in the spatial plan, the consultant has estimated in which modelled year these should be included. They are:

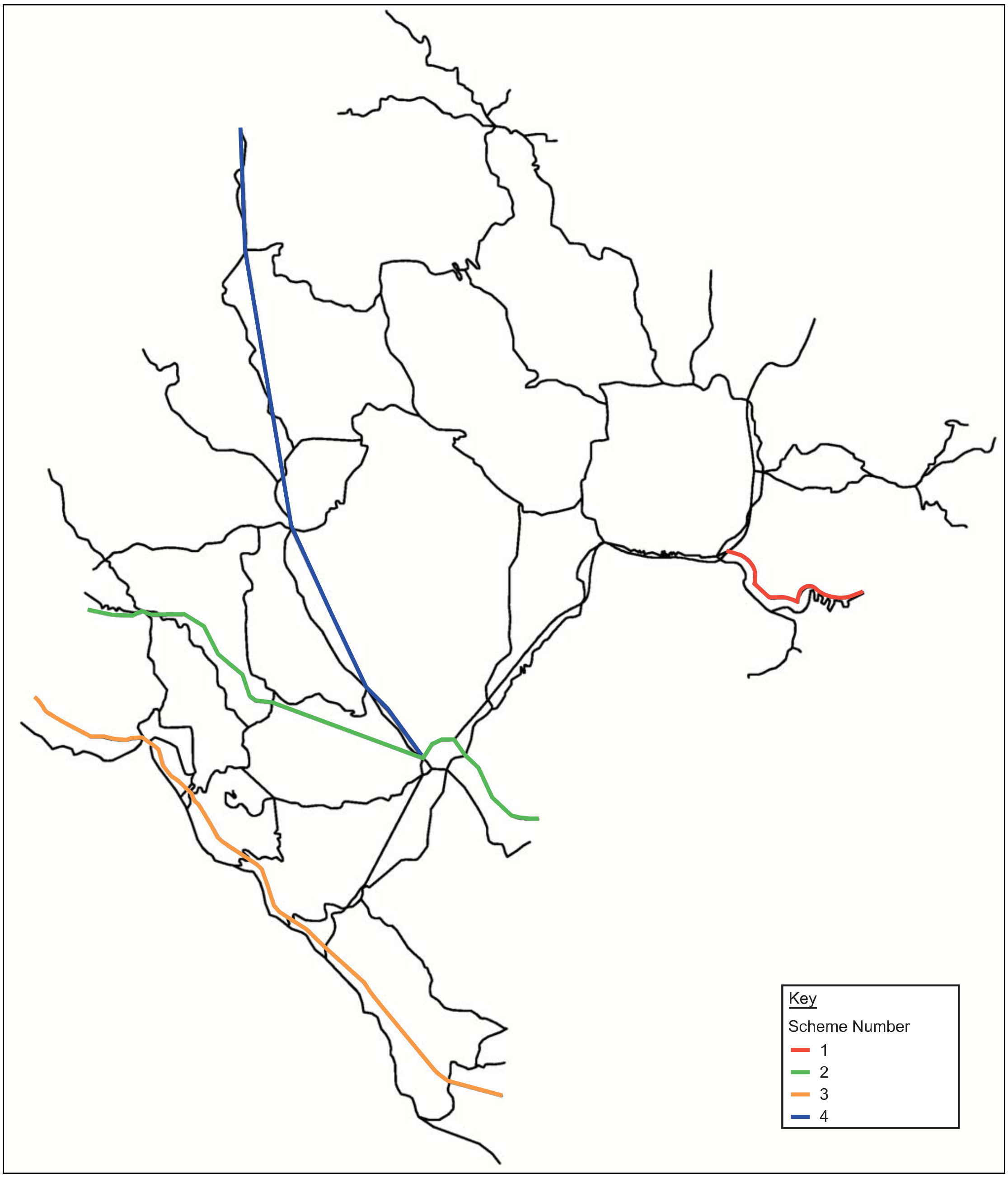
Table 6.1: Proposed schemes for inclusion in Do-Minimum

Number	Scheme	Years modelled
1	Part of the motorway from the connection to the highway Beograd - Bar to the border with Kosovo (Kosovo and Metohija): Andrijevica – Murino – Čakor - Bjeluha.	2026, 2036
2	Part of the Adriatic-Ionnian motorway: border with Bosnia and Herzegovina (in region of Nudola) – Grahovo–Cevo – Podgorica (bypass) – the tunnel through Dečić (border with Albania).	2026, 2036
3	Adriatic highway for fast motor vehicle traffic: Debeli brijeg (border with Croatia) – Herceg Novi (crossing over Bokokotorski Bay)– Tivat – Budva – Bar – Ulcinj – Fraskanjela region (Albanian state border).	2026, 2036
4	Šćepan Polje (border with Bosnia and Herzegovina) – Plužine – Nikšić – Podgorica.	2026, 2036

Source: *Spatial Plan of Montenegro until 2020* and consultant's analysis

Figure 6.1 shows the location of these various schemes.

Figure 6-1: Location of proposed schemes for inclusion in Do-Minimum



Source: *Spatial Plan of Montenegro until 2020* and consultant's analysis

The other scenarios have all been developed using the Do-Minimum networks as a basis.

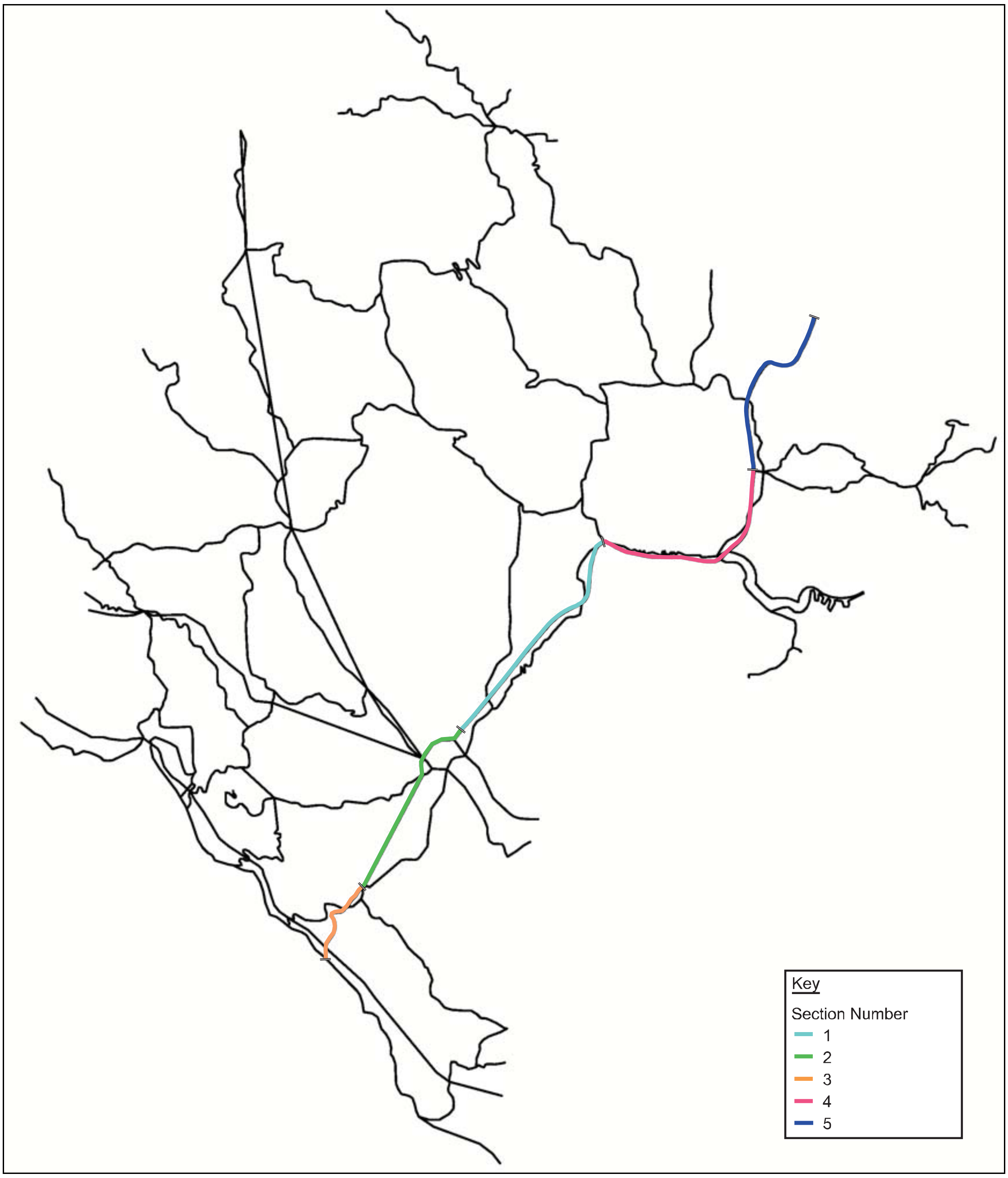
6.2 Do-Something networks

Based on our understanding of the phasing of the project, the completion of construction of the sections has been taken as follows:

- 1. Smokovac – Matesevo 2013
- 2. Smokovac – Virpazar 2015
- 3. Virpazar – Coast 2015
- 4. Matesevo – Berane 2016
- 5. Berane – Boljare 2016

The location of these various sections is shown in Figure 6.2.

Figure 6-2: Location of new Bar – Boljare motorway sections



Source: Consultant's analysis

Thus in addition to the DM scenario, ten scenarios have been developed, one per opening of a new section above plus one for each section on its own. Graphically, this can be summarised as follows:

Table 6.2: Proposed scenarios

	Virpazar - Coast	Smokovac - Virpazar	Smokovac - Matesevo	Matesevo – Berane	Berane - Boljare
DM					
S1			■		
S2		■			
S3	■				
S4				■	
S5					■
S6		■	■		
S7	■	■	■		
S8	■	■	■	■	
S9	■	■	■	■	■
S10	■	■			

■ Motorway section - Dual two

Source: Consultant's analysis

The proposed motorway sections have been coded as dual two links (two lanes in each direction). Within the model, the motorway has been given the following characteristics:

- Two lanes in each direction;
- Design speed of 100 kilometres per hour; and
- Capacity of 30,000 vehicles per day per direction.

In order to accurately represent driving behaviours of the three categories included in the model, maximum travelling speeds have been capped for each user class independently of road classification:

- Passenger car – maximum 120 km/h
- LGV – maximum 100 km/h
- HGV – maximum 80 km/h

Connections to Belgrade are not explicitly modelled, and only represented as centroid connectors as at the edge of the model and exist in both the Do-Minimum and Do-Something networks. This underlies the assumption that the motorway from Belgrade to Boljare is assumed to be open by the time the northernmost section of the Bar – Boljare motorway between Berane and Boljare is completed. It should be noted that the only impact of this would be on traffic generation[11] which forms a relatively small element of the corridor demand.

[11] Trip generation/induction presented in section 7.8 of this report

6.3 Impedance and generalised costs

The same impedance formulations have been used for the forecast years as for the base year with only an increase in values of time in line with GDP growth using an elasticity of 0.7. The factors applied are given in Table 6.3 and details can be found in the economic report.

Table 6.3: VOC and VOT growth factors

Year	VOC growth	VOT growth
2007	1.00	1.00
2016	1.00	1.28
2026	1.00	1.75
2036	1.00	2.08
2046	1.00	2.45

Source: Consultant's analysis

6.4 Tolling

The tolling optimisation has been tested for scenario 9 only, which assumes that the motorway is in operation throughout the entire Bar – Boljare corridor.

Based on the year 2007 and year 2036 scenario 9, the toll levels for cars, LGV and HGV have been raised by increments of one eurocent/km from a minimum of 1 eurocent/km to 30 eurocent/km. From the analysis of these model runs the optimum toll levels have been derived and presented in chapter 9 of this report.

7 FORECAST TRIP MATRICES

Forecast matrices have been developed for three different years, namely 2016, 2026 and 2036. A Do-Minimum forecast has been developed for each year, then for each scenario and year, induced traffic has been derived.

7.1 General methodology

The methodology used includes growth and redistribution of the trips based on population as well as on GDP per capita (representing employment).

The method selected was to forecast future trip ends for origins and destinations and to apply a Furness using these figures to the base year matrix, to arrive at the forecast matrices.

7.2 Population forecasts

Any increases or decreases in population or in the distribution of population will have a direct influence on the amount of traffic and on traffic patterns.

The regional population forecast of LB was based on the draft of the so-called *Physical Plan of Montenegro*. This has subsequently been updated and renamed the *Spatial Plan of Montenegro*. The population forecast assumes that the spatial plan is fully implemented. A revised forecast based on the spatial plan adjusted to the years appropriate for use in the current review is shown in Table 7.1.

Table 7.1: population forecasts

Zone number	Zone name	2007	2016	2026	2036
1	Herceg Novi	33,264	33,788	34,684	35,295
2	Tivat	13,789	14,152	14,611	14,869
3	Kotor	23,116	23,502	24,137	24,562
4	Budva	16,366	17,441	18,387	18,711
5	Bar	40,822	42,644	44,462	45,246
6	Ulcinj	20,658	21,511	22,388	22,782
7	Cetinje	18,428	18,307	18,561	18,889
8	Niksic	76,892	80,641	84,261	85,746
9	Danilovgrad	16,588	16,736	17,115	17,417
10	Podgorica	175,155	189,501	201,462	205,012
11	Plužine	4,257	4,222	4,277	4,352
12	Šavnik	2,911	2,831	2,836	2,886
13	Kolasin	9,911	9,825	9,950	10,126
14	Andrijevica	5,789	5,797	5,904	6,008
15	Plav	14,187	15,085	15,884	16,164
16	Žabljak	4,187	4,150	4,202	4,276
17	Mojkovac	10,236	10,628	11,044	11,239
18	Berane	36,119	38,601	40,759	41,477
19	Rožaje	24,003	27,233	29,727	30,251
20	Pljevlja	36,072	36,678	37,671	38,335
21	Bijelo Polje	51,535	54,466	57,156	58,163
Total Montenegro		**634,285**	**667,739**	**699,478**	**711,806**

Source: *Spatial Plan of Montenegro until 2020*, Table 11, and Consultant's analysis

Traffic to external zones is essentially traffic to Serbia. Forecasts of population in Serbia indicate that it is expected to remain more or less constant for the next 20 to 30 years (EPTISA 2007). Based on this assumption, population forecasts for all external zones have been assumed to be constant.

7.3 GDP per capita forecasts

Traffic is forecast to grow as GDP increases. The LB study based GDP forecasts on those of the Central Bank of Montenegro (CBCG) for the period 2006 - 2012. The CBCG "most likely" scenario forecasts average growth in total GDP of 6.0 percent per year and 5.4 percent per year in terms of GDP per capita. This was assumed by LB to continue to 2021, with slightly

[12] Louis Berger SAS (2008) Technical Memorandum no. 13A, General Traffic Forecast - Revision

lower growth rates thereafter in keeping with the greater level of uncertainty that is inherent in longer term forecasts. Thus the assumed rates of growth of GDP per capita were 3.6 percent per annum during the period 2022 to 2027 and 2.4 percent per annum between 2028 and 2037.

Since the LB study, the GDP forecast for the years 2009-2012 has been revised in light of the recent economic instability[13]. Given the uncertainty associated with forecasting GDP, the rates from year 2013 on are regarded as credible and it is not considered necessary to change them. However, it is necessary to adjust them to average annual rates of growth for the time periods being used in the current review.

In the traffic model, traffic to and from external zones is predominantly traffic to and from Serbia. Recent traffic studies in Serbia have used a GDP forecast of 5.0 percent per year to 2020 and 4.0 percent thereafter (EPTISA) but latest forecasts by the International Monetary Fund (IMF) have recognised a slightly lower growth for the period 2009-2014 in Serbia. The resulting annual growth rates are shown in Table 7.2.

Table 7.2: Summary of GDP / capita forecast growth rates (percent per annum)

Period	Montenegro	External zones
2007 - 2016	3.98%	3.57%
2017 - 2026	4.50%	4.40%
2027 - 2036	2.52%	4.00%
2037 - 2046	2.40%	4.00%

Source: Consultant's analysis

GDP growth in Montenegro is forecast to vary by region, and summarised in the table below. Further details on the derivation of these can be found in the economic report.

[13] IMF Country report No. 09/88 – March 2009

Table 7.3: Assumed regional differentials in economic development

Percentage growth in relation to the national average

-15%	0%	15%	30%
Northern region:	Central region:	Coastal region:	Capital area:
Plužine	Niksic	Herceg Novi	Podgorica
Šavnik	Danilovgrad	Tivat	
Kolasin		Kotor	
Andrijevica		Budva	
Plav		Bar	
Žabljak		Ulcinj	
Mojkovac		Cetinje	
Berane			
Rožaje			
Pljevlja			
Bijelo Polje			

Source: Consultant's analysis

7.4 Demand forecast

The general formula for each zone, and each attractions and production is as follows:

$$\text{Forecast trip end} = \text{existing trip end} \times \frac{\text{Future population}}{\text{existing population}} \times \text{GDP per capita growth} \times \text{Elasticity}$$

An elasticity of 1.2 has been assumed for cars in the growth in trip making with respect to the growth in GDP per capita while it has been assumed to be 1.0 for freight traffic. LB assumed an income elasticity of demand of 1.5 in 2007 for all traffic, declining to 1.3 by 2017. While it is true that high elasticities have been observed for short periods in neighbouring countries as they entered periods of change, an elasticity of 1.2 has typically been found to be appropriate for passenger cars in the central and east European region.

An analysis of the current transport of commodities, as presented in section 2.7 of this report, showed that the transport industry was not relying heavily on particular commodities. This means that the freight traffic forecast does not need to be derived from any expected changes in production of some of the commodities over the next 30 years, but can be considered to be in line with GDP. Furthermore, analyses of freight traffic in Europe have shown that on average freight traffic can be assumed to grow directly with GDP per capita (i.e. with an elasticity of 1.0). These rates are supported by an analysis of growth in GDP and corresponding growth in passenger and freight transport based on IRF World Road Statistics for the UK, France and Germany for the period 1970 to 1990. Further analysis can be found in the economic report.

Further adjustments have been carried out focussing especially on the potentials of the port of Bar and the development of the railway. These are presented in the following sections.

7.5 The port of Bar

The development of the port of Bar has been cited as a potential generator of traffic for the Bar – Boljare corridor. The port has therefore been considered separately in this review.

The port of Bar currently handles approximately two million tons of freight per year, an amount that has remained more or less constant during the period 2003 to 2007. In 2007 approximately 12 percent of freight was containerised; container traffic has increased from 8,633 TEU in 2003 to 27,095 in 2007. RO-RO traffic constitutes about 4 percent of total freight traffic. In 2006, about 80,000 passengers used the port.

Table 7.4: Port of Bar traffic 2003 – 2007

		Year				
	Units	2003	2004	2005	2006	2007
Passengers	'000	n/a	n/a	66	80	n/a
freight loaded	million tons	n/a	n/a	1.24	1.06	n/a
freight unloaded	million tons	n/a	n/a	0.92	1.15	n/a
total freight	million tons	1.92	1.95	2.16	2.21	2.18
Of which:						
liquid bulk	million tons	0.37	0.46	0.39	0.39	0.45
dry bulk	million tons	1.03	0.98	1.04	0.79	0.54
general cargo	million tons	0.52	0.51	0.73	1.03	1.19
container traffic	TEU	8,633	11,434	12,258	17,854	27,095
container traffic	million tons	0.068	0.085	0.094	0.147	0.264
RO-RO traffic	million tons	n/a	n/a	0.08	0.09	n/a

Source: SEETO, MTMAT

The current capacity of the port is about 4.5 million tons per year; although with investment in equipment and infrastructure this could ultimately be increased to about 10 million tons per year. To achieve this level of increase in traffic, investment would also be needed in the road and/or rail links to the port. The Bar – Boljare motorway would be essential for the further development of the port. Serbian authorities[14] have indicated that their principal seaborne commerce would be transferred from Thessaloniki to Bar, once the motorway link from Belgrade to Bar is completed. Nevertheless, such a comment must be treated with a certain amount of caution, since the increasingly privatised commercial sector will be free to choose whichever port offers the most appropriate service. In parallel, upgraded rail infrastructure

[14] Serbian Infrastructure Minister Velemir Ilic, announcement 19 March 2008.

would influence the proportion of traffic using rail as opposed to road. Assuming necessary investments are made; capacity of the port might be reached by 2020.

Analysis of the LB RSI surveys identified about 180 truck journeys per day between the port of Bar and the border with Serbia. Assuming full development of the port, from the current 2.1 million tons per annum to ten million tons per annum, a quadrupling of the number of trucks to 720 per day could be expected by 2020, assuming the modal split between road and rail remains constant.

Table 7.5: Volumes of trucks to / from Bar by corridor section (AADT)

Year / Section	2007 Existing	2020 Growth	2020 Total
Bijelo Polje - Serbia	180	540	720
Berane - Bijelo Polje	230	690	920
Andrijevica - Berane	310	930	1,240
Kolasin - Andrijevica	330	990	1,320
Podgorica - Kolasin	330	990	1,320
Bar - Podgorica	540	1,620	2,160

Source: LB surveys and Consultant's analysis

The port of Bar may be expected to have above average growth. While the growth of general traffic will not be significantly more than other coastal zones, the growth of truck traffic will be significantly higher. This is considered explicitly in the traffic model by converting the link flows above into truck trips demand from and to the port of Bar (two-way) as shown in Table 7.6 and ensuring these are reached in the forecast matrices for years 2026 and 2036.

Table 7.6: Expected daily truck demand to / from Bar for 2020

Origin - Destination	2020 truck Demand
Bar – Serbia	720
Bar - Bijelo Polje	200
Bar – Berane	320
Bar – Andrijevica	80
Bar – Kolasin	0
Bar – Podgorica	840

Source: LB surveys and Consultant's analysis

If these targets are not reached in the forecast matrices, truck trip demand is increased to match these.

7.6 Development of the railway

It may be expected that investment will be made in the rail system and that traffic will be attracted to rail in the future. At the same time, however, investment will be made in the highway network, counteracting some or all of the additional attractiveness of the railway. Nevertheless, it is useful to consider the implications of a change in modal split. If it is assumed that the levels of traffic observed in 1989 are indicative of the maximum traffic that might be carried, the effect on traffic on the Bar – Boljare motorway may be estimated.

Between 1989 and 2007, the number of tons carried by rail fell from 4.50 million to 1.76 million, a fall of 2.74 million tons per year, or 7,500 tons per day, of which 5,000 tons were international freight. This is equivalent to about 200 loaded trucks per day, or 400 trucks per day in total, that could potentially be switched back from road to rail.

In 2007 the railway carried 1.2 million passengers, 40 percent of the 1989 patronage of about 3.0 million. Thus, about 1.8 million passengers have been lost, of which 57 percent (2,800 per day) were travelling internationally. This is equivalent to approximately 1,300 cars per day[15] switched back from road to rail.

If rail traffic were to grow at 5 percent per year, these modal shifts of trucks and cars from road to rail could be achieved by the year 2028.

Modal shifts from road to rail are included explicitly in the traffic model however the modal shifts were incorporated on the basis of intuitive assumptions. Because of changes in vehicle ownership, travel behaviour etc, it is assumed that by the year 2026 only half the potential transfers back to rail outlined in the paragraphs above occur. This has been modelled assuming a removal of 200 trucks and 650 cars per day from the Bar – Boljare highway corridor[16].

7.7 Final Do-Minimum demand

Table 7.7 shows the matrix totals for the Do-Minimum vehicle demand (excluding trip generation) for the various forecast years. This demand includes the correction for the port of Bar and for the railway as these are considered to be relatively independent from the introduction of the Bar – Boljare motorway (effects of the port of Bar might be increased and of the railway decreased due to the construction of the Bar – Boljare motorway, this will be calculated as part of the model of induced traffic).

It should be notes that at this stage, all the intrazonal demand (which cannot be assigned) has been removed from the matrices.

[15] Based on an occupancy of 2.14 persons per vehicle as presented in section 3.3 of this report.
[16] Some of this traffic might come back on the motorway, this calculated as part of the induced traffic, as described in section 7.8 of this report.

Table 7.7: DM forecast demand and growth from 2007

Modes	Base 2007 Total	Total Growth from 2007
Car	56,241	-
LGV	8,452	-
HGV	6,644	-
Total	**71,337**	**-**
DM 2016		
Car	102,511	82.3%
LGV	12,882	52.4%
HGV	10,054	51.3%
Total	**125,447**	**75.9%**
DM 2026		
Car	162,820	189.5%
LGV	20,635	144.1%
HGV	16,988	155.7%
Total	**200,443**	**181.0%**
DM 2036		
Car	212,695	278.2%
LGV	27,058	220.1%
HGV	21,838	228.7%
Total	**261,591**	**266.8%**

Source: Consultant's analysis

7.8 Model of induced traffic

Construction of a new motorway may lead to the generation of "induced traffic", that is, traffic resulting from trips which would not have been made had the facility not been constructed.

In the current study, an estimate has been made of the amount of induced traffic which might be generated for each scenario for each forecast year. It represents, therefore, what might be expected to be the most likely amount of traffic induced.

A simple approach has been adopted which relates the traffic generated to the change in travel time resulting from the construction of the motorway for each origin-destination pair in the matrix. The form of the relationship is:

$Dem_{DS} = Dem_{DM} \times (c_1/c_0)^b$

where Dem_{DM} is the Do-Minimum demand as presented in section 7.7,

Dem_{DS} is the Do-Something demand including generated traffic,

c_0 is the journey time without the motorway, or Do-Minimum time skim[17]

c_1 is the journey time with the motorway, or Do-Something time skim and

b is an elasticity.

An elasticity of -0.24 has been assumed, which is the value recommended for off-peak inter urban trips in the UK[18]. This methodology has been used for other east European countries (Poland for example) to represent the expected trips generated due to the addition of new motorway links and hence reduced travel costs. The advantages of this technique are that it considers possible generation for all origin-destination pairs independently. Thus, origin-destination pairs away from the infrastructure improvements and not likely to use it will not produce any induced demand while origin-destination pairs directly close to the project will enjoy high induction. Furthermore, long distance trips where time savings are likely to be significant will benefit from greater induction than short distance trips for which time savings are minimal.

This induction of traffic in fact reflects three possible changes in behaviour towards travelling, these are:

- Trip distribution also called destination choice, or long term relocation of either or both home, work or shopping locations as the result of the motorway increasing accessibility to certain areas;
- Mode shift, which corresponds to people's willingness to change mode as the result of an improvement. For example trips being transferred from rail or air to road as the quality of travel improves thanks to the motorway;
- Trip frequency or the willingness to travel as the result of transport infrastructure improvements. While before travelling from A to B was considered too long to be worthwhile new travel times make the trip possible.

In the case of the Bar – Boljare motorway, it is considered that the above approach accounts for four main factors:

- The possible further development of the port of Bar as road improvements to Podgorica and to Serbia would strengthen the position of the port of Bar;
- The possible transfer (mode shift) form rail to road as, even if the railway would have been improved, the Bar – Boljare motorway would bring significant time savings for long distance trips on the corridor;
- The possible development of the northern part of Montenegro which will be much more accessible from the coast and capital. Possible such developments include ski resorts in the mountainous areas and more accessible national parks close to the northern sections of the motorway; and

[17] Time skim: travel time between each Origin Destination pair as demand weighted average between all routes used between each Origin Destination pair
[18] Department of Transport (1997) Design Manual for Roads and Bridges, Traffic Appraisal Advice

- The possible development of new settlements and extensions to urban areas along the corridor directly related to trip distribution.

8 FUTURE YEAR ASSIGNMENTS

After completing the development of the various forecast networks and matrices, demand split between motorway and non-motorway and assignments were carried out and analysed. For each scenario and year, two assignments were carried out, first the Do-Minimum matrix was assigned to the Do-Something scenario before extracting the travel time skim. Then the model of generated traffic was run to derive the DS demand which was assigned to the Do-Something scenario.

Post assignment, including generated traffic, old road and motorway flows, speeds and travel times were extracted for analysis. Only the results from the most valid scenarios are presented and discussed here, although all the assignments undertaken were used as input to the economic analysis process. The scenarios discussed in this section are:

- Scenario 1: Smokovac to Matesevo, which the GOM considers should be constructed first;
- Scenario 9: the entire route from the coast to Boljare; and
- Scenario 10: from the coast to Virpazar.

Other information such as global network statistics and traffic patterns across Montenegro can be found in **Appendix 7** of this report.

8.1 Motorway/non-motorway demand split on Bar – Boljare corridor

The derivation of the demand split between motorway and non-motorway was carried out using a logit model and the costs (reverse of utilities) calculated as part of the willingness to pay survey. This methodology, using an iterative process includes the following steps:

1. For each user class, an initial split of 10% motorway demand, 90% non-motorway demand is assumed, and applied to the entire matrix.
2. Assignment of the demand is carried out, using multi-user equilibrium and assuming that the non-motorway demand can only use the existing network while the motorway demand can use all links including the new motorway.
3. Extraction of time distance and toll skims were for each of the 6 demand categories (car motorway, car non-motorway, LGV motorway, LGV non-motorway, HGV motorway, HGV non-motorway).
4. Calculation of the costs for each of the 6 demand categories using:

$$C_{car\_mot} = 0.0127 \times Time + 0.0109 \times Distance + 0.1192 \times Toll - 1.368$$

$$C_{LGV\_mot} = 0.0324 \times Time + 0.0260 \times Distance + 0.2039 \times Toll - 1.257$$

$$C_{HGV\_mot} = 0.0375 \times Time + 0.0000 \times Distance + 0.1382 \times Toll - 1.878$$

$$C_{car\_non\_mot} = 0.0127 \times Time + 0.0109 \times Distance$$

$$C_{LGV\_non\_mot} = 0.0324 \times Time + 0.0260 \times Distance$$

$$C_{HGV\_non\_mot} = 0.0375 \times Time + 0.0000 \times Distance$$

5. Calculation for each user class (car, LGV, HGV) of new split motorway/non-motorway for each origin-destination pair using the logit model:

   $\Pr(i)_{mot} = \frac{e^{C(i)non-mot}}{e^{C(i)non-mot} + e^{C(i)mot}}$ and $\Pr(i)_{non-mot} = 1 - \Pr(i)_{mot}$ where $\Pr(i)_{mot}$ is the new proportion of motorway demand for a user class i and $\Pr(i)_{non-mot}$ the new proportion of non-motorway demand for a user class i.

6. Assignment, using multi-user equilibrium and assuming that the non-motorway demand can only use the existing network while the motorway demand can use all links including the new motorway.

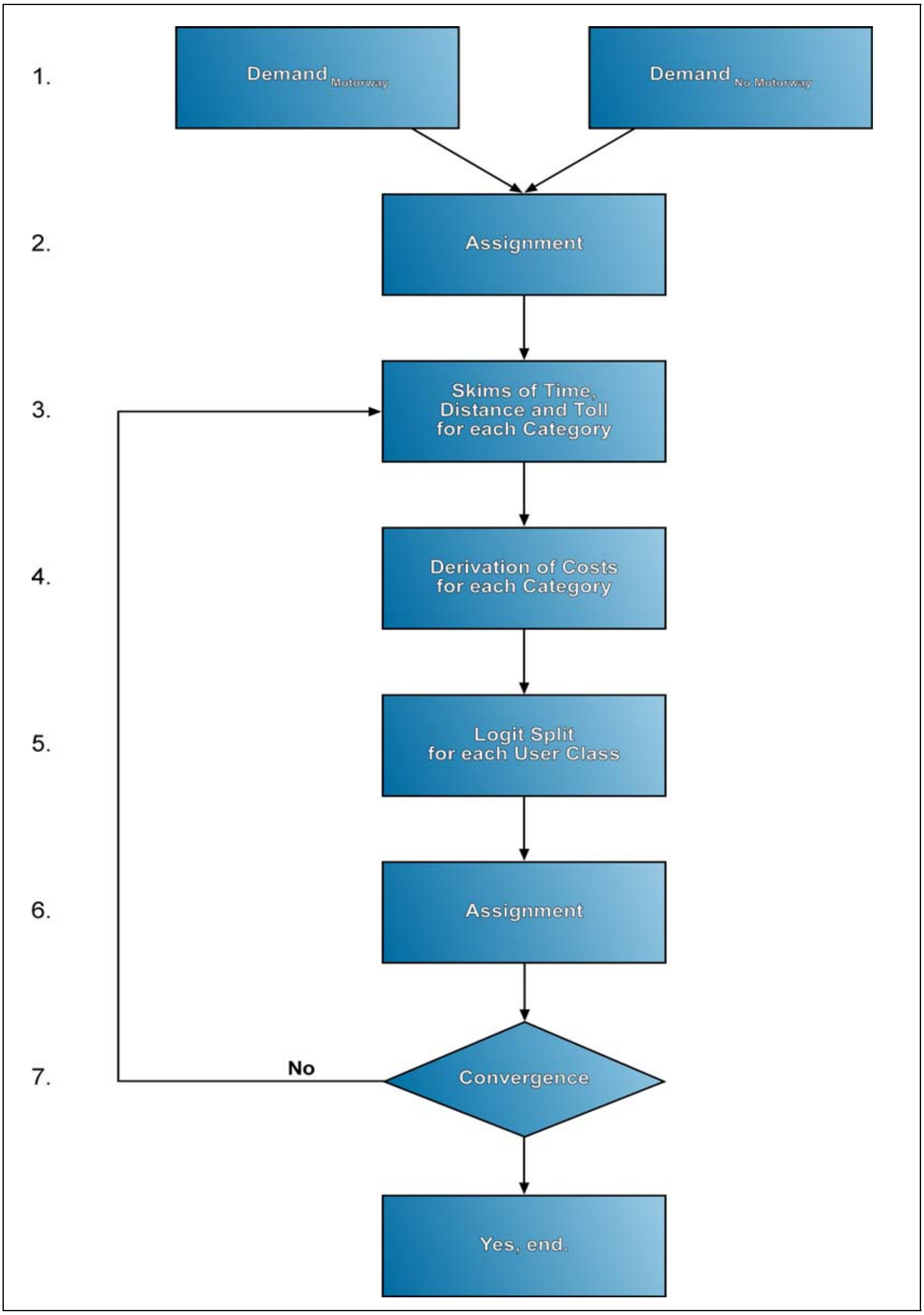
7. Looping to step 3. except if change in flow on all links satisfies:

   $ABS(X(n) - X(n-1)) < \min(0.01 \times \max(X(n), X(n-1)), 10)$ where X(n) corresponds to the total flow on a link for iteration n and X(n-1) to the total flow on a link for iteration n-1.

This process is summarised in the flow chart in figure 8.1. This methodology provides the opportunity for the model to converge between demand and supply thus ensuring that the forecasted demand on the motorway reflects on the expected traffic conditions.

After the split motorway and non-motorway demand is completed, the induction module is run, before carrying out an assignment again. This entire process is controlled through Excel Visual Basic, thus avoid possible manual errors.

Figure 8-1: Methodology for split between motorway and non-motorway demand



8.2 Generated demand

The derivation of generated traffic has been detailed in the previous chapter of this report. The table below presents the outputs in terms of generated demand for each user class. It shows that the level of generated demand is much higher when the entire corridor is in place. It shows that in scenario 1, time savings for the origin-destination pairs using this corridor are small hence limiting the level of generated traffic. In comparison, once the entire corridor is converted to motorway, time savings are significant enough and focussing on corridors in great demand, thus generating relatively high demand. It also shows that generated traffic increases over the years as time savings on the motorway against the increasingly congested existing road amplify.

Table 8.1: Generated demand levels

Scenario		Modes	Year 2007	2016	2026	2036
DM		Car	56,241	102,511	162,820	212,695
		LGV	8,451	12,882	20,635	27,058
		HGV	6,644	10,054	16,998	21,838
		Total	**71,336**	**125,447**	**200,453**	**261,591**
DS	Scenario 1	Car	56,852	103,749	167,871	218,261
		LGV	8,526	13,001	21,194	27,640
		HGV	6,738	10,170	17,564	22,382
		Total	**72,116**	**126,920**	**206,629**	**268,283**
	Scenario 9	Car	58,167	106,810	172,909	226,396
		LGV	8,706	13,342	21,655	28,591
		HGV	6,846	10,391	18,063	23,219
		Total	**73,719**	**130,542**	**212,627**	**278,206**
	Scenario 10	Car	57,153	104,990	169,536	221,628
		LGV	8,556	13,122	21,245	27,974
		HGV	6,752	10,249	17,659	22,634
		Total	**72,462**	**128,360**	**208,440**	**272,236**
Absolute Difference (DS - DM)	Scenario 1	Car	611	1,238	5,051	5,566
		LGV	75	119	559	582
		HGV	94	116	566	544
		Total	**780**	**1,473**	**6,176**	**6,692**
	Scenario 9	Car	1,926	4,299	10,089	13,701
		LGV	255	460	1,020	1,533
		HGV	202	337	1,065	1,381
		Total	**2,383**	**5,095**	**12,174**	**16,615**
	Scenario	Car	912	2,479	6,716	8,933

	10	LGV	105	240	610	916
		HGV	108	195	661	796
		Total	**1,126**	**2,913**	**7,987**	**10,645**
Percentage Difference (DS - DM)	**Scenario 1**	Car	1.09%	1.21%	3.10%	2.62%
		LGV	0.89%	0.92%	2.71%	2.15%
		HGV	1.42%	1.16%	3.33%	2.49%
		Total	**1.09%**	**1.17%**	**3.08%**	**2.56%**
	Scenario 9	Car	3.42%	4.19%	6.20%	6.44%
		LGV	3.02%	3.57%	4.94%	5.67%
		HGV	3.04%	3.35%	6.27%	6.32%
		Total	**3.34%**	**4.06%**	**6.07%**	**6.35%**
	Scenario 10	Car	1.62%	2.42%	4.12%	4.20%
		LGV	1.25%	1.86%	2.96%	3.39%
		HGV	1.62%	1.94%	3.89%	3.65%
		Total	**1.58%**	**2.32%**	**3.98%**	**4.07%**

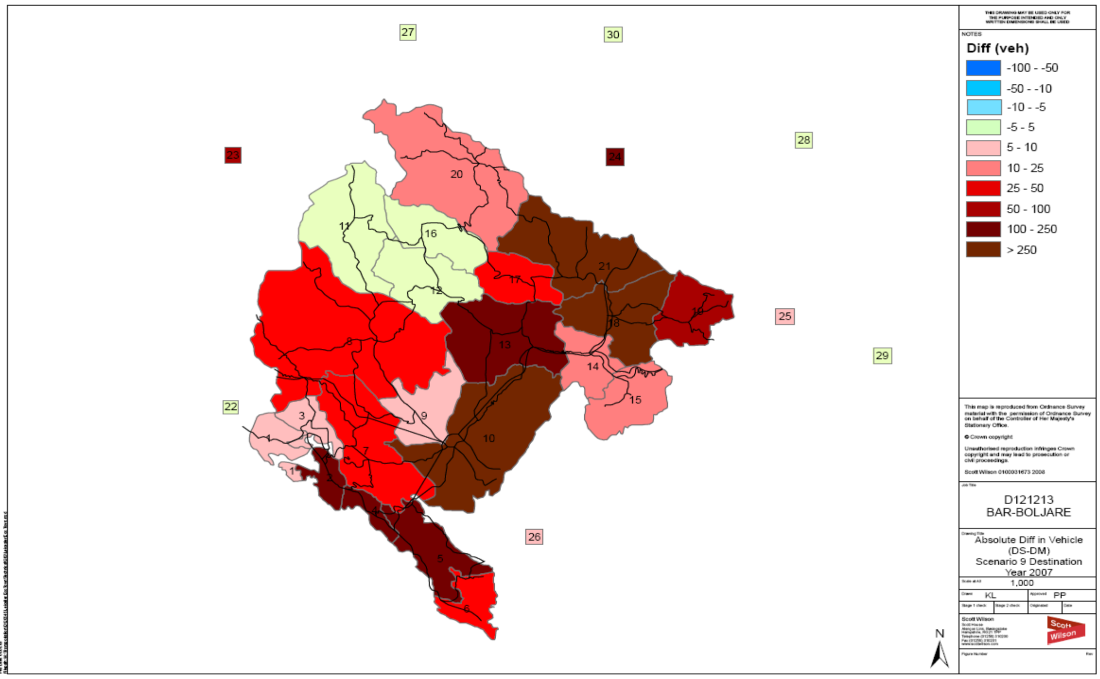
Source: Consultant's analysis

Figures 8.2 and 8.3 present the areas most affected by the trip induction for scenario 9. These validate two things:

- Highest levels of induction occur along the Bar – Boljare corridor where the motorway is built, confirming the points presented in section 7.8 of this report;
- Both figures show induction not only along the corridor but throughout Montenegro. As induction can be directly related to time savings[19], it substantiates the fact that the Bar – Boljare motorway is of strategic importance as it would improve accessibility to most parts of Montenegro and neighbouring countries.

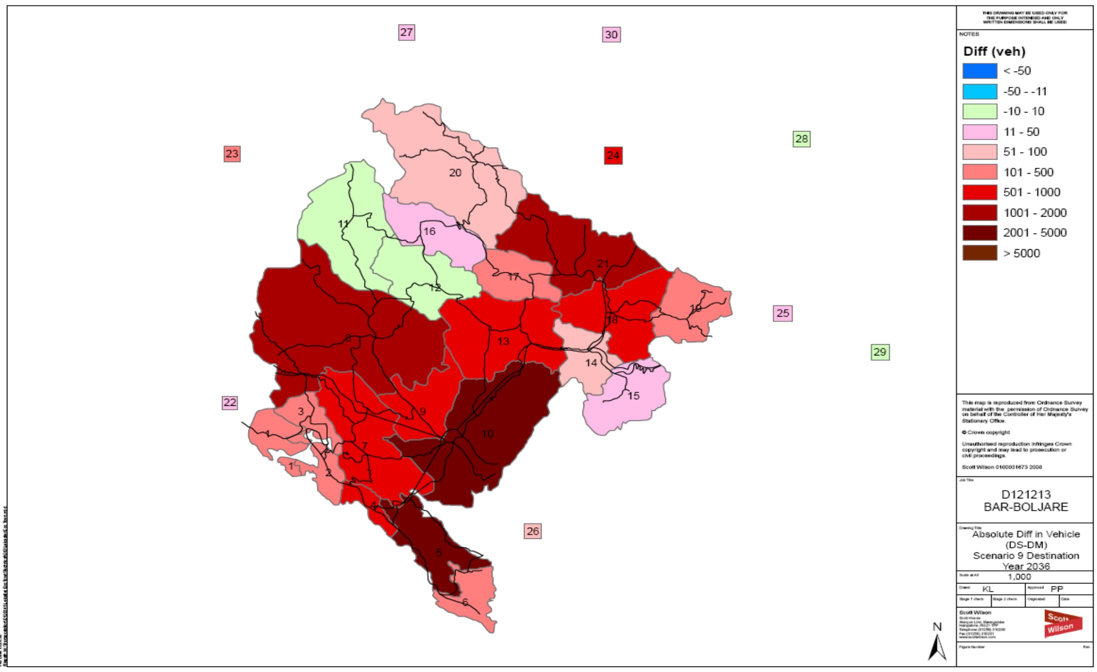
[19] As induction is derived from time savings, as presented in section 8.8 of this report.

Figure 8-2: Impact of generated traffic on demand – scenario 9 – year 2007



Source: Consultant's analysis

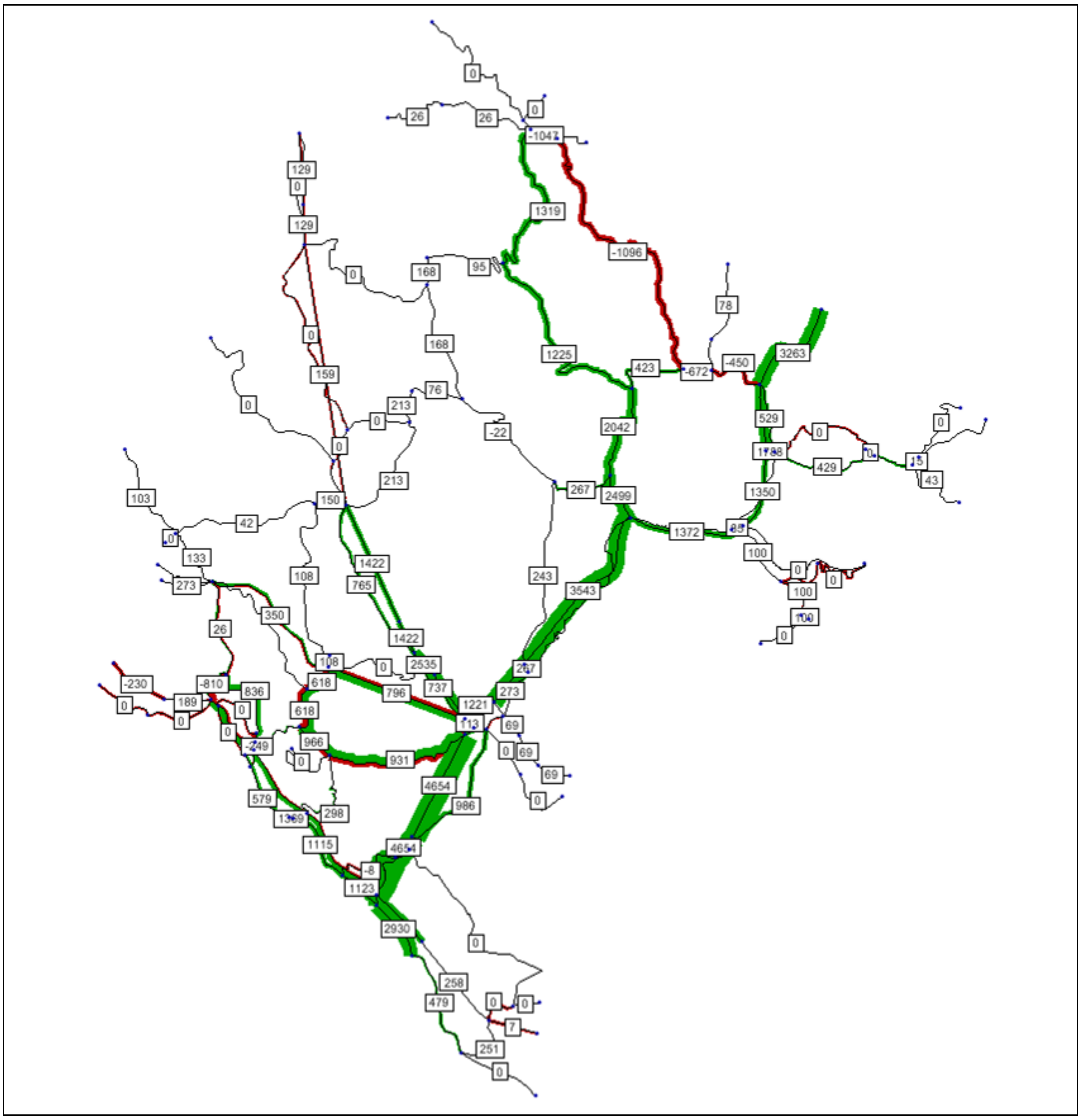
Figure 8-3: Impact of generated traffic on demand – scenario 9 – year 2036



Source: Consultant's analysis

Figure 8.4 shows the impact of generated traffic on the motorway flow. It focuses on scenario 9 for year 2036. It shows that due to overall reductions in travel times across the network, generated demand is mainly along the proposed Bar – Boljare motorway corridor but also extend further as for example some of the generated traffic uses the old Podgorica to Virpazar road. The highest levels of generated traffic are in the south along the coast and between Bar and Podgorica (about 5,000 vehicles a day). This clearly emphasizes the strategic nature of the corridor.

Figure 8-4: Impact of generated traffic – scenario 9 – year 2036



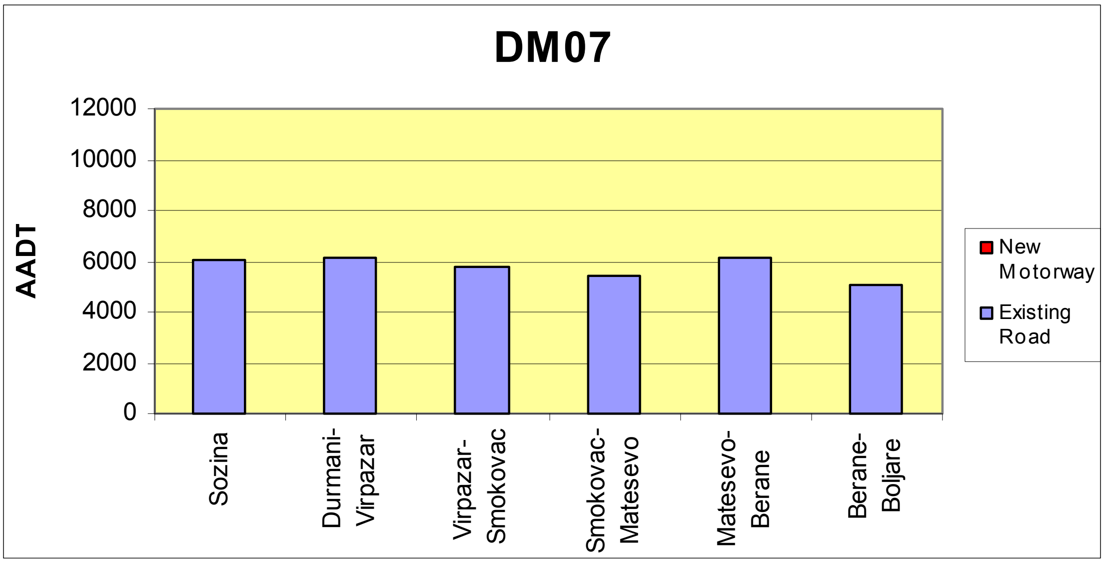
Source: Consultant's analysis

8.3 Bar – Boljare corridor traffic flows

It is clear from the above that the Bar – Boljare motorway will be beneficial, as it will improve traffic conditions throughout Montenegro.

An analysis focussing specifically on the Bar – Boljare has been carried out. AADT flows have been extracted on the corridor for both the old road and new motorway. Figure 8.5 shows the traffic levels on the 6 sections of the corridor.

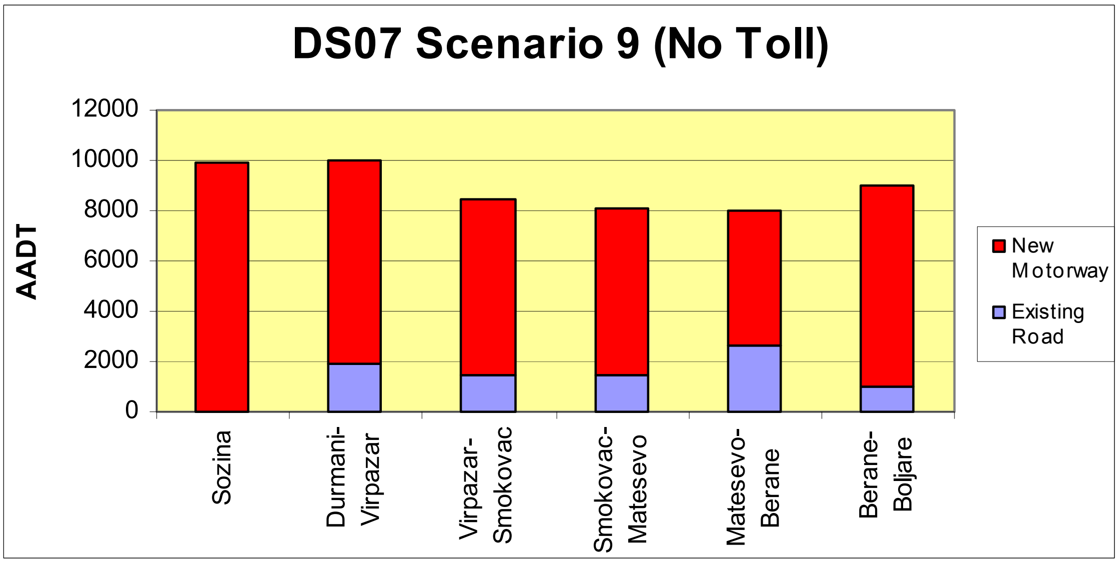
Figure 8-5: DM AADT flows on Bar – Boljare corridor for year 2007



Source: Consultant's analysis

Figure 8.6 considers scenario 9 and shows that in the south all traffic transfers to the new motorway. It should be noted that on the Djurmani – Virpazar section it corresponds to the addition of a second carriageway and second bore of the Sozina tunnel. In the north the old road remains used as it is still the main access to the north west parts of Montenegro from the south (at it uses a completely different alignment form the new motorway) and because the old road still remains a possible border crossing point to Serbia (even if it is assumed that there is a good connection to Belgrade on the Serbian side of the Bar – Boljare motorway). A comparison between the two figures also shows that there is an increase in total travel on the corridor in the order of 30%. Experienced AADT levels are still relatively small (around 8,000 to 10,000 vehicles a day) and do not fully justify the need for a dual two motorway along the corridor.

Figure 8-6: Scenario 9 AADT flows on Bar – Boljare corridor for year 2007

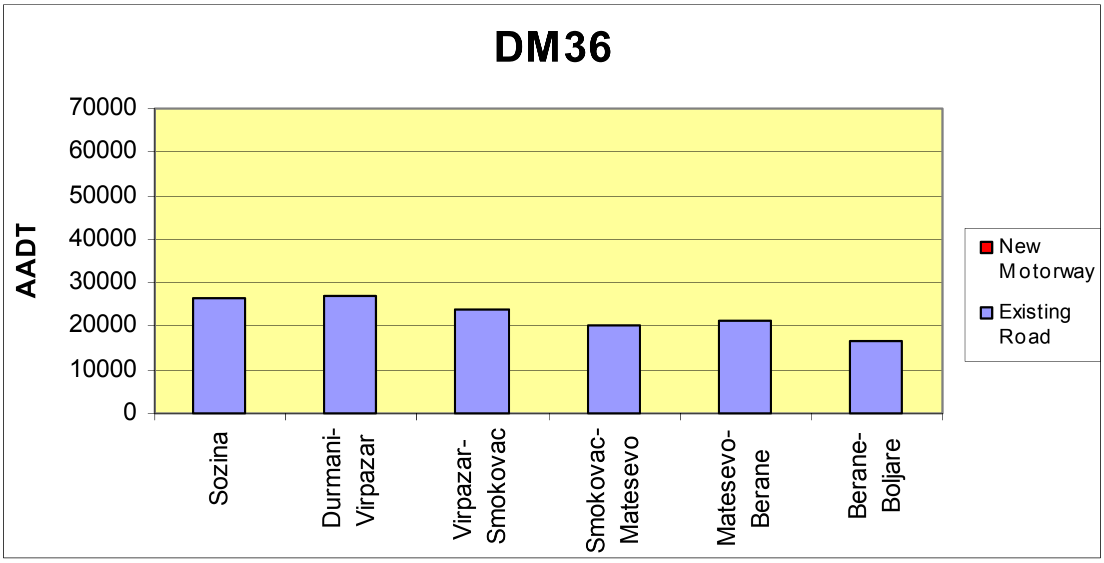


Source: Consultant's analysis

The same analysis has carried out for scenarios 1 and 10 and can be found in **appendix 8**.

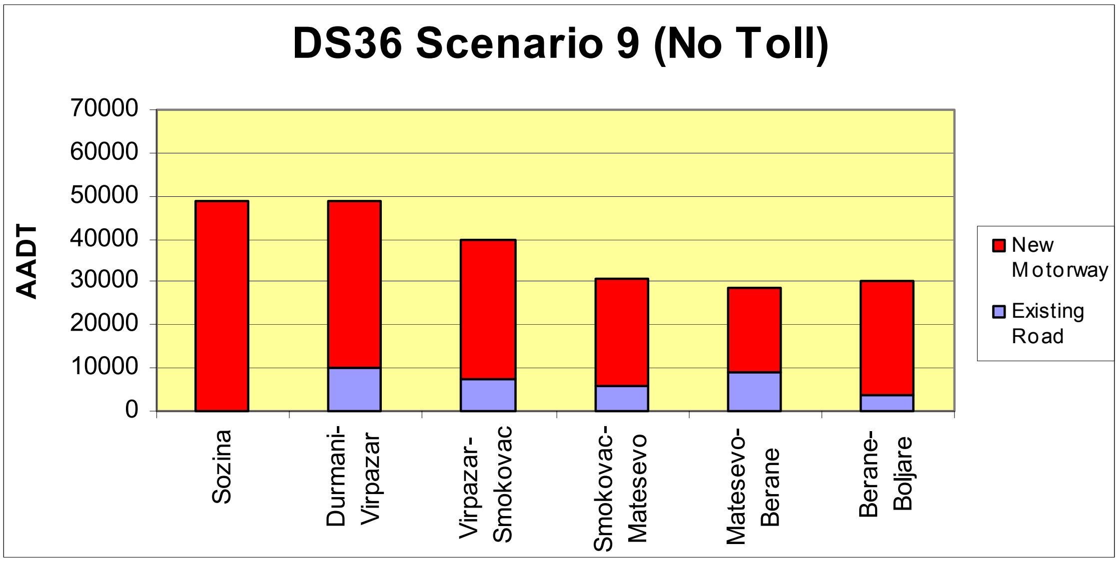
Figures 8.7 and 8.8 present similar graphs for year 2036. A similar pattern as for year 2007 tends to emerge. In the DM, the expected flows are in fact restrained by the capacity of the existing roads and it is clear that a demand of 20,000 to 25,000 vehicles AADT on the existing road is not sustainable due to congestion and safety issues. The addition of the Bar – Boljare motorway generates travel with an overall demand on the corridor multiplied by 2 from the DM scenario. Some of the sections of the motorway are predicted to be heavily trafficked by 2036 with levels in excess of 45,000 vehicles AADT. **Appendix 9** provides similar information for scenarios 1 and 10 and shows that not building the motorway through the entire corridor is not efficient as the sections without the improved links create bottleneck hence not using the improved sections to there full potential (this is especially true if only the Smokovac - Matesevo section is built).

Figure 8-7: DM AADT flows on Bar – Boljare corridor for year 2036



Source: Consultant's analysis

Figure 8-8: Scenario 9 AADT flows on Bar – Boljare corridor for year 2036



Source: Consultant's analysis

8.4 Forecast AADT volumes on Bar – Boljare motorway

Using the outputs from the traffic models, an expected AADT profile for the various sections of the proposed motorway was developed. For the various sections the years of opening have been assumed as follows:

- Smokovac – Matesevo 2013
- Smokovac – Virpazar 2015
- Matesevo – Berane 2015
- Berane – Boljare 2016
- Virpazar – Djurmani 2016

By interpolating demand between the specifically modelled years of 2007, 2016, 2026 and 2036 (using compound growth) and by extrapolating to year 2046, AADT levels, per user class have been produced.

Table 8.2 presents a tabulation of the expected AADT volumes assuming the above opening years of the various sections composing the motorway.

Table 8.2: Forecast AADT volumes

Expected AADT Traffic Volume (No Toll)						
Year	Sozina	Durmani-Virpazar	Virpazar-Smokovac	Smokovac-Matesevo	Matesevo-Berane	Berane-Boljare
2013	-	-	-	8,692	-	-
2014	-	-	-	9,214	-	-
2015	-	-	11,908	10,443	8,723	-
2016	-	-	12,737	11,063	9,291	-
2017	20,711	16,705	13,667	11,651	9,785	14,213
2018	22,194	17,943	14,666	12,272	10,306	14,852
2019	23,784	19,273	15,740	12,928	10,858	15,520
2020	25,489	20,704	16,894	13,622	11,441	16,219
2021	27,318	22,242	18,135	14,354	12,057	16,950
2022	29,279	23,896	19,469	15,129	12,710	17,715
2023	31,383	25,674	20,903	15,948	13,401	18,516
2024	33,640	27,586	22,446	16,815	14,132	19,354
2025	36,062	29,643	24,105	17,731	14,906	20,231
2026	38,660	31,855	25,889	18,701	15,726	21,149
2027	39,567	32,510	26,472	19,239	16,064	21,664
2028	40,496	33,177	27,068	19,792	16,409	22,192
2029	41,447	33,859	27,678	20,361	16,762	22,732
2030	42,421	34,556	28,302	20,947	17,123	23,286
2031	43,418	35,267	28,941	21,550	17,492	23,853
2032	44,439	35,993	29,594	22,170	17,869	24,434
2033	45,485	36,734	30,262	22,808	18,254	25,029
2034	46,555	37,491	30,945	23,465	18,649	25,639
2035	47,652	38,264	31,644	24,140	19,052	26,264
2036	48,774	39,053	32,359	24,835	19,464	26,904
2037	49,921	39,857	33,089	25,550	19,883	27,559

2038	51,094	40,677	33,836	26,285	20,312	28,230
2039	52,296	41,514	34,599	27,041	20,750	28,918
2040	53,525	42,368	35,380	27,819	21,197	29,623
2041	54,784	43,240	36,178	28,620	21,654	30,344
2042	56,072	44,130	36,994	29,443	22,121	31,083
2043	57,390	45,038	37,828	30,291	22,597	31,840
2044	58,739	45,965	38,682	31,162	23,084	32,616
2045	60,120	46,911	39,554	32,059	23,582	33,411
2046	61,534	47,877	40,447	32,981	24,090	34,224

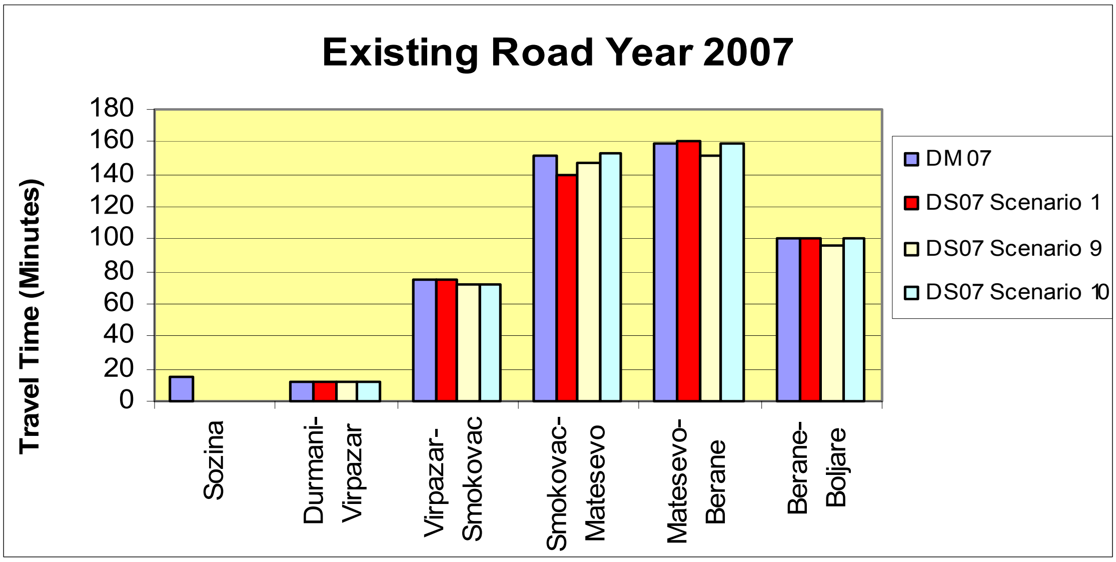
Source: Consultant's analysis

A graphical representation of this table is given in **Appendix 10** of this report.

8.5 Travel times on Bar – Boljare corridor

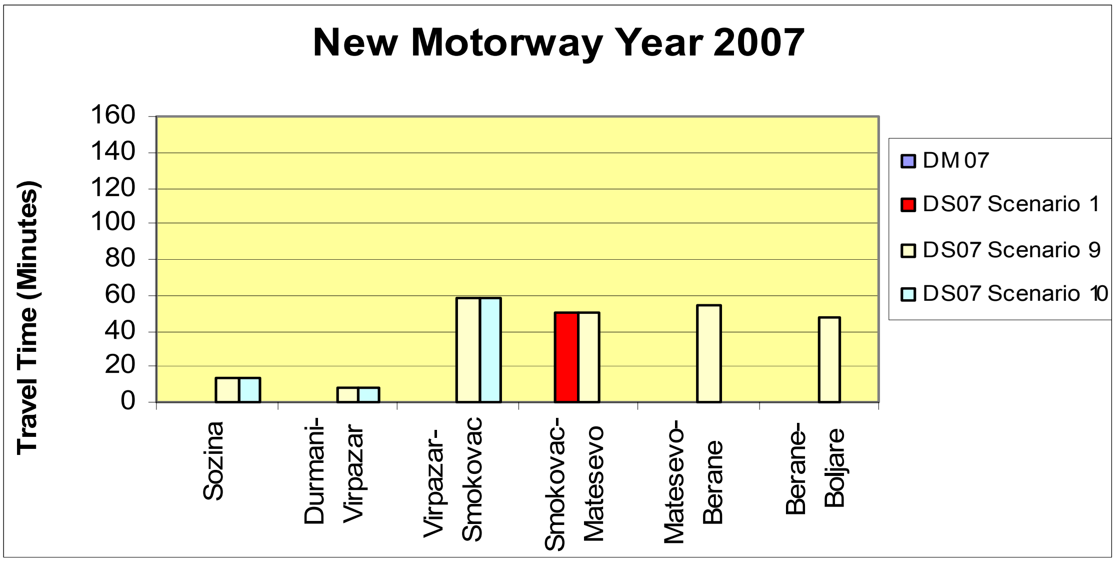
Notional travel times along the corridor have been analysed for year 2007 as depicted in figures 8.9 and 8.10. These show that the new motorway is much faster that the existing road on most sections. Travel time through the entire corridor is expected to be reduced by 50% with the addition of the new motorway. Travel times remain relatively constant throughout all scenarios as AADT flows are low and far from capacity on both the old road and new motorway until the later years.

Figure 8-9: Travel time on existing road (Bar – Boljare corridor) – year 2007



Source: Consultant's analysis

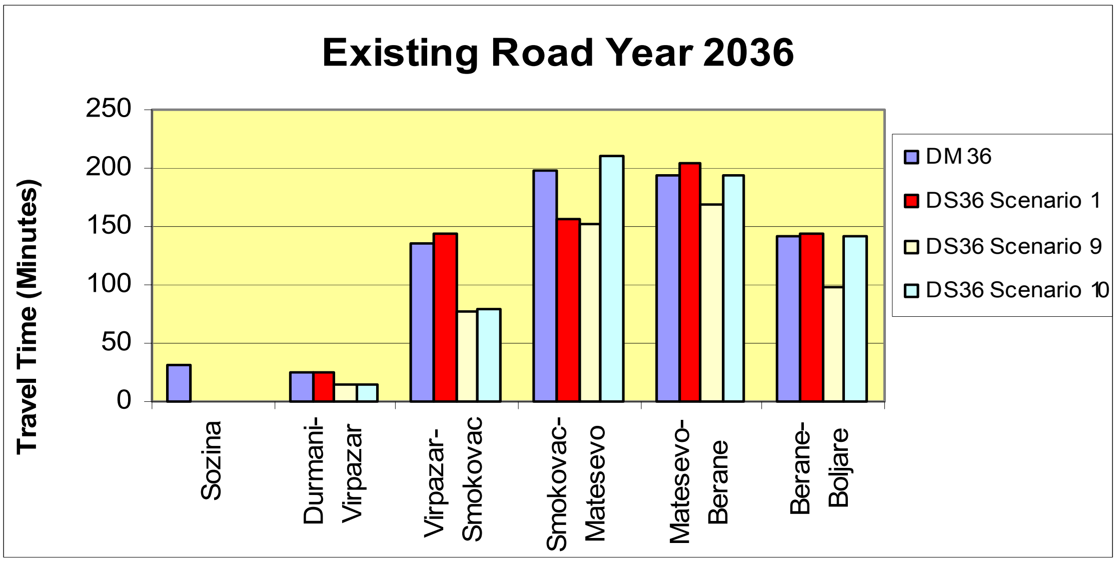
Figure 8-10: Travel time on proposed motorway (Bar–Boljare corridor) – year 2007



Source: Consultant's analysis

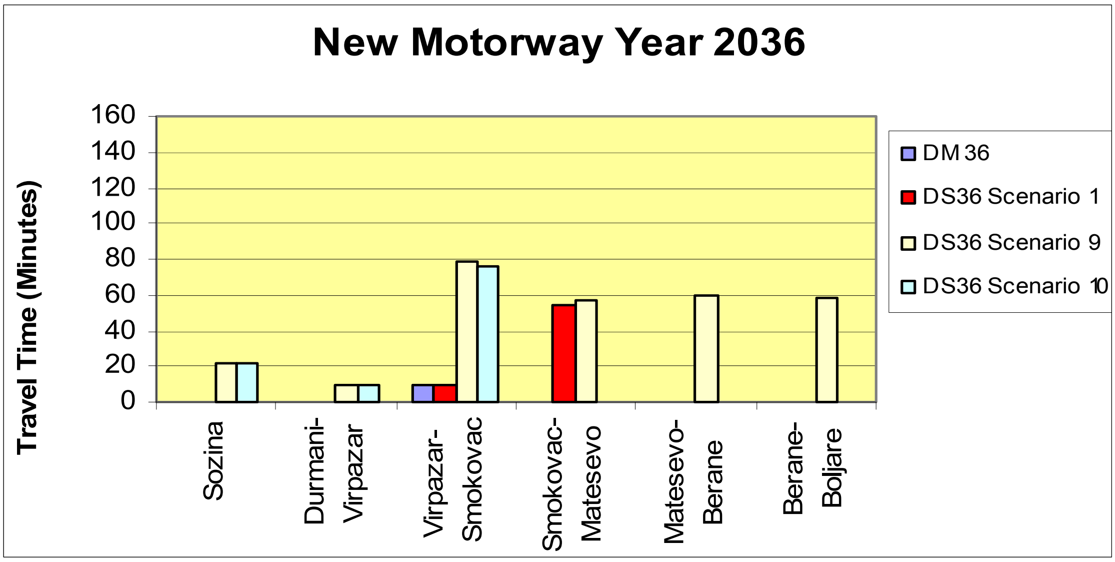
If considering year 2036, as shown in figures 8.11 and 8.12, there is clear evidence that the section between Virpazar and Smokovac is vital as when not in place (as per the DM and scenario 1) travel times on the existing road become unacceptable as in excess of 140 minutes. Once the motorway is built travel times reduce to 75 minutes. In the north, towards Serbia, the existing road remains very attractive; hence journey times are much higher than on the proposed motorway. This could be improved by ensuring that in Serbia the motorway from Belgrade to the border is built and meets the proposed Bar – Boljare motorway.

Figure 8-11: Travel time on existing road (Bar – Boljare corridor) – year 2036



Source: Consultant's analysis

Figure 8-12: Travel time on proposed motorway (Bar – Boljare corridor) – year 2036



Source: Consultant's analysis

9 SENSITIVITY TESTS

Sensitivity tests have been carried out as part of the modelling exercise in order to test the impact of unforeseen events relating to demand assumptions. The tests have all been carried out to provide input to economic models and therefore, no detailed results are presented in the traffic report.

First, the overall demand has been adjusted to represent a more pessimistic view of the potential GDP growth in the region. The expected annual GDP growth was assumed to be one percentage point lower than for the realistic case presented in this report.

Additional tests looked at specific assumptions made within the traffic model. The tests relate to the development of Port of Bar, investments in the railway along the Bar – Boljare corridor and the planned connecting motorway link from Serbia to Boljare.

Table 9.1: Sensitivity tests

Test	Test outline	Results	Scenarios tested
Pessimistic growth	Testing a lower growth in demand over the years 2010-2036. Assumes one percentage point lower annual GDP.	Traffic levels significantly lower, in particular throughout the later years. Less motorway revenue is gained.	All (1-10)
Serbian motorway link not built	The test has been modelled by removing the motorway connection into Serbia.	Traffic levels largely unchanged on the southern part of the network. In the north, traffic re-routes to other roads into Serbia.	9
Port of Bar not developed	Adjustments have been made to the trip matrices, adding trips to allow for the increased activity at the Port. The sensitivity test left these adjustments out.	Bar – Boljare corridor experiences fewer heavy vehicles as the demand is slightly lower.	1, 6, 7, 9
Rail investments not implemented	Adjustments have been made to the trip matrices to allow for investments in the railway. The sensitivity tests left these adjustments out.	As the railway along the Bar – Boljare corridor becomes less competitive; the road corridor experiences a higher traffic flow.	1, 6, 7, 9

10 TOLL OPTIMISATION

This chapter describes how the tolling optimisation was carried out before discussing the impact of tolls on traffic.

10.1 Optimum toll levels

The tolling optimisation has been tested for scenario 9 only, which assumes the opening of the entire Bar – Boljare motorway.

Based on the years 2007 and 2036 scenario 9, the toll levels for cars have been raised by increments of one eurocent/km from a minimum of one eurocent/km to 30 eurocent/km. From the analysis of these model runs the optimum toll levels have been derived calculating the expected revenues.

The revenues have been calculated by multiplying the vehicle-kilometres on the Bar – Boljare motorway by the toll rate per kilometre. The analysis focuses on all sections of the motorway except the Sozina tunnel section where the current toll levels have been kept constant. The revenues quoted below thus exclude potential revenues from the Sozina tunnel itself.

This analysis was done in two passes; first the optimum toll level for cars was derived. In a second phase, the toll rate for car was fixed to the optimum and the toll rate for LGV and HGV varied again to derive the optimum for these user classes.

The analysis, presented in Figures 10.1-10.4 suggests that for 2036, the optimum toll rate to maximise revenues for cars is 0.13 euro per kilometre while in 2007, the optimum toll level is slightly higher. As the traffic levels in 2036 are much higher (and so the total revenue), the 2036 optimisation scenario takes precedence over 2007 and hence 0.13 euro has been used as the preferred toll level. These values are slightly higher than the expected toll rates in Western Europe as the Ecorys[20] study demonstrates. Further analysis shows that these rates are higher than French average toll rates of about 0.08 euro per kilometre[21] (varying from 6.4 to 10.4 cents per kilometre). These relatively high rates for Montenegro are nonetheless justified by the large time savings the project generates as no efficient alternative route exists due to the mountainous nature of the terrain, thus toll penalties appear relatively small compared to time savings. These high rates also include the safety and reliability elements which were clearly stated as part of the results of the willingness to pay survey.

[20] "*Assessing the options for public private participation in the highway sector in Montenegro*" Ecorys report dated July 2008

[21] http://www.journaldunet.com/economie/magazine/enquete/autoroutes-tarifs-des-peages-en-france/autoroutes-quels-sont-les-trajets-les-plus-chers.shtml, data collected first quarter 2008, last accessed 27/05/2009

A comparison of the VOT and VOC savings generated by the addition of the motorway against the tolls for year 2007, as presented in Table 10.1 clearly shows that while the proposed toll levels are high they are heavily outweighed by the combined perceived time and cost savings. For example, if travelling through the entire length of the motorway, the overall toll charges equate to about 25.62 euros, but the VOT savings are about 22.79 euros and the VOC saving are about 24.03 euros thus generating an overall perceived saving of 21.24 euros.

Furthermore Table 10.1 shows that the most important savings are in the northern sections. This is logical as this is where the motorway will bring significant improvements over the existing mountainous road, especially for HGVs.

Table 10.1: Overall cost savings using the motorway - 2007

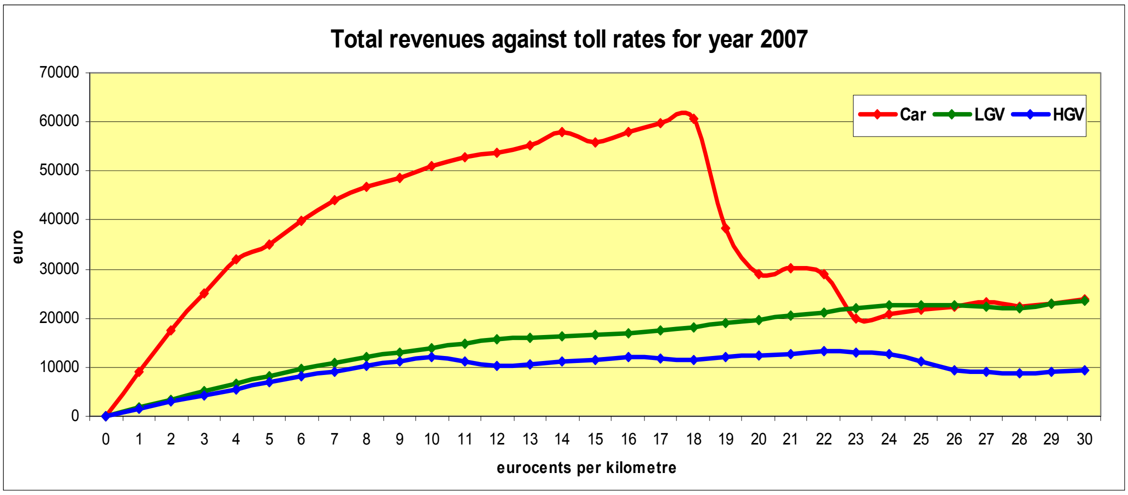
	travel time (minutes)		VOT saving[22] (€)	distance (km)		VOC saving[23] (€)	Toll [24](€)	overall Saving (€)
Section	old road	motorway		old road	motorway			
Djurmani-Virpazar	17	8	0.79	4.0	5.5	0.50	-0.88	**0.40**
Virpazar-Smokovac	75	60	1.31	43.0	42.6	4.94	-6.82	**-0.57**
Smokovac-Matesevo	145	50	8.30	58.7	40.1	6.30	-6.42	**8.18**
Matesevo-Berane	150	56	8.21	66.3	37.3	6.93	-5.97	**9.17**
Berane-Boljare	98	50	4.19	50.2	34.6	5.40	-5.54	**4.05**
Total	**485**	**224**	**22.79**	**222.2**	**160.1**	**24.06**	**-25.62**	**21.24**

Source: Consultant's analysis

It should be noted, however, that the current toll levels for the Sozina tunnel correspond to around 0.34 euro per kilometre (3.25 euro per passage). This is partly due to the Sozina tunnel being perceived as a complicated piece of infrastructure, which gives a different perception to motorways, but also due to significant time savings. Similarly, if particular structures were to be tolled, higher average toll rates across the Bar – Boljare motorway could potentially be reached.

[22] Based on the perceived VOT presented in section 3.4 of this report weighted by vehicle class assuming 75% cars, 10% LGV and 15% HGV
[23] Based on the perceived VOC presented in section 3.4 of this report weighted by vehicle class assuming 75% cars, 10% LGV and 15% HGV
[24] Based on the optimum toll levels weighted by vehicle class assuming 75% cars, 10% LGV and 15% HGV excluding Sozina tunnel

Figure 10-1: Total daily revenues against toll rates for year 2007



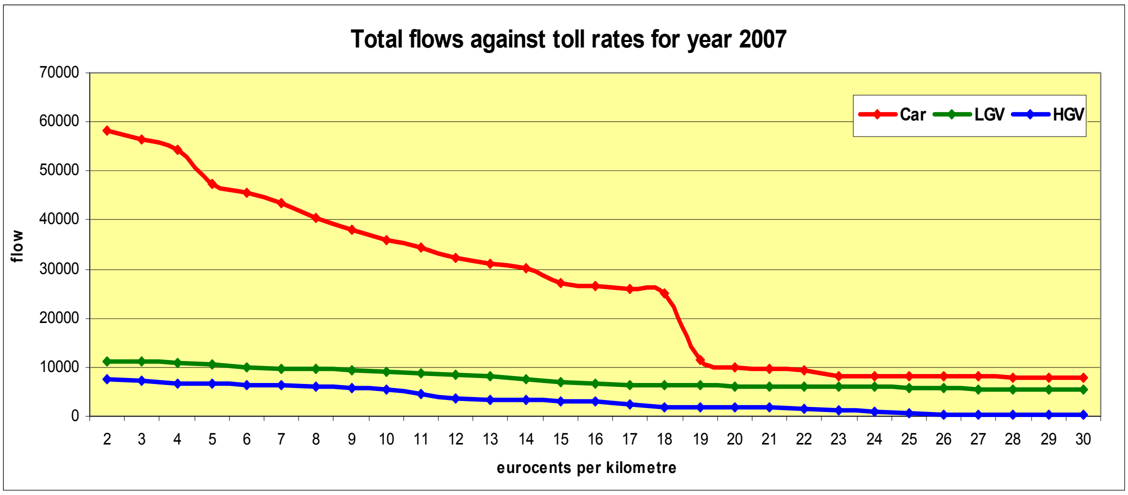
Source: Consultant's analysis

In 2007, the motorway, and to a lesser extent the existing road, operate at virtually free flow conditions, so that there are few speed flow curve responses to changes in traffic levels. This could explain why there are steep drops in the car revenue curve.

The optimum expected car revenues for 2007 are about 62,000 euro per day. The opening year of the first section is likely to be 2013, and by that time, traffic levels would have increased and expected revenues would be higher. Nonetheless, annual figures for 2007 show total revenues from traffic (car, LGV and HGV) of 34 million euro and before deciding on tolling the new Bar – Boljare motorway in the early years, the investment and operational costs of tolling systems should be considered.

Figure 10.2 show how the flow is affected by the increasing toll levels in 2007. It shows that car demand is reducing much quicker than LGV and HGV demand as toll rates increase.

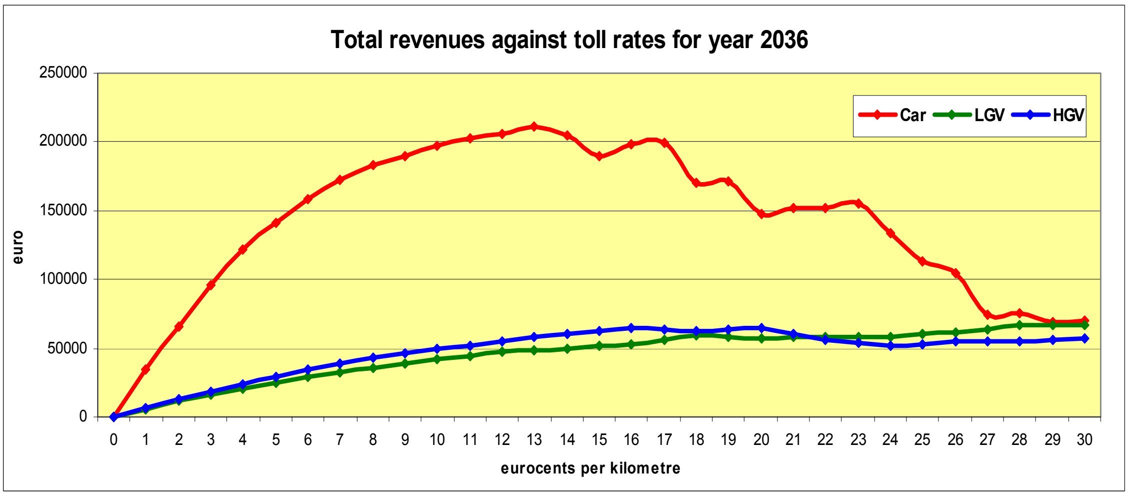
Figure 10-2: AADT flow against toll rates for year 2007



Source: Consultant's analysis

By 2036, traffic levels appear sufficient to sustain a tolling system with combined daily revenues above 330,000 euro.

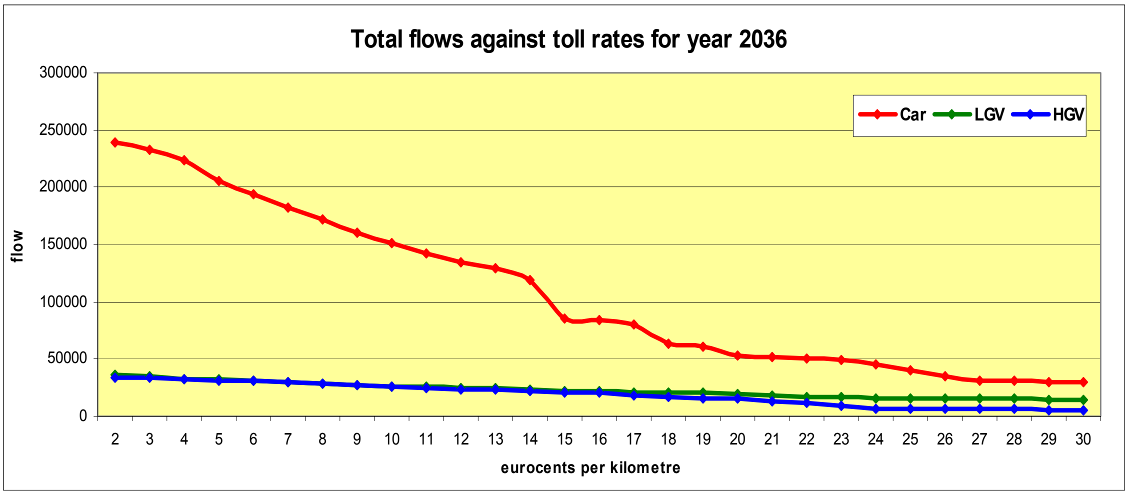
Figure 10-3: Total daily revenues against toll rates for year 2036



Source: Consultant's analysis

Figure 10.4 show how the flow is affected by the increasing toll levels in 2036. Again, this shows that car demand is reducing much quicker than LGV and HGV demand as toll rates increase.

Figure 10-4: AADT flow against toll rates for year 2036



Source: Consultant's analysis

For LGV and HGV, no clear optimal peak exists as these vehicle classes are in minority and also affected by the congestion largely caused by the private car. For 2036, the LGV class peaks at 18 eurocent per kilometre, only to exceed this peak at tolls of 28-30 eurocent. However, it is unlikely that tolls of 28 eurocent or higher would be applicable to the LGV class, therefore 18 eurocent per kilometre has been determined as an appropriate toll level for LGV. This corresponds to a ratio of 1.4 to the car toll level.

HGV revenues are fairly constant across the different toll levels but seem to reach a small peak at 22 eurocent per kilometre (2007) and 20 eurocent per kilometre (2036). With respect to the European experience, these values seem low in relation to the car toll (ratio of 1.70) but as no clear peak has been defined, the toll level can be set higher without much impact. For example, in 2005 the average car-HGV toll ratio for French motorways was 2.90[25]. Using this figure would result in a toll level of 38 eurocent per kilometre but it has to be kept in mind that the French car toll levels were lower in the first instance (8 eurocent per kilometre). For this exercise, however, an HGV toll level of 30 eurocent per kilometre is justifiable according to Figure 9.4 (car-HGV ratio of 2.30) but also considering the French example. This toll level can be further put in context by comparing the HGV toll for other European countries; see Figure 9.5. Switzerland and Austria are mountainous countries where tolled roads are capable of generating significant time savings. This is also expected to occur in the Bar – Boljare corridor.

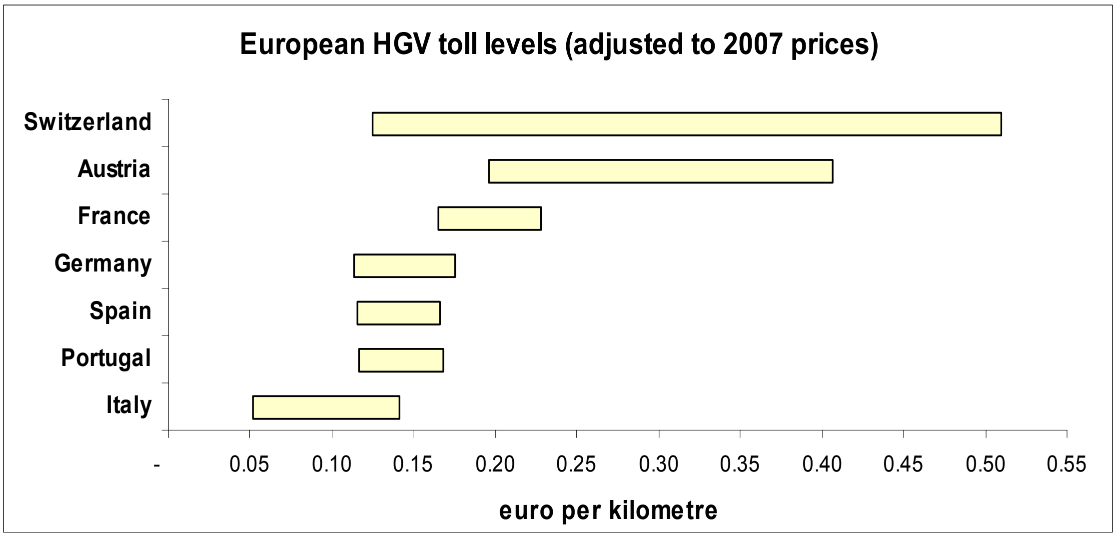
For the LGV and HGV vehicle classes, toll rates of 18 and 30 eurocent per kilometre respectively have been used as the preferred toll level in the model.

Further analysis, per section, is shown in **Appendix 11** of this report. It suggests that the Smokovac – Matesevo is the section with the highest resilience to high toll levels, which is to be expected as the alternative route on this section is of poor standard. It also shows much smoother curves in 2036 than in 2007, as in 2007 the motorway (and to a lesser extent the

[25] *Overall Situation of the French Concessionary Motorways*
http://www.asecap.com/english/documents/ASFANATREP06.pdf, last accessed 06/06/2009

existing road) operate at virtually free flow conditions so that there are no speed flow curve responses to changes in traffic levels. Therefore, the trade-off between travel time and toll operates at a simple all-or-nothing level (all travellers for one origin-destination pair choose one option or the other).

Figure 10-5: Estimated European HGV toll levels



Source: Interurban Road Charging for Trucks in Europe
http://www.irfnet.eu/images/congress/proceedings/Viegas.pdf last accessed 06/06/2009.
(*Prices adjusted by consultant from 2004 levels to 2007 and to include VAT*)

10.2 Impact of tolls on traffic volumes

Based on the average optimised toll rate of 13 eurocent/km for cars, toll rates for other vehicle categories have been derived using the 2036 ratios found above. Weighting factors have been used to calculate toll rates for LGVs and HGVs. With a motorway of this nature, is it not likely to be the policy to discourage any traffic and, as the port of Bar, and the region in general, becomes more developed commercial traffic is likely to be an important part of the revenue, thus LGVs have a 1.4 weighting while HGVs have a 2.3 weighting, these are slightly below the average observed internationally but heavy vehicles should be encouraged to use the motorway to reduce wear and tear on poorer quality and difficult to maintain rural roads. Hence the toll rates assumptions on the motorway are (except Sozina tunnel):

- 13.00 eurocent/km for cars;
- 18.00 eurocent/km for LGVs;
- 30.00 eurocent/km for HGVs.

The toll rates for the Sozina tunnel have been kept as the current levels.

Table 10.2 shows the impact of the above toll rates for year 2036 on scenarios 1 (Smokovac – Matesevo) and 9 (full motorway). It suggests that Smokovac – Matesevo section is relatively inelastic with a limited loss of traffic. This is potentially due to the limited alternative routes available in the area. On the contrary, the northern sections appear to be heavily impacted by the toll levels with demand being halved.

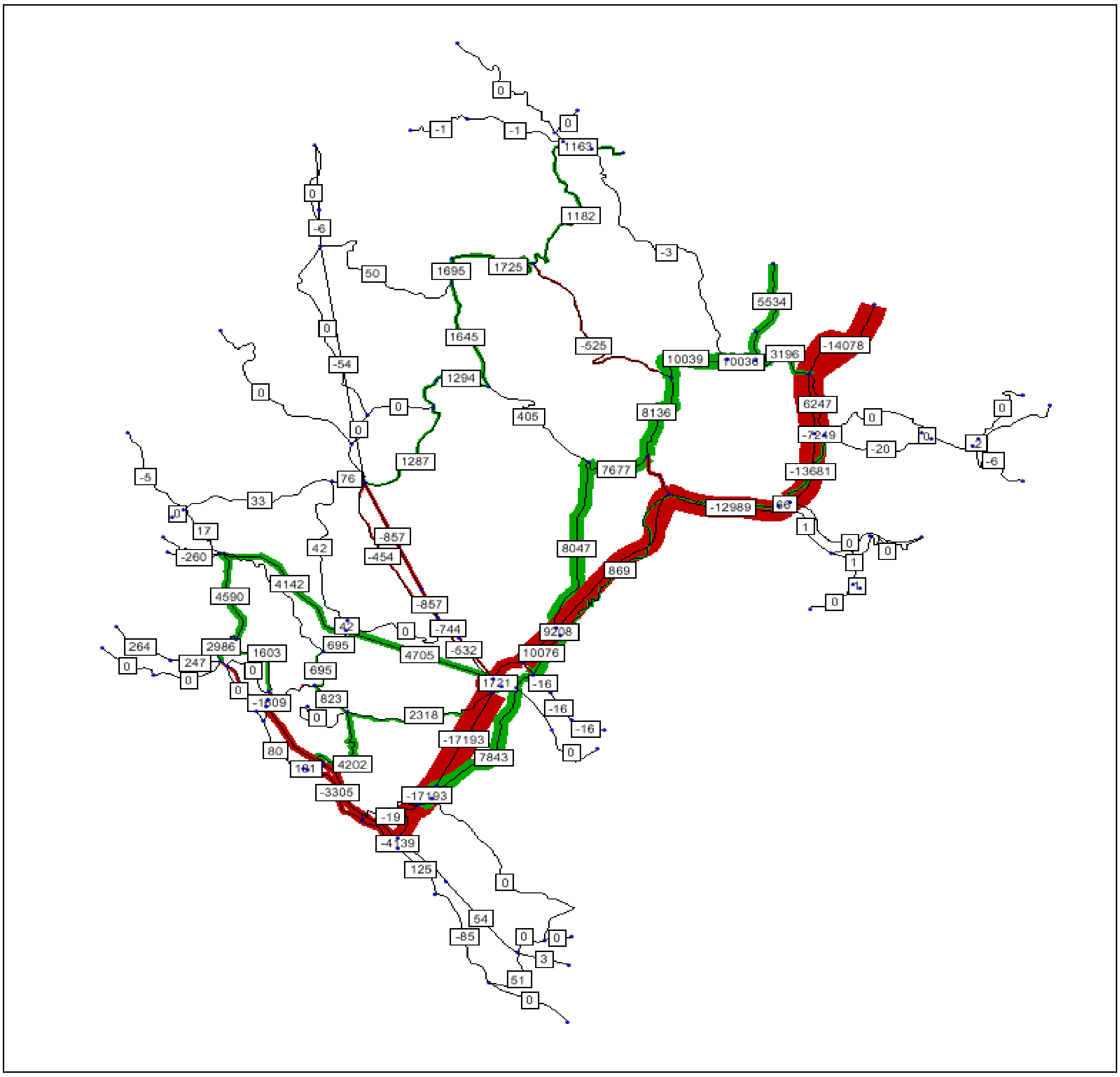
Table 10.2: Impact of tolls on traffic volumes

Section	New Motorway AADT					
	Scenario 1			Scenario 9		
	Toll	No Toll	% Diff.	Toll	No Toll	% Diff.
Djurmani-Virpazar	-	-	-	21,860	39,053	-44%
Virpazar-Smokovac	-	-	-	17,776	32,359	-45%
Smokovac-Matesevo	17,521	21,744	-19%	13,641	24,835	-45%
Matesevo-Berane	-	-	-	6,195	19,464	-68%
Berane-Boljare	-	-	-	11,684	26,904	-57%
Total	**17,521**	**21,744**	**-19%**	**71,156**	**142,615**	**-50%**

Source: Consultant's analysis

The above suggests that there is a substantial risk that the high toll rates will substantially lower the traffic on the motorway, as demonstrated in Figure 10.6 showing the rerouting of traffic from the motorway to the old road as the results of tolling, and impact on the economic benefits. For example, on the Smokovac - Matesevo section, the traffic volume reduced by about 10,000 vehicles a day.

Figure 10-6: Flow difference plot (all user classes) toll at optimum toll - no toll for year 2036



Source: Consultant’s analysis

The implied elasticities of flow to toll rate are given, for each user class, in Table 10.3. These were derived, for 2036, by reducing the toll rate by 10% from the optimum estimated above and using the arc elasticity formulation. These show that cars are relatively elastic to toll rates (elasticity of -1.25) while LGVs and HVs tend to be inelastic, this is in line with the findings of the willingness to pay survey carried out for this study.

Table 10.3: Elasticity of flow to toll rate

Toll Elasticity Test for Year 2036 (Car)				
Section	Full Toll Charges	Elasticity Test	% Diff.	Elasticity
Virpazar-Smokovac	87074	101191	16%	-1.43
Smokovac-Matesevo	15508	16872	9%	-0.80
Matesevo-Berane	16281	18407	13%	-1.16
Berane-Boljare	22913	25362	11%	-0.96
Total	**141776**	**161832**	**14%**	-1.26

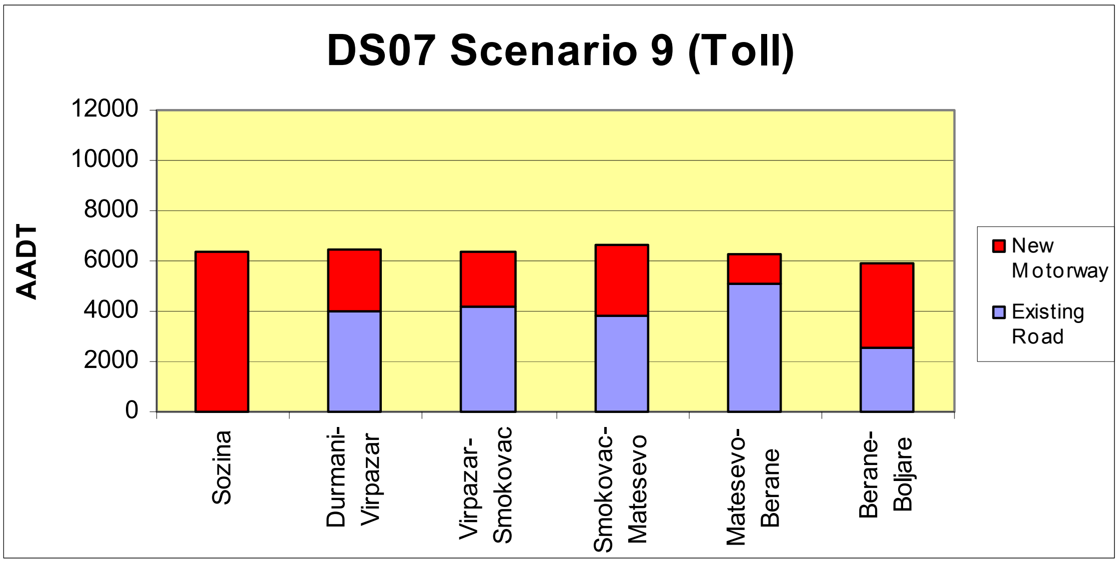
Toll Elasticity Test for Year 2036 (LGV)				
Section	Full Toll Charges	Elasticity Test	% Diff.	Elasticity
Virpazar-Smokovac	10200	10064	-1%	0.13
Smokovac-Matesevo	4991	5010	0%	-0.04
Matesevo-Berane	4312	4334	1%	-0.05
Berane-Boljare	2341	2356	1%	-0.06
Total	**21844**	**21764**	**0%**	0.03

Toll Elasticity Test for Year 2036 (HGV)				
Section	Full Toll Charges	Elasticity Test	% Diff.	Elasticity
Virpazar-Smokovac	3404	3539	4%	-0.37
Smokovac-Matesevo	2626	2633	0%	-0.03
Matesevo-Berane	420	420	0%	0.00
Berane-Boljare	42	42	0%	0.00
Total	**6492**	**6634**	**2%**	-0.21

Source: Consultant’s analysis

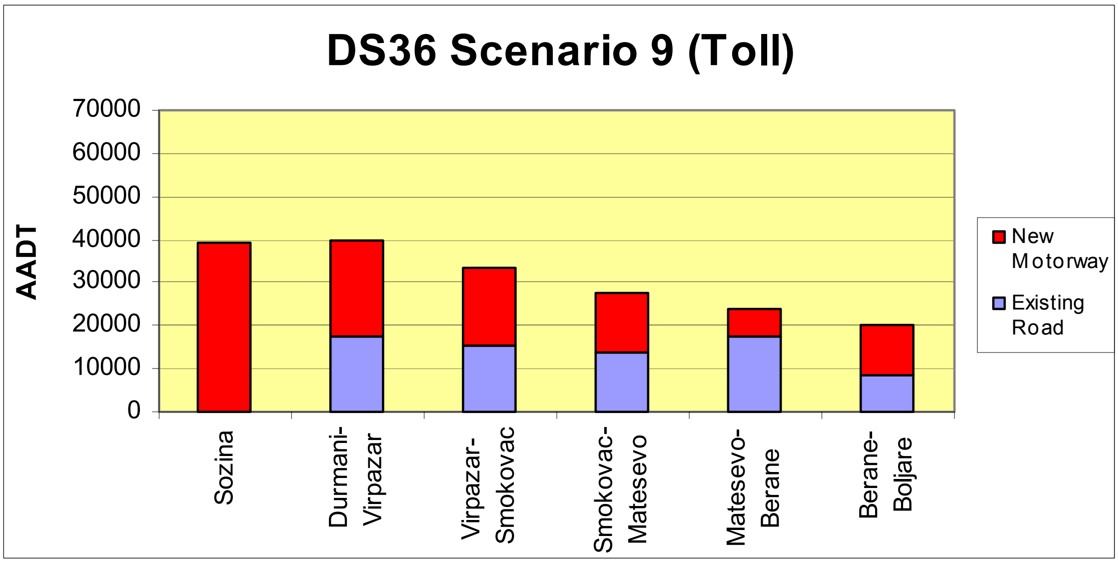
Figures 10.7 and 10.8 show the split of traffic between the old road and the proposed motorway. These suggest that in 2007 the shift from the proposed motorway to the old road due to the toll is very high. Over time, this shift reduces as the old road is congested and cannot accommodate the traffic willing to reroute.

Figure 10-7: Scenario 9 AADT on Bar – Boljare corridor for year 2007 with toll



Source: Consultant's analysis

Figure 10-8: Scenario 9 AADT on Bar – Boljare corridor for year 2036 with toll



Source: Consultant's analysis

10.3 Forecast AADT volumes with tolls

Using the same approach as for the no toll scenario, an expected AADT profile for the various sections of the proposed motorway was developed. For the various sections the years of opening have been assumed as follows:

- Smokovac – Matesevo 2013
- Smokovac – Virpazar 2015
- Matesevo – Berane 2015
- Berane – Boljare 2016
- Virpazar – Djurmani 2016

By interpolating demand between the specifically modelled years of 2007, 2016, 2026 and 2036 (using compound growth) and by extrapolating to year 2046, forecast AADT levels have been produced.

Table 10.4 presents a tabulation of the expected AADT volumes assuming toll rates of:

- 13.00 eurocent/km for cars;
- 18.00 eurocent/km for LGVs;
- 30.00 eurocent/km for HGVs.

Table 10.4: Forecast AADT volumes

	Expected AADT Traffic Volume (Toll)					
Year	Sozina	Durmani-Virpazar	Virpazar-Smokovac	Smokovac-Matesevo	Matesevo-Berane	Berane-Boljare
2013	-	-	-	5,867	-	-
2014	-	-	-	6,270	-	-
2015	-	-	4,055	4,947	2,023	-
2016	-	-	4,380	5,367	2,157	-
2017	13,743	5,688	4,863	5,688	2,296	6,027
2018	14,991	6,356	5,400	6,034	2,445	6,116
2019	16,353	7,103	5,997	6,407	2,606	6,208
2020	17,840	7,939	6,662	6,810	2,779	6,304
2021	19,462	8,876	7,403	7,247	2,966	6,403
2022	21,233	9,926	8,231	7,720	3,168	6,507
2023	23,166	11,102	9,161	8,235	3,387	6,616
2024	25,276	12,421	10,211	8,797	3,624	6,730
2025	27,579	13,900	11,413	9,409	3,883	6,851
2026	30,094	15,688	12,811	10,080	4,164	6,979
2027	30,908	16,208	13,231	10,390	4,329	7,345
2028	31,746	16,746	13,667	10,709	4,500	7,731

2029	32,610	17,305	14,117	11,038	4,680	8,139
2030	33,500	17,885	14,585	11,377	4,868	8,568
2031	34,417	18,487	15,069	11,726	5,065	9,020
2032	35,362	19,111	15,572	12,086	5,270	9,498
2033	36,336	19,759	16,093	12,457	5,486	10,001
2034	37,340	20,433	16,633	12,840	5,711	10,532
2035	38,376	21,133	17,194	13,234	5,948	11,093
2036	39,443	21,860	17,776	13,641	6,195	11,684
2037	40,371	22,310	18,177	14,033	6,329	11,969
2038	41,320	22,769	18,587	14,437	6,465	12,261
2039	42,291	23,237	19,006	14,852	6,605	12,559
2040	43,286	23,715	19,435	15,280	6,747	12,865
2041	44,303	24,203	19,874	15,719	6,892	13,179
2042	45,345	24,702	20,322	16,172	7,041	13,500
2043	46,411	25,210	20,780	16,637	7,193	13,828
2044	47,502	25,729	21,249	17,116	7,348	14,165
2045	48,619	26,258	21,729	17,608	7,506	14,510
2046	49,762	26,799	22,219	18,115	7,668	14,864

Source: Consultant's analysis

A graphical representation of this table is given in **Appendix 10** of this report.

Table 10.5 presents a tabulation of the expected revenues assuming the optimum toll rates derived.

Table 10.5: Forecast expected daily revenues

Year	Total Daily Revenue (Toll)					
	Sozina	Durmani-Virpazar	Virpazar-Smokovac	Smokovac-Matesevo	Matesevo-Berane	Berane-Boljare
2013	-	-	-	19,584	-	-
2014	-	-	-	21,056	-	-
2015	-	-	14,461	18,268	6,907	-
2016	-	-	15,635	20,246	7,357	-
2017	62,083	2,564	17,356	21,652	7,880	16,870
2018	67,755	2,869	19,272	23,199	8,450	17,144
2019	73,951	3,211	21,407	24,905	9,073	17,431
2020	80,719	3,595	23,793	26,791	9,756	17,733
2021	88,112	4,026	26,470	28,883	10,506	18,052
2022	96,189	4,511	29,497	31,207	11,334	18,389
2023	105,012	5,056	32,960	33,797	12,250	18,749
2024	114,653	5,670	36,994	36,688	13,267	19,134
2025	125,186	6,360	41,827	39,925	14,400	19,548

2026	136,696	7,308	47,850	43,556	15,668	19,996
2027	140,089	7,567	49,558	44,920	16,279	21,071
2028	143,586	7,837	51,337	46,326	16,919	22,206
2029	147,190	8,119	53,189	47,777	17,592	23,405
2030	150,907	8,412	55,118	49,273	18,298	24,672
2031	154,739	8,718	57,128	50,816	19,039	26,012
2032	158,692	9,038	59,223	52,408	19,819	27,428
2033	162,770	9,372	61,406	54,049	20,638	28,925
2034	166,978	9,720	63,682	55,742	21,500	30,509
2035	171,321	10,085	66,057	57,488	22,407	32,184
2036	175,805	10,466	68,534	59,289	23,363	33,957
2037	179,938	10,681	70,080	60,995	23,866	34,784
2038	184,169	10,901	71,661	62,750	24,381	35,631
2039	188,499	11,125	73,277	64,556	24,906	36,499
2040	192,931	11,354	74,931	66,413	25,443	37,388
2041	197,467	11,588	76,621	68,324	25,992	38,299
2042	202,109	11,827	78,349	70,290	26,552	39,232
2043	206,861	12,070	80,117	72,312	27,124	40,188
2044	211,724	12,318	81,924	74,393	27,709	41,167
2045	216,702	12,572	83,772	76,534	28,306	42,169
2046	221,797	12,831	85,662	78,736	28,916	43,197

Source: Consultant's analysis

11 CONCLUSION

This report has provided details on the development of a VISUM traffic model for the Bar – Boljare motorway scheme in Montenegro.

The base year model, developed from a variety of data sources including, RSI, counts and WTP surveys, has been successfully calibrated against observed traffic data.

Following the development of the base year model, forecast networks and matrices were produced for three modelling years 2016, 2026 and 2036. These networks and matrices were created for a variety of phased implementation, and included test assignments to determine the effects of implementing a toll regime on the motorway.

The Bar – Boljare motorway has a clear strategic role to play in the regional highway network. It will link the capital of a country in the region and a major tourist destination with other regional capitals and economic centres, providing the infrastructure for fast, safe and reliable travel. The traffic predictions have shown that traffic travelling along the Bar – Boljare corridor will divert away from the existing routes onto the proposed motorway in the future years but the extent to which traffic will use the motorway is a function of the scenario tested and it is clear that:

- Building the Smokovac to Matesevo, which the GOM considers should be constructed first on its own will have limited beneficial impact as travel times on the rest of the corridor will remain slow in the first years and too congested afterwards and will limit the possible use of the Smokovac to Matesevo motorway section;
- Building the entire motorway from the coast to Boljare will bring large travel time savings and will be very attractive;
- Building the southern section from the coast to Virpazar will improve travel times where the highest demand is and appears to be the best short term solution before developing the motorway to the north.

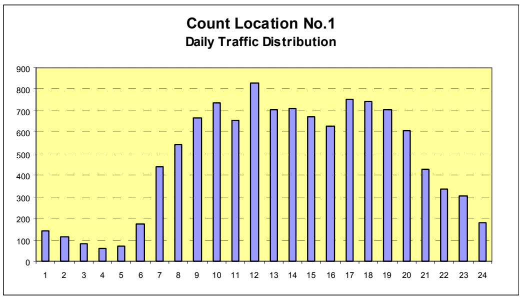
It has also been shown that implementing tolls onto the motorway will shift traffic to the old road. The optimum revenue levels are obtained for a toll of 0.13 euro per kilometre for cars. HGV and LGV are more resilient to toll rates with optimums of 0.30 and 0.18 euro per kilometre. This suggests that by 2036, revenues of about €120 million a year (including Sozina tunnel which accounts for about half of this revenue) could be expected if the full motorway is in place.

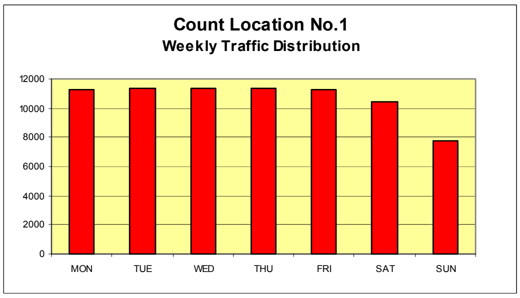
A number of sensitivity tests were carried out to test some of the assumptions underlying the model results, and the model outputs were tested within the economic model.

It is concluded that the VISUM traffic model was developed successfully and is producing results that are both robust and sensible. Data from the model is therefore considered to be suitable for use in the economic appraisal of the Bar – Boljare motorway scheme.

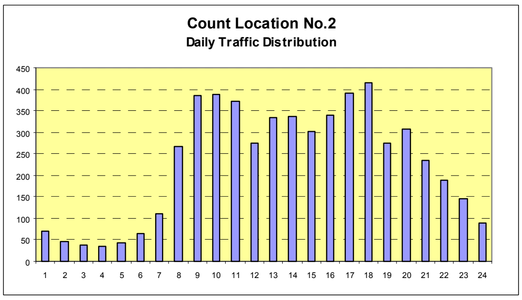
Appendix 1 – MCC and traffic count results

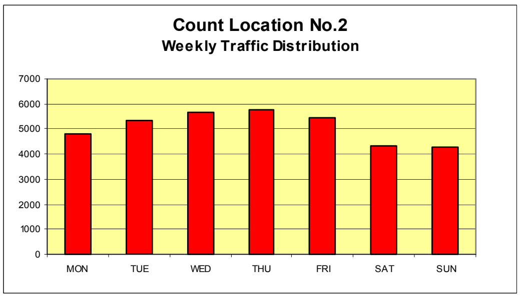
Count Location 1 (Between Budva and Tivta)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	1.006	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	9,042	9,150	9,030	9,198	9,014	8,696	6,793	**60,923**	8,703	8,754	11,661
Light Delivery & Mikro Bus	700	756	793	724	738	570	271	**4,553**	650	654	871
Bus (more than 30 seats)	279	277	290	277	316	273	255	**1,968**	281	283	377
Small Truck	453	465	472	426	475	340	150	**2,782**	397	400	533
Medium Truck	517	573	545	545	474	327	141	**3,122**	446	449	598
Heavy Truck	236	179	253	203	263	200	151	**1,485**	212	213	284
Total	**11,228**	**11,400**	**11,383**	**11,374**	**11,280**	**10,407**	**7,760**	**74,832**	10,690	10,753	14,324



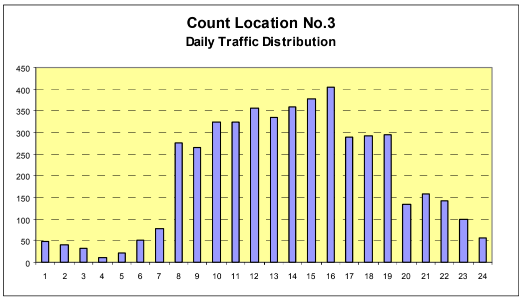


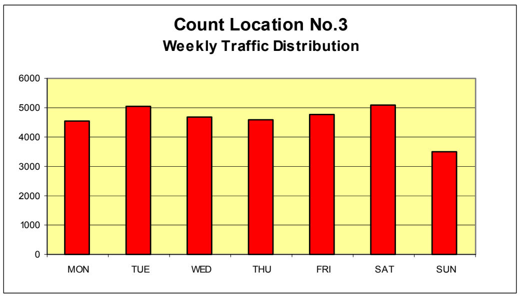
Count Location 2 (Between Budva and Cetinje)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	1.003	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	3,941	4,081	4,449	4,554	4,408	3,543	3,600	**28,575**	4,082	4,096	5,456
Light Delivery & Mikro Bus	281	536	408	466	377	320	236	**2,623**	375	376	501
Bus (more than 30 seats)	139	182	175	150	142	128	152	**1,069**	153	153	204
Small Truck	126	133	148	159	146	101	84	**896**	128	128	171
Medium Truck	177	257	205	213	188	120	90	**1,250**	179	179	239
Heavy Truck	156	170	268	248	186	139	105	**1,273**	182	182	243
Total	**4,820**	**5,359**	**5,654**	**5,790**	**5,447**	**4,350**	**4,267**	**35,686**	5,098	5,115	6,814



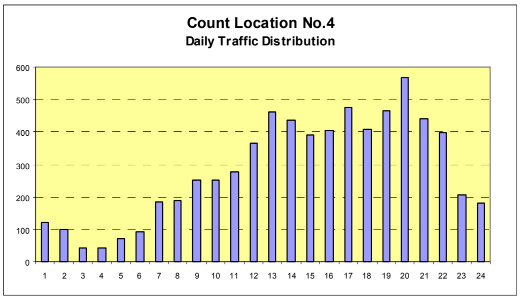


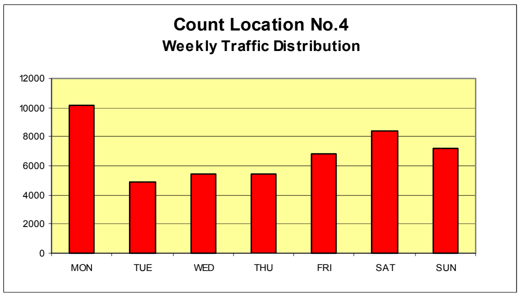
Count Location 3 (Between Budva and Petrovac)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	1.003	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	3,480	3,914	3,588	3,631	3,605	3,823	2,695	**24,735**	3,534	3,545	4,722
Light Delivery & Mikro Bus	257	339	294	271	321	308	201	**1,991**	284	285	380
Bus (more than 30 seats)	164	114	114	97	113	153	133	**887**	127	127	169
Small Truck	175	187	180	159	197	209	129	**1,236**	177	177	236
Medium Truck	174	196	183	167	173	206	131	**1,231**	176	176	235
Heavy Truck	289	309	333	281	358	411	207	**2,187**	312	313	418
Total	**4,538**	**5,059**	**4,692**	**4,605**	**4,767**	**5,110**	**3,496**	32,267	4,610	4,624	6,160



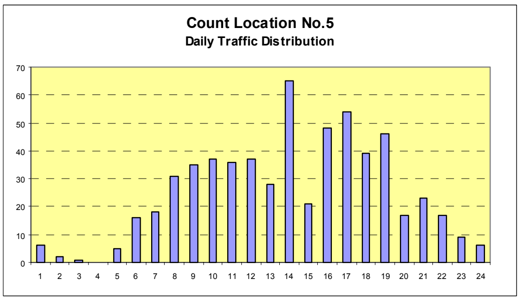


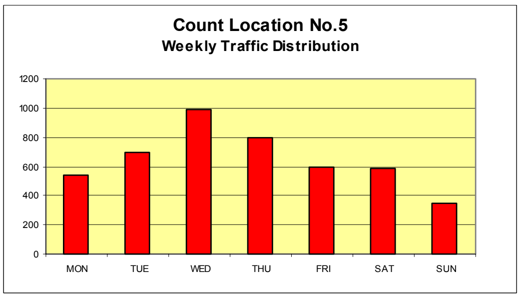
Count Location 4 (Between Petrovac and Bar)									Factors		
October	29	23	24	25	26	27	28	Total	1.000	0.999	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	7,970	3,636	4,145	4,126	5,280	6,363	6,030	**37,551**	5,364	5,359	7,139
Light Delivery & Mikro Bus	640	241	344	315	392	627	396	**2,955**	422	422	562
Bus (more than 30 seats)	131	78	92	71	115	147	62	**695**	99	99	132
Small Truck	350	294	254	271	236	305	172	**1,881**	269	269	358
Medium Truck	488	310	228	287	339	401	247	**2,299**	328	328	437
Heavy Truck	599	326	420	384	456	570	296	**3,050**	436	435	580
Total	**10,177**	**4,884**	**5,483**	**5,453**	**6,818**	**8,414**	**7,203**	**48,431**	6,919	6,912	9,207



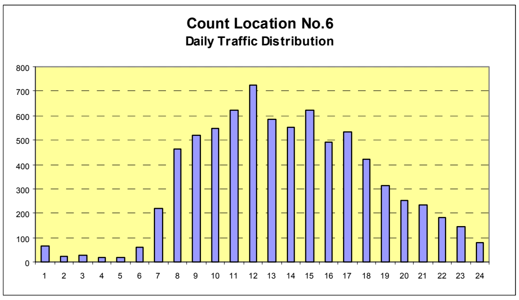


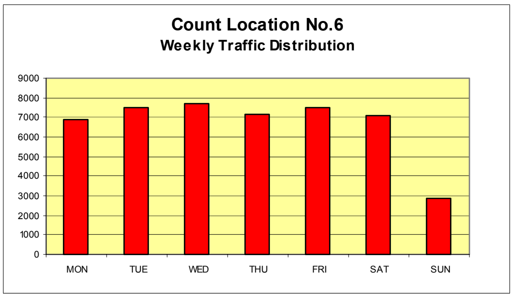
Count Location 5 (Old Road Between Petrovac and Virpazar)									Factors		
October	29	23	24	25	26	27	28	Total	1.000	1.014	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	279	418	502	424	330	315	253	**2,522**	360	365	486
Light Delivery & Mikro Bus	51	63	68	59	55	47	30	**374**	53	54	72
Bus (more than 30 seats)	2	1	1	4	1	1	0	**10**	1	1	2
Small Truck	57	44	92	62	45	34	21	**354**	51	51	68
Medium Truck	71	111	234	182	100	128	26	**851**	122	123	164
Heavy Truck	81	56	93	70	66	57	17	**440**	63	64	85
Total	**541**	**693**	**990**	**801**	**597**	**583**	**347**	**4,552**	650	659	878



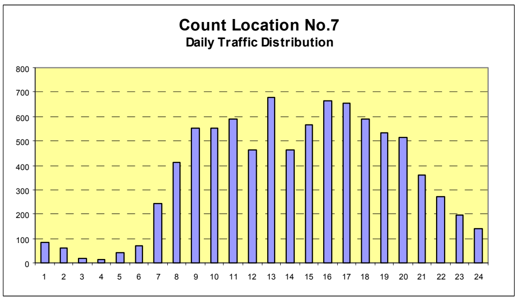


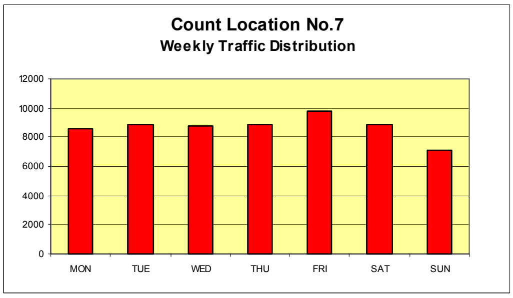
Count Location 6 (Between Podgorica and Tuzi)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	1.010	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	6,264	6,703	6,799	6,444	6,830	6,493	2,697	**42,231**	6,033	6,094	8,117
Light Delivery & Mikro Bus	306	392	397	353	309	311	75	**2,143**	306	309	412
Bus (more than 30 seats)	21	26	31	35	43	31	16	**201**	29	29	39
Small Truck	112	140	195	114	100	84	39	**783**	112	113	150
Medium Truck	71	119	163	98	87	85	24	**646**	92	93	124
Heavy Truck	113	90	142	87	117	90	24	**662**	95	96	127
Total	**6,886**	**7,471**	**7,727**	**7,130**	**7,486**	**7,093**	**2,874**	**46,667**	6,667	6,734	8,970



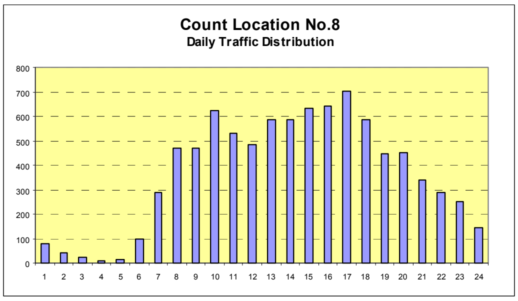


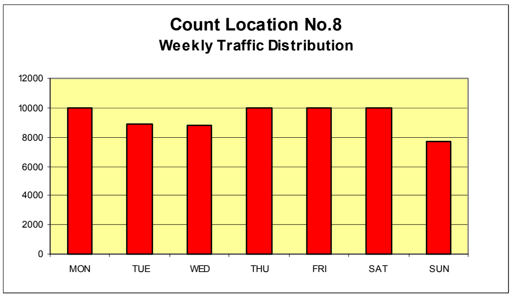
Count Location 7 (Between Podgorica and Cetinje)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	1.000	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	7,269	7,387	7,250	7,244	8,265	7,715	6,436	**51,566**	7,367	7,370	9,817
Light Delivery & Mikro Bus	528	652	596	663	607	492	257	**3,794**	542	542	722
Bus (more than 30 seats)	145	155	162	153	177	128	149	**1,070**	153	153	204
Small Truck	103	169	170	170	127	85	41	**866**	124	124	165
Medium Truck	220	257	317	315	283	181	98	**1,670**	239	239	318
Heavy Truck	299	272	248	307	324	286	161	**1,895**	271	271	361
Total	**8,564**	**8,892**	**8,743**	**8,852**	**9,782**	**8,886**	**7,142**	**60,862**	8,695	8,698	11,587



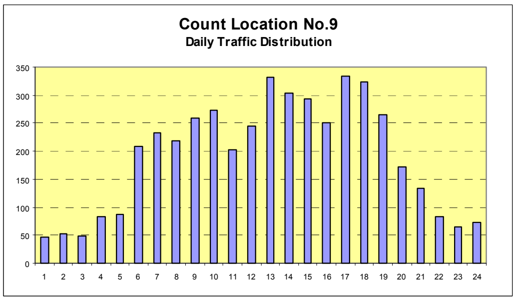


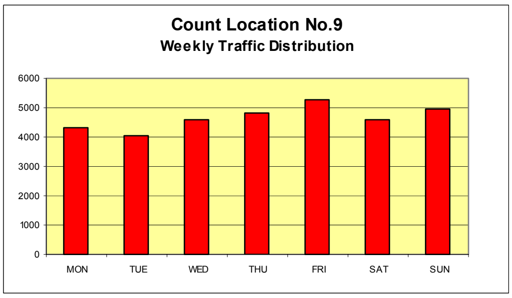
Count Location 8 (Between Podgorica and Danilovgrad)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	0.999	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	8,423	7,229	7,096	8,323	8,133	8,798	7,011	**55,013**	7,859	7,849	10,455
Light Delivery & Mikro Bus	516	624	658	589	677	476	259	**3,800**	543	542	722
Bus (more than 30 seats)	321	309	306	322	336	222	166	**1,983**	283	283	377
Small Truck	151	157	157	192	161	100	55	**973**	139	139	185
Medium Truck	269	278	260	275	330	181	116	**1,709**	244	244	325
Heavy Truck	280	321	312	320	350	251	116	**1,949**	278	278	370
Total	**9,960**	**8,919**	**8,789**	**10,022**	**9,986**	**10,028**	**7,724**	**65,428**	9,347	9,335	12,435



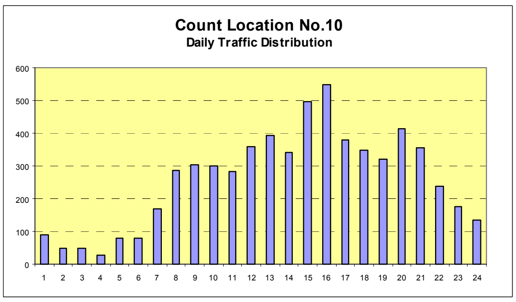


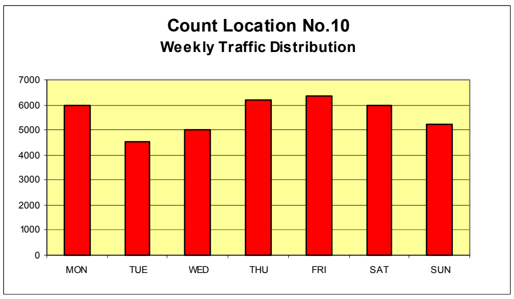
Count Location 9 (Between Podgorica and Bioci)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	0.993	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	3,295	2,818	3,252	3,450	3,829	3,613	4,083	**24,341**	3,477	3,453	4,600
Light Delivery & Mikro Bus	269	292	372	344	354	269	262	**2,162**	309	307	409
Bus (more than 30 seats)	108	81	123	112	141	124	146	**835**	119	119	158
Small Truck	133	139	150	161	146	68	70	**869**	124	123	164
Medium Truck	224	254	243	279	285	187	136	**1,607**	230	228	304
Heavy Truck	307	447	440	469	496	329	245	**2,734**	391	388	517
Total	**4,338**	**4,031**	**4,580**	**4,814**	**5,251**	**4,590**	**4,944**	**32,548**	4,650	4,617	6,151



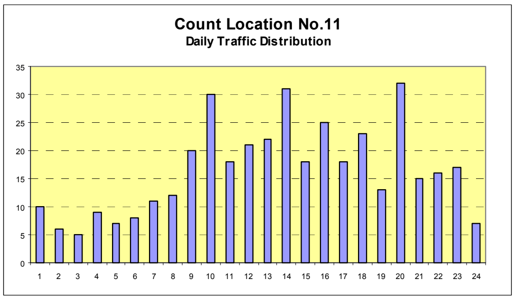


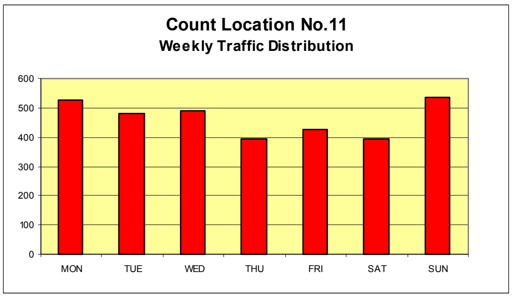
Count Location 10 (Between Kolasin and Crkvine)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	0.992	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	4,739	3,026	3,657	4,164	4,710	4,637	4,115	**29,049**	4,150	4,118	5,485
Light Delivery & Mikro Bus	400	306	446	589	452	373	323	**2,889**	413	410	546
Bus (more than 30 seats)	93	104	83	167	111	126	109	**793**	113	112	150
Small Truck	92	147	87	203	140	121	84	**875**	125	124	165
Medium Truck	174	263	148	276	244	187	99	**1,392**	199	197	263
Heavy Truck	484	658	583	812	697	557	489	**4,281**	612	607	808
Total	**5,982**	**4,505**	**5,005**	**6,211**	**6,354**	**6,003**	**5,220**	**39,279**	5,611	5,568	7,417



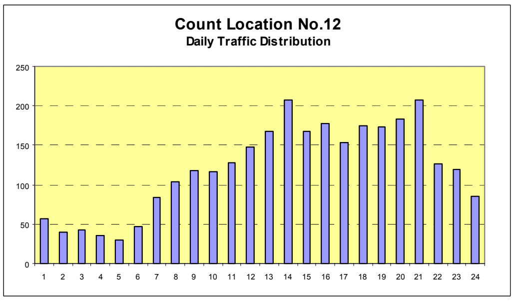


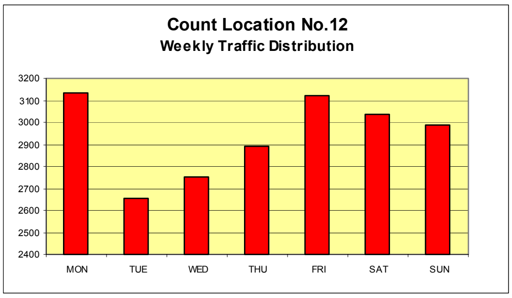
Count Location 11 (Between Matesevo and Kraljse Bare)									Factors		
October	29	30	24	25	26	27	28	**Total**	1.000	1.007	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	451	407	441	336	354	370	489	**2,848**	407	410	546
Light Delivery & Mikro Bus	20	6	14	16	14	8	2	**80**	11	12	15
Bus (more than 30 seats)	0	0	0	0	0	0	0	**0**	0	0	0
Small Truck	9	15	7	10	17	4	12	**73**	10	11	14
Medium Truck	40	48	25	23	32	8	28	**202**	29	29	39
Heavy Truck	5	5	6	9	11	4	4	**44**	6	6	8
Total	**525**	**481**	**492**	**394**	**428**	**394**	**535**	**3,248**	464	467	623



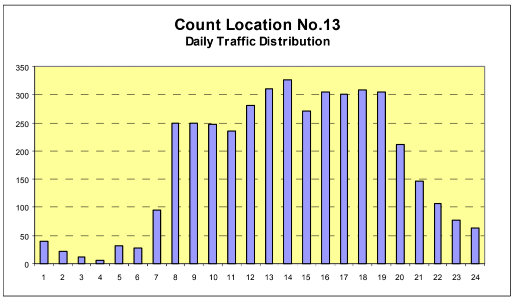


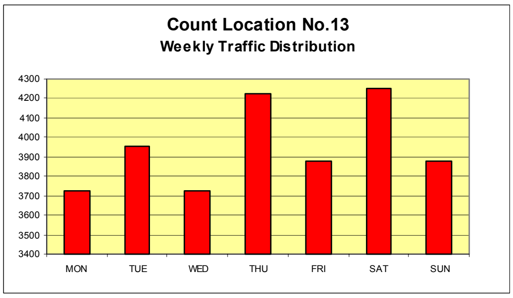
Count Location 12 (Between Berane and Rozaje)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	0.997	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	2,546	2,072	2,237	2,263	2,479	2,393	2,500	**16,490**	2,356	2,348	3,128
Light Delivery & Mikro Bus	176	166	150	170	210	199	139	**1,210**	173	172	229
Bus (more than 30 seats)	80	80	97	79	94	70	62	**561**	80	80	106
Small Truck	52	69	57	93	100	77	39	**488**	70	70	93
Medium Truck	96	81	68	92	68	120	50	**575**	82	82	109
Heavy Truck	181	186	143	195	170	178	199	**1,252**	179	178	238
Total	**3,131**	**2,653**	**2,753**	**2,892**	**3,120**	**3,038**	**2,989**	**20,576**	2,939	2,930	3,903



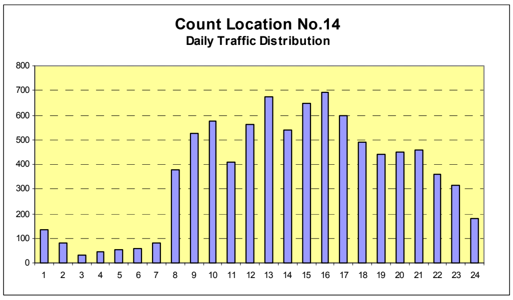


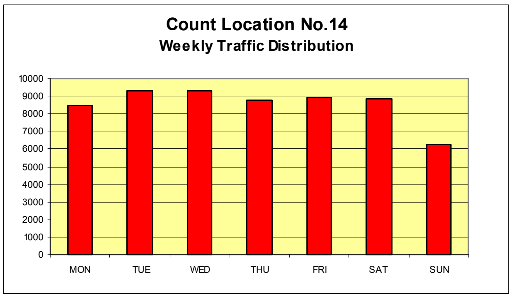
Count Location 13 (Interchange Ribarevina)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	0.996	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	3,013	3,154	2,902	3,186	3,150	3,574	3,279	**22,258**	3,180	3,168	4,221
Light Delivery & Mikro Bus	160	347	330	272	131	174	143	**1,556**	222	222	295
Bus (more than 30 seats)	117	79	115	134	107	91	93	**735**	105	105	139
Small Truck	129	50	71	176	165	108	95	**794**	113	113	151
Medium Truck	155	174	113	193	142	142	103	**1,022**	146	145	194
Heavy Truck	153	150	194	262	182	162	162	**1,266**	181	180	240
Total	**3,726**	**3,954**	**3,725**	**4,223**	**3,877**	**4,250**	**3,876**	**27,632**	3,947	3,933	5,239



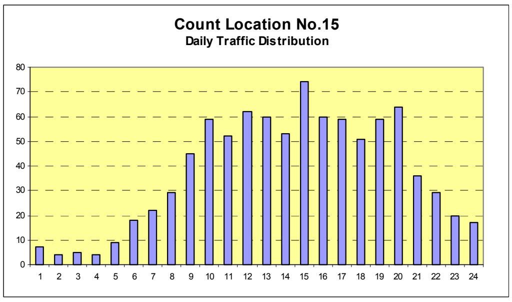


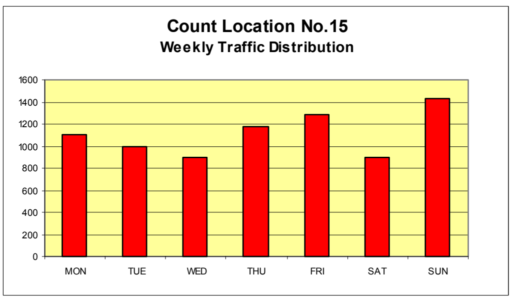
Count Location 14 (Between B. Polje and Barski Most)									Factors		
October	29	23	24	25	26	27	28	Total	1.000	1.005	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	7,739	8,188	8,194	7,842	7,963	8,121	5,727	**53,775**	7,682	7,723	10,288
Light Delivery & Mikro Bus	237	506	400	319	350	295	231	**2,338**	334	336	447
Bus (more than 30 seats)	76	94	88	91	106	66	32	**551**	79	79	105
Small Truck	107	124	162	80	127	87	72	**760**	109	109	145
Medium Truck	144	124	219	182	147	129	74	**1,019**	146	146	195
Heavy Truck	194	266	285	252	264	184	129	**1,573**	225	226	301
Total	**8,497**	**9,302**	**9,347**	**8,766**	**8,958**	**8,882**	**6,264**	**60,016**	8,574	8,620	11,482



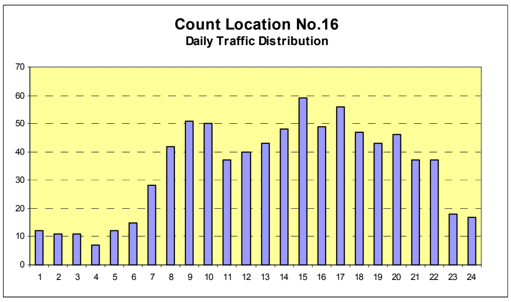


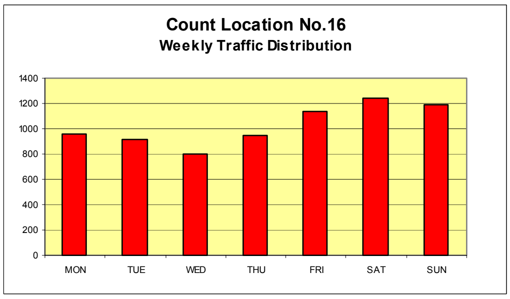
Count Location 15 (Between Niksic and Jasenovo Polje)									Factors		
October	29	23	24	25	26	27	28	Total	1.000	0.990	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	851	756	704	928	987	748	1,222	**6,195**	885	876	1,167
Light Delivery & Mikro Bus	89	82	69	65	91	64	94	**555**	79	78	105
Bus (more than 30 seats)	19	15	13	15	25	4	16	**106**	15	15	20
Small Truck	66	51	49	80	79	35	51	**412**	59	58	78
Medium Truck	69	62	58	85	76	35	39	**424**	61	60	80
Heavy Truck	5	24	5	3	21	10	9	**77**	11	11	15
Total	**1,098**	**990**	**898**	**1,175**	**1,279**	**896**	**1,432**	**7,769**	1,110	1,099	1,464



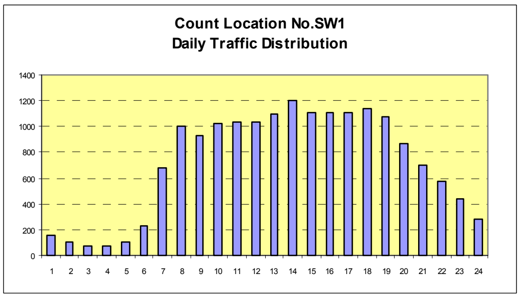


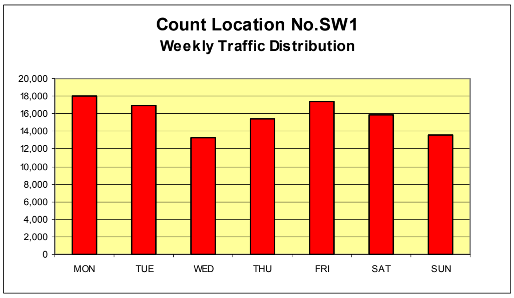
Count Location 16 (Between Visusi and Klobuk)									Factors		
October	29	23	24	25	26	27	28	**Total**	1.000	0.987	1.332
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
P. Car	774	680	579	716	870	1,048	990	**5,657**	808	798	1,063
Light Delivery & Mikro Bus	42	56	62	71	75	43	47	**396**	57	56	74
Bus (more than 30 seats)	7	1	2	4	5	2	3	**24**	3	3	5
Small Truck	14	22	22	30	31	16	16	**151**	22	21	28
Medium Truck	26	45	24	36	54	29	26	**240**	34	34	45
Heavy Truck	98	114	115	93	103	107	107	**737**	105	104	138
Total	**961**	**918**	**804**	**950**	**1,138**	**1,245**	**1,189**	7,205	1,029	1,016	1,354



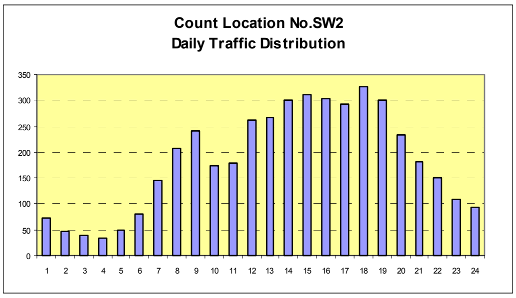


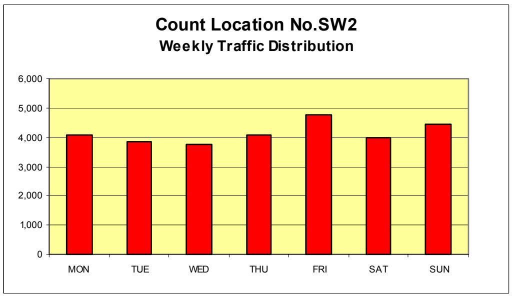
Count Location SW1 (Between Podgorica and Golubovci)									Factors		
October	27	28	29	30	31	01	26	**Total**	1.000	1.002	1.330
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
Car	15,919	14,712	11,592	13,558	15,426	14,076	12,428	**97,710**	13,959	13,981	18,591
LGV	1,095	1,200	891	1,097	1,184	1,067	653	**7,187**	1,027	1,028	1,367
HGV	984	1,003	727	759	796	751	500	**5,520**	789	790	1,050
Total	**17,998**	**16,914**	**13,210**	**15,414**	**17,405**	**15,894**	**13,582**	**110,417**	15,774	15,800	21,009



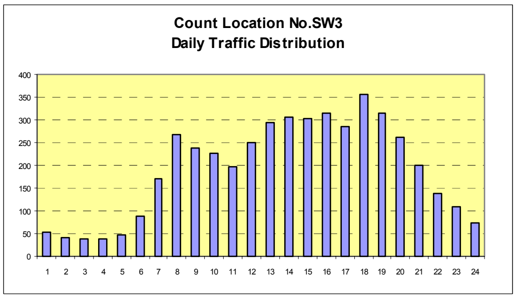


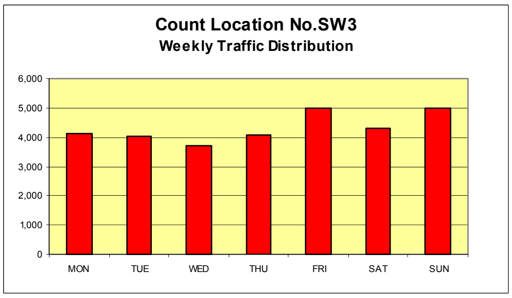
Count Location SW2 (Between Kolasin and Mojkovac)									Factors		
October	27	28	29	30	31	01	26	**Total**	1.000	0.994	1.330
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
Car	3,204	2,870	2,672	3,047	3,754	3,189	3,751	**22,489**	3,213	3,194	4,247
LGV	374	401	448	435	416	382	273	**2,730**	390	388	516
HGV	483	596	627	596	603	436	417	**3,758**	537	534	710
Total	**4,062**	**3,867**	**3,748**	**4,079**	**4,773**	**4,007**	**4,441**	**28,976**	4,139	4,116	5,472





Count Location SW3 (Bioce)									Factors		
October	27	28	29	30	31	01	26	**Total**	1.000	0.992	1.330
Day	MON	TUE	WED	THU	FRI	SAT	SUN		AWDT	AMDT	AADT
Car	3,227	2,937	2,597	2,960	3,852	3,457	4,217	**23,246**	3,321	3,294	4,380
LGV	429	474	466	486	492	399	357	**3,102**	443	440	585
HGV	483	640	628	614	628	454	427	**3,874**	553	549	730
Total	**4,139**	**4,051**	**3,692**	**4,059**	**4,972**	**4,309**	**5,000**	**30,223**	4,318	4,283	5,695





Appendix 2 – Description of commodity groups

Standard Goods Classification for Transport Statistics
Nomenclatures NST / R

Chapter	NST/R groups	Description
0	1	Cereals
	02, 03	Potatoes, other fresh or frozen fruit and vegetables
	00, 06	Live animals, sugar beet
	5	Wood and cork
	04, 09	Textiles, textile articles and man-made fibres, other raw animal and vegetable materials
1	11, 12, 13, 14, 16, 17	Foodstuffs and animal fodder
	18	Oil seeds and oleaginous fruits and fats
2	21, 22, 23	Solid mineral fuels
3	31	Crude petroleum
	32, 33, 34	Petroleum products
4	41, 46	Iron ore, iron and steel waste and blast furnace dust
	45	Non-ferrous ores and waste
5	51, 52, 53,54, 55, 56	Metal products
6	64, 69	Cement, lime, manufactured building materials
	61, 62, 63,65	Crude and manufactured minerals
7	71, 72	Natural and chemical fertilizers
8	83	Coal chemicals, tar
	81, 82, 89	Chemicals other than coal chemicals and tar
	84	Paper pulp and waste paper
9	91, 92, 93	Transport equipment, machinery, apparatus, engines, whether or not assembled, and parts thereof
	94	Manufactures of metal
	95	Glass, glassware, ceramic products
	96, 97	Leather, textile, clothing, other manufactured articles
	99	Miscellaneous articles

Appendix 3 – Double counting matrix

Double counting matrix

1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	0	0	0	1	3	3	2	1	1	3	2	2	4	5	5	2	5	6	7	2	5	0	0	6	7	4	6	6	7	6	**87**
2	0	0	0	1	3	3	2	0	4	3	1	1	4	5	5	4	5	6	7	4	5	0	0	6	7	4	6	6	7	6	**98**
3	0	0	0	1	3	3	2	0	4	3	1	1	4	5	5	4	5	6	7	4	5	0	0	6	7	4	6	6	7	6	**105**
4	1	1	1	0	2	2	1	1	3	2	2	2	3	4	4	3	4	4	4	3	4	1	1	4	4	3	4	4	4	4	**80**
5	3	3	3	2	0	0	3	1	1	0	2	2	1	2	2	1	2	2	2	1	2	3	2	2	2	1	2	2	2	2	**53**
6	3	3	3	2	0	0	3	1	1	0	2	2	1	2	2	1	2	2	2	1	2	3	2	2	2	0	2	2	2	2	**52**
7	2	2	2	1	3	3	0	0	2	1	1	3	2	3	3	2	3	3	3	2	3	2	1	3	3	2	3	3	3	3	**67**
8	1	0	0	3	1	1	2	0	0	1	1	1	2	3	3	1	3	3	5	1	3	1	1	1	5	2	1	4	5	4	**59**
9	1	4	4	3	1	1	2	0	0	1	1	1	2	3	3	1	3	4	5	1	3	1	1	4	5	2	4	4	5	4	**74**
10	3	3	3	2	0	0	1	1	1	0	2	2	1	2	2	1	2	3	4	1	2	3	2	3	4	1	3	3	4	3	**62**
11	2	1	1	4	2	2	3	1	1	2	0	0	0	1	1	0	1	2	3	0	1	2	0	0	3	3	0	2	3	2	**43**
12	2	1	1	4	2	2	3	1	1	2	0	0	0	1	1	0	1	2	3	0	1	2	0	0	3	3	0	2	3	2	**43**
13	4	4	4	3	1	1	2	2	2	1	0	0	0	1	1	0	1	2	3	1	1	4	0	2	3	2	2	2	3	2	**54**
14	5	5	5	4	2	2	3	3	3	2	1	1	1	0	0	1	1	0	1	1	1	5	1	2	1	3	2	2	1	2	**61**
15	5	5	5	4	2	2	3	3	3	2	1	1	1	0	0	1	1	0	1	1	1	5	1	2	1	3	2	2	1	2	**61**
16	2	4	4	3	1	1	2	1	1	1	0	0	0	1	1	0	0	1	2	0	0	2	0	0	2	2	0	1	2	1	**35**
17	5	5	5	4	2	2	3	3	3	2	1	1	1	1	1	0	0	1	2	0	0	5	0	1	2	3	1	1	2	1	**58**
18	6	6	6	5	3	3	4	4	4	3	2	2	2	0	0	1	1	0	1	1	1	6	1	2	1	4	2	2	1	2	**76**
19	7	7	7	6	4	4	5	5	5	4	3	3	3	1	1	2	2	1	0	2	2	7	2	3	0	5	3	3	0	3	**100**
20	2	4	4	3	1	1	2	1	1	1	0	0	1	1	1	0	0	1	2	0	0	2	0	0	2	2	0	1	2	1	**36**
21	5	5	5	4	2	2	3	3	3	2	1	1	1	1	1	0	0	1	2	0	0	5	0	1	2	3	1	1	2	1	**58**
22	0	0	0	1	3	3	2	1	1	3	2	2	4	5	5	2	5	6	7	2	5	0	0	6	7	4	6	6	7	6	**101**
23	0	0	0	1	2	2	1	1	1	2	0	0	0	1	1	0	0	1	2	0	0	0	0	0	3	3	0	1	3	1	**26**
24	6	6	6	5	3	3	4	1	4	3	0	0	2	2	2	0	1	2	3	0	1	6	0	0	3	4	0	0	3	0	**70**
25	7	7	7	6	4	4	5	5	5	4	3	3	3	1	1	2	2	1	0	2	2	7	3	3	0	5	3	3	0	3	**101**
26	4	4	4	3	1	0	2	2	2	1	3	3	2	3	3	2	3	4	5	2	3	4	3	4	5	0	4	4	5	4	**89**
27	6	6	6	5	3	3	4	1	4	3	0	0	2	2	2	0	1	2	3	0	1	6	0	0	3	4	0	0	3	0	**70**
28	6	6	6	5	3	3	4	4	4	3	2	2	2	2	2	1	1	2	3	1	1	6	1	0	3	4	0	0	3	0	**80**
29	7	7	7	6	4	4	5	5	5	4	3	3	3	1	1	2	2	1	0	2	2	7	3	3	0	5	3	3	0	3	**101**
30	6	6	6	5	3	3	4	4	4	3	2	2	2	2	2	1	1	2	3	1	1	6	1	0	3	4	0	0	3	0	**80**
	101	**105**	**105**	**95**	**58**	**57**	**82**	**55**	**74**	**62**	**37**	**39**	**54**	**61**	**61**	**33**	**58**	**71**	**92**	**36**	**58**	**101**	**26**	**66**	**93**	**89**	**66**	**76**	**93**	**76**	**2080**

Source: consultant’s analysis

Appendix 4 – Prior matrices

Car prior matrix including intrazonal – AADT in vehicles

1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	10	27	22	273	126	24	58	180	74	270	6	0	4	0	2	0	5	14	2	21	15	9	37	37	2	2	0	0	0	0	**1221**
2	0	39	9	1232	86	6	75	203	12	210	0	0	0	0	0	2	0	12	0	2	9	0	0	26	0	0	0	0	0	0	**1923**
3	0	12	9	1214	197	36	153	248	16	445	0	0	8	0	7	3	2	21	2	2	27	0	0	37	0	4	0	0	0	0	**2445**
4	248	1438	1456	1655	850	94	530	512	53	1051	0	4	11	0	6	4	3	45	2	16	27	68	57	84	0	3	3	0	0	2	**8222**
5	70	94	119	594	1459	106	59	155	96	575	0	0	12	12	0	24	6	68	54	32	48	13	10	126	0	0	0	0	4	0	**3736**
6	11	27	20	66	40	13	11	27	14	151	0	0	0	0	0	0	0	6	41	0	18	6	0	40	37	0	0	0	0	0	**529**
7	39	60	99	442	73	10	8	135	48	1381	0	0	5	0	4	0	4	4	0	0	12	0	20	18	3	0	0	0	0	0	**2365**
8	212	117	173	140	332	27	89	544	12	1621	107	71	26	8	8	48	13	37	5	49	20	14	83	97	0	0	0	0	0	0	**3853**
9	37	9	9	41	0	0	12	0	134	1719	12	0	7	0	4	0	0	0	0	0	17	0	0	3	0	0	0	0	0	0	**2003**
10	276	163	496	1114	882	208	2270	2196	2205	8054	6	12	414	73	61	36	82	242	55	120	288	25	91	212	20	94	7	0	0	0	**19704**
11	0	0	0	0	6	6	0	107	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**138**
12	0	0	0	0	12	0	0	202	0	32	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	**259**
13	4	0	3	28	13	21	6	32	13	386	0	0	995	82	23	0	289	67	4	12	118	0	0	56	3	0	0	0	3	0	**2159**
14	4	2	0	0	7	0	0	0	0	21	0	0	237	0	0	0	0	13	35	0	43	0	0	13	0	0	0	0	0	0	**375**
15	0	0	0	0	0	0	0	3	0	63	0	0	0	0	0	0	0	0	35	0	79	0	13	9	17	0	4	0	0	7	**229**
16	0	0	3	7	0	0	0	107	0	72	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	**202**
17	2	2	2	3	12	7	8	18	0	89	0	0	185	0	13	0	0	66	9	0	74	0	12	0	0	0	0	0	0	0	**503**
18	6	3	6	22	33	4	7	20	0	173	0	0	7	0	0	0	66	545	589	13	836	2	12	167	52	0	4	0	0	0	**2567**
19	3	1	1	12	2	9	2	0	0	25	0	0	3	0	43	0	17	554	0	7	134	0	7	0	0	2	0	0	0	0	**824**
20	23	17	6	6	35	27	0	12	14	106	0	0	0	0	0	0	0	26	0	0	25	4	14	0	0	0	0	0	0	0	**316**
21	19	5	6	16	12	7	8	25	25	201	0	0	109	38	26	0	53	899	91	25	7294	0	41	390	11	0	0	0	0	25	**9324**
22	0	9	0	31	34	23	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0	**132**
23	0	34	19	14	17	7	10	24	0	66	0	0	9	0	0	0	0	26	11	0	0	0	14	19	0	0	0	0	0	0	**268**
24	28	16	22	52	89	26	9	103	16	172	0	0	0	15	9	0	0	141	0	49	614	1	0	0	0	0	0	0	0	0	**1364**
25	0	3	0	1	0	20	0	0	0	20	0	0	3	0	17	0	0	17	0	0	9	0	0	0	0	0	0	0	0	10	**101**
26	0	0	0	3	13	9	0	36	0	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	**202**
27	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	**5**
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
29	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	**11**
30	2	0	3	1	0	3	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	2	0	0	0	0	**29**
	996	**2078**	**2483**	**6969**	**4334**	**692**	**3322**	**4890**	**2732**	**17101**	**131**	**87**	**2034**	**229**	**224**	**117**	**540**	**2816**	**933**	**363**	**9712**	**142**	**412**	**1345**	**151**	**110**	**18**	**0**	**7**	**43**	**65011**

Source: consultant's analysis

Car prior matrix excluding intrazonal – AADT in vehicles

1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	0	27	22	273	126	24	58	180	74	270	6	0	4	0	2	0	5	14	2	21	15	9	37	37	2	2	0	0	0	0	**1211**
2	0	0	9	1232	86	6	75	203	12	210	0	0	0	0	0	2	0	12	0	2	9	0	0	26	0	0	0	0	0	0	**1884**
3	0	12	0	1214	197	36	153	248	16	445	0	0	8	0	7	3	2	21	2	2	27	0	0	37	0	4	0	0	0	0	**2436**
4	248	1438	1456	0	850	94	530	512	53	1051	0	4	11	0	6	4	3	45	2	16	27	68	57	84	0	3	3	0	0	2	**6567**
5	70	94	119	594	0	106	59	155	96	575	0	0	12	12	0	24	6	68	54	32	48	13	10	126	0	0	0	0	4	0	**2277**
6	11	27	20	66	40	0	11	27	14	151	0	0	0	0	0	0	0	6	41	0	18	6	0	40	37	0	0	0	0	0	**515**
7	39	60	99	442	73	10	0	135	48	1381	0	0	5	0	4	0	4	4	0	0	12	0	20	18	3	0	0	0	0	0	**2357**
8	212	117	173	140	332	27	89	0	12	1621	107	71	26	8	8	48	13	37	5	49	20	14	83	97	0	0	0	0	0	0	**3309**
9	37	9	9	41	0	0	12	0	0	1719	12	0	7	0	4	0	0	0	0	0	17	0	0	3	0	0	0	0	0	0	**1870**
10	276	163	496	1114	882	208	2270	2196	2205	0	6	12	414	73	61	36	82	242	55	120	288	25	91	212	20	94	7	0	0	0	**11650**
11	0	0	0	0	6	6	0	107	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**138**
12	0	0	0	0	12	0	0	202	0	32	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	**259**
13	4	0	3	28	13	21	6	32	13	386	0	0	0	82	23	0	289	67	4	12	118	0	0	56	3	0	0	0	3	0	**1163**
14	4	2	0	0	7	0	0	0	0	21	0	0	237	0	0	0	0	13	35	0	43	0	0	13	0	0	0	0	0	0	**375**
15	0	0	0	0	0	0	0	3	0	63	0	0	0	0	0	0	0	0	35	0	79	0	13	9	17	0	4	0	0	7	**229**
16	0	0	3	7	0	0	0	107	0	72	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	**202**
17	2	2	2	3	12	7	8	18	0	89	0	0	185	0	13	0	0	66	9	0	74	0	12	0	0	0	0	0	0	0	**503**
18	6	3	6	22	33	4	7	20	0	173	0	0	7	0	0	0	66	0	589	13	836	2	12	167	52	0	4	0	0	0	**2022**
19	3	1	1	12	2	9	2	0	0	25	0	0	3	0	43	0	17	554	0	7	134	0	7	0	0	2	0	0	0	0	**824**
20	23	17	6	6	35	27	0	12	14	106	0	0	0	0	0	0	0	26	0	0	25	4	14	0	0	0	0	0	0	0	**316**
21	19	5	6	16	12	7	8	25	25	201	0	0	109	38	26	0	53	899	91	25	0	0	41	390	11	0	0	0	0	25	**2030**
22	0	9	0	31	34	23	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0	**132**
23	0	34	19	14	17	7	10	24	0	66	0	0	9	0	0	0	0	26	11	0	0	0	0	19	0	0	0	0	0	0	**255**
24	28	16	22	52	89	26	9	103	16	172	0	0	0	15	9	0	0	141	0	49	614	1	0	0	0	0	0	0	0	0	**1364**
25	0	3	0	1	0	20	0	0	0	20	0	0	3	0	17	0	0	17	0	0	9	0	0	0	0	0	0	0	0	10	**101**
26	0	0	0	3	13	9	0	36	0	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	**202**
27	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	**5**
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
29	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	**11**
30	2	0	3	1	0	3	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	2	0	0	0	0	**29**
	985	**2039**	**2475**	**5314**	**2875**	**679**	**3314**	**4346**	**2598**	**9047**	**131**	**87**	**1039**	**229**	**224**	**117**	**540**	**2271**	**933**	**363**	**2418**	**142**	**399**	**1345**	**151**	**110**	**18**	**0**	**7**	**43**	**44238**

Source: consultant's analysis

LGV prior matrix including intrazonal - AADT in vehicles

1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	12	13	0	51	17	7	13	78	14	89	0	0	3	0	0	0	0	0	0	10	4	9	0	3	0	0	0	0	0	0	**323**
2	0	0	9	188	8	6	4	22	3	23	0	0	2	0	0	0	0	1	0	0	3	9	0	0	0	0	0	0	0	0	**279**
3	0	9	10	248	32	17	25	118	0	103	0	0	0	0	0	0	2	2	0	5	2	0	0	2	0	0	0	0	0	0	**575**
4	94	325	154	134	166	50	73	49	5	198	0	0	0	0	3	5	0	0	3	0	0	17	14	14	0	0	0	0	0	0	**1303**
5	25	30	19	59	266	0	5	54	41	41	0	0	0	0	0	0	0	37	0	20	30	0	0	10	0	0	0	0	0	0	**637**
6	8	3	3	18	27	13	4	0	0	62	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	**144**
7	4	13	12	57	16	4	0	62	12	205	0	0	5	0	0	0	4	0	0	0	0	0	10	0	0	0	4	0	0	0	**408**
8	60	22	64	21	13	21	10	119	0	127	36	48	0	0	0	0	4	12	2	12	0	0	0	25	0	0	0	0	0	0	**596**
9	0	0	2	5	0	22	12	14	27	146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**227**
10	51	31	49	109	212	90	294	618	286	871	0	0	45	26	4	14	17	63	14	48	95	0	24	51	9	9	4	0	3	0	**3036**
11	0	0	0	0	0	0	0	12	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**18**
12	0	0	0	0	0	0	0	24	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**36**
13	3	2	0	3	13	0	6	0	0	122	0	0	116	0	0	0	35	0	0	0	35	0	0	0	0	0	0	0	0	0	**334**
14	0	0	0	0	0	0	0	0	0	6	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**36**
15	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	**15**
16	0	0	0	0	0	0	6	48	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**66**
17	2	0	0	0	6	0	0	17	5	12	0	0	35	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	**89**
18	0	1	6	2	0	0	3	10	0	21	0	0	0	0	0	0	13	17	87	26	166	0	0	4	17	0	0	0	0	0	**374**
19	0	0	0	0	6	0	0	0	0	13	0	0	3	0	0	0	0	87	0	0	48	0	0	4	0	0	0	0	0	0	**161**
20	4	3	0	0	24	13	0	27	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**121**
21	7	10	0	0	15	0	0	5	9	63	0	0	48	0	26	0	0	140	47	0	998	0	0	42	0	0	0	0	0	0	**1411**
22	0	0	0	9	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**
23	0	0	0	0	7	0	10	12	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	**39**
24	4	4	4	7	21	0	0	35	2	65	0	0	18	4	0	0	0	17	0	0	70	0	0	0	0	0	0	0	0	0	**252**
25	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0	0	0	0	0	0	**35**
26	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**26**
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	275	**467**	**332**	**909**	**855**	**244**	**466**	**1323**	**404**	**2281**	**36**	**48**	**304**	**31**	**34**	**18**	**75**	**423**	**167**	**121**	**1450**	**34**	**48**	**155**	**30**	**9**	**8**	**0**	**3**	**2**	**10551**

Source: consultant's analysis

LGV prior matrix excluding intrazonal – AADT in vehicles

1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	0	13	0	51	17	7	13	78	14	89	0	0	3	0	0	0	0	0	0	10	4	9	0	3	0	0	0	0	0	0	**311**
2	0	0	9	188	8	6	4	22	3	23	0	0	2	0	0	0	0	1	0	0	3	9	0	0	0	0	0	0	0	0	**279**
3	0	9	0	248	32	17	25	118	0	103	0	0	0	0	0	0	2	2	0	5	2	0	0	2	0	0	0	0	0	0	**565**
4	94	325	154	0	166	50	73	49	5	198	0	0	0	0	3	5	0	0	3	0	0	17	14	14	0	0	0	0	0	0	**1169**
5	25	30	19	59	0	0	5	54	41	41	0	0	0	0	0	0	0	37	0	20	30	0	0	10	0	0	0	0	0	0	**371**
6	8	3	3	18	27	0	4	0	0	62	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	**130**
7	4	13	12	57	16	4	0	62	12	205	0	0	5	0	0	0	4	0	0	0	0	0	10	0	0	0	4	0	0	0	**408**
8	60	22	64	21	13	21	10	0	0	127	36	48	0	0	0	0	4	12	2	12	0	0	0	25	0	0	0	0	0	0	**477**
9	0	0	2	5	0	22	12	14	0	146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**200**
10	51	31	49	109	212	90	294	618	286	0	0	0	45	26	4	14	17	63	14	48	95	0	24	51	9	9	4	0	3	0	**2164**
11	0	0	0	0	0	0	0	12	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**18**
12	0	0	0	0	0	0	0	24	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**36**
13	3	2	0	3	13	0	6	0	0	122	0	0	0	0	0	0	35	0	0	0	35	0	0	0	0	0	0	0	0	0	**218**
14	0	0	0	0	0	0	0	0	0	6	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**36**
15	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	**15**
16	0	0	0	0	0	0	6	48	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**66**
17	2	0	0	0	6	0	0	17	5	12	0	0	35	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	**89**
18	0	1	6	2	0	0	3	10	0	21	0	0	0	0	0	0	13	0	87	26	166	0	0	4	17	0	0	0	0	0	**357**
19	0	0	0	0	6	0	0	0	0	13	0	0	3	0	0	0	0	87	0	0	48	0	0	4	0	0	0	0	0	0	**161**
20	4	3	0	0	24	13	0	27	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**121**
21	7	10	0	0	15	0	0	5	9	63	0	0	48	0	26	0	0	140	47	0	0	0	0	42	0	0	0	0	0	0	**413**
22	0	0	0	9	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**
23	0	0	0	0	7	0	10	12	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	**39**
24	4	4	4	7	21	0	0	35	2	65	0	0	18	4	0	0	0	17	0	0	70	0	0	0	0	0	0	0	0	0	**252**
25	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0	0	0	0	0	0	**35**
26	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**26**
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	263	**467**	**322**	**775**	**589**	**231**	**466**	**1204**	**377**	**1409**	**36**	**48**	**188**	**31**	**34**	**18**	**75**	**405**	**167**	**121**	**452**	**34**	**48**	**155**	**30**	**9**	**8**	**0**	**3**	**2**	**7967**

Source: consultant's analysis

HGV prior matrix including intrazonal - AADT in vehicles

1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	0	0	0	9	26	17	4	72	0	65	0	0	0	5	0	0	0	9	2	13	3	0	10	7	2	0	0	0	0	0	**243**
2	17	34	0	51	9	0	8	45	11	21	0	0	0	0	0	0	0	0	0	2	3	0	0	7	0	0	0	0	0	0	**210**
3	0	9	0	77	12	7	4	81	0	44	0	0	0	0	0	0	0	3	1	2	9	0	0	13	0	0	0	0	0	0	**260**
4	9	68	111	41	31	0	0	46	5	32	0	0	0	3	0	0	0	0	0	0	2	0	34	2	0	0	0	0	0	0	**383**
5	52	20	24	60	93	0	19	66	0	127	0	0	0	0	0	0	0	7	6	0	6	0	11	42	17	0	4	0	0	6	**561**
6	19	6	8	4	0	0	10	14	0	49	0	0	0	0	0	0	0	0	0	12	4	11	4	20	0	0	0	0	0	0	**161**
7	0	0	0	8	0	7	0	0	7	90	0	0	6	0	0	0	0	0	0	0	0	4	10	4	0	0	0	0	0	0	**137**
8	67	0	53	3	65	27	0	73	0	55	12	12	0	0	0	0	0	4	2	12	4	12	36	12	0	0	0	0	0	0	**448**
9	0	0	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	**53**
10	52	20	63	42	94	29	46	586	178	427	7	0	21	0	23	12	18	33	3	81	54	16	38	47	6	0	11	0	0	4	**1913**
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
13	0	0	2	0	0	0	0	0	0	49	0	0	58	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	**115**
14	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
15	0	0	0	0	7	0	0	4	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**23**
16	6	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**18**
17	0	0	2	0	0	0	0	4	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**31**
18	5	1	4	2	29	4	0	6	3	35	0	0	7	0	0	0	0	17	9	10	25	0	0	0	0	0	0	0	0	0	**159**
19	0	0	0	0	3	0	0	2	0	6	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
20	0	0	0	0	7	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	**44**
21	0	2	5	3	31	0	0	13	0	10	0	0	12	0	13	0	25	51	17	0	322	0	0	124	0	0	0	0	0	0	**626**
22	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0	0	0	0	0	**9**
23	22	0	0	7	8	4	0	24	0	12	0	0	0	0	0	0	0	0	0	0	0	0	12	0	8	3	0	0	0	0	**101**
24	10	2	3	15	94	19	0	85	3	130	0	0	25	12	0	0	0	12	0	0	124	2	26	0	4	0	0	0	0	0	**566**
25	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**
26	0	0	0	4	0	0	0	0	0	61	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	**69**
27	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**
28	1	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
29	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	**6**
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	**3**
	261	**162**	**276**	**328**	**515**	**118**	**92**	**1132**	**207**	**1342**	**19**	**12**	**128**	**29**	**37**	**12**	**42**	**141**	**39**	**132**	**570**	**63**	**181**	**277**	**41**	**6**	**16**	**0**	**0**	**10**	**6187**

Source: consultant's analysis

HGV prior matrix excluding intrazonal – AADT in vehicles

1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	0	0	0	9	26	17	4	72	0	65	0	0	0	5	0	0	0	9	2	13	3	0	10	7	2	0	0	0	0	0	**243**
2	17	0	0	51	9	0	8	45	11	21	0	0	0	0	0	0	0	0	0	2	3	0	0	7	0	0	0	0	0	0	**175**
3	0	9	0	77	12	7	4	81	0	44	0	0	0	0	0	0	0	3	1	2	9	0	0	13	0	0	0	0	0	0	**260**
4	9	68	111	0	31	0	0	46	5	32	0	0	0	3	0	0	0	0	0	0	2	0	34	2	0	0	0	0	0	0	**342**
5	52	20	24	60	0	0	19	66	0	127	0	0	0	0	0	0	0	7	6	0	6	0	11	42	17	0	4	0	0	6	**467**
6	19	6	8	4	0	0	10	14	0	49	0	0	0	0	0	0	0	0	0	12	4	11	4	20	0	0	0	0	0	0	**161**
7	0	0	0	8	0	7	0	0	7	90	0	0	6	0	0	0	0	0	0	0	0	4	10	4	0	0	0	0	0	0	**137**
8	67	0	53	3	65	27	0	0	0	55	12	12	0	0	0	0	0	4	2	12	4	12	36	12	0	0	0	0	0	0	**375**
9	0	0	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	**53**
10	52	20	63	42	94	29	46	586	178	0	7	0	21	0	23	12	18	33	3	81	54	16	38	47	6	0	11	0	0	4	**1487**
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
13	0	0	2	0	0	0	0	0	0	49	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	**57**
14	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
15	0	0	0	0	7	0	0	4	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**23**
16	6	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**18**
17	0	0	2	0	0	0	0	4	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**31**
18	5	1	4	2	29	4	0	6	3	35	0	0	7	0	0	0	0	0	9	10	25	0	0	0	0	0	0	0	0	0	**142**
19	0	0	0	0	3	0	0	2	0	6	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
20	0	0	0	0	7	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	**44**
21	0	2	5	3	31	0	0	13	0	10	0	0	12	0	13	0	25	51	17	0	0	0	0	124	0	0	0	0	0	0	**304**
22	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0	0	0	0	0	**9**
23	22	0	0	7	8	4	0	24	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	3	0	0	0	0	**89**
24	10	2	3	15	94	19	0	85	3	130	0	0	25	12	0	0	0	12	0	0	124	2	26	0	4	0	0	0	0	0	**566**
25	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**
26	0	0	0	4	0	0	0	0	0	61	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	**69**
27	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**
28	1	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
29	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	**6**
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	**3**
	261	**127**	**276**	**287**	**422**	**118**	**92**	**1059**	**207**	**916**	**19**	**12**	**70**	**29**	**37**	**12**	**42**	**124**	**39**	**132**	**249**	**63**	**169**	**277**	**41**	**6**	**16**	**0**	**0**	**10**	**5110**

Source: consultant's analysis

Appendix 5 – Calibration

This appendix gives full details of the calibration exercise carried out to ensure good fit of the modelled flows to observed flows.

Matrix estimation

The process of combining the trip matrices from the various sources as discussed in section 5 produces what is called a ‘prior’ matrix. This is effectively a first estimate of what the matrix is likely to contain. The next step is to assign this prior matrix onto the coded network, and use Matrix Estimation (ME2) techniques to calibrate the matrix.

ME2 is required to ensure that the trip matrices are reproducing, within defined limits, a set of observed conditions, when they are assigned to the model networks. During matrix estimation, adjustments are made to the trip matrices to improve the degree of match between the observed and modelled data.

ME2 is undertaken with the TFLOWFUZZY module within VISUM. This module takes as inputs target traffic counts at various locations within the network. The module then seeks to undertake minimum revisions to the matrix so that it matches these user defined link flows as much as possible.

Calibration results

The two directional observed counts at the 16 RSI locations and at the Sozina tunnel were used as input controls for the ME2 procedure, as shown in Figure A5.1.

Due to the very high level of intrazonal traffic at some of the RSI sites, target flows needed to be adjusted as the purpose of the study is to focus on the traffic which may potentially transfer to the new Bar – Boljare motorway rather than to focus on localised (urban demand). If this adjustment is not carried out, the model is likely to overestimate the potential demand on the motorway. Sites 14 and 6 have been identified as sites needing adjustment as showing more than 50% intrazonals[26]. For these sites, the target flows were reduced, for each user class, in line with the percentage of intrazonal demand observed, as shown in Table A5.1.

[26] See table 4.5.

Table A5.1: Corrected observed flows (AADT)

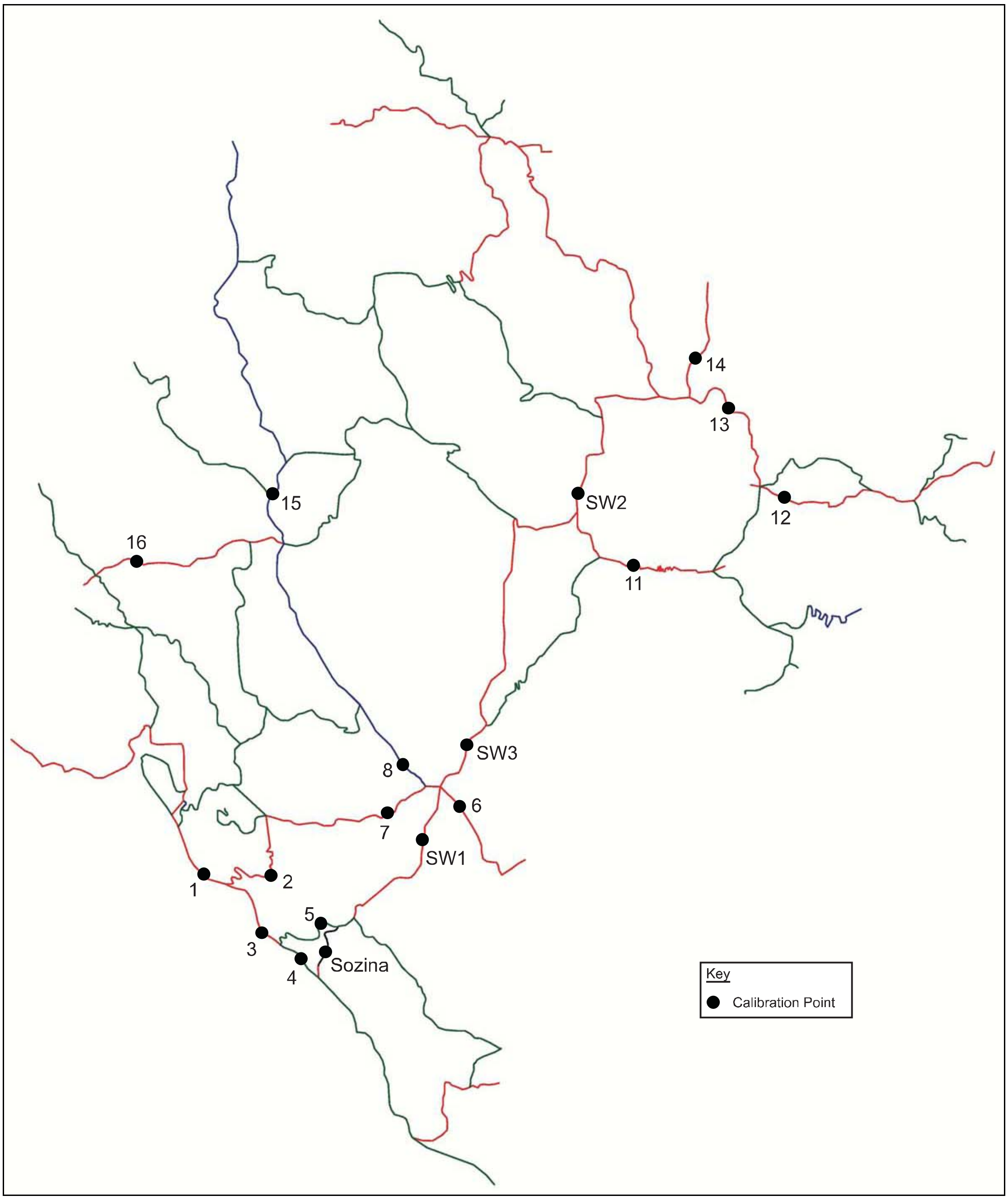
Site	Car		LGV		HGV	
	Total Trips	Intrazonal Trips	Total Trips	Intrazonal Trips	Total Trips	Intrazonal Trips
6	7,302	5,831	1,066	748	602	327
new target demand	1,471		318		275	
14	8,983	6,360	1,361	866	1,138	322
new target demand	2,623		495		817	

The calibration results have been assessed by comparing the observed and modelled (assigned) flows at all of the locations used as input to the matrix estimation process. The main indicator for the goodness of fit is the GEH statistic, which is defined as[27]:

$$GEH = \sqrt{\frac{(\text{modelled flow - observed flow})^2}{0.5 \times (\text{observed flow} + \text{modelled flow})}}$$

[27] In fact it is a function of the square root of an average Chi Squared test

Figure A5.0-1: Location of calibration counts



Source: Consultant's analysis

Site SW1 has been excluded from calibration, as it showed that modelled results were still very far from observed only being at one third of the expected level. This was mainly due to the high level of local traffic recorded at site SW1[28] which cannot be represented at matrix level, or only through intrazonal trips, which are not assigned. It is clear that most of the traffic at site SW1

[28] As presented in section 3.4 of this report.

being very local, it cannot be considered as strategic and is unlikely to use the proposed new Bar – Boljare motorway. As no RSI were conducted at this site no proportion of local traffic could be identified to be removed to create the target flows for the matrix estimation.

Model calibration

A total of 17 points were chosen for ME2. All three user classes were subject to matrix estimation to improve the fit to observed counts.

It is generally considered acceptable that 85% of all links analysed should have a GEH value of 5 or less. Table A5.2 shows the results when the prior matrix is assigned to the network. It shows that apart from sites 7 and 14, the modelled flows are far from the observed AADT. For the other sites, modelled flows are lower than observed, this can be explained by the number of intrazonal (local) trips recorded at all sites, that the model does not assigned specifically.

Table A5.3 shows the results post matrix estimation excluding site SW1. The results show a high level of calibration has been achieved on the existing links, for both directions of movements for most sites. The mean GEH for the three user classes are all below 2, and more than 85% of the links have GEH below 5. Only sites 3 and 4, on the coast, show a GEH higher than 5 but this should not impact on the forecast results as these locations are not directly on the corridor of the Bar – Boljare motorway. Sites 14, SW2, SW3 and the Sozina tunnel show a good fit between observed and modelled flows, this is important at it is anticipated that traffic using the new Bar – Boljare motorway will largely reassign from that route.

Table A5.2: GEH using prior matrix

Site	PRIOR MATRIX			MODELLED				OBSERVED				GEH			
	LINK	FROM	TO	SUM	CAR	LCV	HCV	SUM	CAR	LCV	HCV	SUM	CAR	LCV	HCV
1	7	112	113	5158	4332	608	218	7161	5616	548	997	25.5	18.2	2.5	31.6
1	7	113	112	6228	5111	724	392	7161	5616	548	997	11.4	6.9	7.0	23.0
2	125	185	195	3564	3278	204	82	3407	2694	485	228	2.7	10.7	15.1	11.7
2	125	195	185	3683	3268	327	89	3407	2694	485	228	4.6	10.5	7.8	11.0
3	100	194	195	1507	1100	174	233	3080	2426	342	312	32.8	31.6	10.5	4.8
3	100	195	194	2019	1583	327	109	3080	2426	342	312	21.0	18.8	0.8	14.0
4	136	194	204	2067	1583	327	157	4604	3346	752	506	43.9	35.5	18.3	19.2
4	136	204	194	1576	1100	174	302	4604	3346	752	506	54.5	47.6	26.9	10.1
6	33	149	151	275	181	26	68	1033	736	159	138	29.6	25.9	13.8	6.9
6	33	151	149	127	109	12	6	1033	736	159	138	37.6	30.5	15.9	15.6
7	152	121	185	5675	4742	625	308	5793	4984	563	246	1.6	3.5	2.5	3.7
7	152	185	121	5039	3988	697	354	5793	4984	563	246	10.2	14.9	5.3	6.2
8	154	104	123	4609	3997	391	221	6217	4805	788	624	21.9	12.2	16.4	19.6
8	154	123	104	7017	5017	1066	934	6217	4805	788	624	9.8	3.0	9.1	11.1
SW3	121	109	132	3318	2146	573	599	3075	2115	361	599	4.3	0.7	9.8	0.0
SW3	121	132	109	3892	2789	574	529	3075	2115	361	599	13.8	13.6	9.9	2.9
SW2	79	102	105	2261	1668	321	272	3708	2690	584	434	26.5	21.9	12.4	8.6
SW2	79	105	102	2015	1229	362	424	3708	2690	584	434	31.6	33.0	10.2	0.5
11	47	162	167	1015	746	115	154	312	267	30	15	27.3	21.3	10.0	15.1
11	47	167	162	1380	1060	185	135	312	267	30	15	36.7	30.8	14.9	13.9
12	110	143	161	1162	932	201	29	1951	1614	294	43	20.0	19.1	5.9	2.3
12	110	161	143	1375	1094	201	80	1951	1614	294	43	14.1	14.1	5.9	4.7
13	130	142	200	1752	1384	251	117	2620	2179	362	79	18.6	18.8	6.3	3.8
13	130	200	142	1737	1441	261	35	2620	2179	362	79	18.9	17.3	5.7	5.8
14	87	191	192	1691	1274	126	291	1967	1311	248	408	6.5	1.0	8.9	6.3
14	87	192	191	1903	1237	196	470	1967	1311	248	408	1.5	2.1	3.5	3.0
15	65	180	182	319	131	70	118	732	577	113	42	18.0	23.7	4.5	8.5
15	65	182	180	242	138	53	51	732	577	113	42	22.2	23.2	6.6	1.3
16	26	116	139	589	440	64	85	677	420	117	140	3.5	1.0	5.6	5.2
16	26	139	116	470	297	88	85	677	420	117	140	8.6	6.5	2.9	5.2
Sozina	147	203	208	2070	1546	301	223	3020	2508	288	224	18.8	21.4	0.8	0.1
Sozina	147	208	203	2565	1803	466	296	3020	2508	288	224	8.6	15.2	9.2	4.5
MEAN												**19.0**	**17.3**	**8.9**	**8.8**
Percentage of links with a GEH value of more than 5%												**81%**	**81%**	**78%**	**63%**

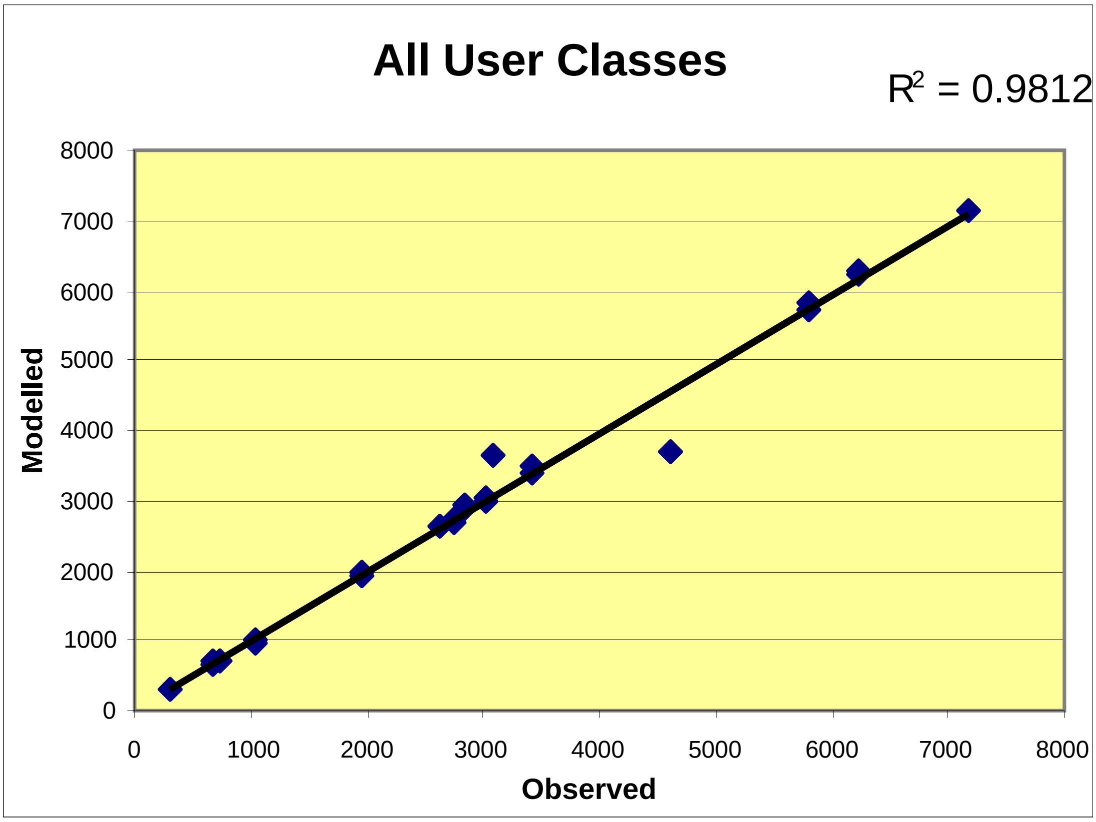
Source: Consultant's analysis

Table A5.3: GEH using estimated matrix – excluding site SW1

Site	2 sites at 38% & 38%			MODELLED				OBSERVED				GEH			
	LINK	FROM	TO	SUM	CAR	LGV	HGV	SUM	CAR	LGV	HGV	SUM	CAR	LGV	HGV
1	7	112	113	7134	5622	551	960	7161	5616	548	997	0.3	0.1	0.1	1.2
1	7	113	112	7159	5645	557	956	7161	5616	548	997	0.0	0.4	0.4	1.3
2	125	185	195	3409	2726	469	214	3407	2694	485	228	0.0	0.6	0.7	0.9
2	125	195	185	3484	2776	474	233	3407	2694	485	228	1.3	1.6	0.5	0.3
3	100	194	195	3648	2801	470	377	3080	2426	342	312	9.8	7.3	6.4	3.5
3	100	195	194	3652	2810	470	372	3080	2426	342	312	9.9	7.5	6.4	3.2
4	136	194	204	3705	2810	470	426	4604	3346	752	506	13.9	9.7	11.4	3.7
4	136	204	194	3682	2801	470	411	4604	3346	752	506	14.3	9.8	11.4	4.4
6	33	149	151	1003	713	153	137	1033	736	159	138	0.9	0.9	0.5	0.1
6	33	151	149	978	706	150	122	1033	736	159	138	1.7	1.1	0.7	1.4
7	152	121	185	5804	4972	575	257	5793	4984	563	246	0.1	0.2	0.5	0.7
7	152	185	121	5730	4903	574	252	5793	4984	563	246	0.8	1.2	0.5	0.4
8	154	104	123	6205	4826	774	606	6217	4805	788	624	0.2	0.3	0.5	0.7
8	154	123	104	6302	4872	798	633	6217	4805	788	624	1.1	1.0	0.4	0.4
SW3	121	109	132	2901	2231	290	380	2848	2193	285	370	1.0	0.8	0.3	0.5
SW3	121	132	109	2914	2225	294	395	2848	2193	285	370	1.2	0.7	0.5	1.3
SW2	79	102	105	2688	2106	249	334	2736	2134	246	356	0.9	0.6	0.2	1.2
SW2	79	105	102	2729	2123	249	357	2736	2134	246	356	0.1	0.2	0.2	0.1
11	47	162	167	317	271	30	16	312	267	30	15	0.3	0.2	0.0	0.3
11	47	167	162	320	275	30	15	312	267	30	15	0.5	0.5	0.0	0.0
12	110	143	161	1935	1601	292	42	1951	1614	294	43	0.4	0.3	0.1	0.2
12	110	161	143	1936	1603	291	42	1951	1614	294	43	0.3	0.3	0.2	0.2
13	130	142	200	2614	2171	363	81	2620	2179	362	79	0.1	0.2	0.1	0.2
13	130	200	142	2619	2177	363	78	2620	2179	362	79	0.0	0.0	0.1	0.1
14	87	191	192	1971	1325	236	409	1967	1311	248	408	0.1	0.4	0.8	0.0
14	87	192	191	1986	1328	243	416	1967	1311	248	408	0.4	0.5	0.3	0.4
15	65	180	182	728	560	111	57	732	577	113	42	0.1	0.7	0.2	2.1
15	65	182	180	720	560	112	47	732	577	113	42	0.4	0.7	0.1	0.7
16	26	116	139	688	432	116	140	677	420	117	140	0.4	0.6	0.1	0.0
16	26	139	116	677	420	117	140	677	420	117	140	0.0	0.0	0.0	0.0
Sozina	147	203	208	2993	2472	285	237	3020	2508	288	224	0.5	0.7	0.2	0.9
Sozina	147	208	203	3028	2503	293	232	3020	2508	288	224	0.1	0.1	0.3	0.5
MEAN												**1.9**	**1.5**	**1.4**	**1.0**
Percentage of links with a GEH value of more than 5%												**13%**	**13%**	**13%**	**0%**

A graphical representation of the correlation between observed and modelled flow is given in Figure A5.2. It shows a high level of correlation, confirming that the model properly represents observations.

Figure A5.0-2: Correlation between observed and modelled flow all modes



Source: Consultant's analysis

Regression analysis

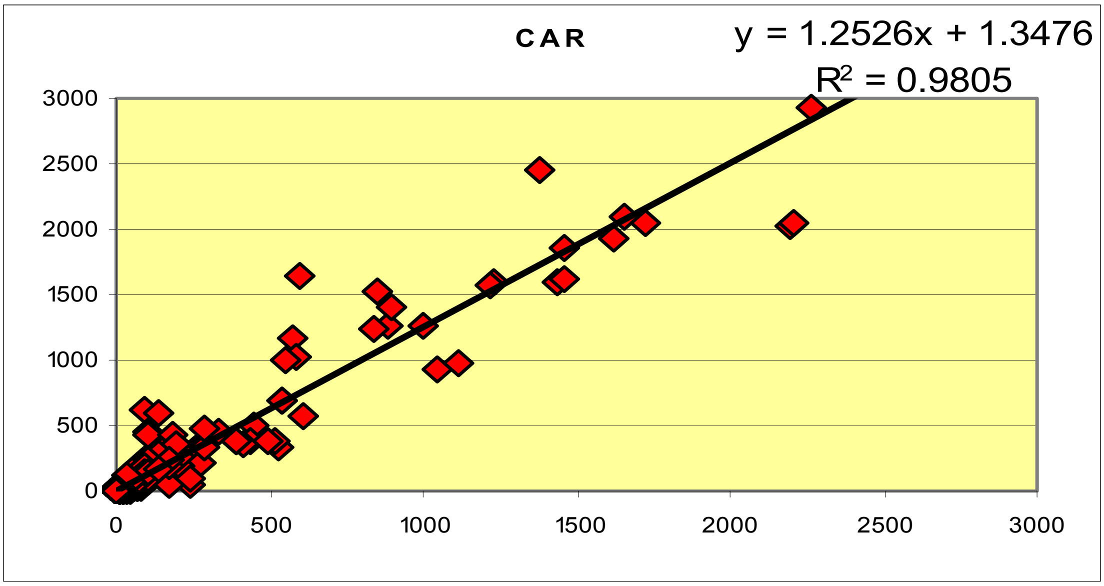
In order to ensure that the integrity of the matrices has not been materially jeopardised due to the ME2 process, a regression analysis has been carried out for the three different user classes. The analysis compares the pre and post ME2 trips within the zones.

The R-squared values for the three user classes and a combined estimate are high. This confirms that the post estimation matrices have retained the characteristics of the relevant prior matrices and demonstrates that the matrices have not been adversely affected by the ME2 process. The R^2 values are:

- Car: 0.98;
- LGV: 0.92;
- HGV: 0.76; and
- All: 0.98.

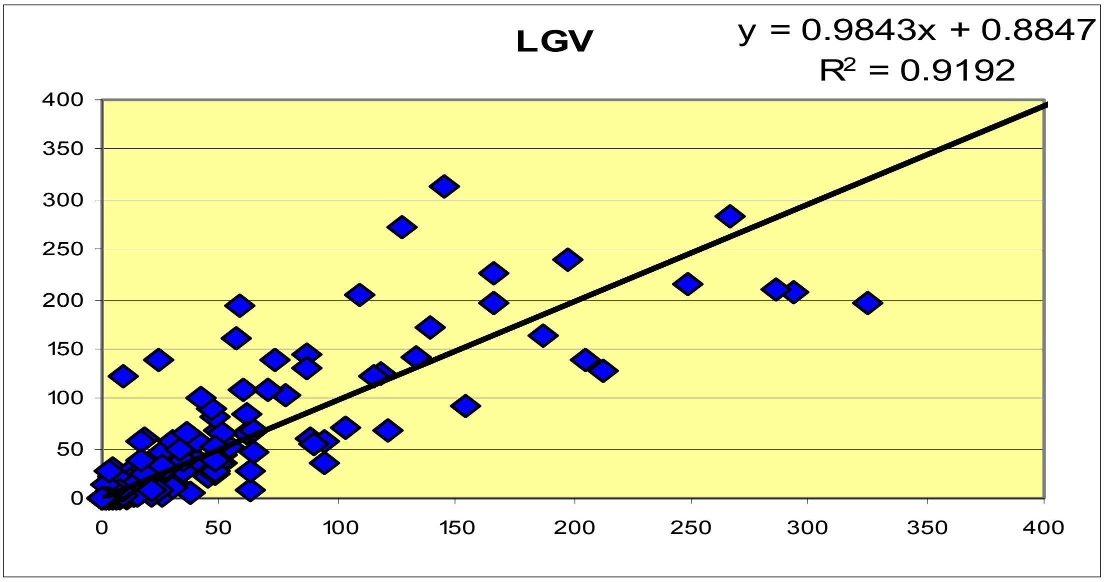
Figures A5.3 to A5.6 illustrate the regression analysis for the three different user classes and combined demand. These show that the prior demand tended to underestimate the demand and the matrix estimation adjusted this to the higher observed demand. This can be explained by the need for the demand to increase to match observed flows at the validation points as the intrazonal demand is not assigned.

Figure A5.0-3: Regression analysis for car demand



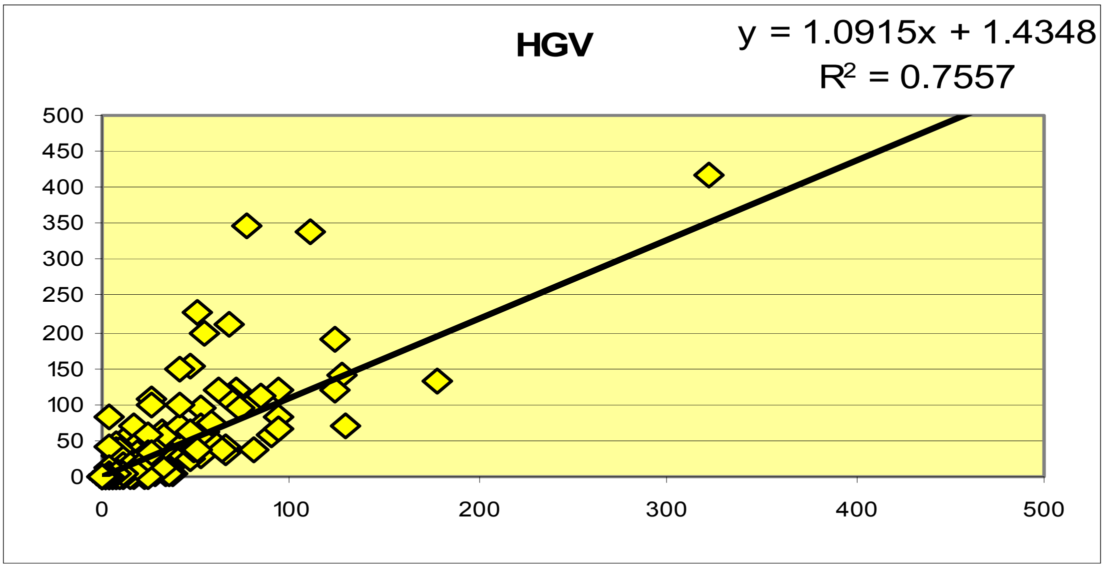
Source: Consultant's analysis

Figure A5.0-4: Regression analysis for LGV demand



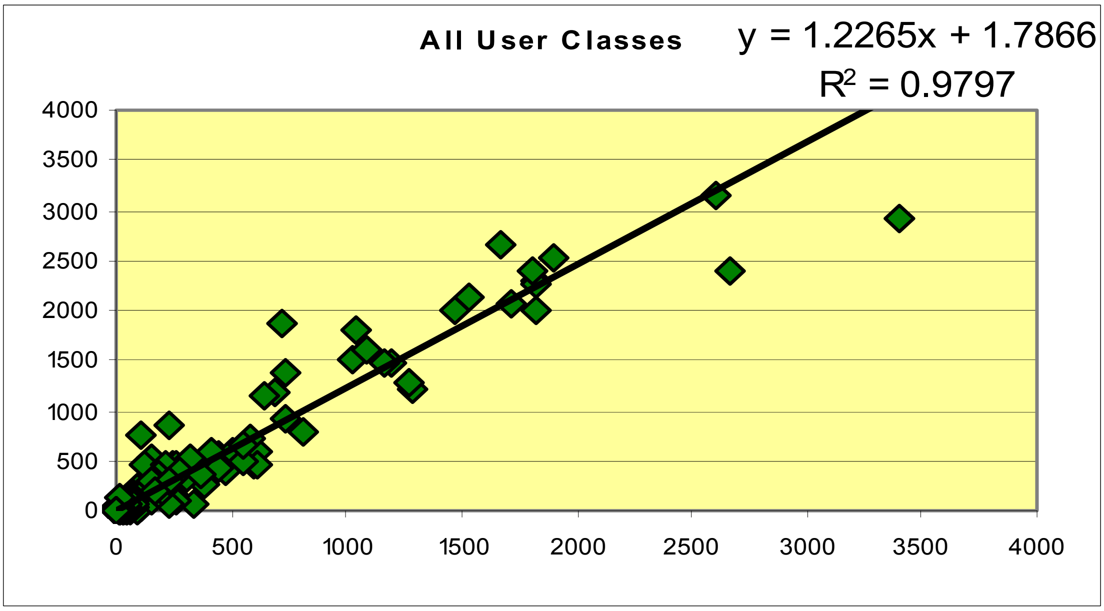
Source: Consultant's analysis

Figure A5.0-5: Regression analysis for HGV demand



Source: Consultant's analysis

Figure A5.0-6: Regression analysis for total demand



Source: Consultant's analysis

Estimated matrices

As the calibration-validation process produced satisfactory results, the 'estimated' matrices are considered to be the base year matrices for cars, LGVs and HGVs and are as shown in Table

A5.4. Copies of the final estimated matrix for each vehicle class are given in **Appendix 6** with and without intrazonals.

Table A5.4: Prior and estimated matrix totals

	Prior		Estimated	
	Total	Intrazonals	Total	Intrazonals
Car	65,005	20,773	82,654	26,412
LGV	10,551	2,584	11,187	2,736
HGV	6,185	1,077	8,045	1,401

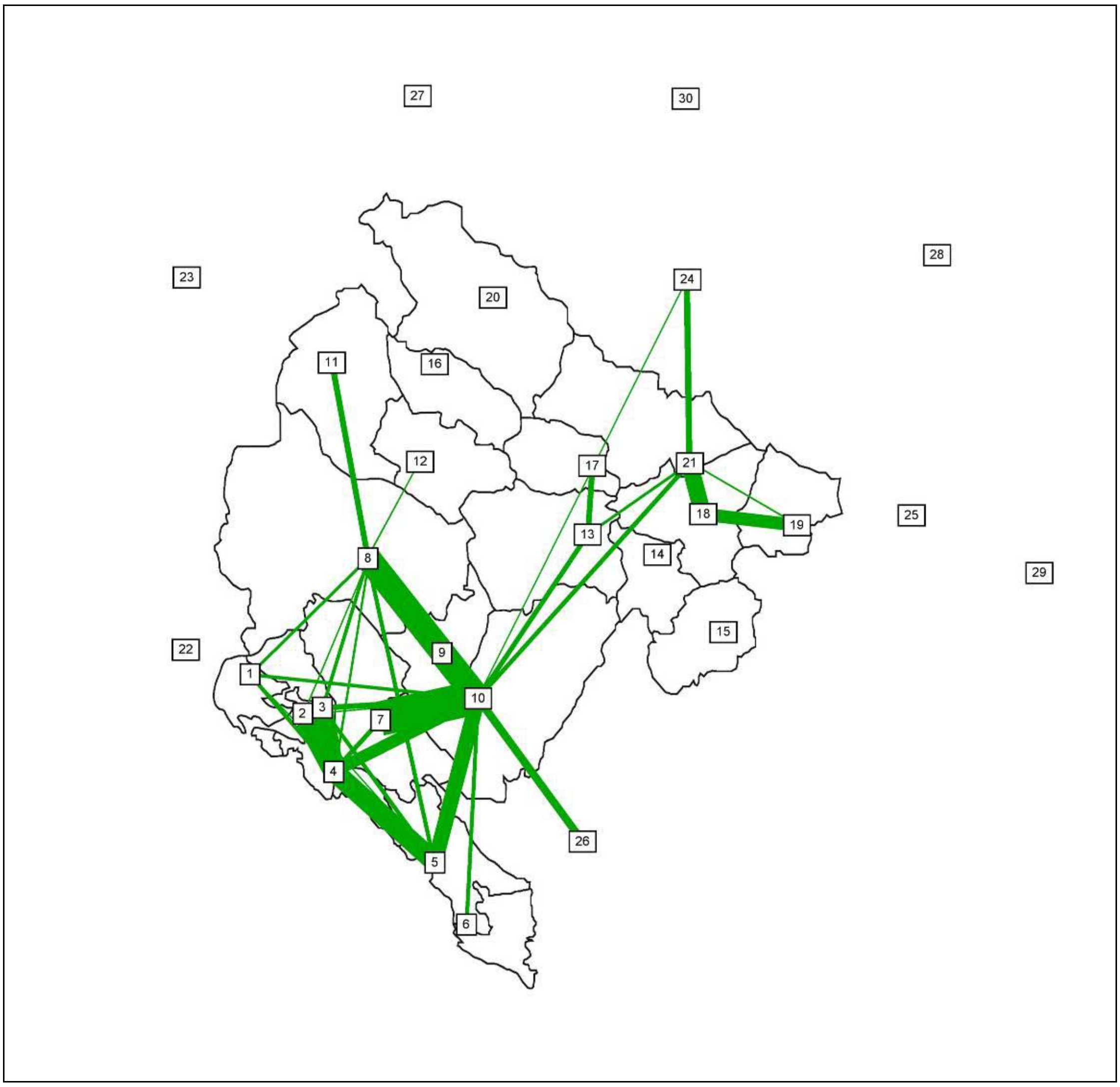
Source: Consultant's analysis

Desire lines

Desires lines show the origin-destination movements spatially. The figures below show the main origin-destination movements, post matrix estimations for the three user classes. It should be noted that only the main movements are represented to avoid confusion, hence no representation does not necessarily mean no demand.

Figure A5.7 shows that there are three main poles of attraction for car are, Podgorica, the coast and the Montenegrin Serbian border. On the Bar – Boljare corridor, most of the demand is between Bar and Podgorica. The demand between Bijelo Polje – Berane – Rožaje is also relatively high. There are some movements between the coast and Serbia but these are relatively limited.

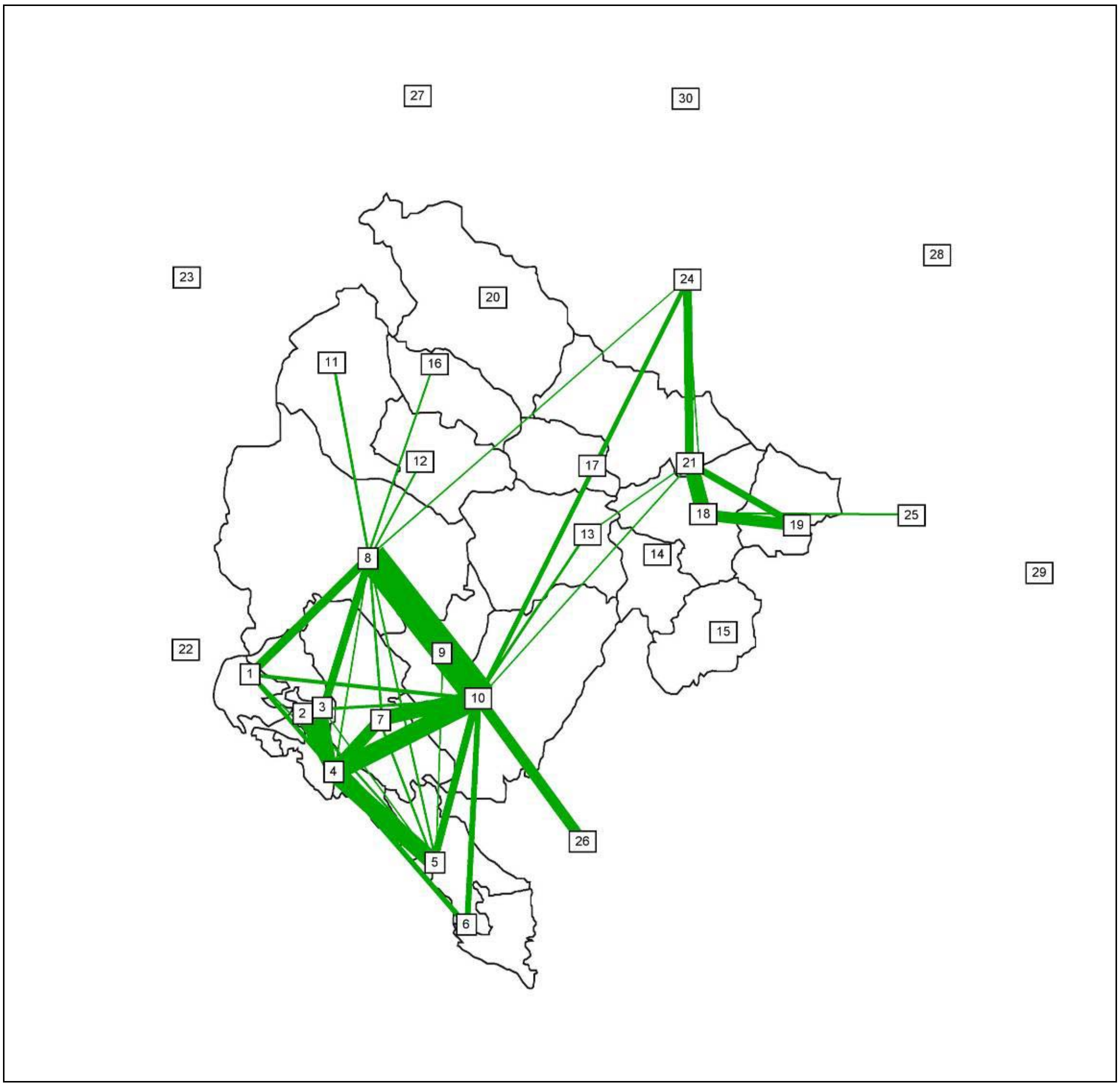
Figure A5.0-7: Desire lines for car demand



Source: Consultant's analysis

For LGVs, Figure A4.8, the desires lines show a relatively similar picture to cars. The demand is relatively more sprayed than for cars suggesting more long distance movements.

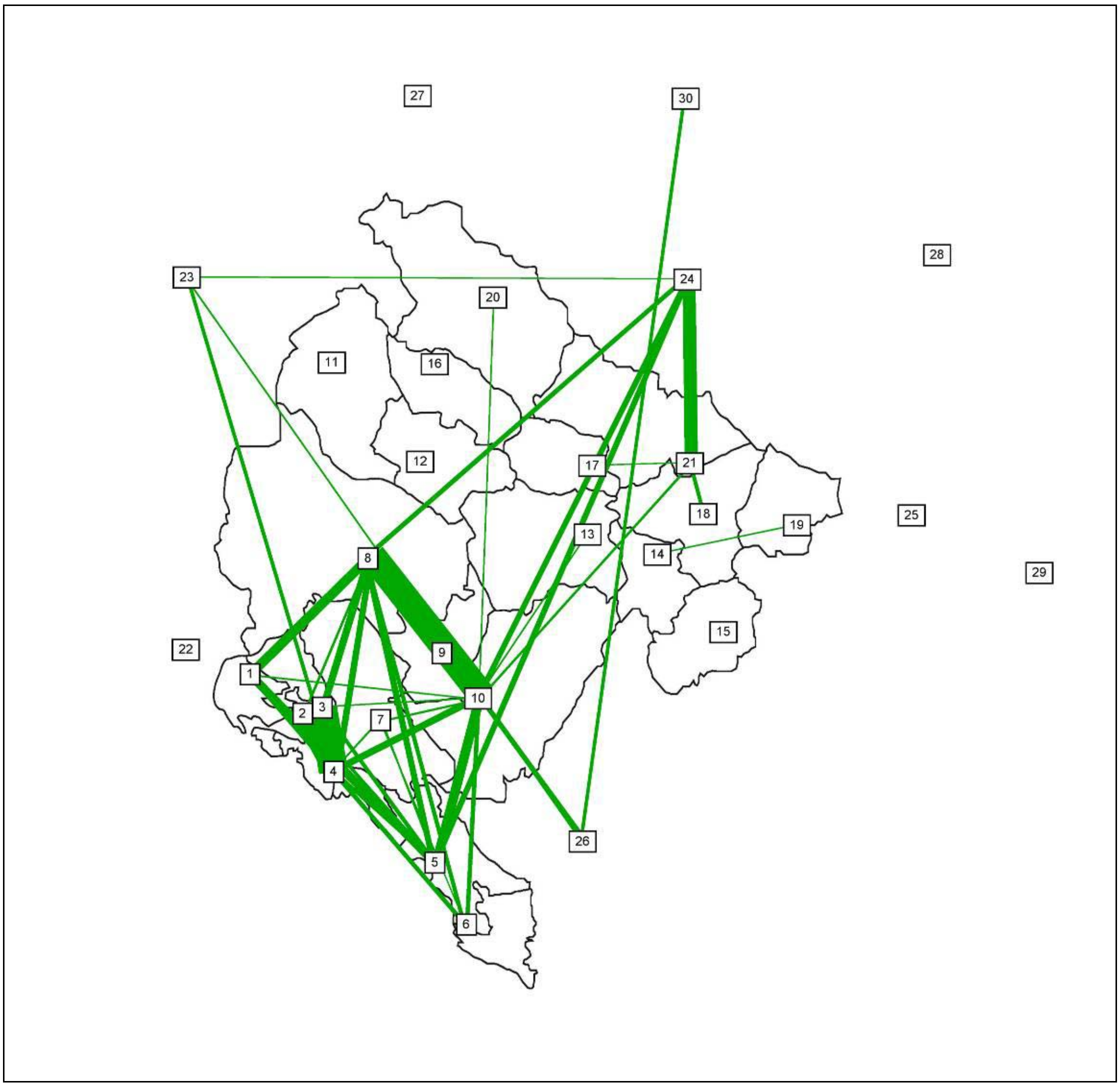
Figure A5.0-8: Desire lines for LGV demand



Source: Consultant's analysis

HGV desire lines, in Figure A5.9, are more scattered throughout the network and confirm the existence of relatively long distance traffic. The main poles of attraction remain Podgorica, Niksic, the coast, Serbia and to a lesser extent Albania. The Bar – Boljare corridor appears to be more vital for HGVs than cars and LGVs with a large demand from Serbia to the coastal regions.

Figure A5.0-9: Desire lines for HGV demand



Source: Consultant's analysis

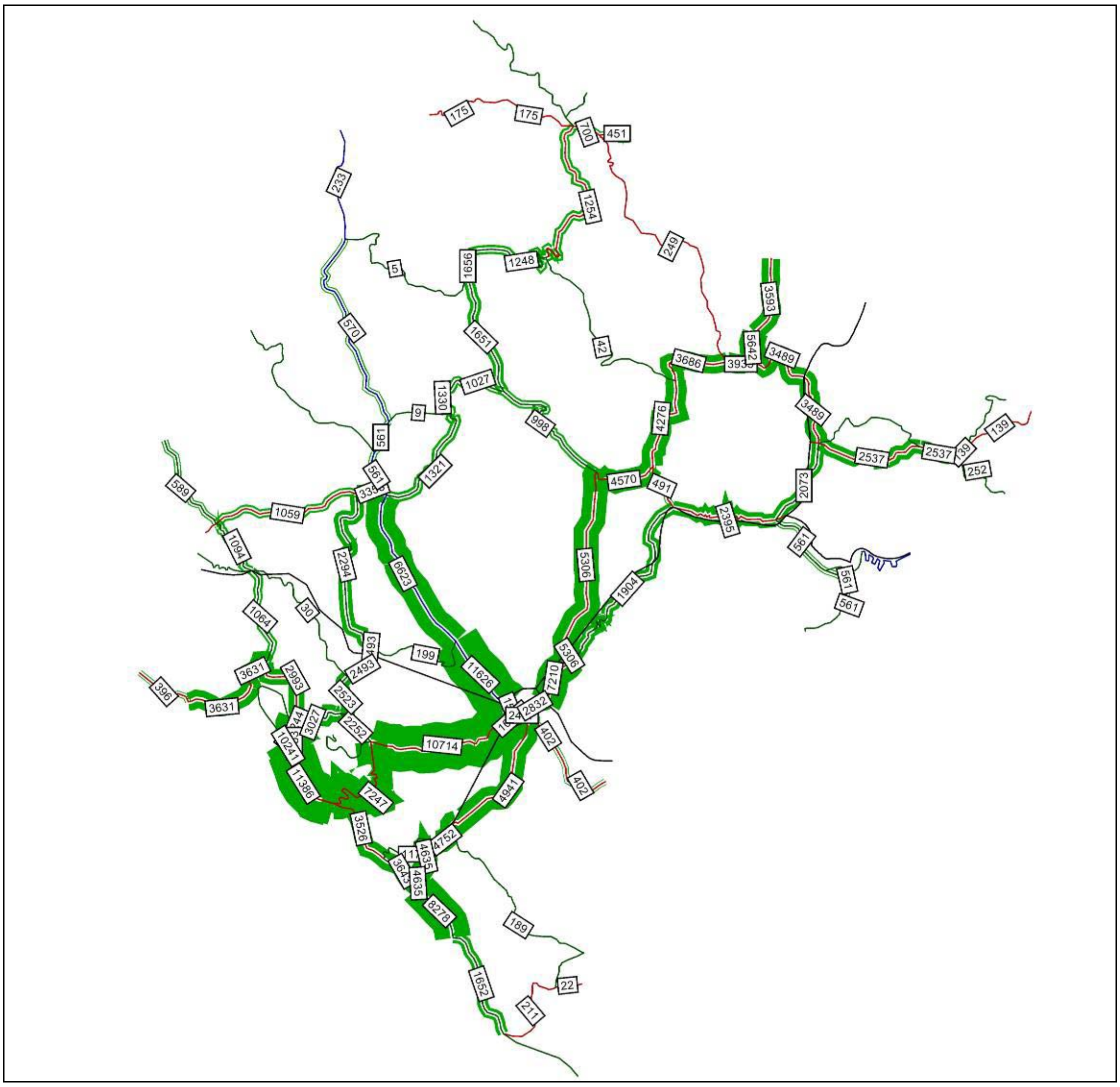
The above analysis demonstrates the strategic nature of the Bar – Boljare corridor. Three separate sections can clearly be identified:

- The Coast to Podgorica, with very high demand, especially from cars and LGVs using the section for short distance trips. HGVs also using this section but for more long distance strategic traffic;
- Long distance North-South movements, all using Podgorica to Kolasin, a section with a high proportion of HGVs;
- The northern sections to Serbia, with both relatively local traffic between the various urban areas of Bijelo Polje, Berane and Rožaje and more long distance strategic HGV traffic.

Assignment results

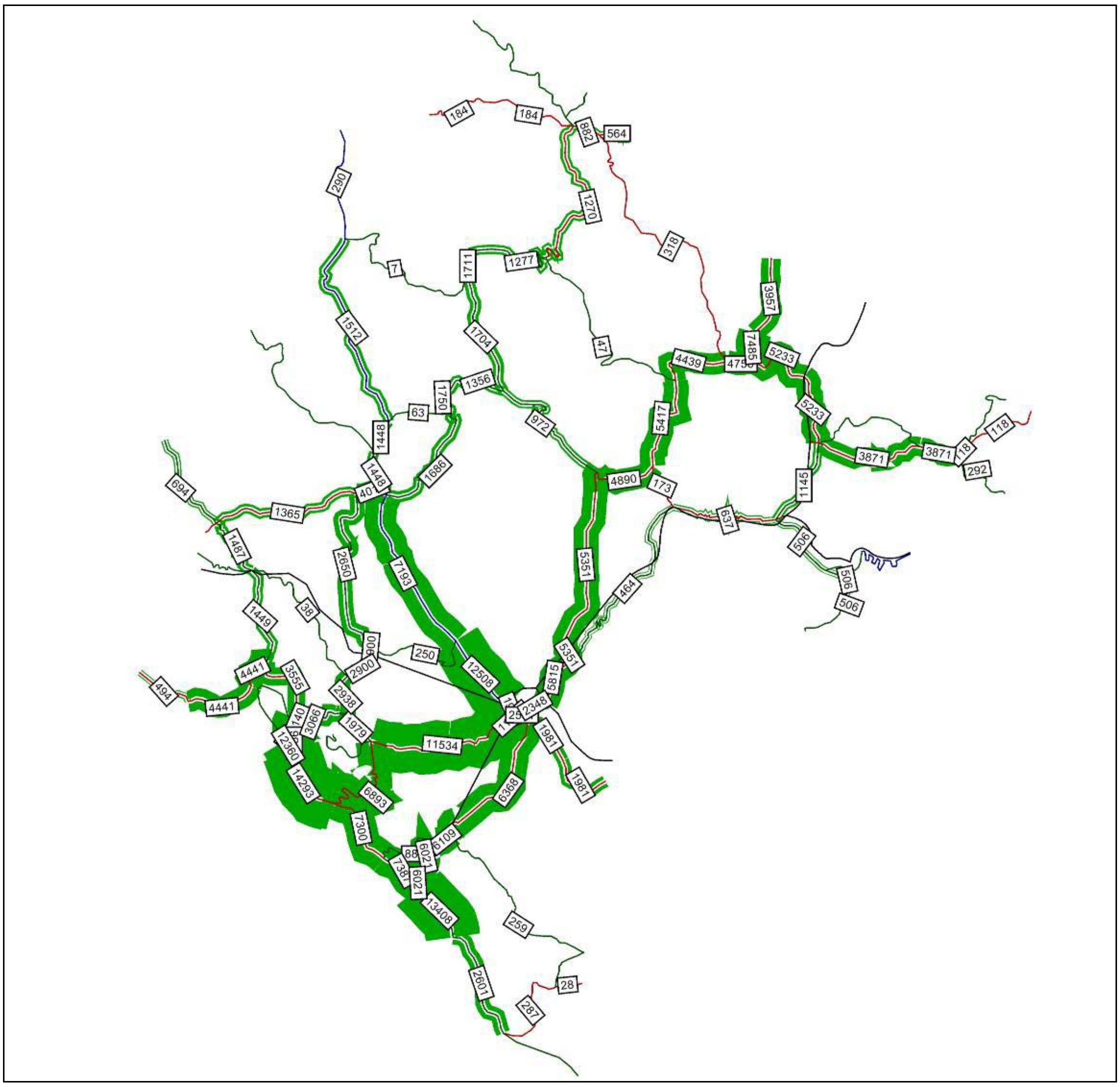
Figure A5.10 shows the assignment of the prior matrix and Figure A5.11 the assignment of the estimated matrix. This shows that matrix estimation as adjusted flows by increasing traffic levels on the Bar – Boljare corridor to match observed flows.

Figure A5.0-10: Assignment of prior matrix



Source: Consultant's analysis

Figure A5.0-11: Assignment of estimated matrix

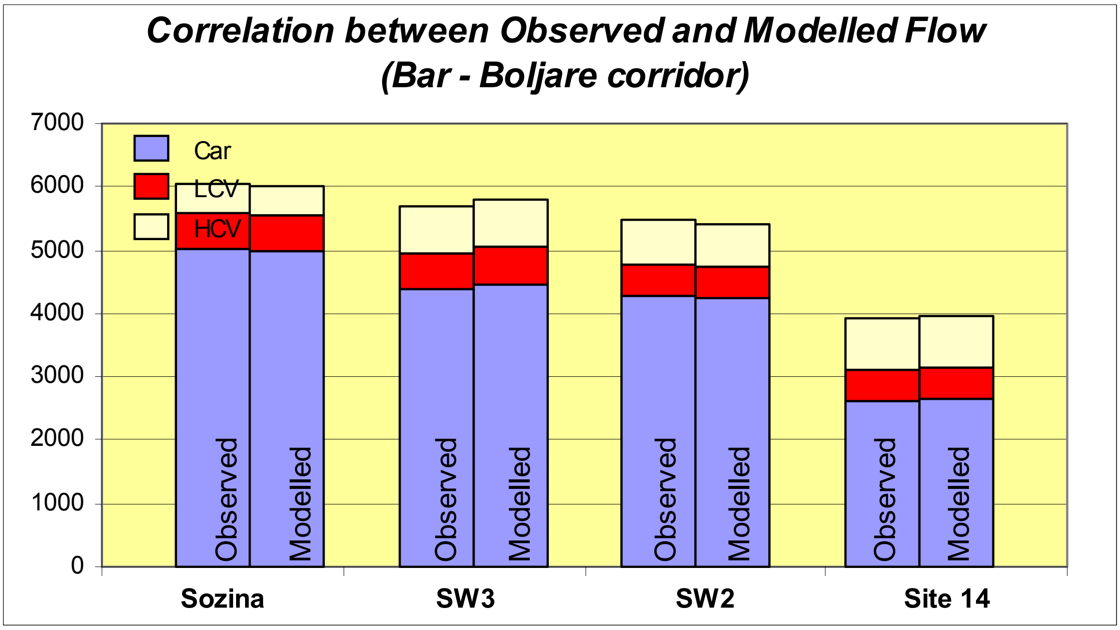


Source: Consultant's analysis

Focus on Bar – Boljare corridor

The focus on the study is on the Bar – Boljare corridor and the modelled flows for each user class must represent observed closely. Figure A5.12 demonstrates that, on the corridor, modelled flows matched very closely observed flows for all cars, LGVs and HGVs. It also shows that the volume of strategic traffic decreases continuously form the coast to the Serbian border.

Figure A5.0-12: Correlation between and modeled flow on Bar – Boljare corridor



Source: Consultant's analysis

Validation

No validation of the model has been carried out due to the lack of reliable count data. The only set available was from the Crnagoraput and collected on the main and regional roads for a single day (24 hours) in September 2007. This data was considered not to give sufficient information in terms of average annual flow (AADT) as this is only a "spot" count on a single day missing the weekly variation, monthly variation and annual variation and not robust enough to use for validation.

The lack of validation is not considered important because the counts used for calibration are well spread across the network. On the Bar – Boljare corridor specifically, the coverage of the calibration data provides a robust set of observed information for comparison with the modelled outputs.

Appendix 6 – Estimated matrices

Car estimated matrix including intrazonal - AADT in vehicles

Car	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	13	34	28	354	231	44	47	246	94	302	28	0	3	0	0	0	5	2	0	29	12	11	47	30	0	12	0	0	0	0	**1573**
2	0	50	11	1599	157	11	60	258	15	235	0	0	0	0	0	3	0	2	0	3	7	0	0	21	0	0	0	0	0	0	**2433**
3	0	15	11	1576	360	66	123	315	20	498	0	0	6	0	1	4	2	4	0	3	22	0	0	30	0	23	0	0	0	0	**3080**
4	276	1599	1619	2104	1523	168	332	388	34	918	0	3	7	0	1	2	2	6	0	10	22	76	63	52	0	14	2	0	0	1	**9223**
5	168	226	286	1634	1855	135	80	230	142	1171	0	0	17	4	0	34	11	22	23	46	91	31	24	183	0	0	0	0	2	0	**6416**
6	26	65	48	182	51	17	15	40	21	308	0	0	0	0	0	0	0	2	18	0	34	14	0	58	16	0	0	0	0	0	**914**
7	29	45	75	382	89	12	10	172	62	2445	0	0	6	0	1	0	7	1	0	0	20	0	25	23	1	0	0	0	0	0	**3405**
8	221	149	220	121	447	36	113	692	15	1935	461	90	22	1	1	61	14	7	1	62	22	15	87	123	0	0	0	0	0	0	**4918**
9	47	11	11	34	0	0	15	0	170	2052	52	0	6	0	1	0	0	0	0	0	19	0	0	3	0	0	0	0	0	0	**2421**
10	211	125	380	976	1264	298	2928	2031	2039	10240	19	11	369	14	12	32	97	48	15	107	339	19	69	192	5	627	6	0	0	0	**22474**
11	0	0	0	0	26	26	0	436	0	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**560**
12	0	0	0	0	14	0	0	257	0	32	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	**320**
13	2	0	2	19	15	24	6	41	9	387	0	0	1265	23	6	0	485	19	2	20	198	0	0	72	1	0	0	0	1	0	**2598**
14	1	0	0	0	2	0	0	0	0	6	0	0	92	0	0	0	0	17	60	0	64	0	0	15	0	0	0	0	0	0	**258**
15	0	0	0	0	0	0	0	1	0	19	0	0	0	0	0	0	0	0	60	0	117	0	2	10	29	0	5	0	0	8	**252**
16	0	0	4	5	0	0	0	136	0	72	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	**237**
17	2	2	2	4	24	14	15	41	0	161	0	0	424	0	7	0	0	104	19	0	94	0	17	0	0	0	0	0	0	0	**931**
18	1	1	1	5	11	1	2	4	0	53	0	0	3	0	0	0	98	693	1012	19	1243	0	15	191	89	0	5	0	0	0	**3449**
19	1	0	0	4	1	4	1	0	0	11	0	0	2	0	78	0	36	1011	0	15	286	0	15	0	0	5	0	0	0	0	**1470**
20	24	22	8	4	39	30	0	15	18	106	0	0	0	0	0	0	0	41	0	0	32	4	18	0	0	0	0	0	0	0	**361**
21	21	5	7	20	24	14	15	57	33	363	0	0	250	60	41	0	67	1412	193	32	9274	0	52	382	23	0	0	0	0	27	**12373**
22	0	11	0	40	62	42	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	12	0	0	0	0	**203**
23	0	43	24	18	31	13	13	33	0	85	0	0	11	0	0	0	0	41	23	0	0	0	18	24	0	0	0	0	0	0	**377**
24	22	13	17	47	132	39	12	131	15	227	0	0	0	17	10	0	0	162	0	62	570	1	0	0	0	0	0	0	0	0	**1478**
25	0	1	0	0	0	10	0	0	0	9	0	0	2	0	31	0	0	31	0	0	19	0	0	0	0	0	0	0	0	16	**119**
26	0	0	0	9	17	11	0	111	0	592	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	**741**
27	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	**7**
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
29	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	**11**
30	2	0	2	1	0	4	7	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	14	0	0	0	0	**48**
	1069	**2419**	**2758**	**9141**	**6377**	**1021**	**3792**	**5634**	**2688**	**22342**	**560**	**104**	**2486**	**120**	**192**	**136**	**826**	**3644**	**1427**	**425**	**####**	**172**	**453**	**1423**	**173**	**706**	**17**	**0**	**3**	**52**	**82654**

Source: consultant's analysis

Car estimated matrix excluding intrazonal – AADT in vehicles

Car	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	0	34	28	354	231	44	47	246	94	302	28	0	3	0	0	0	5	2	0	29	12	11	47	30	0	12	0	0	0	0	**1561**
2	0	0	11	1599	157	11	60	258	15	235	0	0	0	0	0	3	0	2	0	3	7	0	0	21	0	0	0	0	0	0	**2383**
3	0	15	0	1576	360	66	123	315	20	498	0	0	6	0	1	4	2	4	0	3	22	0	0	30	0	23	0	0	0	0	**3069**
4	276	1599	1619	0	1523	168	332	388	34	918	0	3	7	0	1	2	2	6	0	10	22	76	63	52	0	14	2	0	0	1	**7119**
5	168	226	286	1634	0	135	80	230	142	1171	0	0	17	4	0	34	11	22	23	46	91	31	24	183	0	0	0	0	2	0	**4561**
6	26	65	48	182	51	0	15	40	21	308	0	0	0	0	0	0	0	2	18	0	34	14	0	58	16	0	0	0	0	0	**897**
7	29	45	75	382	89	12	0	172	62	2445	0	0	6	0	1	0	7	1	0	0	20	0	25	23	1	0	0	0	0	0	**3395**
8	221	149	220	121	447	36	113	0	15	1935	461	90	22	1	1	61	14	7	1	62	22	15	87	123	0	0	0	0	0	0	**4227**
9	47	11	11	34	0	0	15	0	0	2052	52	0	6	0	1	0	0	0	0	0	19	0	0	3	0	0	0	0	0	0	**2250**
10	211	125	380	976	1264	298	2928	2031	2039	0	19	11	369	14	12	32	97	48	15	107	339	19	69	192	5	627	6	0	0	0	**12234**
11	0	0	0	0	26	26	0	436	0	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**560**
12	0	0	0	0	14	0	0	257	0	32	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	**320**
13	2	0	2	19	15	24	6	41	9	387	0	0	0	23	6	0	485	19	2	20	198	0	0	72	1	0	0	0	1	0	**1333**
14	1	0	0	0	2	0	0	0	0	6	0	0	92	0	0	0	0	17	60	0	64	0	0	15	0	0	0	0	0	0	**258**
15	0	0	0	0	0	0	0	1	0	19	0	0	0	0	0	0	0	0	60	0	117	0	2	10	29	0	5	0	0	8	**252**
16	0	0	4	5	0	0	0	136	0	72	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	**237**
17	2	2	2	4	24	14	15	41	0	161	0	0	424	0	7	0	0	104	19	0	94	0	17	0	0	0	0	0	0	0	**931**
18	1	1	1	5	11	1	2	4	0	53	0	0	3	0	0	0	98	0	1012	19	1243	0	15	191	89	0	5	0	0	0	**2756**
19	1	0	0	4	1	4	1	0	0	11	0	0	2	0	78	0	36	1011	0	15	286	0	15	0	0	5	0	0	0	0	**1470**
20	24	22	8	4	39	30	0	15	18	106	0	0	0	0	0	0	0	41	0	0	32	4	18	0	0	0	0	0	0	0	**361**
21	21	5	7	20	24	14	15	57	33	363	0	0	250	60	41	0	67	1412	193	32	0	0	52	382	23	0	0	0	0	27	**3099**
22	0	11	0	40	62	42	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	12	0	0	0	0	**203**
23	0	43	24	18	31	13	13	33	0	85	0	0	11	0	0	0	0	41	23	0	0	0	0	24	0	0	0	0	0	0	**360**
24	22	13	17	47	132	39	12	131	15	227	0	0	0	17	10	0	0	162	0	62	570	1	0	0	0	0	0	0	0	0	**1478**
25	0	1	0	0	0	10	0	0	0	9	0	0	2	0	31	0	0	31	0	0	19	0	0	0	0	0	0	0	0	16	**119**
26	0	0	0	9	17	11	0	111	0	592	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	**741**
27	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	**7**
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
29	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	**11**
30	2	0	2	1	0	4	7	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	14	0	0	0	0	**48**
	1056	**2369**	**2747**	**7036**	**4522**	**1004**	**3782**	**4942**	**2518**	**12102**	**560**	**104**	**1221**	**120**	**192**	**136**	**826**	**2951**	**1427**	**425**	**3221**	**172**	**435**	**1423**	**173**	**706**	**17**	**0**	**3**	**52**	**56242**

Source: consultant’s analysis

LGV estimated matrix including intrazonal - AADT in vehicles

LGV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	13	14	0	44	19	8	14	103	15	60	0	0	1	0	0	0	0	0	0	13	1	10	0	2	0	0	0	0	0	0	**317**
2	0	0	10	163	9	7	4	23	3	16	0	0	1	0	0	0	0	0	0	0	1	10	0	0	0	0	0	0	0	0	**246**
3	0	10	11	216	36	19	26	125	0	70	0	0	0	0	0	0	0	0	0	5	0	0	0	2	0	0	0	0	0	0	**520**
4	57	196	93	142	227	68	138	44	4	240	0	0	0	0	0	3	0	0	1	0	0	10	8	21	0	0	0	0	0	0	**1252**
5	47	56	35	194	282	0	29	51	39	56	0	0	0	0	0	0	0	6	0	13	15	0	0	17	0	0	0	0	0	0	**841**
6	15	6	6	59	29	14	23	0	0	85	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	**238**
7	4	14	13	160	58	14	0	66	6	139	0	0	2	0	0	0	1	0	0	0	0	0	18	0	0	0	3	0	0	0	**497**
8	108	23	68	18	16	25	11	126	0	272	64	51	0	0	0	0	3	3	1	13	0	0	0	26	0	0	0	0	0	0	**829**
9	0	0	2	19	0	27	17	15	29	313	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**421**
10	36	22	35	205	127	54	208	452	209	923	0	0	23	3	1	7	6	8	3	24	36	0	30	66	2	122	5	0	1	0	**2607**
11	0	0	0	0	0	0	0	20	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**41**
12	0	0	0	0	0	0	0	25	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**51**
13	1	1	0	3	4	0	2	0	0	69	0	0	123	0	0	0	28	0	0	0	28	0	0	0	0	0	0	0	0	0	**259**
14	0	0	0	0	0	0	0	0	0	1	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**
15	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	**16**
16	0	0	0	0	0	0	2	51	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**60**
17	1	0	0	0	1	0	0	13	1	5	0	0	27	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	**64**
18	0	0	1	1	0	0	0	1	0	4	0	0	0	0	0	0	15	18	143	31	197	0	0	16	28	0	0	0	0	0	**456**
19	0	0	0	0	1	0	0	0	0	4	0	0	2	0	0	0	0	131	0	0	81	0	0	23	0	0	0	0	0	0	**241**
20	7	3	0	0	8	4	0	29	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**78**
21	2	3	0	0	3	0	0	4	3	26	0	0	37	0	32	0	0	172	89	0	1057	0	0	101	0	0	0	0	0	0	**1528**
22	0	0	0	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**12**
23	0	0	0	0	14	0	17	20	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	**79**
24	2	2	2	9	9	0	0	37	1	47	0	0	24	9	0	0	0	37	0	0	109	0	0	0	0	0	0	0	0	0	**288**
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	**50**
26	0	0	0	0	0	0	0	0	0	139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	**153**
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
29	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	0	**28**
	293	**349**	**274**	**1241**	**846**	**241**	**493**	**1206**	**310**	**2573**	**64**	**51**	**250**	**12**	**33**	**10**	**54**	**441**	**253**	**99**	**1525**	**30**	**56**	**273**	**37**	**150**	**8**	**0**	**1**	**14**	**11187**

Source: consultant's analysis

LGV estimated matrix excluding intrazonal – AADT in vehicles

LGV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	0	14	0	44	19	8	14	103	15	60	0	0	1	0	0	0	0	0	0	13	1	10	0	2	0	0	0	0	0	0	**305**
2	0	0	10	163	9	7	4	23	3	16	0	0	1	0	0	0	0	0	0	0	1	10	0	0	0	0	0	0	0	0	**246**
3	0	10	0	216	36	19	26	125	0	70	0	0	0	0	0	0	0	0	0	5	0	0	0	2	0	0	0	0	0	0	**510**
4	57	196	93	0	227	68	138	44	4	240	0	0	0	0	0	3	0	0	1	0	0	10	8	21	0	0	0	0	0	0	**1110**
5	47	56	35	194	0	0	29	51	39	56	0	0	0	0	0	0	0	6	0	13	15	0	0	17	0	0	0	0	0	0	**559**
6	15	6	6	59	29	0	23	0	0	85	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	**224**
7	4	14	13	160	58	14	0	66	6	139	0	0	2	0	0	0	1	0	0	0	0	0	18	0	0	0	3	0	0	0	**497**
8	108	23	68	18	16	25	11	0	0	272	64	51	0	0	0	0	3	3	1	13	0	0	0	26	0	0	0	0	0	0	**703**
9	0	0	2	19	0	27	17	15	0	313	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**393**
10	36	22	35	205	127	54	208	452	209	0	0	0	23	3	1	7	6	8	3	24	36	0	30	66	2	122	5	0	1	0	**1684**
11	0	0	0	0	0	0	0	20	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**41**
12	0	0	0	0	0	0	0	25	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**51**
13	1	1	0	3	4	0	2	0	0	69	0	0	0	0	0	0	28	0	0	0	28	0	0	0	0	0	0	0	0	0	**136**
14	0	0	0	0	0	0	0	0	0	1	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**
15	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	**16**
16	0	0	0	0	0	0	2	51	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**60**
17	1	0	0	0	1	0	0	13	1	5	0	0	27	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	**64**
18	0	0	1	1	0	0	0	1	0	4	0	0	0	0	0	0	15	0	143	31	197	0	0	16	28	0	0	0	0	0	**438**
19	0	0	0	0	1	0	0	0	0	4	0	0	2	0	0	0	0	131	0	0	81	0	0	23	0	0	0	0	0	0	**241**
20	7	3	0	0	8	4	0	29	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**78**
21	2	3	0	0	3	0	0	4	3	26	0	0	37	0	32	0	0	172	89	0	0	0	0	101	0	0	0	0	0	0	**471**
22	0	0	0	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**12**
23	0	0	0	0	14	0	17	20	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	**79**
24	2	2	2	9	9	0	0	37	1	47	0	0	24	9	0	0	0	37	0	0	109	0	0	0	0	0	0	0	0	0	**288**
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	**50**
26	0	0	0	0	0	0	0	0	0	139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	**153**
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
29	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	0	**28**
	280	**349**	**264**	**1099**	**565**	**227**	**493**	**1080**	**281**	**1650**	**64**	**51**	**127**	**12**	**33**	**10**	**54**	**423**	**253**	**99**	**468**	**30**	**56**	**273**	**37**	**150**	**8**	**0**	**1**	**14**	**8451**

Source: consultant's analysis

HGV estimated matrix including intrazonal - AADT in vehicles

HGV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	0	0	0	40	109	71	5	119	0	42	0	0	0	0	0	0	0	0	0	21	2	0	13	5	0	0	0	0	0	0	**427**
2	22	44	0	229	38	0	10	59	14	13	0	0	0	0	0	0	0	0	0	3	2	0	0	5	0	0	0	0	0	0	**439**
3	0	12	0	346	50	29	5	105	0	28	0	0	0	0	0	0	0	0	0	3	5	0	0	8	0	0	0	0	0	0	**592**
4	28	209	340	53	37	0	0	153	6	61	0	0	0	0	0	0	0	0	0	0	3	0	59	4	0	0	0	0	0	0	**953**
5	95	37	44	47	121	0	44	33	0	140	0	0	0	0	0	0	0	1	1	0	4	0	3	72	2	0	7	0	0	10	**662**
6	35	11	15	3	0	0	23	11	0	64	0	0	0	0	0	0	0	0	0	6	4	20	0	26	0	0	0	0	0	0	**218**
7	0	0	0	44	0	36	0	0	3	58	0	0	1	0	0	0	0	0	0	0	0	5	2	3	0	0	0	0	0	0	**151**
8	110	0	69	13	112	98	0	95	0	200	2	16	0	0	0	0	0	1	1	16	12	20	7	16	0	0	0	0	0	0	**788**
9	0	0	0	0	0	0	0	0	0	149	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	**165**
10	29	11	36	100	83	38	26	441	134	555	1	0	10	0	2	6	20	3	0	38	60	9	4	61	1	0	14	0	0	5	**1687**
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
13	0	0	1	0	0	0	0	0	0	39	0	0	75	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	**117**
14	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
15	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
16	10	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
17	0	0	1	0	0	0	0	5	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**23**
18	0	0	0	0	3	0	0	0	0	3	0	0	1	0	0	0	0	22	14	22	56	0	0	0	0	0	0	0	0	0	**122**
19	0	0	0	0	1	0	0	0	0	1	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**39**
20	0	0	0	0	7	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	**43**
21	0	1	2	4	11	0	0	16	0	7	0	0	14	0	9	0	33	36	14	0	419	0	0	189	0	0	0	0	0	0	**754**
22	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**4**
23	29	0	0	31	2	1	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	16	0	7	41	0	0	0	0	**132**
24	2	0	1	15	65	11	0	111	1	72	0	0	23	6	0	0	0	6	0	0	121	0	34	0	3	0	0	0	0	0	**472**
25	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
26	0	0	0	14	0	0	0	0	0	120	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	**137**
27	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
28	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
29	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	0	0	0	0	**81**
	361	**325**	**507**	**943**	**642**	**285**	**114**	**1163**	**157**	**1603**	**3**	**16**	**125**	**44**	**11**	**6**	**52**	**71**	**30**	**108**	**707**	**73**	**138**	**388**	**13**	**122**	**21**	**0**	**0**	**16**	**8045**

Source: consultant’s analysis

HGV estimated matrix excluding intrazonal – AADT in vehicles

HGV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	0	0	0	40	109	71	5	119	0	42	0	0	0	0	0	0	0	0	0	21	2	0	13	5	0	0	0	0	0	0	**427**
2	22	0	0	229	38	0	10	59	14	13	0	0	0	0	0	0	0	0	0	3	2	0	0	5	0	0	0	0	0	0	**395**
3	0	12	0	346	50	29	5	105	0	28	0	0	0	0	0	0	0	0	0	3	5	0	0	8	0	0	0	0	0	0	**592**
4	28	209	340	0	37	0	0	153	6	61	0	0	0	0	0	0	0	0	0	0	3	0	59	4	0	0	0	0	0	0	**899**
5	95	37	44	47	0	0	44	33	0	140	0	0	0	0	0	0	0	1	1	0	4	0	3	72	2	0	7	0	0	10	**541**
6	35	11	15	3	0	0	23	11	0	64	0	0	0	0	0	0	0	0	0	6	4	20	0	26	0	0	0	0	0	0	**218**
7	0	0	0	44	0	36	0	0	3	58	0	0	1	0	0	0	0	0	0	0	0	5	2	3	0	0	0	0	0	0	**151**
8	110	0	69	13	112	98	0	0	0	200	2	16	0	0	0	0	0	1	1	16	12	20	7	16	0	0	0	0	0	0	**693**
9	0	0	0	0	0	0	0	0	0	149	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	**165**
10	29	11	36	100	83	38	26	441	134	0	1	0	10	0	2	6	20	3	0	38	60	9	4	61	1	0	14	0	0	5	**1132**
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
13	0	0	1	0	0	0	0	0	0	39	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	**42**
14	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
15	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
16	10	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
17	0	0	1	0	0	0	0	5	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**23**
18	0	0	0	0	3	0	0	0	0	3	0	0	1	0	0	0	0	0	14	22	56	0	0	0	0	0	0	0	0	0	**100**
19	0	0	0	0	1	0	0	0	0	1	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**39**
20	0	0	0	0	7	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	**43**
21	0	1	2	4	11	0	0	16	0	7	0	0	14	0	9	0	33	36	14	0	0	0	0	189	0	0	0	0	0	0	**335**
22	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**4**
23	29	0	0	31	2	1	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	41	0	0	0	0	**116**
24	2	0	1	15	65	11	0	111	1	72	0	0	23	6	0	0	0	6	0	0	121	0	34	0	3	0	0	0	0	0	**472**
25	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
26	0	0	0	14	0	0	0	0	0	120	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	**137**
27	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
28	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
29	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	0	0	0	0	**81**
	361	**280**	**507**	**890**	**521**	**285**	**114**	**1068**	**157**	**1048**	**3**	**16**	**49**	**44**	**11**	**6**	**52**	**49**	**30**	**108**	**288**	**73**	**123**	**388**	**13**	**122**	**21**	**0**	**0**	**16**	**6644**

Source: consultant's analysis

Appendix 7 – Network statistics and traffic patterns

Network statistics

Global network statistics include the overall average speed, average travel and average travel time for each vehicle class. These are given for each forecast year in Tables A7.1 to A7.4. For the DS, these include the effect of generated traffic.

The DM figures show that the average network speed[29] drops significantly in 2016 but then improves in 2026, thanks to the additional road schemes but slows down again in 2036. In the mean time, the average travel distance remains fairly constant but average travel time shows a constant increase over time. This demonstrates that on the corridors with great demand congestion levels increase significantly.

Scenario 9 is clearly the most beneficial in terms of improved speeds and reduced travel times, as the entire East West axis benefits from improvements. In the early years both scenarios 1 and 10 show similar travel time improvements but over the years, as scenario 10 is built where the demand for travel is, it seems to perform better than scenario 1.

Overall the average travel distance is not really affected by the addition of any section of the proposed motorway.

Table A7.1: Network statistics for year 2007

Average Network Speed (km/h)				
Modes	Base 2007	DS07 Sc1	DS07 Sc9	DS07 Sc10
Car	51.8	39.6	43.7	41.9
LGV	51.8	39.6	43.7	41.9
HGV	51.8	39.6	42.8	41.3

Average Travel Distance				
Modes	Base 2007	DS07 Sc1	DS07 Sc9	DS07 Sc10
Car	13.0	13.0	12.9	12.7
LGV	13.6	13.5	14.1	13.9
HGV	13.5	13.2	13.6	13.3

Average Travel Time				
Modes	Base 2007	DS07 Sc1	DS07 Sc9	DS07 Sc10
Car	15.0	19.7	17.7	18.1
LGV	15.7	20.4	19.4	19.8
HGV	15.6	20.0	19.1	19.4

Source: Consultant's analysis

[29] Direct average of all link speeds

Table A7.2: Network statistics for year 2016

Average Network Speed (km/h)				
Modes	DM 2016	DS16 Sc1	DS16 Sc9	DS16 Sc10
Car	49.1	37.7	42.1	40.1
LGV	49.1	37.7	42.1	40.1
HGV	49.1	37.6	41.5	39.7

Average Travel Distance				
Modes	DM 2016	DS16 Sc1	DS16 Sc9	DS16 Sc10
Car	13.0	12.9	12.7	12.5
LGV	13.6	13.6	13.9	13.7
HGV	13.3	13.2	13.5	13.2

Average Travel Time				
Modes	DM 2016	DS16 Sc1	DS16 Sc9	DS16 Sc10
Car	15.8	20.6	18.1	18.8
LGV	16.6	21.7	19.9	20.5
HGV	16.2	21.0	19.5	20.0

Source: Consultant's analysis

Table A7.3: Network statistics for year 2026

Average Network Speed (km/h)				
Modes	DM 2026	DS26 Sc1	DS26 Sc9	DS26 Sc10
Car	51.8	39.6	43.7	41.9
LGV	51.8	39.6	43.7	41.9
HGV	51.8	39.6	42.8	41.3

Average Travel Distance				
Modes	DM 2026	DS26 Sc1	DS26 Sc9	DS26 Sc10
Car	13.0	13.0	12.9	12.7
LGV	13.6	13.5	14.1	13.9
HGV	13.5	13.2	13.6	13.3

Average Travel Time				
Modes	DM 2026	DS26 Sc1	DS26 Sc9	DS26 Sc10
Car	15.0	19.7	17.7	18.1
LGV	15.7	20.4	19.4	19.8
HGV	15.6	20.0	19.1	19.4

Source: Consultant's analysis

Table A7.4: Network statistics for year 2036

Average Network Speed (km/h)				
Modes	DM 2036	DS36 Sc1	DS36 Sc9	DS36 Sc10
Car	49.1	37.7	42.1	40.1
LGV	49.1	37.7	42.1	40.1
HGV	49.1	37.6	41.5	39.7

Average Travel Distance				
Modes	DM 2036	DS36 Sc1	DS36 Sc9	DS36 Sc10
Car	13.3	13.5	12.9	12.7
LGV	13.5	13.8	14.1	14.0
HGV	13.5	13.7	13.9	13.6

Average Travel Time				
Modes	DM 2036	DS36 Sc1	DS36 Sc9	DS36 Sc10
Car	16.3	21.5	18.4	19.0
LGV	16.4	22.0	20.1	20.9
HGV	16.5	21.8	20.1	20.6

Source: Consultant's analysis

Traffic patterns

The plots in **Appendix 12** depict the flow, speeds and volume over capacity ratios[30] for the DM and scenario 9 for year 2007. These show that there is a clear transfer form the old road to the new motorway on the southern sections and towards the north up to Matesevo. From Matesevo onwards traffic splits between the existing road and new motorway. Speeds are much higher on the motorway than anywhere else on the network and volume over capacity ratios are low confirming that in the base year traffic levels are far from congesting the network.

The same set of plots is provided for year 2036 in **appendix 13**. These suggest that that in 2036, in the DM scenario, two areas are clearly under pressure:

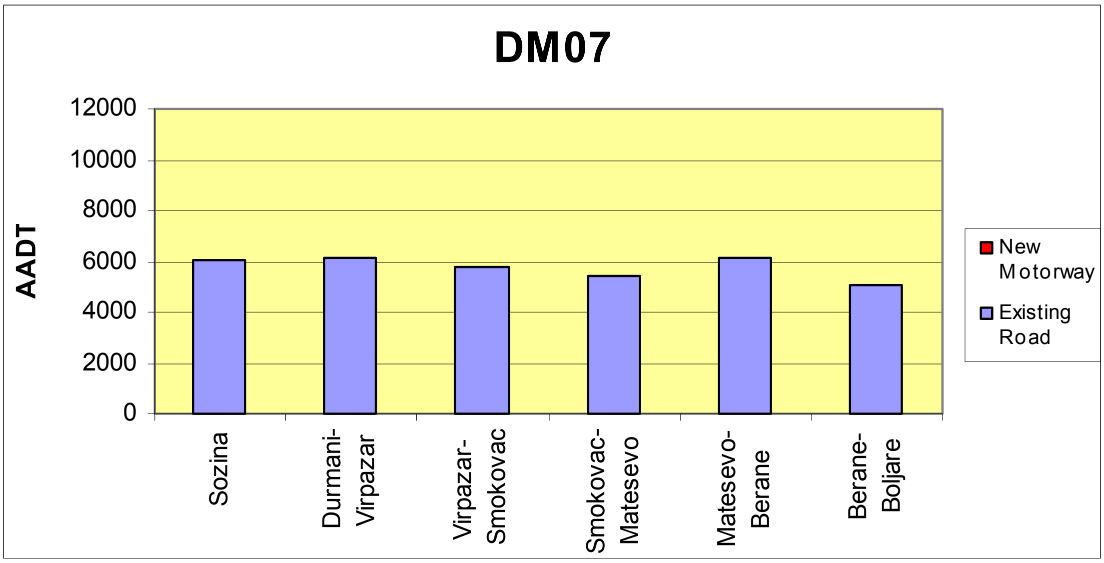
- The coastal area;
- The Bar to Serbia corridor.

In the costal area, the addition of the Adriatic highway is vital, as even with this scheme in place the road network in the area depicts high flows and volume over capacity ratios above 100%. On the Bar – Boljare corridor, some of the expected AADT flow are high, in excess of 27,000 vehicles per day, and the strategic network, constituted mainly single two carriageways (one lane in each direction) cannot cope with the demand.

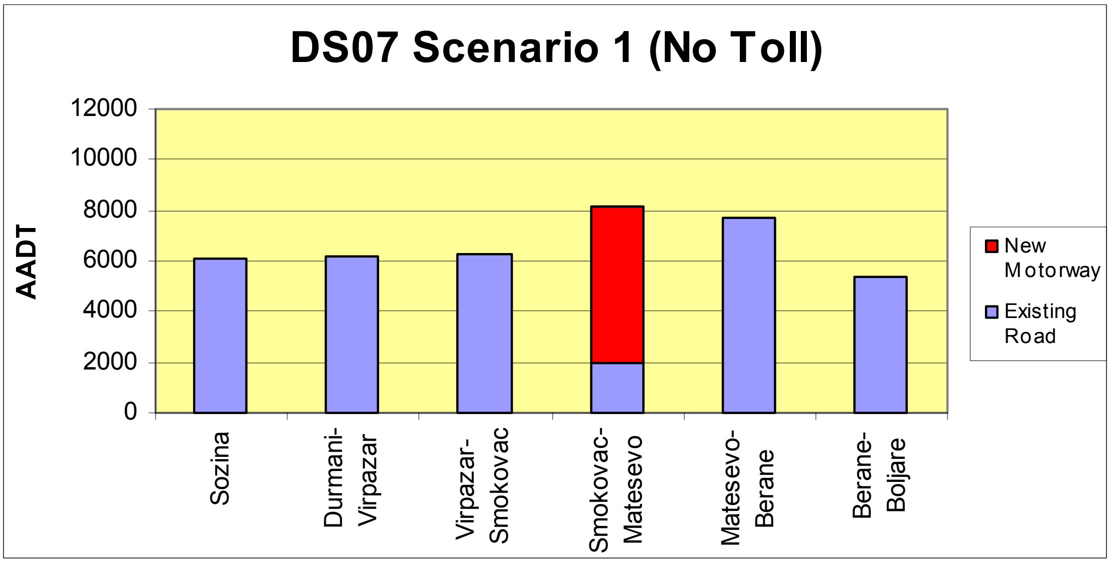
[30] The volume over capacity ratio represents a measure of congestion as it assess how far form the maximum capacity of the road the flow is. A volume over capacity ratio above 85 represents a road which is close to capacity, levels above 100 represent heavily congested roads.

In scenario S9, there is a clear transfer from the old road to the new motorway in the South. Flow at the Sozina tunnel jump from about 27,000 vehicles a day to 40,000 vehicles a day. After Matesevo the picture is different, and the old road to the border remains significantly used. The main reason for this is that access to the northwestern parts of Montenegro from the south is still the best through the old road.

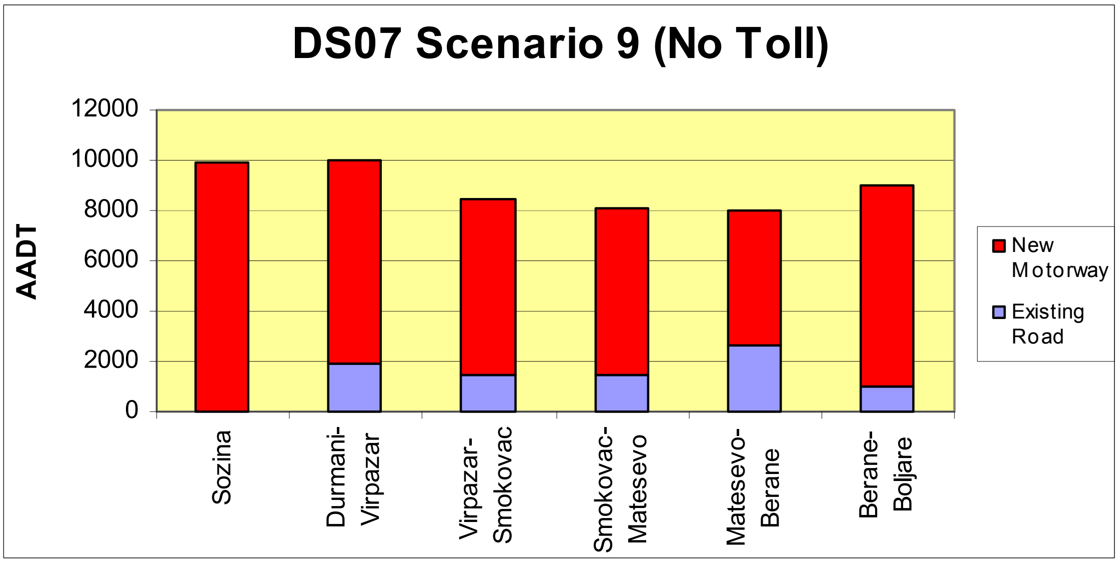
Appendix 8 – Traffic flows on Bar – Boljare corridor – year 2007



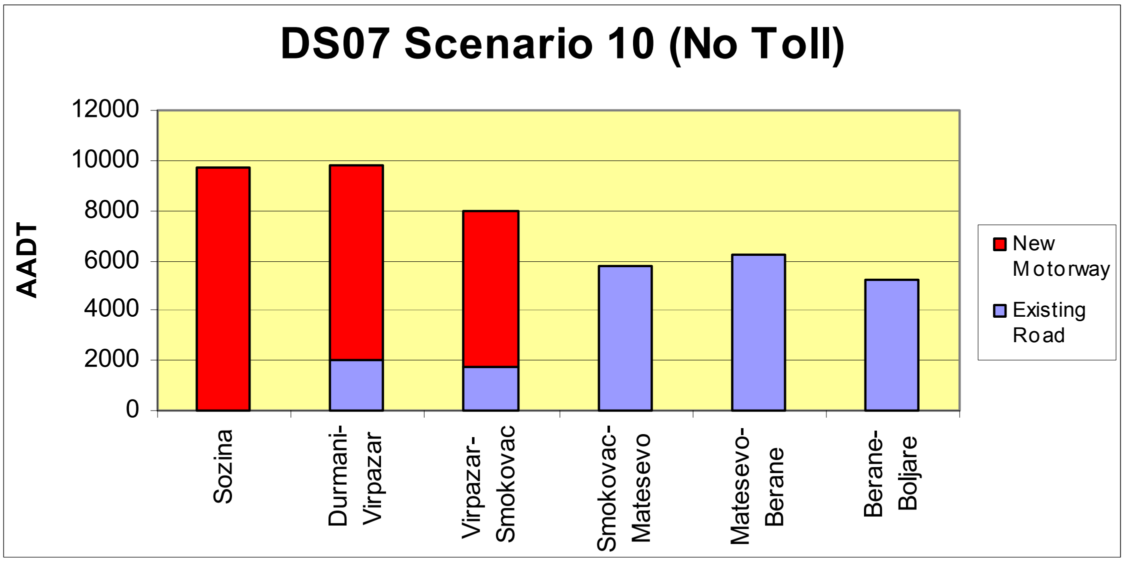
Source: consultant's analysis



Source: consultant's analysis

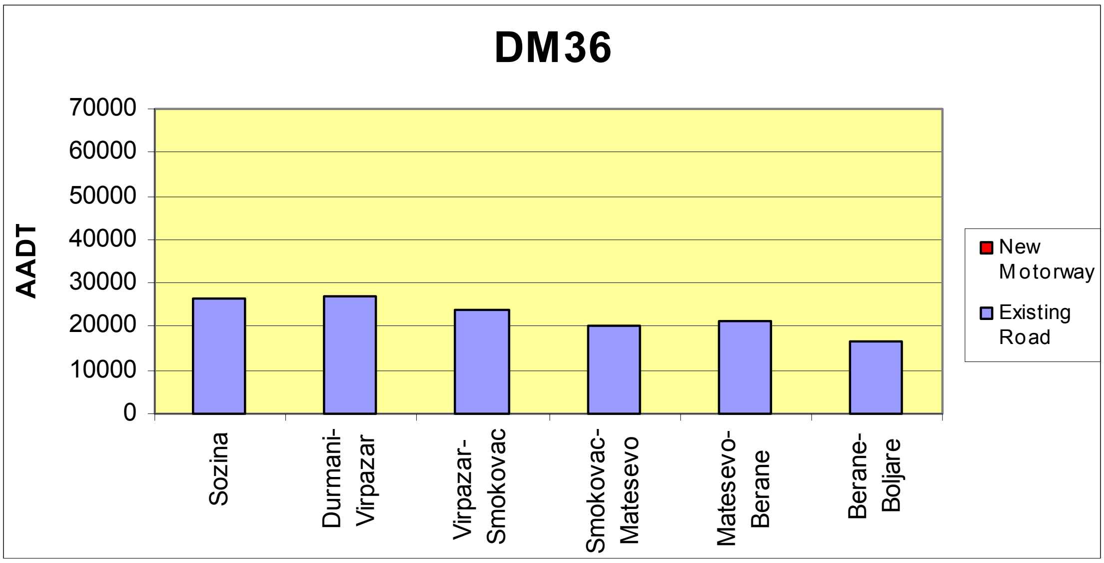


Source: consultant's analysis

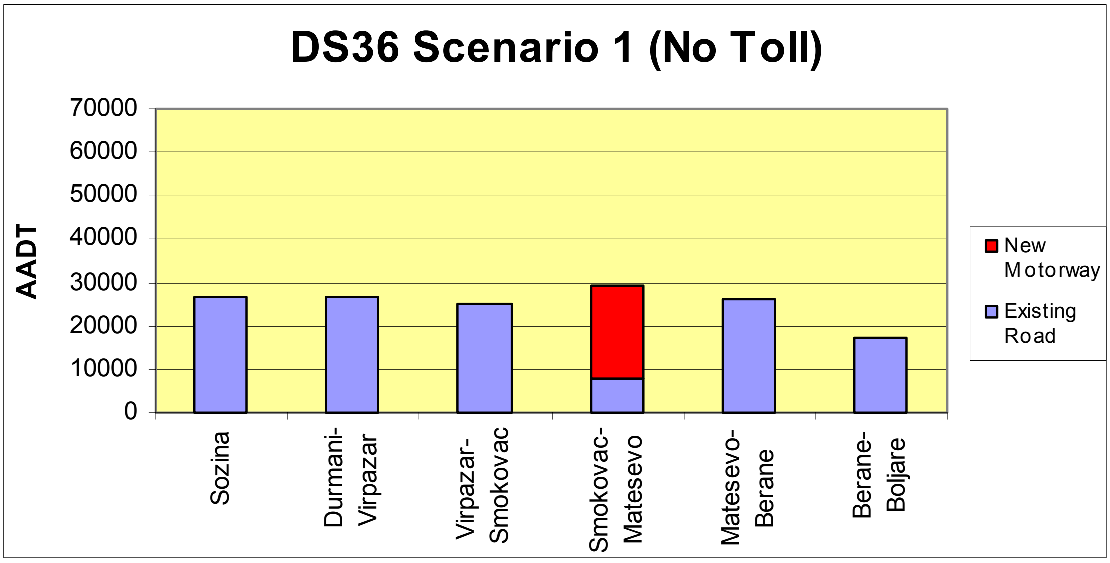


Source: consultant's analysis

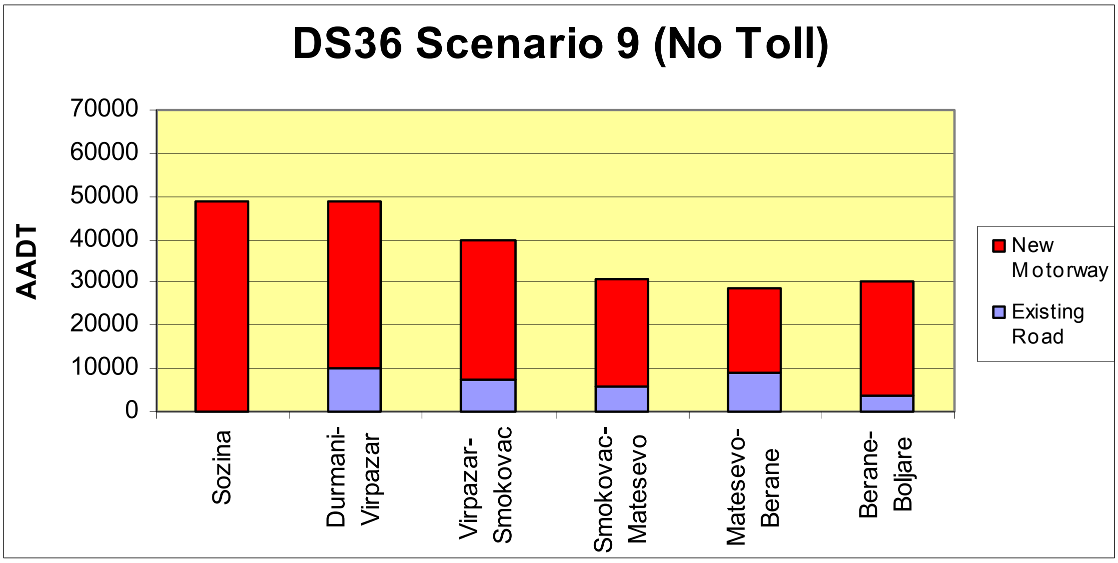
Appendix 9 – Traffic flows on Bar – Boljare corridor – year 2036



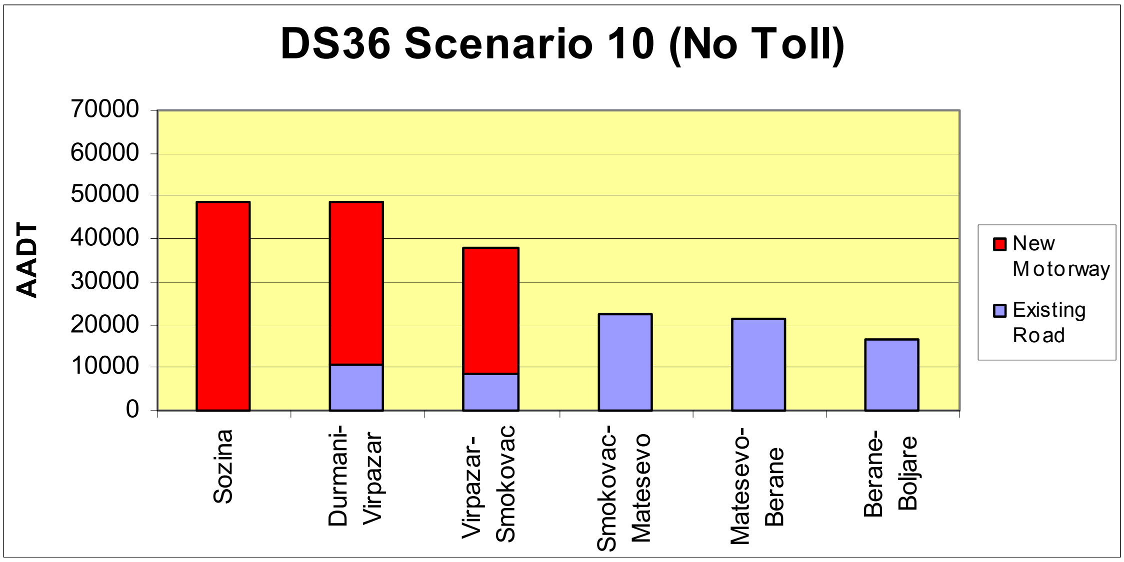
Source: consultant's analysis



Source: consultant's analysis

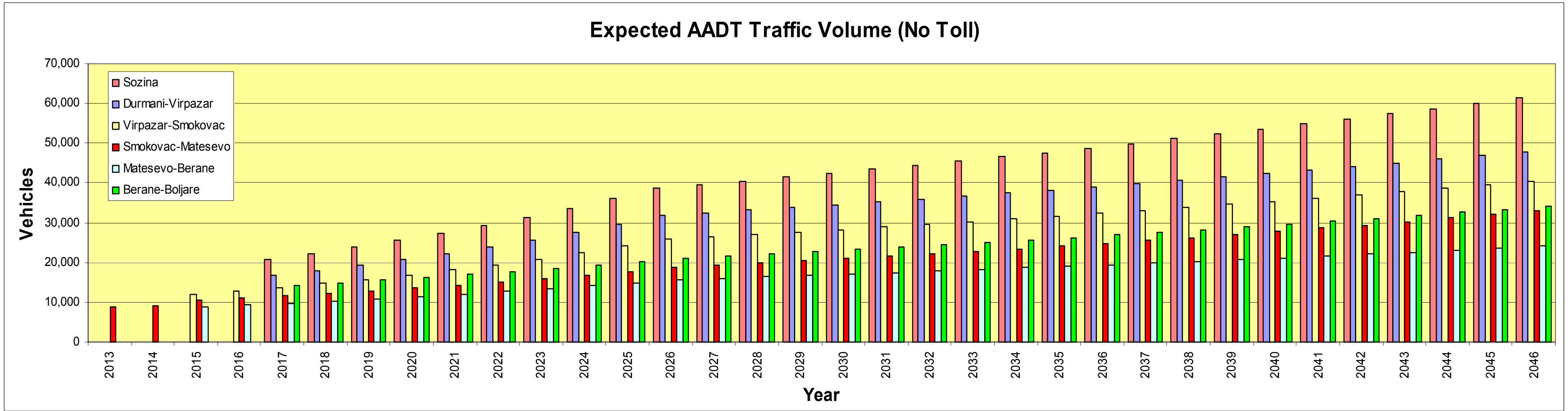


Source: consultant's analysis



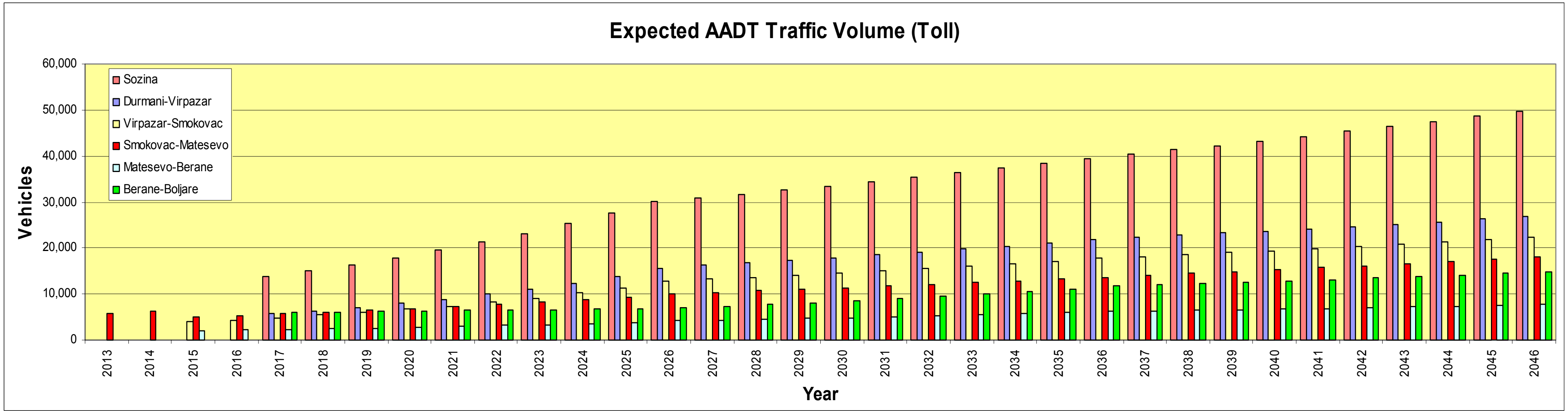
Appendix 10 – Expected AADT volumes on Bar – Boljare motorway

Expected AADT volumes on Bar – Boljare motorway – no toll case



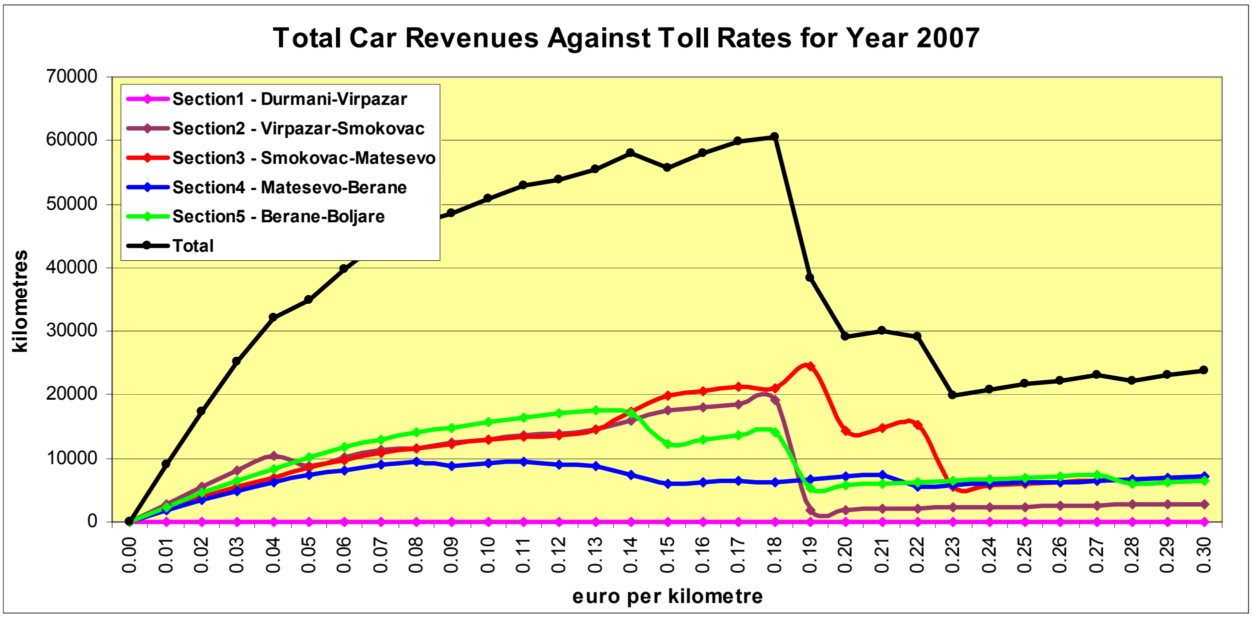
Source: consultant's analysis

Expected AADT volumes on Bar – Boljare motorway – toll case

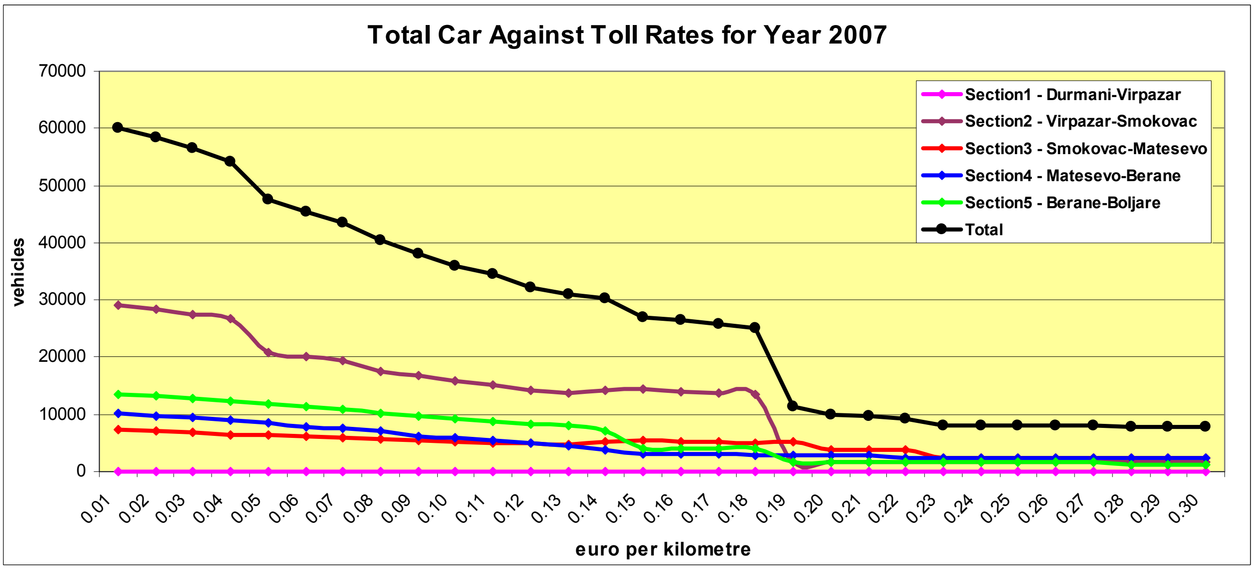


Source: consultant's analysis

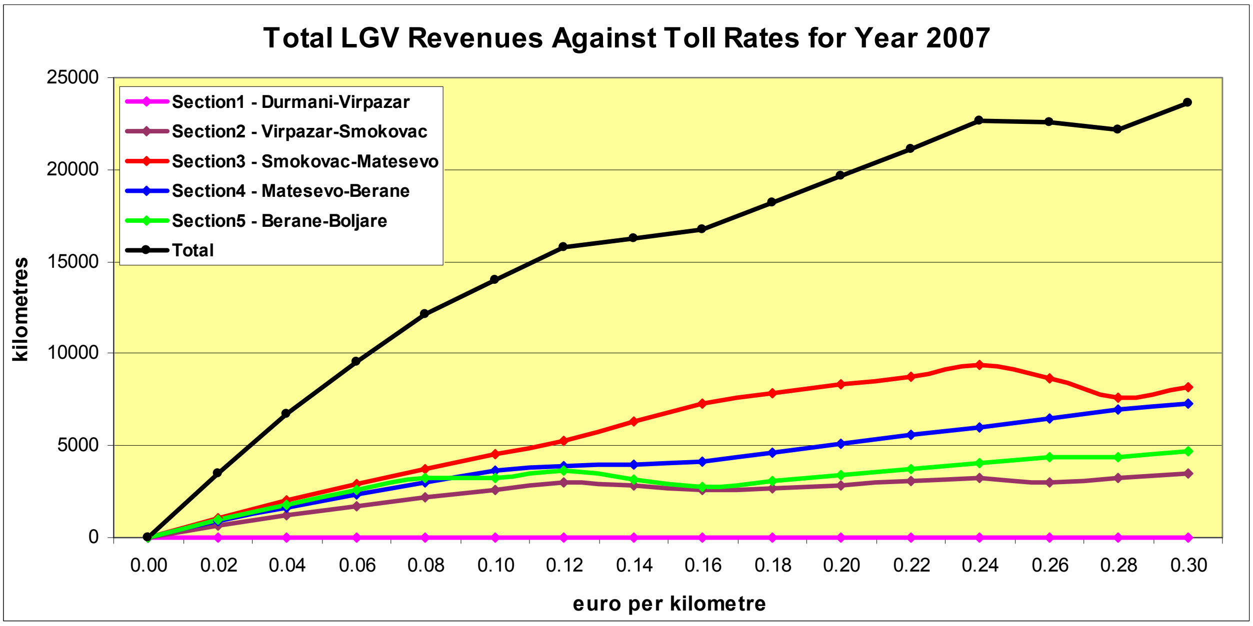
Appendix 11 – Toll optimisation per section



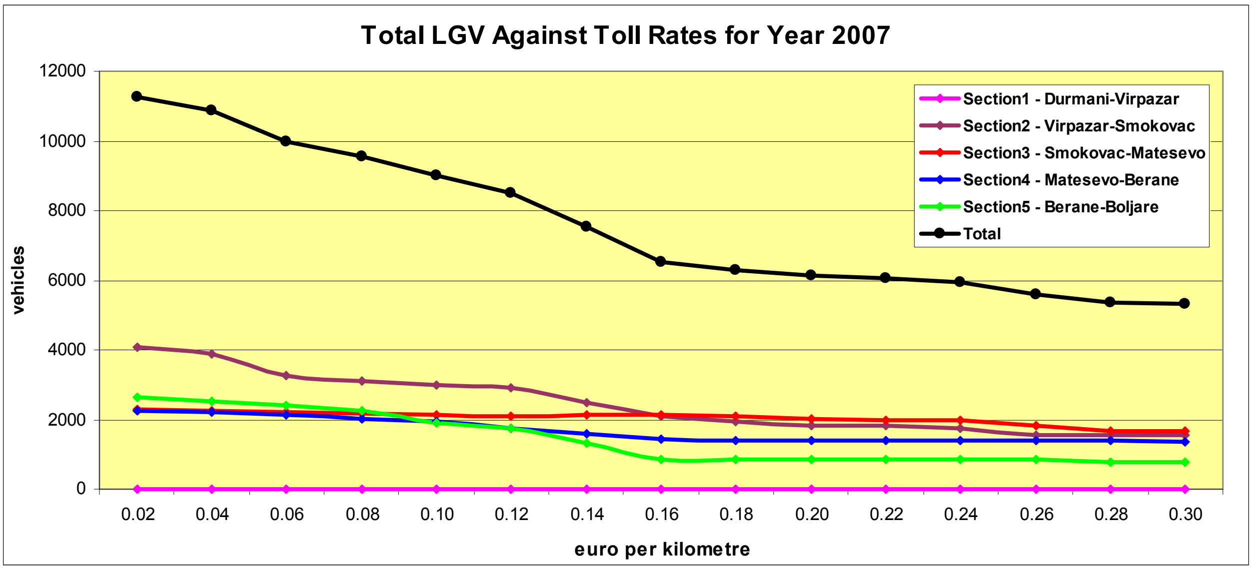
Source: consultant's analysis



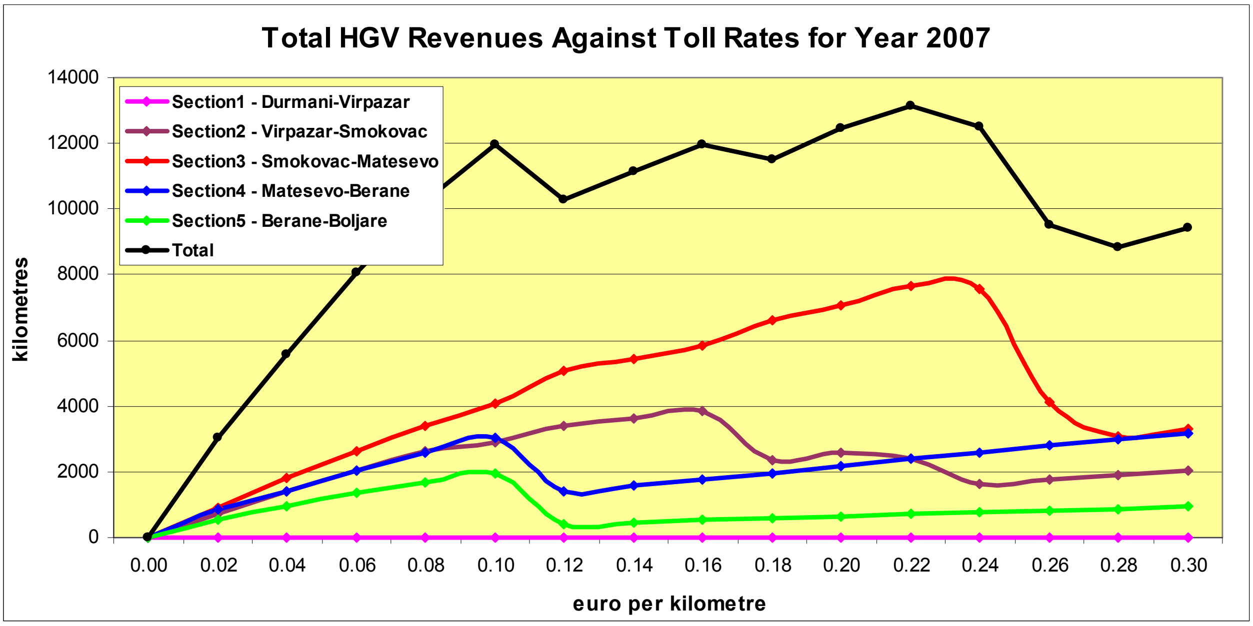
Source: consultant's analysis



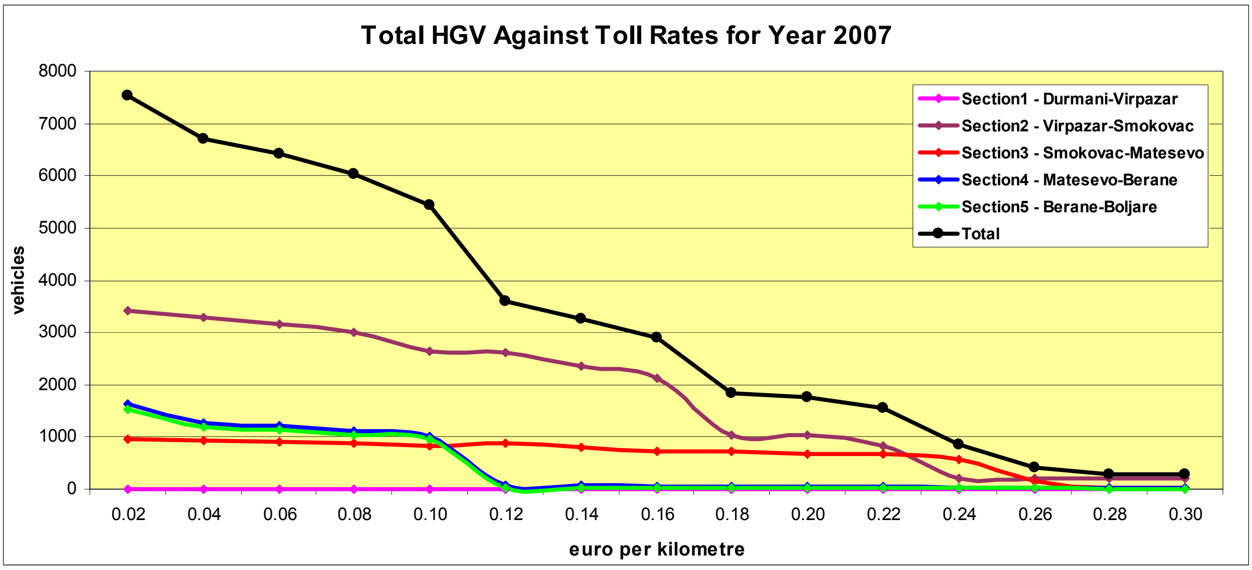
Source: consultant's analysis



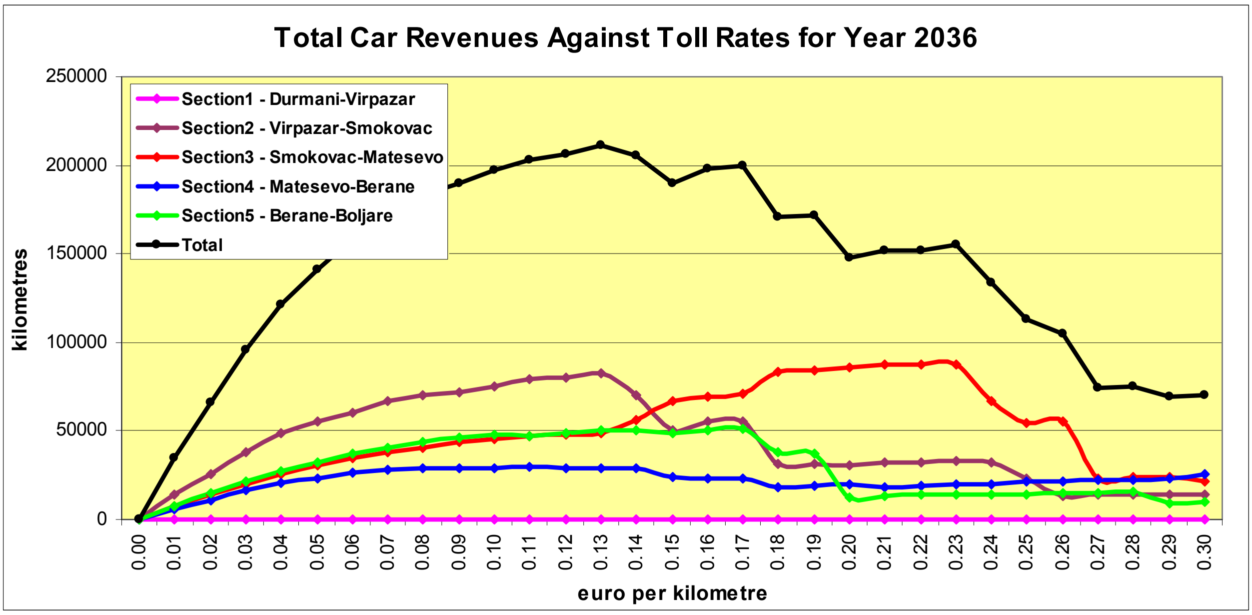
Source: consultant's analysis



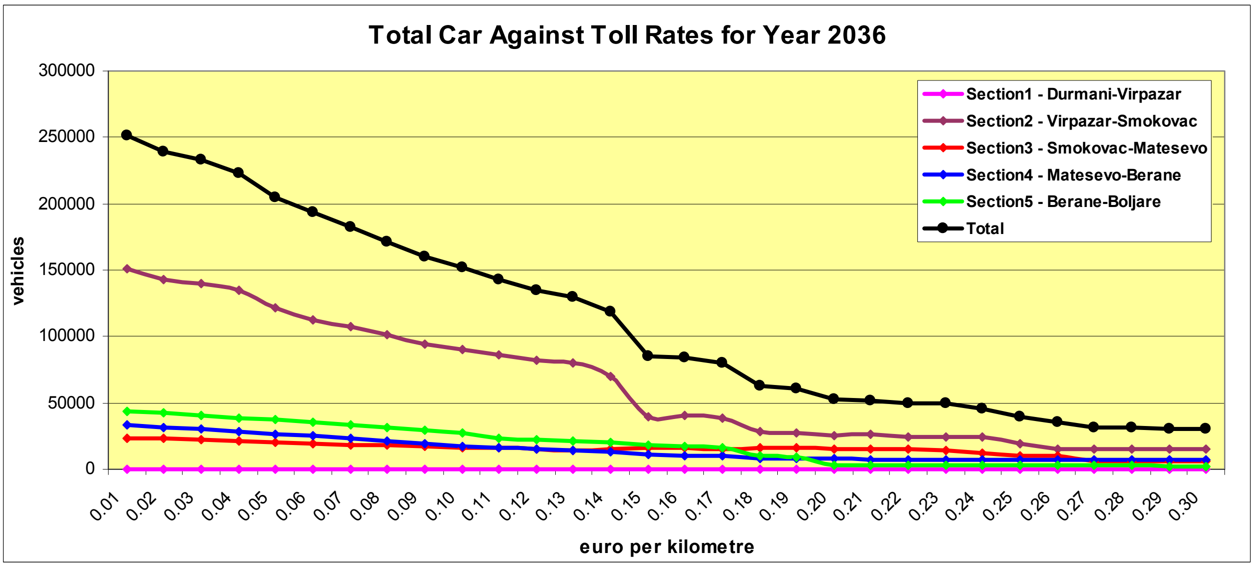
Source: consultant's analysis



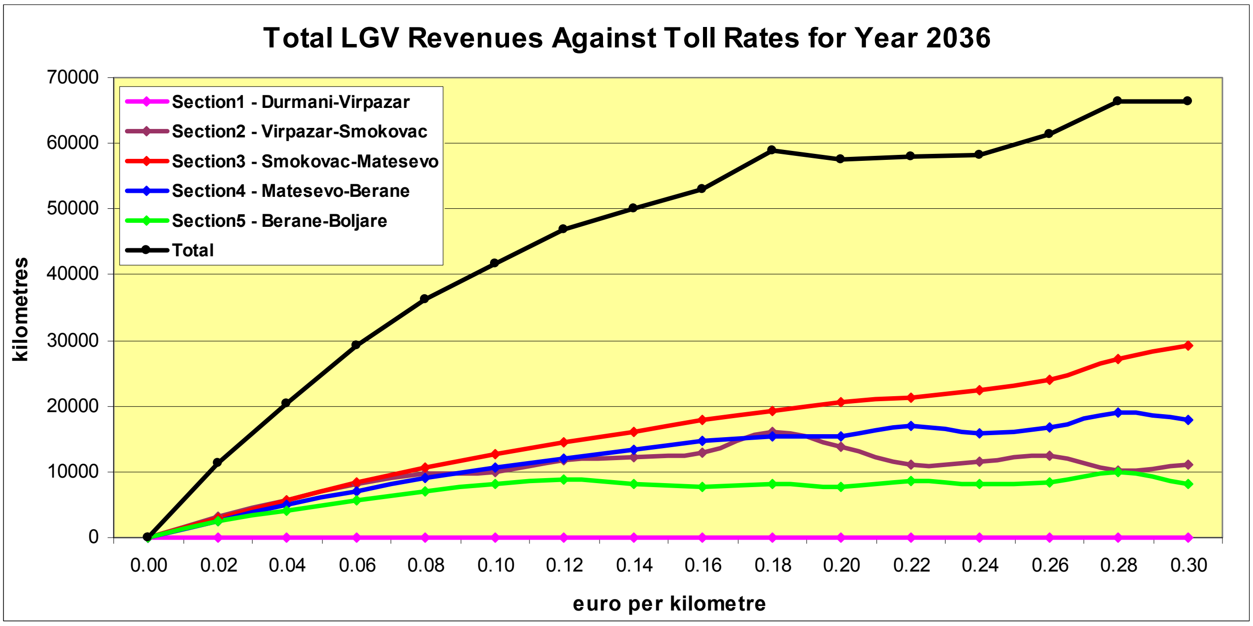
Source: consultant's analysis



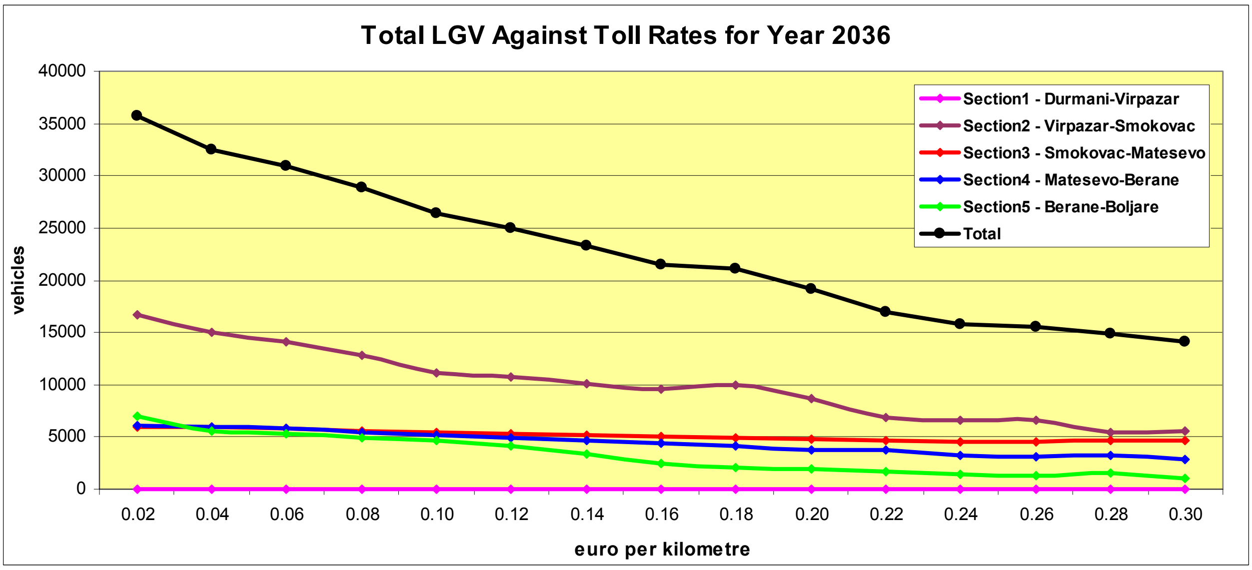
Source: consultant's analysis



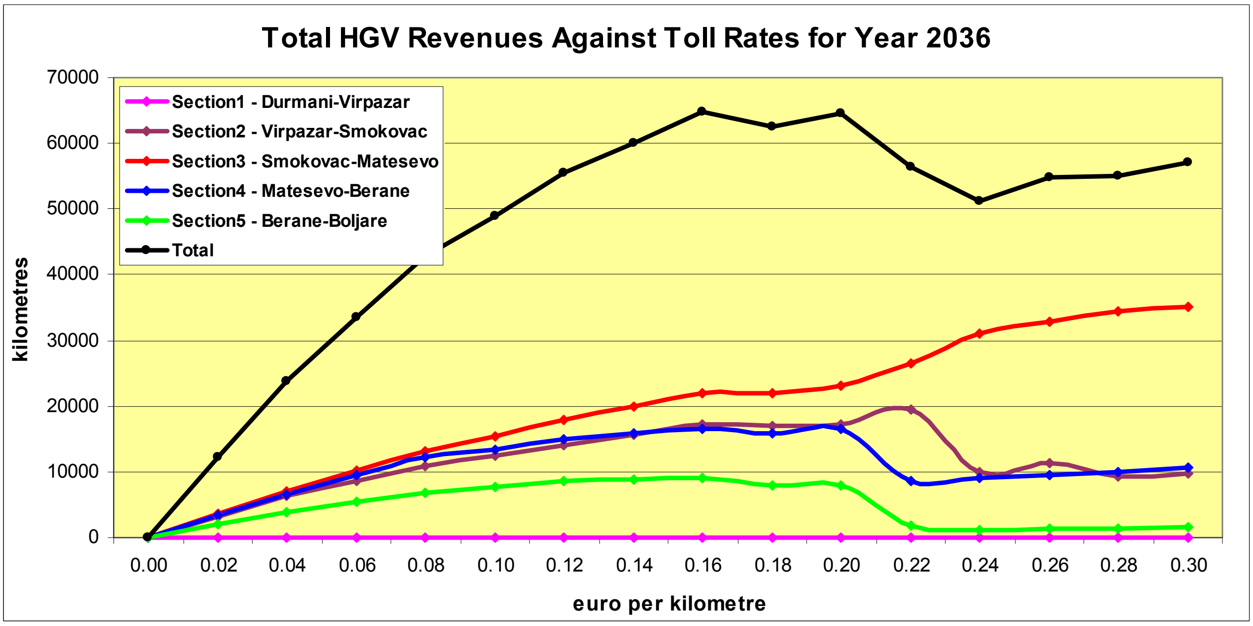
Source: consultant's analysis



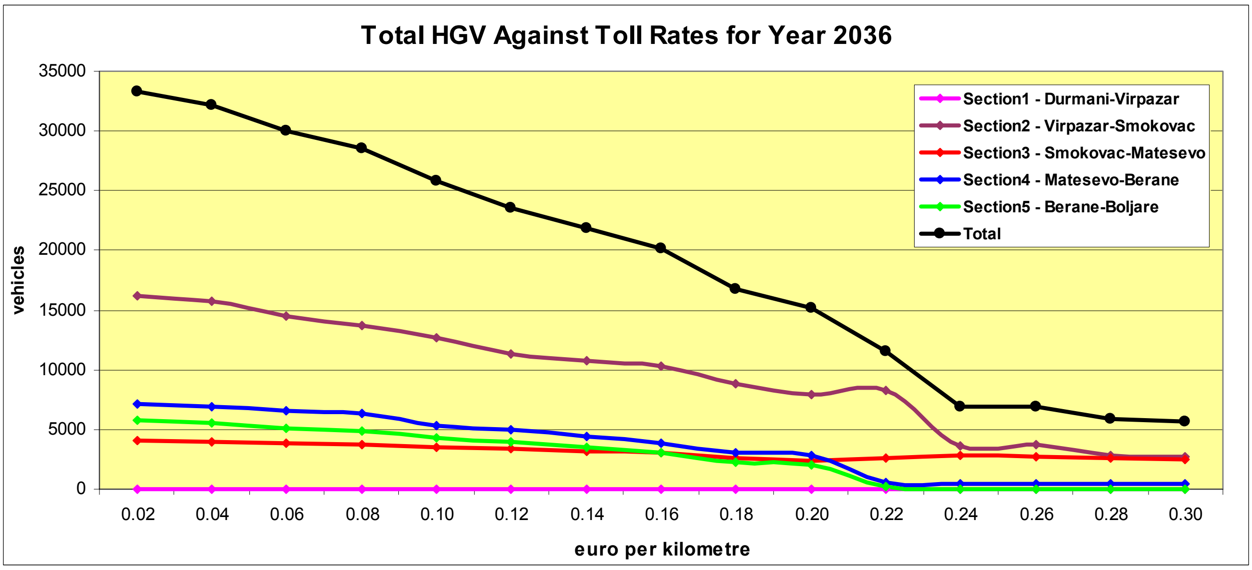
Source: consultant’s analysis



Source: consultant’s analysis



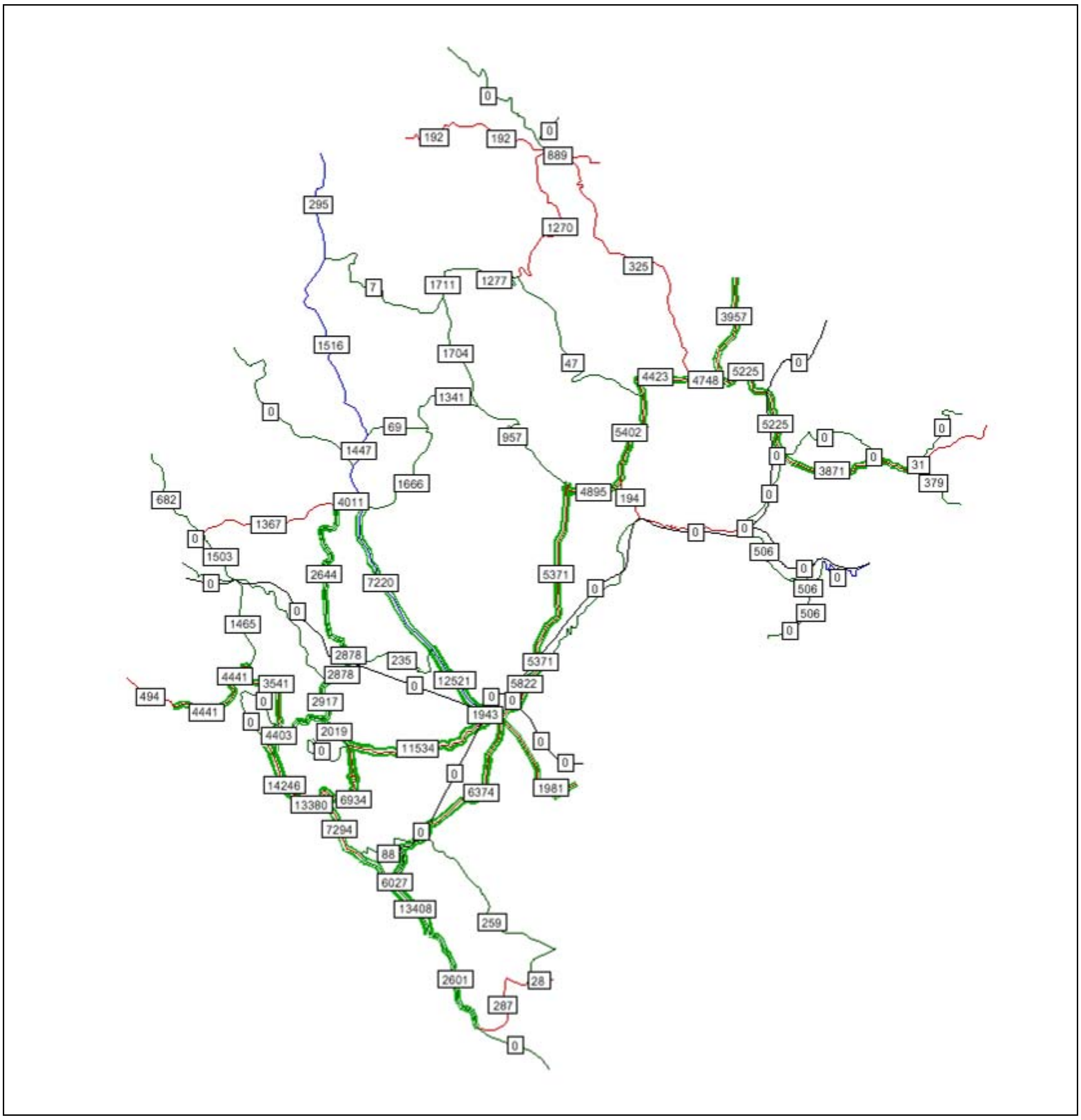
Source: consultant's analysis



Source: consultant's analysis

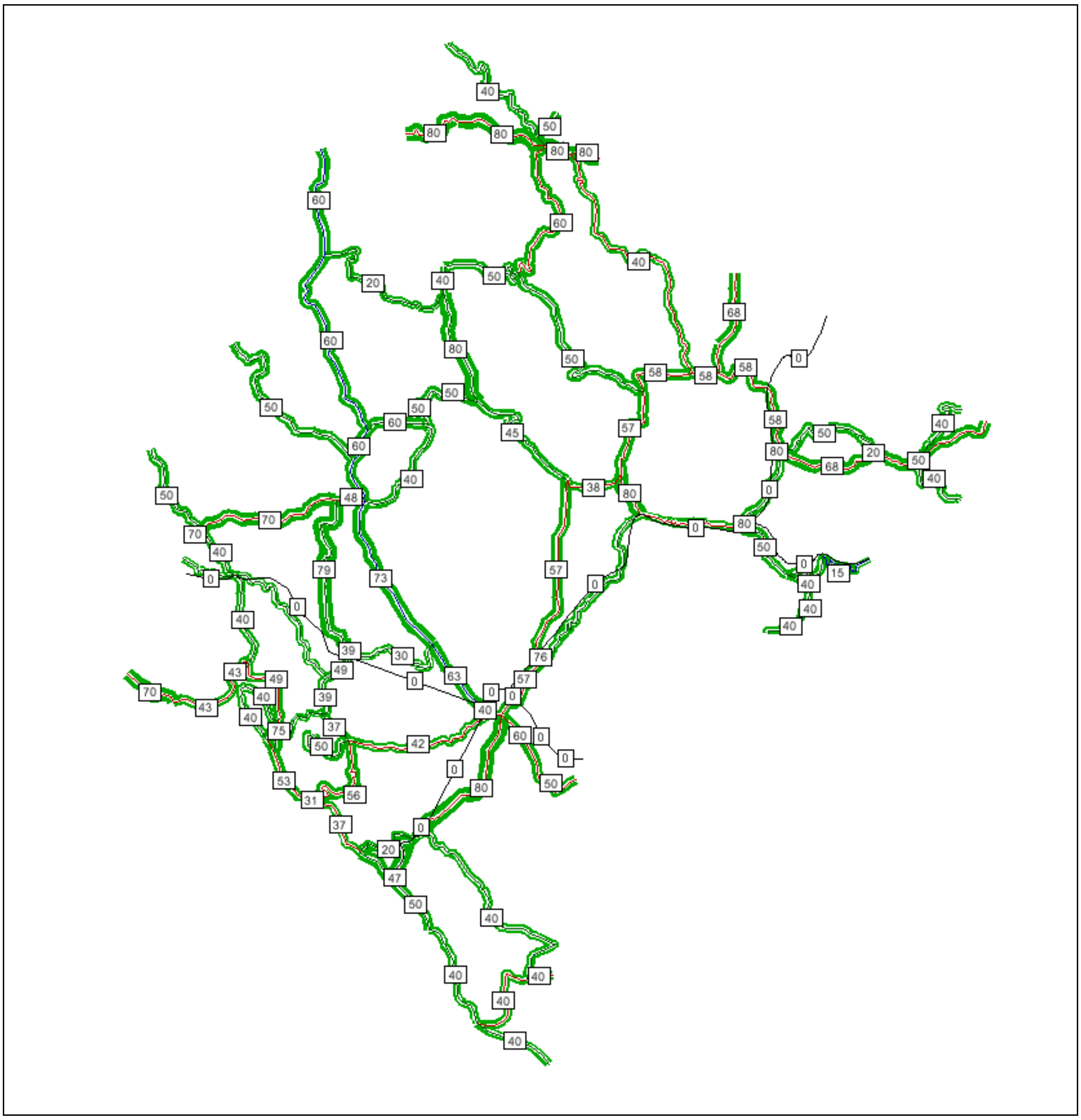
Appendix 12 – Year 2007 Plots

Year 2007 – DM AADT flow



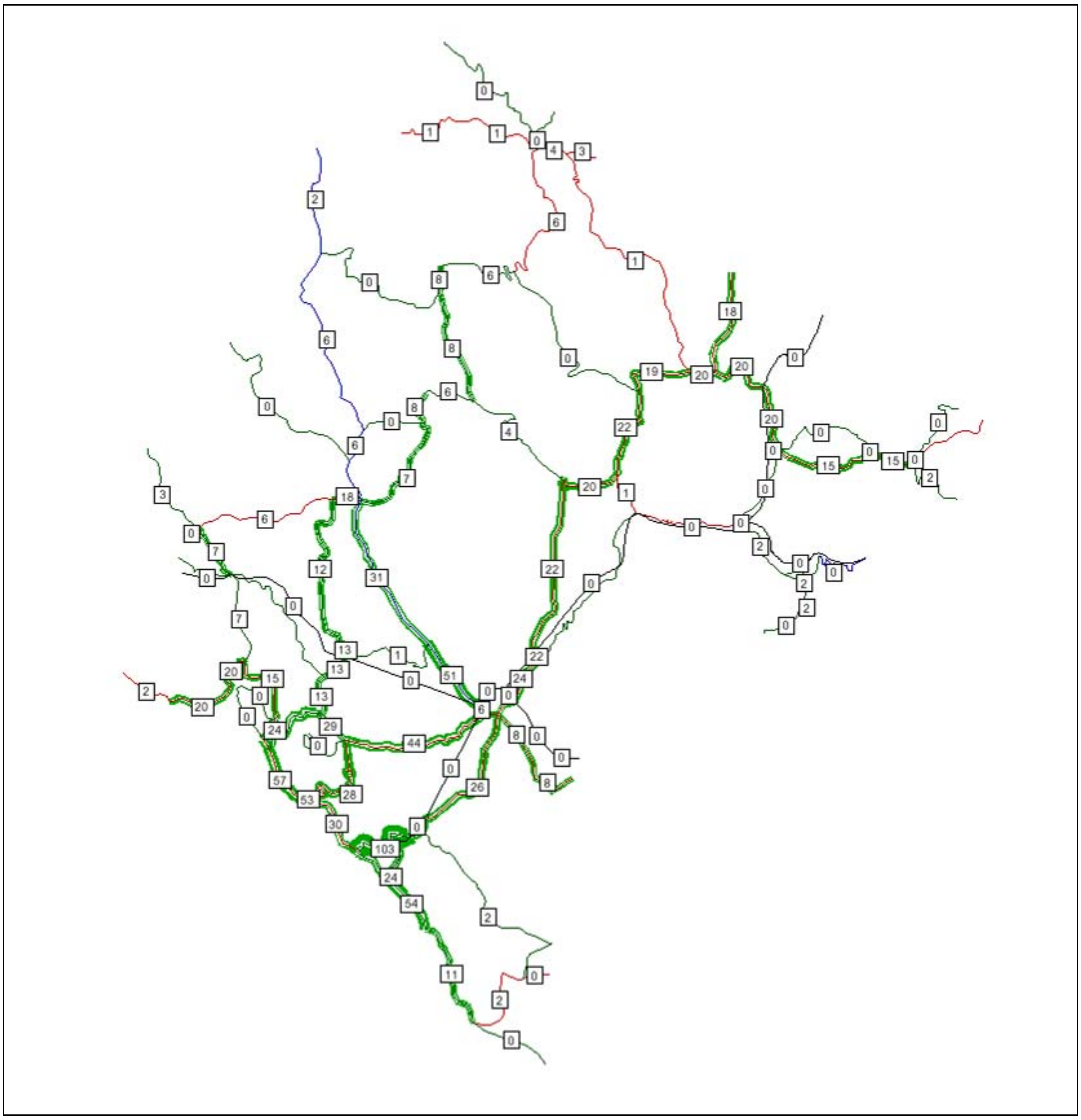
Source: consultant’s analysis

Year 2007 – DM Speed in km



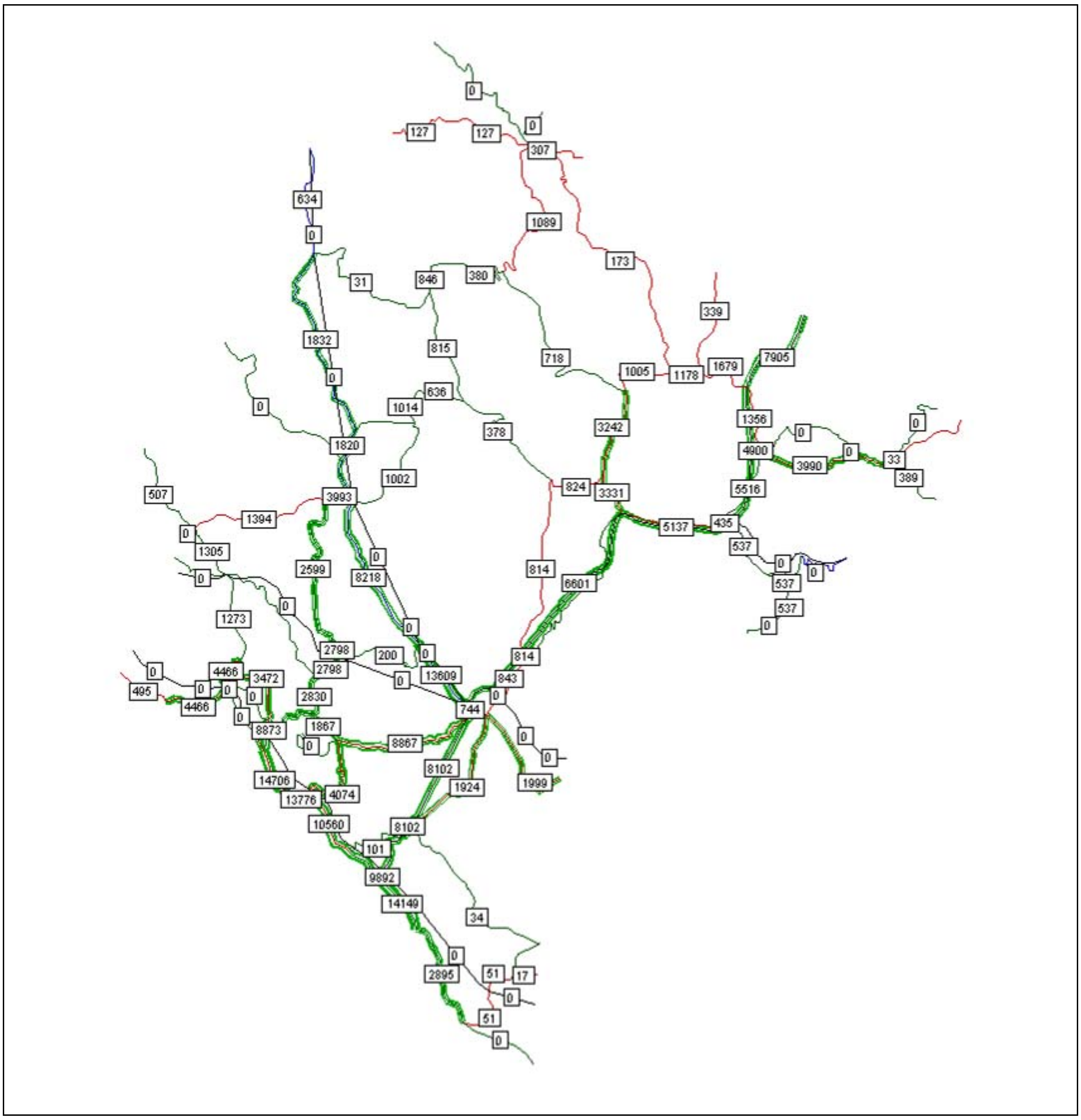
Source: consultant's analysis

Year 2007 – DM V over C



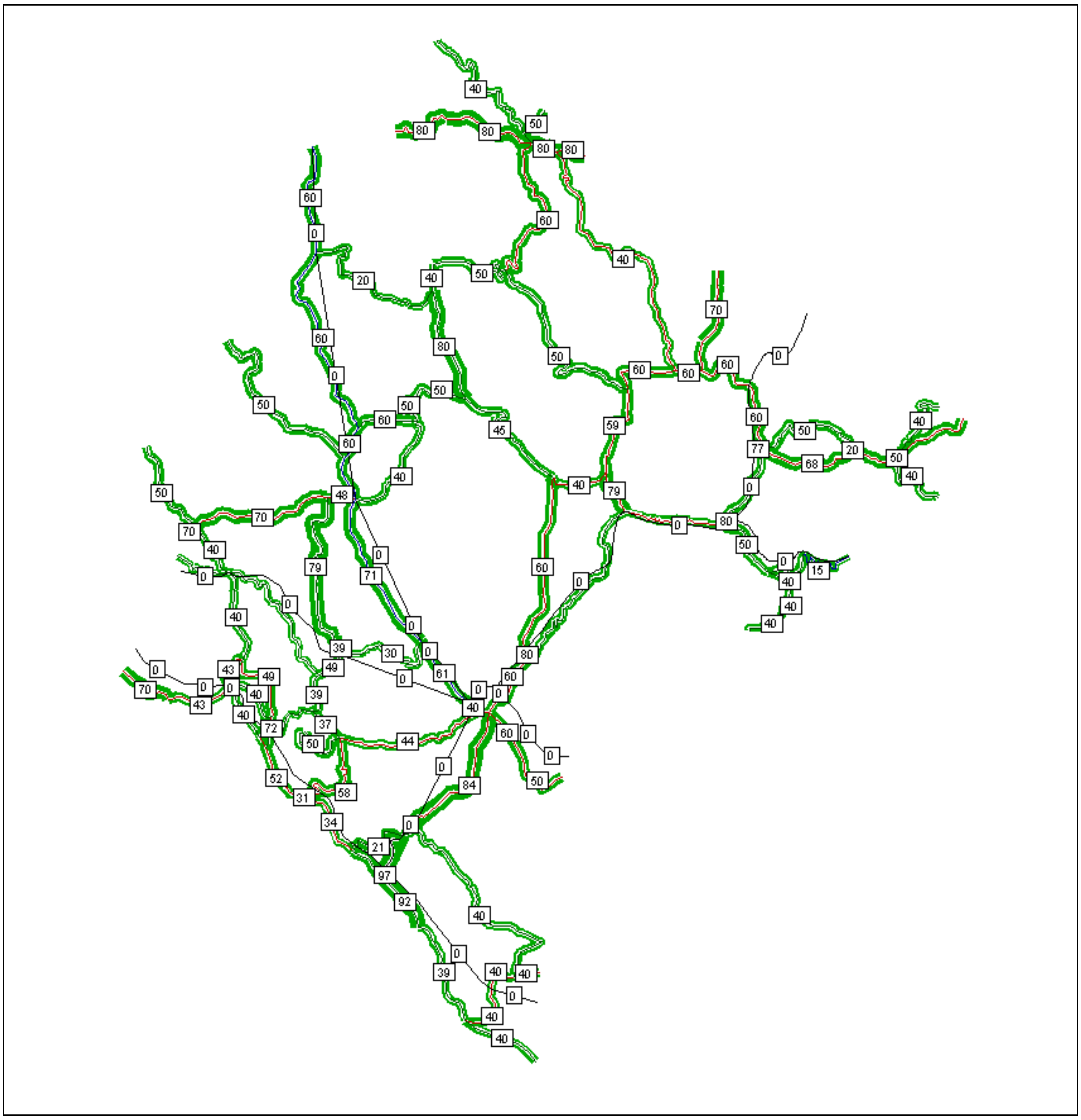
Source: consultant's analysis

Year 2007 – S9 AADT flow



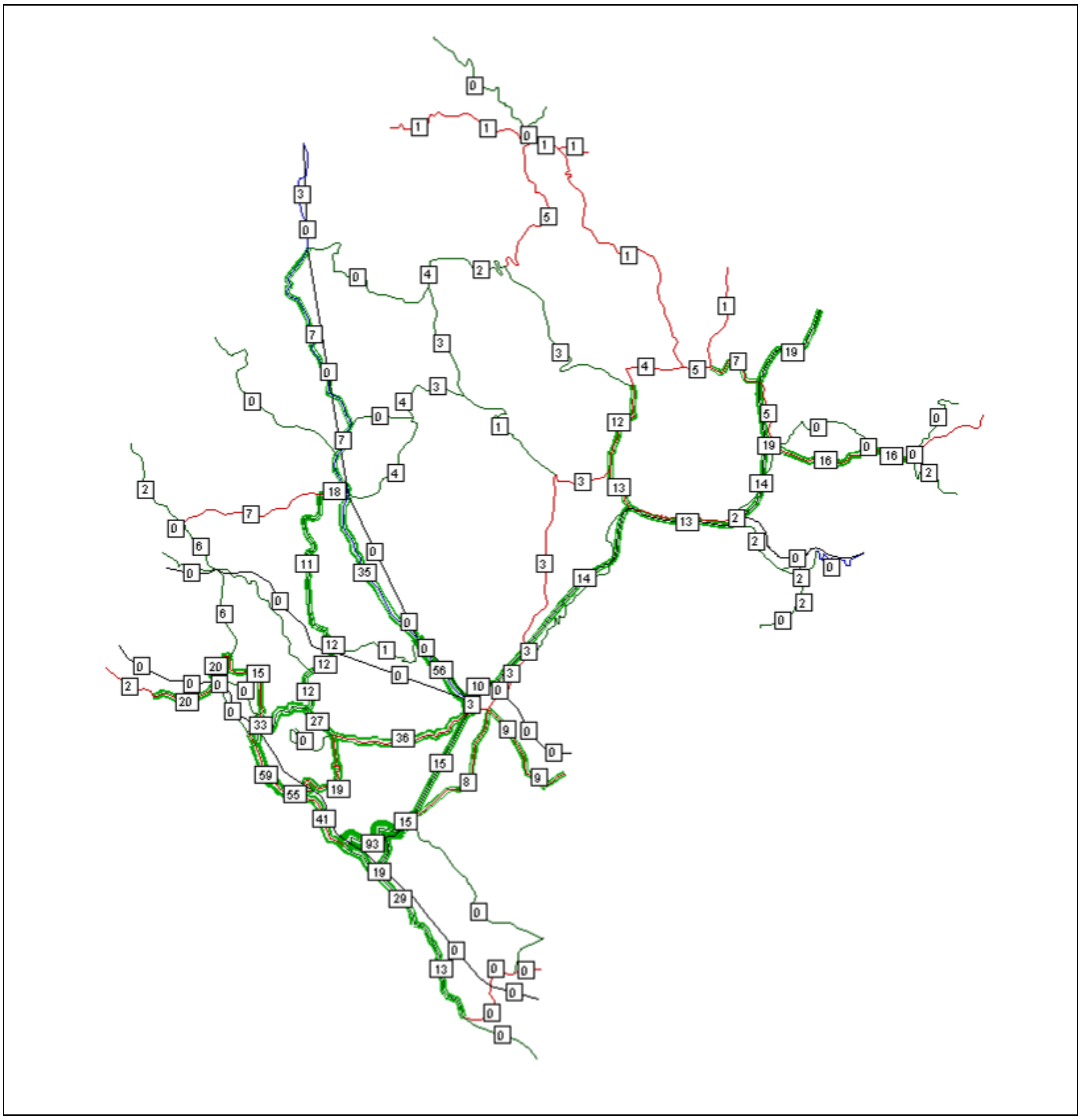
Source: consultant's analysis

Year 2007 – S9 Speed in km



Source: consultant's analysis

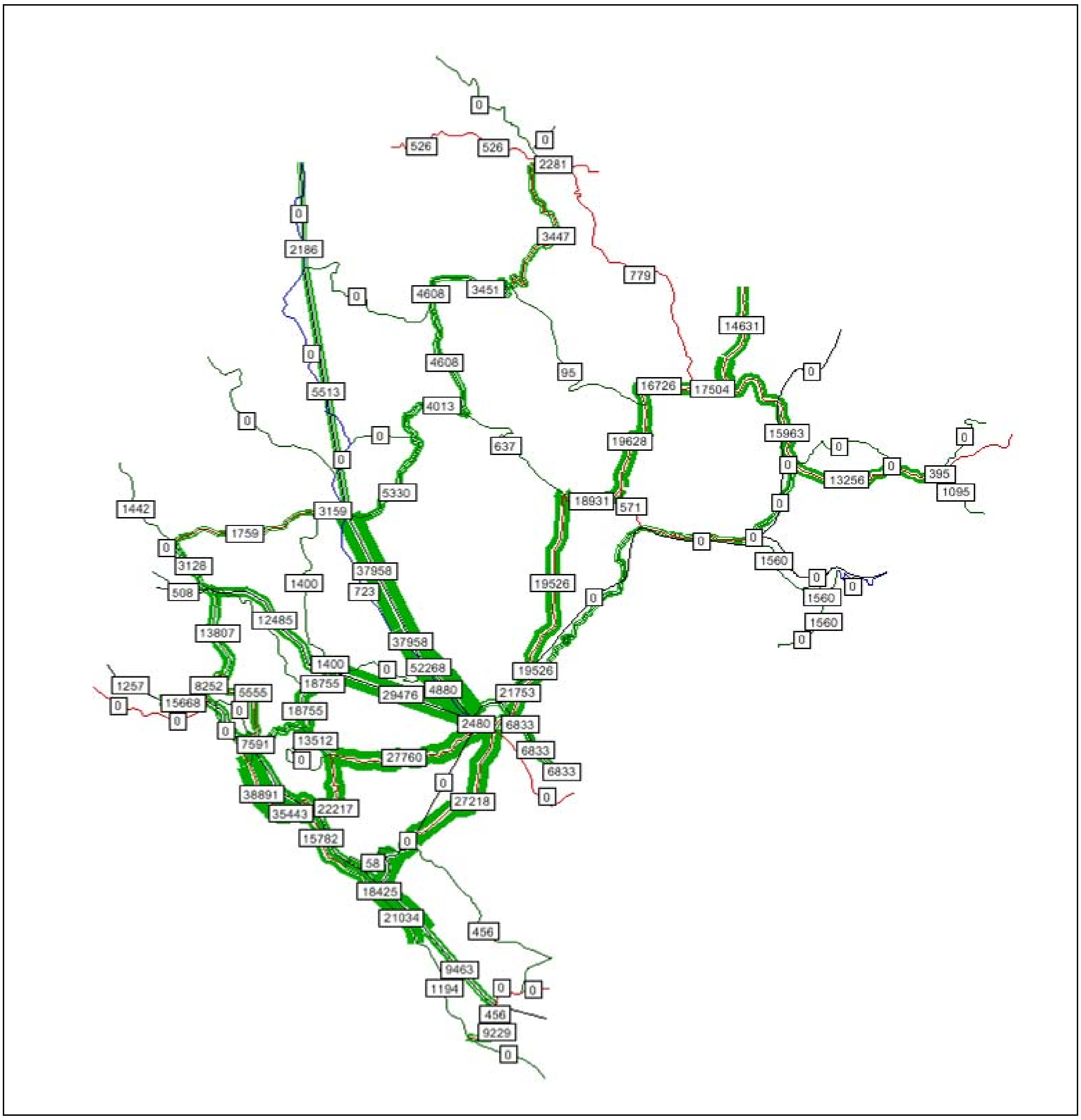
Year 2007 – S9 V over C



Source: consultant's analysis

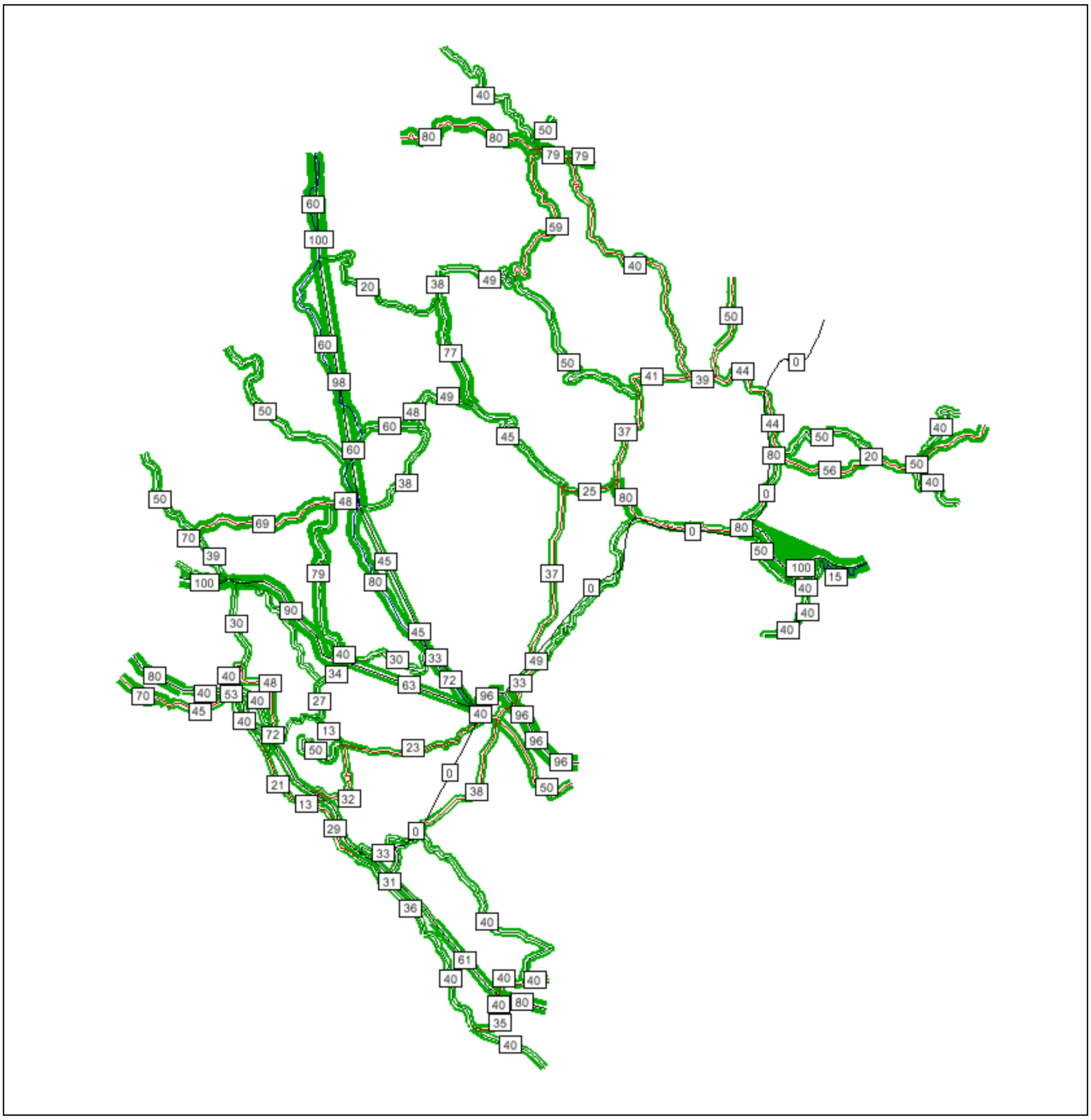
Appendix 13 – Year 2036 Plots

Year 2036 – DM AADT flow



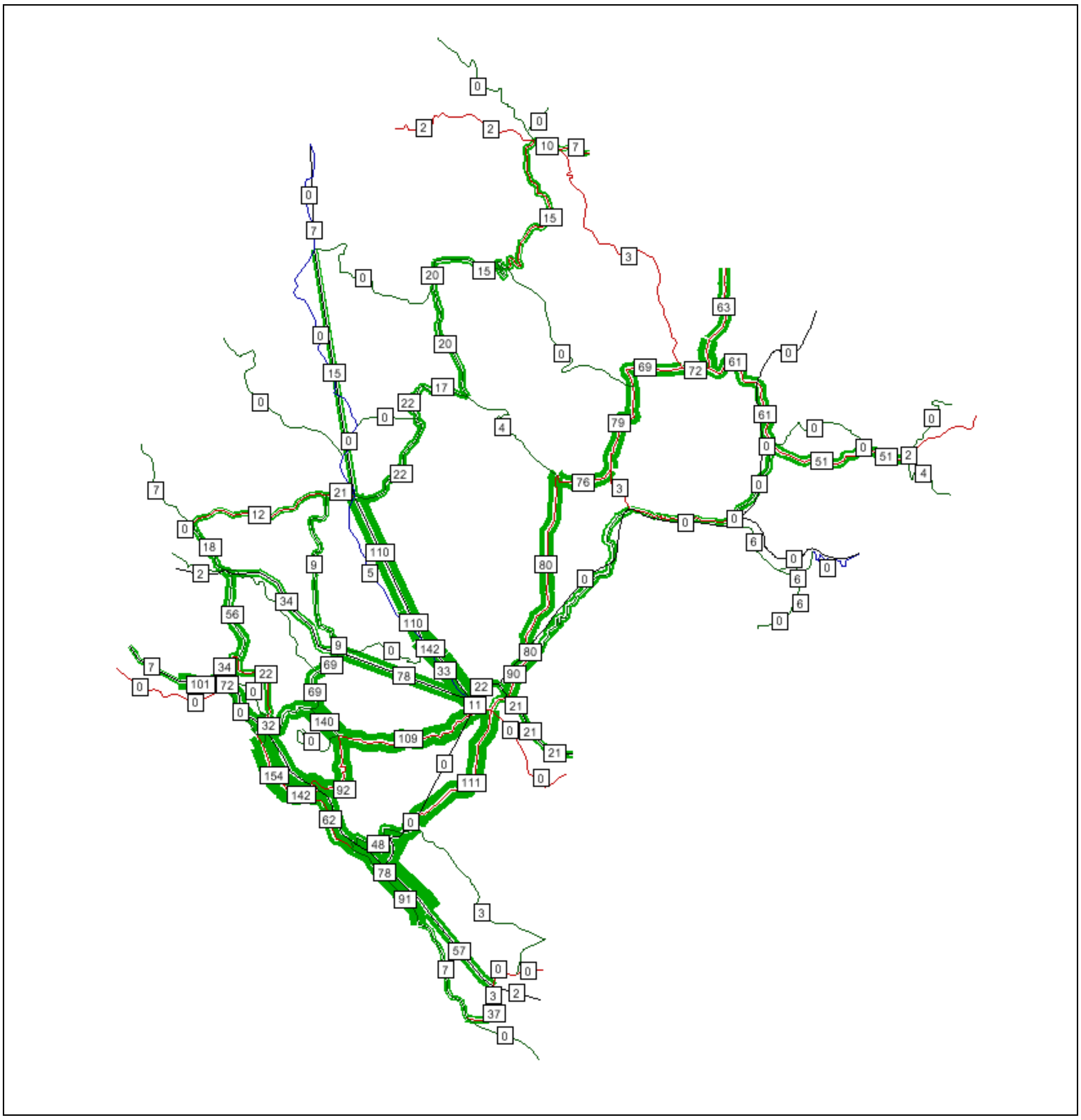
Source: consultant's analysis

Year 2036 – DM Speed in km



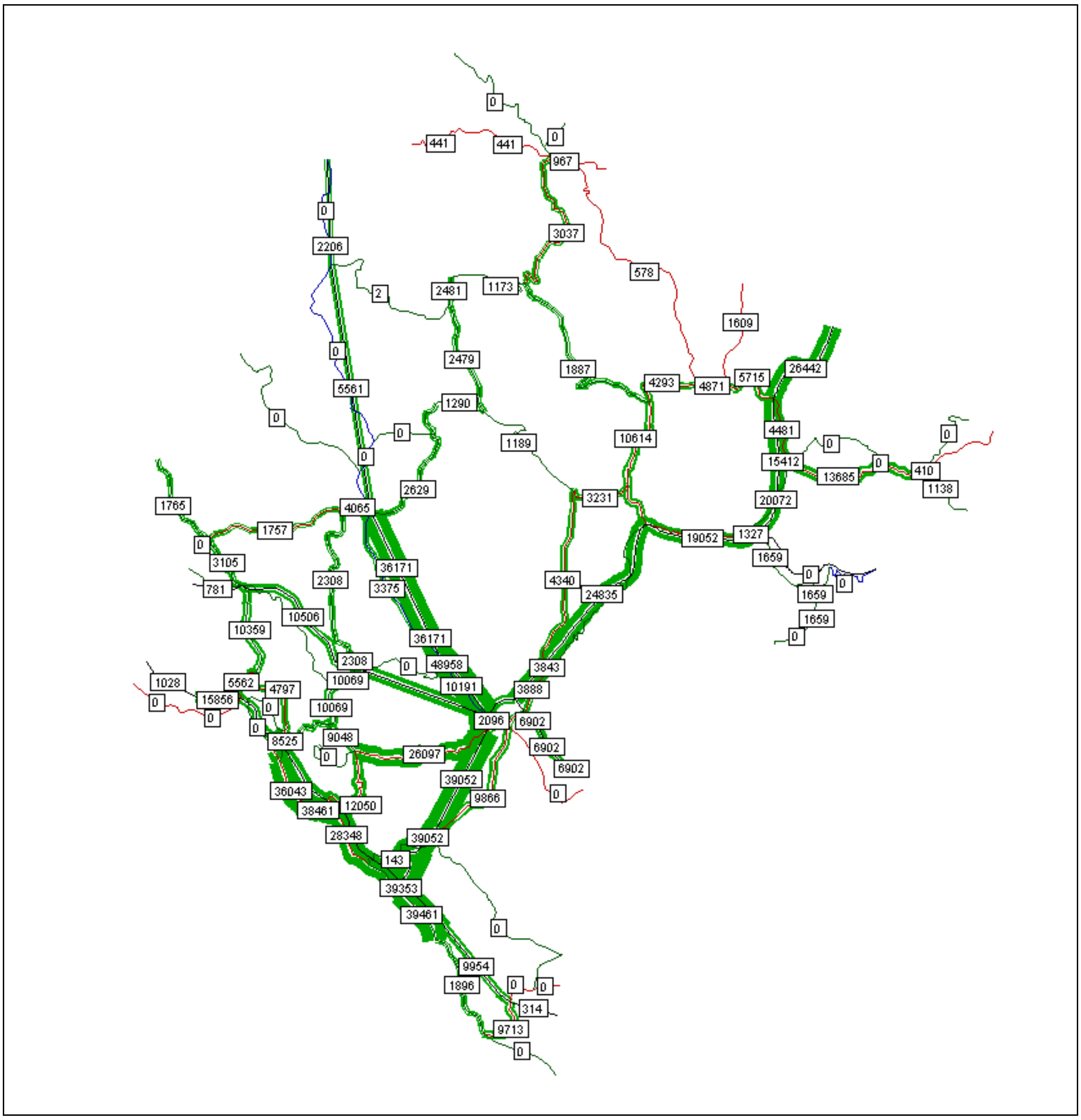
Source: consultant’s analysis

Year 2036 – DM V over C



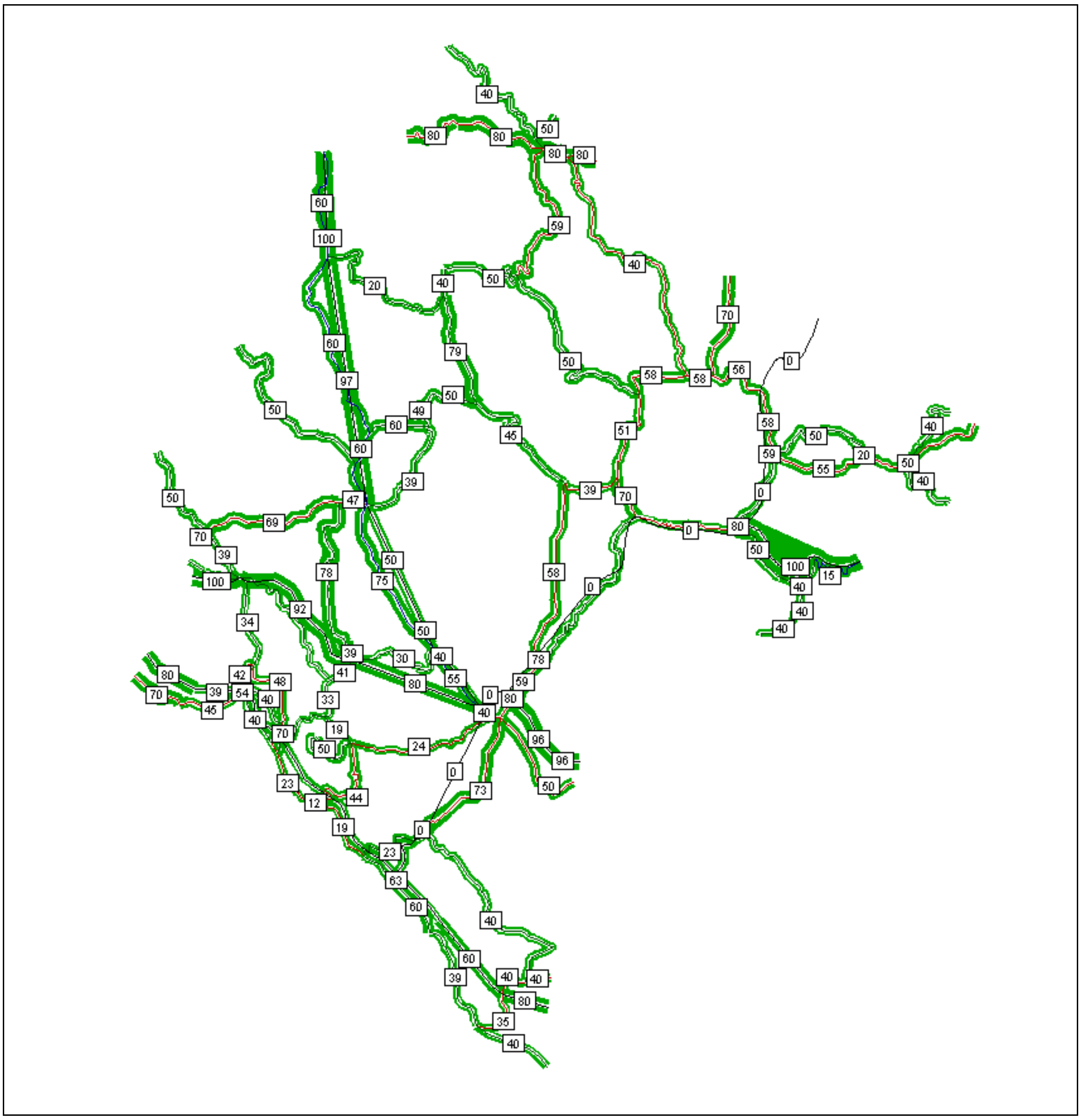
Source: consultant's analysis

Year 2036 – S9 AADT flow



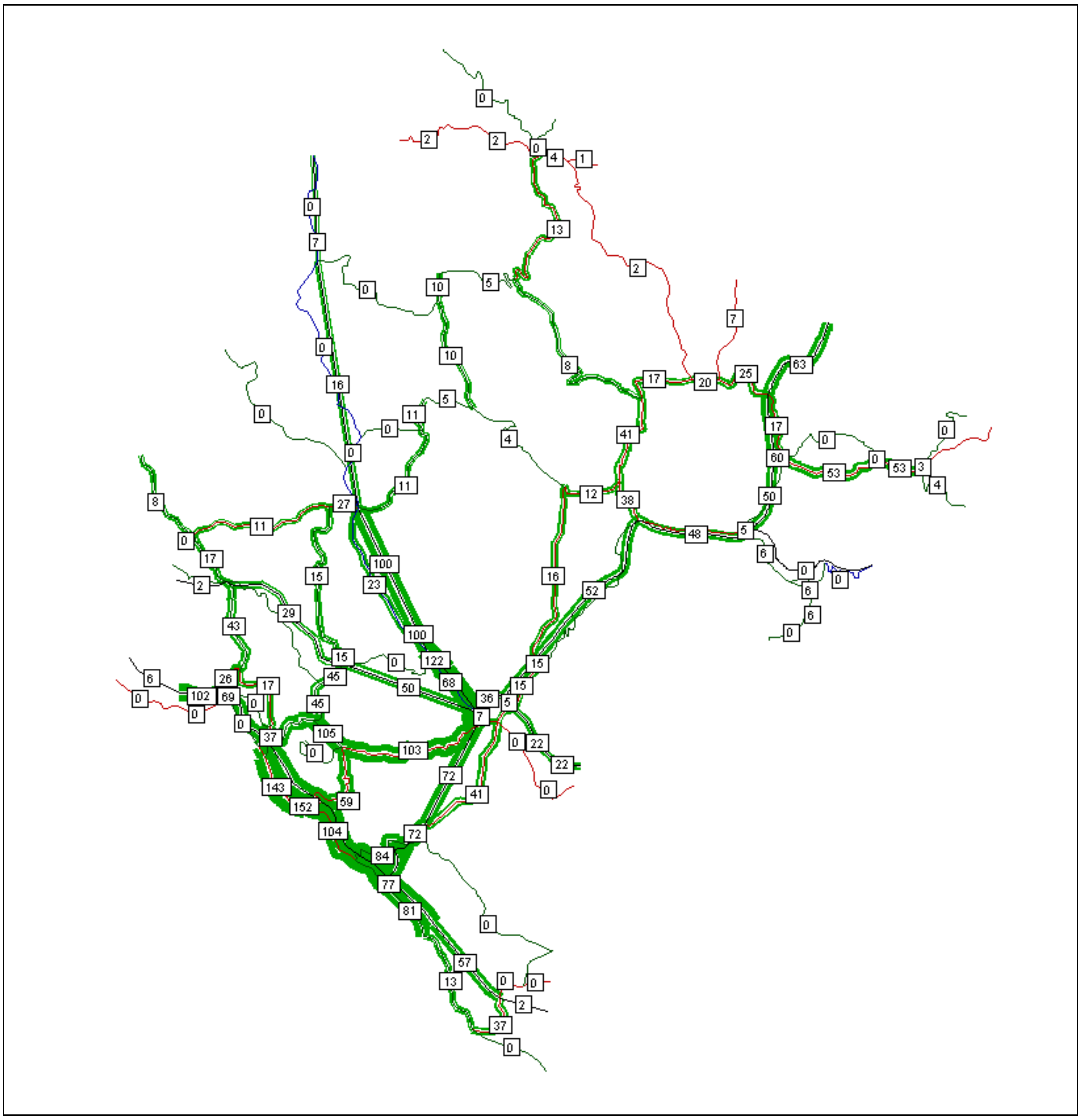
Source: consultant’s analysis

Year 2036 – S9 Speed in km



Source: consultant's analysis

Year 2036 – S9 V over C



Source: consultant's analysis

Revision Schedule

Engineering Studies
December 2008

Rev	Date	Details	Prepared by	Reviewed by	Approved by
01	November 2008	Engineering studies report	**Simon Roberts** Technical Director	**Mike Thomas** Team Leader	**Martin Edge** Director
02	December 2008	Engineering Studies Report	**Simon Roberts** Technical Director	**Mike Thomas** Team Leader	**Martin Edge** Director

Scott Wilson
Scott House
Alencon Link
Basingstoke
Hampshire
RG21 7PP
UK
Tel +44 (0) 1256 310200
Fax +44 (0) 1256 310201

www.scottwilson.com

Table of Contents

1 Introduction

Scott Wilson commenced this assignment during August 2008. At this time, the design data described in the Terms of Reference and which we had expected to be available upon commencement of the assignment was not available. Scott Wilson sought to obtain the design information directly from the various designers and the Government of Montenegro. This was a significant exercise as a number of designers were involved and the Preliminary Designs for Smokovac-Matesevo section were incomplete. The design information that was made available through these efforts (together with additional data provided by IFC) is included within the virtual data room for the project at http://www.montenegroroads.org. Much of the design information only became available after commencement of the project with some important information only becoming available at the end of December 2008. It was apparent that the design information was not available in an organised manner, the file names give little indication of the content and virtually all the information is available only in the Montenegrin language. Consequently, much effort has expended obtaining information and subsequently ascertaining its content.

The absence of a contents list also made it impossible to determine whether or not all of the available documents had been provided.

Further, no design reports were identified. These reports should clearly set out:

- the design standards, regulations and codes pertaining to the particular item of design;
- design principles and methodology;
- assumptions made;
- constraints and parameters;
- details of any material or other investigations undertaken together with laboratory test results;
- other supporting information used as part of the design;
- unusual aspects;
- health and safety considerations including risk assessment;
- drawings;
- specifications;
- Bills of Quantities;
- Cost estimates.

As a minimum, it would be reasonable to expect to find separate design reports for the tunnels, bridges and highway elements of the project. Consequently, whilst we have some design output (ie drawings), we do not know what process has been followed to produce this output. As a result of the lack of design reports and the total lack of any structure to the output, we have not undertaken a technical audit.

This report therefore provides a brief summary of the available information.

The bridge information for the Smokovac to Matesevo section did include, in English, the Terms of Reference (ToR) for the Preliminary Design of the bridges. It was apparent from the design information provided that many of the requirements of the ToR had not been met. The ToR is attached at Appendix B of this report, for reference.

The information that is available has been organised in a data room. The organisation of the data room is discussed in Section 15 of this report.

2 General and Preliminary Design

The designs for the Bar-Boljare Motorway are described as either “General” or “Preliminary” Design. The General Design is the initial design stage which is followed by Preliminary Design which should provide much more detail. In accordance with Montenegrin Law, General or Preliminary design is required to provide the following:

2.1 General Design

According to the Official Gazette of the Republic of Montenegro, General Designs should include:

- Highway alignment details at 1:25,000 scale
- Typical cross sections (1:200)
- Topographical plan
- Long section (1:25,000 or 1:10,000)
- Studies including:
    - Traffic and economics;
    - Geotechnical;
    - Climate;
    - Hydrology;
    - Previous Environmental Impact Assessment.

The above list is a summary only and is not exhaustive.

For the Bar-Boljare Motorway, General Design has been undertaken on the following sections:

- Bar (Djurmani) – Virpazar;
- Virpazar – Smokovac;
- Smokovac-Matesevo;
- Matesevo-Berane;
- Berane-Boljare.

The General Design has provided a highway alignment at 1:25,000 scale together with a longitudinal section at 1:25,000 scale. The long section indicates the location and extent of the tunnels and bridges. No environmental impact assessments have been undertaken.

2.2 Preliminary Design

According to Articles 150 to 154 of the Official Gazette of the Republic of Montenegro, Preliminary Design should include:

- Article 150 - Technical Summary providing the following:
    - General information;
    - Basis of design;
    - Conclusion;
    - Cost estimate (priced BoQ).
- Article 151 – Numerical Documentation
    - Co-ordinates and levels
- Article 152 – Graphical Documentation
    - Cross sections (1:100);
    - Topgraphical plans and long section with alignment geometry indicating cut and fill (1:5,000 or 1:2,500);

    - Drainage details;
    - Interchange details;
    - Quantities.
- Article 153 – Preliminary Design Related Reports
    - In particular geotechnical and hydrological reports
- Article 154 – For agreed alignment also includes
    - Tunnel and bridge design;
    - Engineering structures design;
    - Environmental protection design – technical procedures

The above list is a summary only and is not exhaustive.

The Preliminary Design should result in a comprehensive set of design documents which describe in detail the approach to design accompanied by calculations, drawings, specifications and a priced bills of quantities.

For the Bar-Boljare Motorway, Preliminary Design has only been undertaken for the Smokovac to Uvac section (Faculty of Civil Engineering in Podgorica) and the Uvac to Matesevo section (IGH, Zagreb). For these sections, the detailed design reports and priced bills of quantities are not available. An environmental impact assessment (EIA) has been undertaken for the Smokovac to Matesevo section but we understand that this report is not yet available. Following the EIA, a social impact assessment (SIA) will be required which, depending upon the outcome, may lead to a requirement for a resettlement action plan (RAP).

3 Current Design Status

The highway route from Bar through to Boljare has been the subject of various studies over the last 20 years on a section by section basis and a variety of alternative routes has been considered for each section with previous evaluations being based on technical, economic, environmental, and social considerations. Community interests have also been taken into account through public participation.

In the previous Outline General Designs, the design standards applied to each section varied from 80 – 100 kph design speeds and the road categories varied from urban dual carriageway, urban bypass, and expressway to full motorway standard.

All previous outline general designs are available in hard copy for inspection at the MTMAT offices and represent the historical study background for what has now become the Bar to Boljare Motorway Project. Selected data from these hard copies is available electronically on the virtual bid data room ftp site.

It should be recognised that these previous outline general designs have been developed in relation to previous design and environmental standards that now need to be reassessed against the current national, European, and international standards as appropriate.

The sections examined are summarised as follows:

Section 1: Djurmani – Virpazar (11.2 km)

Section 2: Virpazar - Farmaci - Smokovac (38 km including Podgorica Bypass)

Section 3A: Smokovac – Verusa - Uvac (34 km)

Section 3B: Uvac – Matesevo (7 km)

Section 4A: Matesevo – Andrijevica (23 km)

Section 4B: Andrijevica – Berane (11 km)

Section 5: Berane – Boljare (41 km)

It should be noted that the section from Bar to Djurmani (13..8 km) is not expected to form part of the PPP Concession Project but is planned for separate independent development as an untolled urban expressway in due course, and on this basis the remaining part of Section 1 from Djurmani to Virpazar is now 11.2 kms in length.

Phase 1 of the section from Djurmani to south of Virpazar was completed and opened to traffic in 2005, including the Solzina Tunnel and currently operates as a 2 lane tolled highway. No further preliminary design or main final design has been carried out to upgrade to a full 4 lane motorway.

During 2007-2008, the international consultants Louis Berger SAS produced new outline general designs for Section 2: Virpazar-Farmaci-Smokovac [including Podgorica Bypass] and Section 4-A: Matesevo-Andrijevica in order to address the latest urban issues around Podgorica, and to upgrade the Section 4-A from an 80 kph road to 100 kph motorway standards.

In all of the above outline general designs, no detailed consideration was given to the influence or requirements of public or military utilities such as underground or overhead power or communication cables, ductways, pipelines, etc as these subjects are addressed mainly during the subsequent preliminary design stage.

All of the above outline general designs will need to be updated to comply with the latest national, European, and international design standards as appropriate, including TEM.

During 2007-2008, the Preliminary Design for the Smokovac – Uvac section has been progressed by the Faculty of Civil Engineering of the University of Montenegro [FoCE] in partnership with CPV of Novi Sad, Serbia and for the Uvac – Mateshevo section by the Civil Engineering Institute of Zagreb, Croatia [IGH]. These Preliminary Designs have also been reviewed progressively by the appointed “Revision Commission” as the design was developed, and consequently it is anticipated that Revision Commission approval may be completed and confirmed for both sections during October 2008. However, at present, such approval continues to be outstanding. Design standards referred to in these preliminary designs for highways, bridges and tunnels include TEM and upgraded SODOC [Slovanian] standards.

These preliminary designs are currently the subject of an Environmental Impact Assessment Studies in accordance with the latest national and international EIA criteria and the Environmental Impact Assessment Law “Official Gazette of Montenegro”, No. 80/05 in order to identify the compliance requirements for the final designs and the eventual construction works. Approval for these EIA studies will be the responsibility of the project team in MTMAT and the related Revision Commission.

Independent from the mandatory Revision Commission approval process for the previous general and preliminary designs, an additional technical audit of these designs is being carried out by international consultants during preparation of the bidding documents and the consultant’s report will also be made available to bidders in due course.

On Friday 05 September 2008, the Government of Montenegro adopted a draft spatial plan for the Bar-Boljare Motorway Corridor that encompasses an area of 1,400 square kilometres with a length of 165 kms. This plan has now been adopted.

Following the approval of the Preliminary Designs for the Smokovac-Matesevo Section, the related land acquisition procedures will be commenced with the necessary land/property mapping being compiled by the Directorate of Real Estate, followed by land/property financial expropriation also by the Directorate of Real Estate. Completion of all related land/property expropriation is normally resolved through direct negotiation, or in the case of any disputes, by the determination through the courts whose decisions are then non-negotiable and binding on all parties.

The overall design status of the above sections is set out in the following Table 1.

Table 1 – Current Design Status

SUBJECT	Section 1 BAR [DJURMAN] TO VIRPAZAR [11.2 kms]	Section 2 VIRPAZAR FARMACI SMOKOVAC [38 kms]	Section 3 –A SMOKOVAC VERUSA UVAC [34 kms]	Section 3 – B UVAC TO MATESEVO [7 kms]	Section 4 – A MATESEVO TO ANDRIJEVICA [23 kms]	Section 4 – B ANDRIJEVICA TO BERANE [11 kms]	Section 5 BERANE TO BOLJARE [41 kms]
GENERAL DESIGN [including examination of alternative routes using 1:25,000 scale mapping]	COMPLETED In 1998 [Bar to Tanki Rt.] BY Saobracaj Inzenjering & Civil Engineering Faculty, Podgorica	COMPLETED in 1998 And updated BY Louis Berger In 2008 [3 alternative alignments]	COMPLETED And updated by Civil Engineering Faculty, Podgorica in 2007. [Smokovac to Verusa subsequently extended to Uvac]	COMPLETED BY Put Inzenjering, Podgorica	COMPLETED And updated By Louis Berger In 2008 [2 alternative alignments]	COMPLETED in 1998 BY Put Inzenjering, Podgorica One defined alignment	COMPLETED in 1998 BY Put Inzenjering, Podgorica One defined Alignment
Revision Commission APPROVAL	1998 - FIRST PHASE APPROVED [2 lanes]	APPROVED	APPROVED	APPROVED	APPROVED	APPROVED	APPROVED
DIGITISED MAPPING	COMPLETED Based on 1980 1:25,000 scale Contoured maps	COMPLETED Based on 1980 1:25,000 scale Contoured maps	COMPLETED Based on 1980 1:25,000 scale Contoured maps	COMPLETED Based on 1980 1:25,000 scale Contoured maps	COMPLETED Based on 1980 1:25,000 scale Contoured maps	COMPLETED Based on 1980 1:25,000 scale Contoured maps	COMPLETED Based on 1980 1:25,000 scale Contoured maps
ALIGNMENT SELECTION	Second Phase Alignment yet to be reviewed and updated	One alignment selected in preliminary design	One alignment selected in preliminary design	One alignment selected in preliminary design	One alignment selected for preliminary design	One alignment selected for preliminary design	One alignment selected for preliminary design
AERIAL SURVEY	COMPLETED In 2007	COMPLETED In 2007	COMPLETED In 2007	COMPLETED In 2007	COMPLETED In 2007	COMPLETED In 2007	COMPLETED In 2007
UPDATED DIGITISED MAPPING		2008	2008	2008			
PRELIMINARY DESIGN	FIRST PHASE APPROVED [2 lanes] SECOND PHASE [extra 2 lanes and extra 2 lane tunnel Yet to be designed	Concessionaire to complete	COMPLETED Civil Engineering Faculty, Podgorica [FoCE]	COMPLETED Institut Gradjevinarstva Hrvatske, Zagreb {IGH}	Concessionaire to complete	Concessionaire to complete	Concessionaire to complete
ENVIRONMENTAL IMPACT ASSESSMENT FOR PRELIMINARY DESIGN			FoCE to complete by Feb 2009	FoCE to complete by Feb 2009			
Revision Commission APPROVAL			Report awaited	Report awaited			

4 Geometric Design

Scott Wilson did not identify a Preliminary Design report which discussed the geometric aspects of the design. The Louis Berger reports [Technical Memoranda 1C and 15] do however discuss the geometric design standards and, in part, this was used as a basis for the requirements that were included within the Employer's Requirements. The General Design drawings are at a scale of 1:25,000 and do not contain any geometric design information. We did not identify Preliminary Design reports or drawings on the Smokovac-Matesevo with information regarding the geometric design.

Formal approval of highway alignment design is provided by the Revision Commission. Where approval has been granted, this is recorded in a report by the Revision Commission which is included in the data room. To date, the following approvals have been given:

4.1 Bar (Djurmani) – Virpazar Section

Bar-Tanki Rt	Variant 3

4.2 Virpazar – Smokovac Section:

Three designs cover the Motorway between Virpazar and Smokovac, called:

Bar-Tanki Rt	Variant 3
Tanki Rt-Farmaci	Variant 6,1,3,1 as follows:

Variant 6 between chainages 0km to 2.742

Variant 1 between chainages 2.742 – 9.800

Variant 3 between chainages 9.800 -16.300

Variant 1 between chainages 16.300 – end

Farmaci-Smokovac	Variant 3

4.3 Smokovac – Mateševo Section

This section is sub-divided into two sections, namely:

Smokovac-Uvac and

Uvac-Matesevo

To date, the Revision Commission has not granted approval for either of these sub-sections.

4.4 Mateševo - Berane Section

For section between Matesevo – Andrijevica, the design documentation is divided into two sections, namely:

Matesevo-Andrijevica	Variant 1
Andrijevica- Berane-Boljare	Variant 1 with sub-Variant 2

4.5 Berane – Boljare Section

Andrijevica-Berane-Boljare	Variant 1 with sub-variant 2

5 Hydrology and Hydraulic Design

Scott Wilson did not identify a design report which discussed the hydrological study of the area surrounding the project road or the subsequent hydraulic design of the bridges and other major drainage structures. However, the General Design for Bar (Djurmani) to Virpazar (Analiza hid.doc) does provide some information regarding return periods, intensity and corresponding flows.

6 Geological and Geotechnical Design

The reports titled "TEHNICKI IZVJESTAJ" or "TEHNICKI OPIS" are written in the Montenegrin language and appear to provide very general information about the bridges, including some information regarding geology and geotechnical investigations.

Initially, we were unable to locate any reports which dealt specifically with the geological or geotechnical aspects of the design of the tunnels, bridges and highway. In late December additional geotechnical information was made available and is included within the Montenegro Roads dataroom in folders titled "New information" and dated 22nd December 2008 and 30th December 2008. It has not been possible to undertake a detailed review of this information but it would appear that a limited number of generally shallow boreholes have been undertaken together with a seismic study of the Motorway corridor. The report also includes some laboratory tests and geophysical and geological maps.

7 Pavement Design

We did not identify a pavement design report amongst the data available prior to 13th October although, subsequently, the Uvac to Matesevo preliminary design did contain a reasonably detailed pavement design report [Pavement/UM_Kolnicka.doc] which was written in the Montenegrin language. This is the only report which appears to have addressed pavement design.

The layout plan presented in this design lacks some necessary elements for proper consideration, namely the basic topographic plan and data. It would appear that both carriageways have been designed following the same alignment. If each carriageway was designed to its own alignment the possibility exists of a more economical geometric design through reduction of very large cuts and fills.

Other details relating to the layout, such as gradients, are not always given on the drawings, but are present in the model. There are instances where the actual gradient appears to differ from that suggested by the technical report.

The road pavement with an overall thickness of 60cm (of which the bituminous layers are 15cm thick) should be more clearly defined, particularly the roadbase BNS 22sA, with a thickness of 6cm. We would normally anticipate that the bituminous layers would be thicker, perhaps a roadbase with 2x7cm BNSa. The shoulders should be of the same construction as the main carriageway, this is not the case in the present design.

Pavement design on steep gradients, in tunnels and at toll plazas will require particular attention.

The normal cross section included within the preliminary design (Standard cross section) is not applicable since it does not include all the elements of a layout: cuts, fills, curves, and grade separations. Furthermore, the gutters, kerbs, central reserve and safety fence require design which should have been included as part of the preliminary design process.

Pavement drainage has not been properly defined in the preliminary design. A proper solution should have a conceptual and methodological approach, which does not appear to be included in the current design. Since drainage plays a very prominent role in maintenance and prolonged durability of the pavement structure, it should be given particular attention. The drainage system with manholes and the carrier drain in the central reserve, as included in the design, is absolutely impractical. The actual drainage of the central reserve is not defined. The drainage channel on the high side of the carriageway is effectively redundant as it only captures water falling directly into it. There does not appear to be proper consideration of how the slopes in cuttings are drained. In mountainous areas and with significant cuts in certain places this is a very important aspect. This could result in greatly increased pipe diameters and lead to oversized interceptors.

In summary, the geometric, pavement and drainage design included within the preliminary design all leave considerable room for improvement in final design.

8 Tunnel Design

We have not identified any reports which provided adequate information regarding the approach to tunnel design. General Design documents include some outline information however with regards to the Preliminary Design (Smokovac to Matesevo) and given the significant amount of tunnel included on most of the Bar-Boljare Motorway this is a significant omission from the design documents.

The specific consequence of a lack of a tunnel design report is that this creates risk for the Contractor to quantify and manage. The Contractor will have to decide whether he is able to use the existing “design” or whether he needs to undertake his own design without reference to any of the information available. In the former instance, the Contractor may assume that the risk associated with using the existing “design” is greater than is actually the case.

The current design appears to allow two 3.5m wide lanes without shoulders generally. However, two tunnels (numbers 5 and 6) have three 3.5m wide lanes. Although the gradient within these tunnels is about 4%, the need for three lanes may be a reflection upon the gradient on the tunnel approach. However, if the approach gradient could be reduced it may be possible to avoid the significant expense of including a crawler lane within the tunnel.

Additionally, it is unclear whether the tunnel cross section makes allowance for the edge marking lines (0.25m) and verges (1.0m).

9 Bridge Design

The bridge information for the Smokovac to Matesevo section did include, in English, the Terms of Reference (ToR) for the Preliminary Design of the bridges. Although we did not locate a design report in English, it was apparent from the design information provided that much of the requirements of the ToR had not been met. This is discussed in more detail below. For reference, a copy of the ToR for bridge design is attached at Appendix C of this report.

The ToR (para 4.5.3) requires that a technical report be prepared which should include the following:

- Description of the site;
- Review of climatic conditions;
- Review of conclusions of Revision Commission;
- Explanation of structural concept;
- Method and depth of foundation engineering;
- Description of geomechanical and hydrological characteristics of the soil and terrain;
- Static and structural concept of design;
- Detailed structural calculations;
- Drainage, equipment, traffic signs etc;
- Durability issues;
- Construction technology;
- Priced BoQ;
- Other issues;
- List of laws, general and technical regulations, codes of practice and standards.

However, the information received to date for Smokovac – Matesevo provides only the following:

- Plan showing the location of each bridge along the route – in some instances more than one variant is indicated;
- Semi-detailed structural calculations;
- Basic general arrangement drawings;
- Un-priced BoQ (providing a level of detail which exceeds that shown on the drawings).

It is apparent that the information provided is significantly less than that required by the ToR – tables 1 and 2 below provide an analysis of the report produced for a sample bridge.

We note also that the Preliminary Design bridge drawings for the Smokovac to Uvac section all show the same type of foundation. This could be an indication that ground investigations have not been undertaken and that the foundations would need to be re-designed once the actual ground conditions have been established.

The Specification should be appropriate to the particular bridges (much of the Specification refers to steel structures although all the designs seem to be for reinforced concrete structures) and should not include reference to measurement or payment. These should be deleted.

Each bridge has its own Bills of Quantities which are detailed (rather more than the drawings) but are presented in the style of a re-measurement contract.

	Questions	Yes	No	Comments
1	Does the document adequately describe the design methodology?	✔		
2	Has the design followed the requirements of the Terms of Reference?	✔		see Table 2
3	Has the design followed appropriate standards?	✔	✔	In part the Designer is not following contemporary local norms and standards
4	Does the design document identify the assumptions made – what are these assumptions and are they reasonable?			No Designer assumptions have been indicated
5	Does the design describe the constraints and parameters relevant to the design?	✔		
6	Are the calculations sufficient?		✔	
7	Is there any evidence that geotechnical investigations have been undertaken and how have the results been incorporated into the design?		✔	
8	If no geotechnical investigations were done, what is the basis of the foundation design? Does the document contain recommendations for detailed site investigations?		✔	There is no info about geotech investigations. Avarage soil bearing capacity was adapted (1 Mpa)
9	What hydrological studies have been undertaken?		✔	There is no info about hydrological investigations
10	How does the design allow for seismic parameters?		✔	Spectral analysis was used for seismic loads, but without link to the microseismic report data
11	What measures have been taken to optimise the design?		✔	
12	Do the drawings reasonably reflect the design?	✔		
13	Has maintenance and inspection of the bridge been taken into account?		✔	General notes about maintenance of the Bridge could be incorporated into the Design

Table 1 Review of design report

	Requirements from the ToR	Yes	No	Significance	Quality of the description given in Tech Report	Total Points
1	Description of the site, chainage, and position of a STRUCTURE on the route	✔		high	poor	2.00
2	Review of the climatic conditions	✔		high	good	3.00
3	Review of the conclusions of the Commission on adoption of the optimal design	✔		high	good	3.00
4	Description of the layout design of a STRUCTURE with the explanation of the structural concept	✔		high	poor	2.00
5	Description of the horizontal and vertical of the route of the access road	✔		intermediate	very poor	0.75
6	Review of the method and depth of foundation engineering,	✔		high	poor	2.00
7	Description of envisaged materials,	✔		intermediate	good	2.25
8	Review of the artistic and aesthetic aspects of the design and their matching and adaptation to the environs	✔		intermediate	very poor	0.75
9	Description of the geomechanical and hydrological characteristics of the soil and of the terrain	✔		high	poor	2.00
10	Description of the technical characteristics and parameters of the STRUCTURES with the explanation of the structural concept of a STRUCTURE	✔		high	good	3.00
11	Explanation of the statical and structural concept of a STRUCTURE	✔		high	very poor	1.00
12	Description of the completed calculation of the structure of a STRUCTURE	✔		high	poor	2.00
13	Description of the method of drainage and regulation,	✔		high	very poor	1.00
14	Description of the equipment and traffic signs and signals	✔		intermediate	very poor	0.75
15	Review of the construction technologies	✔		high	good	3.00
16	Review of the required measures of environmental protection	✔		high	poor	2.00
17	Review of indicators of specific consumption of materials	✔		high	very poor	1.00
18	Review of bill of quantities and priced bill of quantities	✔		high	very poor	1.00
19	Other aspects of the design the author wishes to particularly point to	✔		high	very poor	1.00
20	List of all applied laws, general and technical regulations, codes of practice, and standards	✔		high	good	3.00
					Total Points (should not be less then 50 - preferably 75)	36.50

Table 2 Assessment of compliance with requirements of ToR

10 Short comings

Much of the design information is historical, in some instances dating back over twenty years. Subsequently, designs have been revised and updated by a number of different organisations which has led to confusion and a lack of clarity regarding the actual scope of the project. In particular, the design sections do not conform to the five Sections into which the Motorway is presently divided. For example the Bar-Tanki Rt design covers two Motorway sections. This is compounded by the apparent absence of high level design reports which describe the approach to design and a lack of a contents list which brings together all of the design output in a coherent package. The lack of design report and contents list is a significant deficiency as these documents are central to gaining an understanding of the extent to which the design is comprehensive and the associated risks.

As described in section 2 of this report, the General Designs include a rather limited amount of information (generally just an alignment indicating the location and extent of bridges and tunnels) and whilst it could be the basis for the Contractor to develop a detailed design, in its current format it would be very difficult to use as a basis for preparing a competitive bid. Contractors will have to undertake a significant amount of work to price the design and construction aspects.

As a consequence of the projects long history, much of the design information includes old and irrelevant information. Where practicable, this information has been moved to a “For Reference” folder to assist Contractors and avoid wasting time reviewing information that may not be helpful. This is a function of the absence of a contents list, lack of proper packaging of design output and unhelpful filenames which give little insight into the file content.

As described in a number of other sections in this report, the Preliminary Designs are not sufficiently detailed and do not meet the requirements established by the Government of Montenegro.

Almost all of the information is in the Montenegrin language which means that bidders will be obliged to employ Montenegrin speaking staff to assist in their interpretation of the contents of the data room.

11 Design and Construction Risks

We have not discovered any documents that highlight the design and construction risks. We consider that the principal risks are a reflection upon the poor standard of available documentation and the short tender period.

Risks include:

- Poor state of general and preliminary design;
- Limited ground investigation;
- Very limited time to develop designs that are sufficient for bid preparation;
- Lack of Environmental Impact Assessment, Social Impact Assessment and possible Resettlement Action Plan;
- Lack of Revision Commission approval of certain alignments;
- Difficult terrain with limited access.

12 Multi Criteria Analysis

Generally, the Revision Commission have given approval (which is recorded in a Revision Commission report) to the specific alignments for each section of the Motorway (as described in Section 2 of this report). We understand that approval for the Smokovac-Matesevo section has not yet been given. In the instance that all the currently proposed alignments have been approved, a multi-criteria analysis is not required as there are no alternative alignment options to compare and evaluate.

However, should the option be granted to the Bidders to present bids based on alternative alignments some form of multi-criteria analysis may be required such that different alignments can be rationally evaluated as part of the bid evaluation process.

13 Cost Estimate

Although a complete Bills of Quantities have been not been prepared for the General Design sections, BoQs have been prepared for the Preliminary Design section. However, these have not been assembled into a single BoQ and have not been priced. Therefore, to provide an initial cost estimate for the General and Preliminary design sections, Scott Wilson have prepared cost estimates based on a per kilometre basis using actual costs from similar schemes in the Balkans. The details are included in Table 1 overleaf. The graph below (Fig 1) is a graphical representation of the different cost per Km of construction under different terrains based on current schemes in the Balkan region. These prices have been used as the basis of the cost estimates provided overleaf in Table 1.

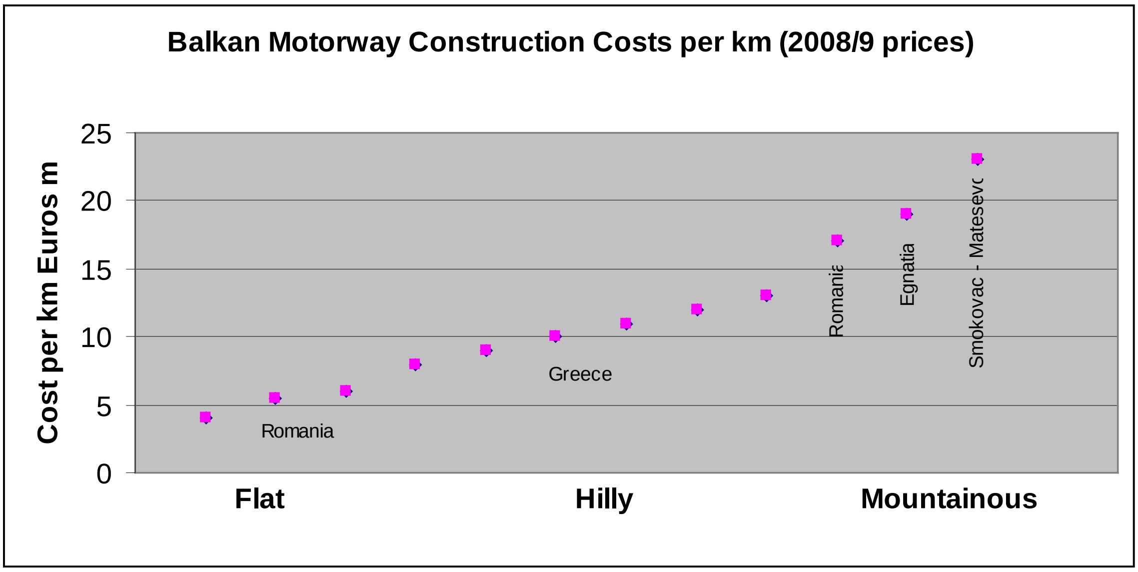


Figure 1 Current Cost of Motorway construction in the Balkan region

Section	Length	Terrain	Tunnels	% tunnels	Bridges	% bridges	Highway	Tunnels	COST	Optimism Bias	**Scott Wilson Estimate**	SW Cost per Km	Original (LB) Estimate	LB Cost per Km
	Km		Km		Km		€m/Km	€m/Km	€m	20%	**€m**	€m	€m	€m
Djurmani-Virpazar	11.7	Flat	5.75	49%	0.9	8%	6.6	24.00	177	35	**213**	18	116	10
Virpazar-Smokovac	38.2	Flat	5.5	14%	4.2	11%	6.6	24.00	348	70	**417**	11	461	12
Smokovac-Matesevo	43.5	V Mountainous	17.835	41%	4.6	11%	16	24.00	839	168	**1,006**	23	641	15
Matesevo-Berane	34.3	Mountainous	5.7	17%	2.9	8%	11	24.00	451	90	**542**	16	314	9
Berane-Boljare	41.3	Mountainous	3.7	9%	1.5	4%	11	24.00	502	100	**603**	15	271	7
TOTAL	**169**		**38.485**	**23%**	**14.1**	**8%**			**2,318**	**464**	**2,781**	16	1,803	11

Assumptions

The above table is based on highway/bridge costs from various Romanian and Greek schemes in different terrain adjusted to 2009 prices (refer to separate chart for details of Balkan Motorway construction costs).

Tunnel costs based on cost of Sozina tunnel (EUR 15.5m/km in 2005 for single bore). EUR 24m/km taken as reasonable for twin bore at 2009 rates.

Cost estimate assumes highway rate for whole length plus the difference between tunnel and highway cost applied to the length of tunnel. Bridges are included in highway rate.

The Igoumenitsa Port to Panagia section of the Egnatia Motorway in Greece is 123Km (costing €m1950 with 30Km (24%) tunnels) including tunnels up to 4.5km.

The average cost was €16m/Km (assumed to be 2006 prices). At 2009 prices this would be about this would be about €19m/km, suggesting that the average cost of €23/km for Smokovac-Matesevo is reasonable given the proportion of tunnels is almost double (41%).

Current rates in Greece and Romania on flat terrain (with little bridge or tunnel construction) are about €5.5m/Km suggesting that the figure of €6.6m/Km including bridges is reasonable.

Current rates in Greece on hilly terrain (with little bridge or tunnel construction) shows construction costs ranging between € 8m/km and €13m/km.

In Romania on mountainous terrain this figure is €17m/km including 17% bridges and 5% tunnels.

For S-M, we have estimated the basic highway/bridges cost at the higher end figure of €16m/Km due to this being the most severe terrain with the highest proportion of bridges.

For Matesevo-Berane and Berane-Boljare we estimated the basic highway cost at €11m/km being the average from Romania and Greece.

Overall, BBM is 169Km with 23% tunnels, very similar to the Igoumenitsa Port to Panagia section (123Km, 24% tunnels). Scott Wilson's average cost per Km is €16m/Km compared to an average of €m 19m for the the Igoumenitsa Port to Panagia section.

Table 1 Initial Construction Cost Estimates

SECTION	MOTORWAY BAR-BOLJARE			TOTAL :	% of Total
	Smokovac - Uvac	Uvac - Matesevo	Notes		
	km 0+000 - km 31+800	km 0+000 - km 9+178			
	L=31.800 km	**L=9.178 km**		**L=41.0 km**	
Preliminaries	61,083,479	21,710,298		**84,964,807**	10.0%
Alignment	103,377,691	30,405,203		**133,782,894**	15.7%
Tunnels	298,202,302	115,125,618		**413,327,920**	48.6%
Bridges	108,421,803	25,779,912		**134,201,715**	15.8%
Interchange	8,805,564	3,992,514		**12,798,078**	1.5%
Drainage	5,339,435	2,258,732		**7,598,167**	0.9%
Equipment	3,186,452	928,355		**4,114,807**	0.5%
Retaining walls	47,265,551	13,765,162		**61,030,713**	7.2%
TOTAL: construction works	**635,682,277.36**	**213,965,793.64**		**849,648,071**	
Other costs				**€ 37,000,000**	
SUB-TOTAL				**886,648,071**	
Optimism Bias			**10%**	**88,664,807**	
TOTAL (EUR) :				**975,312,878**	
Costs per km (Eur)				**23,788,119**	

Date: December 2008

Preliminaries includes for:

Performance security & Insurance
Independent Engineer services during design & construction (50%)
Independent Engineer services during operation & maintenance (50%)
Provision of offices & equipment for Independent Engineer
Monthly maintenance of Independent Engineer offices during construction
Monthly maintenance of Independent Engineer offices during operations
Mobilisation & demobilisation of Contractors site establishment

Other costs (those incurred by the Employer directly) allow for:

Land acquisition, social and resettlement costs
Final design technical control by Revision Commission
Independent Engineer services during design & construction (50%)
Independent Engineer services during operation & maintenance (50%)

Assumptions:

Based on designers BoQ
Where there are obvious ommissions or errors, we have provided our own estimate
Includes Tax at 17%
The bridges have been priced on the basis of the reinforced concrete design (although a steel composite alternative was included in the BoQ)
Unit rates based on schemes from Serbia, Croatia and Montenegro

Table 2 Construction cost estimates based on BoQ

Subsequent to the initial cost estimate (Table 1 above refers) a more detailed cost estimate (Table 2 refers) was prepared based on the actual Bills of Quantities (for the Smokovac-Matesevo section) that were prepared by the designers. This cost estimate is for the total construction costs including direct costs incurred by the Employer in relation to land acquisition, design approvals and the cost of employing the Independent Engineer.

14 Design Review Capabilities & Project Management Unit

The current programme for the design and construction of the entire Bar-Boljare Motorway will place significant demands upon the Independent Engineer and upon the Client's approval processes. Detailed design is programmed to commence mid 2009, lasting until end early 2013. The Independent Engineer will assume much of the responsibility for design checking. However, during this time, the Client will also have responsibility for granting approvals and will be required to have sufficient resources to grant approval in a timely fashion to avoid unreasonably delaying the design process. The Client should consider how he anticipates this role being fulfilled.

The role of the Independent Engineer relates to the design and construction of the project and has recently been extended to include the operation of the Motorway. The Client should give some consideration to the opportunities to gain experience from the Independent Engineer.

15 Organisation of Data Room

Virtually all documents are in the Montenegrin language. The design documents are arranged as follows:

The design documents are arranged in five main folders and contain General and Preliminary Design (Section 2 of this report provides more information regarding General and preliminary design). A graphical presentation (Table 2 below) indicates the folders and sub-folders together with the sub-section of Motorway to which each folder relates.

Section 15.1 provides a brief summary of the Preliminary Design information.

Folder 3 General Design Bar (Djurmani) – Tanki Rt with sub-folder Bar-Tanki Rt. Although this section is titled Bar to Tanki Rt, the Motorway commences at Djurmani. Note that the design has not been amended to reflect this.

Folder 4 General Design Virpazar –Smokovac with 3 sub folders as follows:

Bar-Tanki Rt
Tanki Rt – Farmaci
Farmaci-Smokovac

The Bar to Tanki Rt design includes the Motorway between Djurmani to Tanki Rt and is, therefore included with Folders 3 and 4. The graphic below provides a further explanation.

Folder 5 Preliminary Design Smokovac Matesevo. This section is divided into two sub-folders:

Smokovac – Uvac
Uvac – Matesevo

Further information regarding the content of these folders is included below.

Folder 6 General Design Matesevo-Berane with two sub-folders:

Matesevo-Andrijevica
Andrijevica-Berane-Boljare

Folder 7 General Design Berane-Boljare with sub-folder Andrijevica-Berane-Boljare. As with the section between Matesevo and Berane, the sub-folder Andrijevica-Berane-Boljare covers the Motorway between Andrijevica and Boljare.

As a consequence of the long history of this project, some of the design information is no longer directly relevant to the current design. Wherever possible, this information has been placed in a folder titled “For Reference”.

In the instance that additional information has become available this has been placed into folders titles “New information” together with the date upon which it was initially placed in the data room.

Bar - Boljare Motorway Data Room											
Motorway Section											
Folder No.	Bar	Djurmani	Virpazar	Tanki Rt	Farmaci	Smokovac	Uvac	Matesevo	Andrijevica	Berane	Boljare
3		Bar - Tanki RT									
4			Bar - Tanki RT								
4				Tanki Rt - Farmaci							
4					Farmaci - Smokovac						
5						Smokovac- Uvac					
5							Uvac - Matesevo				
6								Matesevo - Andrijevica			
6									Andrijevica - Berane - Boljare		
7										Andrijevica - Berane - Boljare	

Table 2 Organisation Structure of Data Room

15.1 Preliminary Design content:

Smokovac – Uvač:

The available information is arranged in the following folders:

1. **Alignment**
2. **Bridges**
3. **BoQ**
4. **Drainage**
5. **Electricity**
6. **Geotechnical/ Geological data**
7. **Retaining structures**
8. **Tunnels**

1. Alignment

Alignment folder includes technical reports [basic], layouts, cross sections, long sections and typical cross sections, BoQ.

2. Bridges

Bridge folder which comprise Bridges and Viaducts information. There is a separate folder for each bridge and viaduct which includes layout maps, typical cross section, BoQs, long sections, technical reports [detailed].

3. BoQ

Folder includes different BoQ folders for different issues e.g. Traffic control equipment folder, tunnel folder, drainage folder, bridges folder etc.

4. Drainage

Drainage layouts, cross sections, interceptor drawings, standard details, typical cross section…

5. Electricity

This folder contains textual and graphical documentation.

6. Geotechnical Geological data

Geotechnical investigation reports, seismic study, test information, geological maps, layouts.

7. Retaining structures

Retaining walls drawings, layouts, cross sections, long sections, geotechnical data

8. Tunnels

Tunnel layouts at 1/25000 scale, typical cross section, and for each tunnel there is a specific folder which includes BoQ, cross sections, technical report [detailed].

Uvač-Mateševo:

The available information is arranged in the following folders:

1. **Alignment**
2. **Bridges**
3. **Junctions**
4. **Drainage**
5. **Equipment**
6. **Pavement**
7. **Retaining structures**
8. **Tunnels**

1. Alignment

Alignment folder which includes technical report [detailed], layouts at 1/25000 scale, cross sections, long sections and typical cross sections.

2. Bridges

This folder includes Bridges and Viaducts information. Each bridge has a separate folder and includes layout maps at 1/25000 scale, typical cross section, BoQs, long sections, technical reports [detailed].

3. Junctions

This folder relates only to the grade separated junction at Matesevo. It includes location maps, layouts, cross sections, ramp drawings, BoQ.

4. Drainage

Drainage layouts, cross sections, interceptor technical report, interceptor drawings etc.

5. Equipment

Traffic control and information systems drawings with layout maps and BoQ for equipment.

6. Pavement

Pavement design technical report including technical calculations, standards which were used for design [detailed report].

7. Retaining structures

Retaining wall drawings ,layouts, cross sections, long sections, geotechnical data and BoQ.

8. Tunnels

Tunnels layout map at 1/25000 scale, typical cross section, and for each tunnel there is a specific folder which includes BoQ, cross sections, technical reports [detailed].

Appendix A - Project History

The following designs of certain motorway sections were designed:

- General design of motorway Bar - Tanki rt (R 1:25000)
Saobraćaj-inženjering – Podgorica

- General design of motorway Tanki rt – crossing with the road Podgorica – Cetinje (Farmaci) (R 1:5000)
Put inženjering - Podgorica

- General design of motorway Smokovac – crossing with the road Podgorica-Cetinje (Farmaci) (R 1:5000)
Republic Institute for Urban Planning and Design - Podgorica

- General design of motorway Andrijevica - Berane – Boljare (R 1:25000)
Put inženjering – Podgorica

- Conceptual design of motorway Đurmani - Tanki rt ("Sozina" tunnel) (R 1:1000)
Republic Institute for Urban Planning and Design – Podgorica

- Conceptual design of motorway Smokovac - crossing with the road Podgorica - Cetinje (R1:1000)
Traser - Sarajevo.

- Main design of motorway Đurmani – Virpazar ("Sozina" tunnel)(R 1:1000)
Civil Engineering Institute of Croatia - Zagreb.

- General design of motorway Mateševo – Veruša
Put-inženjering – Podgorica

- Main design of motorway Veruša – Mateševo – the design is not adopted yet (R 1:1000)
Civil Engineering Institute of Croatia - Zagreb.

In the above list, there are several designs prepared by the Republic Institute for Urban Planning and Design from Podgorica 25 years ago (Conceptual solution for the road Podgorica –Mateševo and General design of motorway Bioče-Tanki rt).

Following the adoption of changes and amendments to the Physical plan of the Republic from 1997, the drafting of project documentation for certain sections of Bar-Boljare motorway was started in earnest.

The general design Podgorica – Veruša (which was undertaken by Monteput) developed the “Kuci variant” although the previous conceptual design for Smokovac – Veruša section followed an alignment through Bratonožići.

Conceptual design of motorway (R 1:1000) Smokovac-Veruša, together with Road Center of Vojvodina from Novi Sad, is done by the Civil Engineering faculty from Podgorica.
The Bar-Boljare Motorway was divided into five sections as follows:

- Virpazar – Tanki Rt – Farmaci – Mareza – Smokovac (Podgorica bypass)

- Smokovac – Uvac – Mateševo
- Mateševo – Andrijevica – Berane
- Bar – Đurmani –Sozina tunnel – Virpazar
- Berane – Boljare (border with Republic of Serbia)

1.1 Bar (Djurmani) – Virpazar Section

Information for the General Design between Bar and Virpazar was developed up from the General Design for Bar – Tanki rt section.

The design documents are included within a single design namely, Bar-Tanki Rt (Variant 3).

The Designers were Saobraćaj inženjering and the Civil Engineering faculty from Podgorica. The design was done in 1998 and the responsible design engineer was Ljubica Lazarević, B.Sc. in Civil Engineering. In this design, the Revision Commission, given in the final report from 15th Oct 1998, approved alignment Variant 3.

The General Design included:

- bridges and viaducts 2 430 m
- tunnels 10 070 m
- facilities in total 12 500 m or 50.1%
- open alignments 12451.2 m or 49.9% of overall alignment length.

The design speed V = 100 km/h was used due to hilly terrain and the geometric parameters were:

- minimum horizontal radii Rmin = 450 m (implemented once)
- maximum longitudinal gradient imax = 5% (5.00% at the length of 2080m)
- minimum vertical radii (convex) Rmin = 10 000 m
- minimum vertical radii (concave) Rmin = 7 000 m
- traffic lane width ts = 3,5 m
- emergency lane width tz = 2,5 m
- edge marking line width ti = 0,2 m
- central reserve width Rt = 4,0 m
- shoulders width b = 1,0 m
- gutters width r = 0,75 m
- berm width b' = 1,0 m
- stopping distance p2 = 175 m
- sight distance for overtaking p = 320 m

The General Design includes road between Bar and Djurmani. It was later decided that the road between Bar and Djurmani should not be constructed as Motorway, hence the Motorway starts at Djurmani (effectively Km 13) although this is not reflected in the current General Design.

1.2 Virpazar – Smokovac Section

Louis Berger prepared the General Design for the sub-section between Farmaci and Smokovac. The General Design was developed from a number of previous designs. Hence, three designs cover the Motorway between Virpazar and Smokovac, called:

- Bar-Tanki Rt (Variant 3)
- Tanki Rt-Farmaci (Variant 6,1,3,1)
- Farmaci-Smokovac (Variant 3)

The above routes are described in the Revision Commission report.

- The first part of the alignment, Virpazar-Tanki rt (first 3.0km), was developed from the general design of motorway for Bar – Tanki rt section, designed by Saobraćaj inženjering and Faculty of Civil Engineering from Podgorica. The design was done in 1998, and the responsible design engineer was Ljubica Lazarević, B.Sc. in Civil Engineering;
- The following part, Tanki rt - junction Farmaci, was taken up from the General design of motorway for Tanki rt – crossing with the road Podgorica – Cetinje section. The design was done by the Put inženjering from Podgorica, and the responsible design engineer was Radenko Ostojić, B.Sc. in Civil Engineering;
- The combination of variants was taken up ''6'', ''3'' and ''1'', according to the conclusion of the Revision Commission. The variant (6-3-1) requires further development to avoid a water supply line at Karuč;
- The remaining part of the alignment, on the existing alignment, between the junctions ''Farmaci'' and ''Smokovac'', was developed by Louis Berger.

In all designs previously done the design speed is 100km/h and the following elements of the cross-section were prescribed:

- minimum horizontal radii Rmin = 450 m
- maximum longitudinal gradient imax = 5%
- minimum vertical radii (convex) Rmin = 10 000 m
- minimum vertical radii (concave) Rmin = 7 000 m
- traffic lane width ts = 3,5 m
- emergency lane width tz = 2,5 m
- edge marking line ti = 0,2 m
- central reserve width Rt = 4,0 m
- shoulders width b = 1,0 m
- gutters width r = 0,75 m
- berm width b' = 1,0 m

1.3 Smokovac – Mateševo Section

In the second half of 2007 the Traffic Directorate awarded preparation of the Preliminary Design for the Smokovac - Veruša motorway section to the Civil Engineering Faculty Podgorica University jointly with the Road Center of Vojvodina (from Novi Sad). During design preparation the length of section to Uvac has been extended, i.e. it reached the middle of Verusa – Matesevo section.

The design documentation is divided into two sections:

- Smokovac-Uvac (Revision Commission approval awaited) and
- Uvac to Matesevo (Revision Commission approval awaited)

The Preliminary Design for the section between Smokovac and Uvac has been designed by the Faculty of Civil Engineering in Podgorica whilst the section between Uvac and Matesevo was designed by Institut gradjevinarstva Hrvatske – Zageb.

1.4 Mateševo - Andrijevica – Berane Section

For section between Matesevo – Andrijevica, Louis Berger prepared the General design.

The design documentation is divided into two sections, namely:

- Matesevo-Andrijevica (Variant 1)
- Andrijevica- Berand-Boljare ((Variant 1 with sub-Variant 2)

Design speed of 100 km/h was adopted for the design purposes due to hilly terrain:

- minimum horizontal radii Rmin =450 m
- maximum longitudinal gradient ima imax =5%
- design speed V=100km/h
- traffic lane width tk=3,5 m
- emergency lane width tz=2,5 m
- right edge marking line tikz=0,20 m
- left edge marking line ti=0,35 m
- central reserve width Rt=4,00 m (3.00 m)
- shoulders width b=1,0 m
- gutters width r=0,75 m
- climbing lane ts=3.00m

1.5. Berane – Boljare Section

The General Design for the Berane – Boljare Motorway section was developed from the General Design of the Andrijevica – Berane - Boljare motorway section.

Project documentation designer was Put Inzenjering Company from Podgorica. Design was developed in 1998, and the head Designer was Mr. Radenko Ostojic, B.Sc., Civil Engineering.

The General Design documentation is in a single section titled: Andrijevica-Berane-Boljare (Variant 1with sub-variant 2).

Considering also terrain conditions and expected traffic flow, the following motorway elements are adopted:

- Minimum horizontal radii Rmin = 450 m (min implemented 550m)
- Max longitudinal gradient imax = 7% (implemented 5.50% for 2358.16m)
- Traffic lane width ts = 3,50 m
- Climbing lane width ts = 3,00 m
- Emergency lane width tz = 2,50 m

- Left edge marking lane width ti = 0,35 m
- Right edge marking lane ti = 0,20 m
- Central reserve width Rt = 4,00 (3.00) m
- Shoulder width b = 1,0 m
- Gutter width r = 0,75 m

Appendix B - Terms of Reference for Bridge Design

GOVERNMENT OF THE REPUBLIC OF MONTENEGRO
TRAFFIC DIRECTORATE

TERMS OF REFERENCE

FOR ELABORATION OF THE PRELIMINARY DESIGN OF THE HIGHWAY BAR-BOLJARE SECTION: SMOKOVAC-VERUŠA

L=33.5 km

- BRIDGES, VIADUCTS, LOOPS, OVERPASSES, OBJECTS ON LOOPS, UNDERPASSES, PASSAGES AND SIMILAR-

Podgorica, July 2007

CONTENTS OF THE TERMS OF REFERENCE
FOR ELABORATION OF THE PRELIMINARY DESIGN
OF BAR-BOLJARE HIGHWAY,
SECTION SMOKOVAC-VERUŠA
BRIDGES, VALLEY BRIDGES, OVER BRIDGES, UNDERBRIDGES -

4

1. INTRODUCTION

Traffic route Belgrade – South Adriatic represents the branch of Trans-European primary route (TEM), connecting basic route of TEM (from Gdansk to Athens and Istanbul) with the Adriatic Sea on the Montenegrin territory. Highway Bar – Boljare is the part of TEM traffic route through the Republic o Montenegro. This road is the component of traffic routes E-80 and E-65, meaning that simultaneously represents the part of longitudinal and transversal in the European traffic network

The schematic presentation of the stretch of the subject road is given in the drawing No.1, and the layout presentation – the corridor of the future Highway route is given, in accordance with the General Design, on the reference map 1:25000, drawing No.2.

The subject of the Terms of Reference is establishing of the requirements for elaboration of the Preliminary DESIGN of a bridges, viaducts, loops, overpasses, objects on loops, underpasses, passages and similar on the route (hereinafter referred to as STRUCTURES) of the subject highway.

The types of STRUCTURES should be tailored to the terrain conditions, the conditions of foundation engineering, and harmonization with the environment.

5

In parallel with the activities of elaboration of the Preliminary Design of the route of the highway, after the definition of its parameters, the elaboration of the Preliminary Designs of the STRUCTURES will be proceeded with.

The documents for the design of the Preliminary Designs of the STRUCTURES shall be the Preliminary Designs of the route.

At the stage of elaboration of the Preliminary Design, the Designer shall offer elaboration of minimum two options for each STRUCTURE. For the design solutions offered, the Designer shall make the comparative analysis and selection of the optimal solution.

The applied technical solutions should be modern, rational, functional, durable, and well matched with the route of the highway and the environment.

When analyzing possible structural systems and methods of construction, it is necessary to analyze the possibility of standardization of the STRUCTURES along the

entire route for the purpose of achieving favorable technical and economic solutions. Rational and documented decision-making in the phase of elaboration of the design on the basis of qualitative valuation of numerical indicators is required.
In the phase of elaboration of the Preliminary Designs of the STRUCTURES, the Designer shall, for all optional preliminary designs for each STRUCTURE, make a comparative analysis and propose the optimal design to the Consulting Engineer. The Consulting Engineer will bring the decision on the selection of the optimal option which will be further developed on the level of the Preliminary Design.
The Designer shall tailor the technical solutions to a phased execution.
The STRUCTURES that are the subject of elaboration of the Preliminary Design are of I category.
Calculation should include all the main structural elements and foundation soil, as well as the structure as a whole (evidence of the local and global stability of the structure).
It is necessary to make the calculation of effect within the structure and verification of the adopted dimensions and stresses for the relevant combinations of static and dynamic loads for the typical phases of construction and for the phase of exploitation and, on the basis of these iterations, the structure should be optimized. It is necessary to dimension the structures in the characteristic cross sections (the required class of concrete, reinforcement and cables for prestressing in the cross section).
Calculation should be made for all the phases of construction and exploitation, for all the relevant combinations of external effects and combinations of loads. In the calculation, it is necessary to apply the prevailing regulations and standards, except in the part of the seismic design, where the Designer is referred to EUROCODE 8/2 – Bridges. In case the Designer finds that certain regulations are incomplete, not up-todate or if they are mutually contradictory, EUROCODE or DIN may be applied with the previous consent of the Employer.
All the contents of the Preliminary Design of the STRUCTURES must be presented in such a way that they can be verified in the process of technical control.
6

2. STRUCTURE OF THE TECHNICAL DOCUMENTATION

It is the obligation of the Designer to elaborate the Preliminary Designs for all the STRUCTURES on the route, irrespective of the type, locality, size and number of the STRUCTURES.
The Designer shall, within the Preliminary Designs, provide textual, graphical, and numeric annexes with the required contents from which the technical and functional solutions, structural system, possibilities of construction, and fitting into the route and environs can be clearly identified as well as operating and maintaning costs.

3. DOCUMENTS FOR ELABORATION OF THE PRELIMINARY DESIGNS

The Preliminary Designs of the STRUCTURES shall, inter alia, establish: microlocation, technical and functional characteristics, structural system, the dimensions of structural elements, the applied materials, method of execution of the foundation, value and justifiability of their construction.

Designing of the STRUCTURES calls for a very detailed analysis and study of all relevant factors required for decision-making prior to adoption of the most favorable technical solutions.

The documents for elaboration of the Preliminary Design are:

3.1 Terms of Reference

The Terms of Reference shall be binding to the Designer and it at the same time represents the basis for elaboration of the Preliminary Designs of the STRUCTURES.

3.2 Space-planning technical requirements

The Designer shall adhere to the town planning technical requirements when elaborating the Preliminary Design.

3.3 Technical elements of the HIGHWAY route

The Designer is obliged to harmonize the technical elements of a STRUCTURE with the elements of the route, both in horizontal and in the vertical sense.

3.4 Cross Section of a STRUCTURE

Depending on the space planning and technical requirements and the requirements of the competent authorities and organizations, in the cross section of the STRUCTURES it is necessary to provide the free and traffic profile in line with the category and character of the road as well as the space for accommodation of the channel for drainage, the duct for the installations also taking care of the required access space for their maintenance.

7

3.5 Geodetic documents

The Designer shall, on the basis of the Geodetic documents, which he shall obtain from the Employer in the covered corridor, make readable maps for the Preliminary Designs of the STRUCTURES.

In case the Designer cannot identify favorable solutions within the covered corridor, he shall make additional geodetic surveys.

3.6 Report on geotechnical explorations

The Designer shall, while elaborating the Preliminary Design, take into account all the parameters, findings, conclusions, and recommendations from the report on geotechnical explorations, specifically:

• Type of soil with the characteristics of rockmass

• Hydrogeological characteristics, landslides, unstable and conditionally stable areas,

• The data on the bearing capacity of soil, compressibility, and heave of ground,

• Possibilities of execution of works: excavation for the foundations, placing in the embankments, borrow pits, and stock piles, and

• Sources of quality materials, etc.

The Designer, on the basis of the above parameters, shall provide technical explanation of the engineering and geological and geotechnical conditions aimed at selection of the most favorable micro-location and structural design of the STRUCTURES.

3.7 Hydrological and climatic data

While elaborating the Preliminary Design of a STRUCTURE, the Designer should take into account the climatic, hydrological, and hydrographic parameters, such as:

• Climatic conditions: precipitations, temperatures, winds, fog, insolation, etc.

• River flows (permanent, occasional), the status of regulation of watercourses, small, medium, and big waters,
• Underground waters, levels, courses, aggressiveness,
• Watersheds, catchment areas, characteristics of a river basin and drainage, erosion, etc.,
• Springs, water catchment areas, etc.

On the basis of the gathered data, the Designer shall make the hydraulic calculation, i.e. checking of the free hydraulic profiles of a watercourse on the sections underneath the bridges.

The Designer, on the basis of the above parameters and the adopted finish grades of a STRUCTURE, should elaborate a concrete technical solution for evacuation of precipitation, with controlled drainage, for the purpose of environmental protection and
8
special-purpose areas. Special attention should be paid to the solutions and conditions of drainage of precipitation and adequate technical solutions should be provided.

3.8 Seismic requirements

While elaborating the subject documentation, it is necessary to adhere to the provisions of the Spatial Plan of Montenegro (Official Gazette of the Republic of Montenegro No. 17/97) – item 1.0 – Natural Conditions – General Characteristics, as well as to the conclusions from the Report on geotechnical explorations, made by the very Designer according to separate terms of reference, and supplementary requirements that shall be done by the Designer himself.

The Designer shall be obliged to make microseismic zoning, study and separately elaborate the seismic parameters for the level of elaboration of the Preliminary Design of a STRUCTURE.

3.9 Overview of the existing state

The Designer shall, prior to the commencement of the work on elaboration of the Preliminary Designs, tour the route and/or localities on which construction of the STRUCTURES is required and familiarize himself with all the relevant parameters of the existing state of the roads, of the STRUCTURES, installations, the watercourse, and the environment.

3.10 Longitudinal and cross section

The finish grades and cross sections of the STRUCTURES should be adopted in compliance with the data from the Preliminary Design of the route. (Parallel designing with the route).

In the cross sections, the required spaces should be provided for ducting the installations, taking into account the required access area for their maintenance.

3.11 Requirements for design of the structure

Designing of the structure of the STRUCTURES shall be done applying the advance methods and procedures, in compliance with the prevailing regulations for the applied materials and structural elements with the selection of advanced methods of construction. The calculation shall include all the structural elements for the relevant combinations of the basic, supplementary and exceptional loads and soil. Verification should be made of the adopted dimensions and stresses for the relevant combinations of the static and dynamic loads for the characteristic phases of construction and for the exploitation status.

3.12 Previously elaborated documentation

The Designer shall analyze all the elements and conclusions from the previously elaborated technical documentation.

Further to the analysis of that documentation and the Preliminary Design of the route, the Designer shall decide on further elaboration of all the elements of the Preliminary Design

9

of a STRUCTURE, under the condition that it is not in collision with the Terms of Reference.

3.13 Statutory and technical regulations

When elaborating the Preliminary Design, it is necessary to adhere to the effective technical regulations , standards, codes of practice, and rules of the profession.

In designing, the prevailing domestic regulations and standards shall be applied.

For the definition of certain elements of the design for which the technical norms have not been prescribed in our technical regulations and standards, and bases and requirements provided in the Terms of Reference, it is recommended to use technical requirements and codes of practice provided in the Eurocode and/or some other foreign regulations, with the previous consent from the Client.

Possible deviations from the regulations, bases and requirements that are prescribed by these Terms of Reference are permitted but they should be specifically explained from the aspect of functionality, safety, stability, and cost-effectiveness, in compliance with the scientific and technical achievements in those areas. Such solutions should ensure safety of the STRUCTURES that is not lower than those defined by the regulations.

4. CONTENTS OF THE PRELIMINARY DESIGN

The Designer undertakes to elaborate the following within the Preliminary Design:

4.1 Title page of the design

4.2 General documentation on the design

• Decision on registration of the Designer (in compliance with the Law on Construction of Buildings/STRUCTURES, Official Gazette of the Republic of Montenegro No. 55/2000)

• The decision on registration of the Designer should be submitted in compliance with the Law on Construction of the Buildings/STRUCTURES in the Republic of Montenegro (Official Gazette of the Republic of Montenegro No. 55/2000)

• Decision on the appointment of the chief designer and the designers in charge

• The Decision on the appointment of the chief designer and the designers in charge for each type (part) of the design should be submitted.

• Evidence of the authorization for the chief designer and the designers in charge.
Evidence of the authorization for the chief designer and the designers in charge for each type (part) of the design should be submitted in compliance with Article 47 of the Law on Construction of Buildings/STRUCTURES in the Republic of Montenegro (Official Gazette of the Republic of Montenegro No. 55/2000)

10

• Statements of the chief designer and the designers in charge. The statement of the chief designer and the designers in charge that the Main Design has been elaborated in compliance with the technical and general regulations, codes of practice, and rules of the profession and that all the phases of designing have been mutually harmonized should be submitted.

4.3 Terms of Reference

4.4 Requirements of the competent authorities and organizations

The requirements of the competent authorities and organizations provided by the Client should be submitted.

4.5 Textual documentation

4.5.1 Final report of the Commission on review and adoption of the optimal design of a STRUCTURE

The Final Report of the Commission on the review and adoption of the optimal design of a STRUCTURE should be submitted.

4.5.2 Final report of the commission for revision of the Preliminary Design

The Final report of the commission on revision of the Preliminary Design should be submitted.

4.5.3 Technical report

The technical report, inter alia, should contain:

• Description of the site, chainage, and position of a STRUCTURE on the route;
• Review of the climatic conditions;
• Review of the conclusions of the Commission on adoption of the optimal design;
• Description of the layout design of a STRUCTURE with the explanation of the structural concept,
• Description of the horizontal and vertical of the route of the access road,
• Review of the method and depth of foundation engineering,
• Description of envisaged materials,
• Review of the artistic and aesthetic aspects of the design and their matching and adaptation to the environs;
• Description of the geomechanical and hydrological characteristics of the soil and of the terrain;
• Description of the technical characteristics and parameters of the STRUCTURES with the explanation of the structural concept of a STRUCTURE
• Explanation of the statical and structural concept of a STRUCTURE

11

• Description of the completed calculation of the structure of a STRUCTURE
• Description of the method of drainage and regulation,
• Description of the equipment and traffic signs and signals
• Measures and solutions for ensuring durability of the STRUCTURES;

- Review of the construction technologies;
- Review of the required measures of environmental protection;
- Review of indicators of specific consumption of materials
- Review of bill of quantities and priced bill of quantities;
- Other aspects of the design the author wishes to particularly point to.
- List of all applied laws, general and technical regulations, codes of practice, and standards.

4.5.4 Technical requirements for execution of works

It is necessary to provide the technical requirements for execution of all types of works with: defined types and quality of materials, technologies of construction and method of calculation of works, etc.

The technical requirements, individually for all types of works must be dealt with according to the following separate chapters:

- Type and quality of materials, equipment and semi-finished products,
- Quality of workmanship,
- Methods and technologies of execution of work, fitting of the equipment, semifinished products, etc.,
- Types and methods of investigations and testing,
- Method of measurements, calculation, and payment,
- Possible alternatives and options, and
- Regulations, rulebooks, standards, codes of practice, etc.

Items (numeration) of works from these terms must be harmonized with the numeration from the bill of quantities and priced bill of quantities.

5.5.5 Review of the Report on geotechnical explorations

Review of the Report on geotechnical explorations should be provided and all the significant quantitative parameters and indicators should be listed and all the recommendations to the Designer should be quoted.

The Designer shall, after the definition of the route and of the STRUCTURES on it, i.e. in the course of elaboration of the Preliminary Design, propose to the Employer the sites for which he will do the detailed geological investigations for the purpose of making the Surveys. The proposal must have a graphical annex with the textual explanation.

12

4.5.6 Bill of quantities

Bill of quantities should be made with the description and evidenced measures, for the following works

- Preliminary work;
- Preparatory work,
- Earth work,
- Concrete and reinforced-concrete work,
- Metal work,
- Reinforcing work,
- Insulation work,
- Asphalting work,

• Works on drainage, regulation, interceptions, etc.,
• Protective fences,
• Expansion joints,
• Other work.

4.5.7 Priced bill of quantities

Priced bill of quantities must include the costs of the following works:
• Preliminary work,
• Preparatory work,
• Earth work,
• Concrete and reinforced-concrete work,
• Metal work,
• Reinforcing work,
• Insulation work,
• Asphalting work,
• Works on drainage, regulation, interceptions, etc.,
• Protective fences,
• Expansion joints,
• Traffic control in the course of construction,
• Marking and notifications
• Tests by applying test loads,
13
• Elaboration of the as-built STRUCTURE documentation,
• Other work.

4.6. Numerical documentation

4.6.1 Calculation of the structure of a STRUCTURE

Calculation and results of calculation for all the STRUCTURES on the route should be submitted including checking of adopted dimensions and stresses for the relevant combinations of loads for the phase of construction and the phase of exploitation.

4.7 Graphical documentation

Graphical documentation should contain:
4.7.1 Readable map
4.7.2 Abstract from the Preliminary design site plan of the of route in the zone of a STRUCTURE, R_1= 1:100;
4.7.3 Abstract from the Preliminary design longitudinal sections of the adopted route in the zone of a STRUCTURE, R 1:1000/100;
4.7.4 Characteristic cross sections of the route at the section of a STRUCTURE
4.7.5 Site plan of a STRUCTURE, R=1:200,
4.7.6 View of a STRUCTURE, R=1:100;
4.7.7 Longitudinal cross section R= 1:200;
4.7.8 Cross sections R= 1:50;
4.7.9 Detailed cross sections R= 1:25;
4.7.10 Foundation plan R= 1:200;
4.7.11 Span structure plan R=1:100
4.7.12 Plan of a STRUCTURE, R=1:100

4.7.13 Characteristic details R=1:25
The proposed scales of the drawings are approximate and they, with the consent of the Employer, may be tailored to each concrete STRUCTURE, taking care of the dimensions.

4.8 Accompanying designs and surveys

4.8.1 Preliminary design of soil observation and of the STRUCTURES in the course of construction and exploitation

1 R is abbreviation of Scale in the original language.

14

The Preliminary Design should include soil observation and the STRUCTURES in the course of construction and exploitation with the Preliminary Design of the route.
The Design should be submitted in separate volumes by STRUCTURES.
The Design should contain:
4.8.1.1. Title page of the design
4.8.1.2 General documentation on the design
4.8.1.3 Terms of Reference
Abstract from the terms of reference should be submitted.
4.8.1.4 Textual documentation

- Purpose and task of observation,
- Subject and concept of soil observation and of a STRUCTURES,
- Program of observation,
- Methods of observation,
- Scope of observation,
- Measuring point and instruments,
- Technical requirements of implementation, and
- Conclusion.

4.8.1.5 Bill of quantities and priced bill of quantities for works and operations (for the period of construction)
4.8.1.6 Graphical documentation, which, inter alia should contain:

- Plan of the grid for observation of benchmarks,
- Position fixed data (benchmarks that are observed)
- Other documentation, and
- Details.

4.8.2 Survey of technical and engineering and organizational elements of construction of a STRUCTURE

The Designer shall be obliged to define the basic technical and engineering elements of construction of a STRUCTURE. Additionally, the Designer shall submit the time schedule of the implementation of construction of a STRUCTURE, the method of organization of execution of works, etc. The Designer shall submit the description of the adopted design accompanied by all the relevant elements and diagrams necessary for the presentation of the adopted organizational solutions.
The Survey should contain:

15

4.8.2.1 Title page

4.8.2.2 General documentation on the design
4.8.2.3 Terms of Reference
4.8.2.4 Technical report which should contain:

- Tentative technical and engineering solutions for construction of a STRUCTURE, for the preparatory and main works,
- The structure of the network plan for the implementation of the envisaged technical and engineering solutions;
- Estimated assessment of the duration of the works on the basis of the analysis of the structure of the network obtained from the tentative technical and engineering solutions,
- Approximate assessment of the costs of construction of a STRUCTURE and preparatory work,
- Assessment of the cash flow in the course of construction of a STRUCTURE and preparatory work on the basis of rough assessment of the duration of the works and rough assessment of the costs of construction.

The Survey should be made after the completion of the Preliminary Design of a STRUCTURE.
The Survey should be packed in separate volumes by STRUCTURES.

4.8.3 The Survey on assessment of the impact of a STRUCTURE on the environment

The Survey of the assessment of the impacts of a STRUCTURE on the environment should be included with the Preliminary Design of the route.

4.8.4 The Survey o hydraulic calculation

Based on the gathered data, the Designer shall make the hydraulic calculation, i.e. checking of the free hydraulic profiles of the rivers on the sections underneath the bridges.
The Designer, on the basis of these parameters and the adopted finish grades of the STRUCTURES, should elaborate the concrete technical solution of evacuation of precipitation, with controlled drainage, for the purpose of environmental protection and special-purpose areas. Special attention should be paid to the solutions and conditions of drainage of precipitation and adequate technical solution should be provided.
The Survey should be packed within the Preliminary Design of STRUCTURE as a separate chapter.
16

5. REQUIREMENTS FOR PROCESSING THE PREMLIMINARY DESIGN

The requirements for processing of the design documentation are given in the annex to the Terms of Reference.

TRAFFIC DIRECTORATE
DIRECTOR,
Veselin Grbović, BScE

BAR BOLJARE TRAFFIC FORECASTING

Table of contents

List of tables

List of figures

1.1 Base Year development

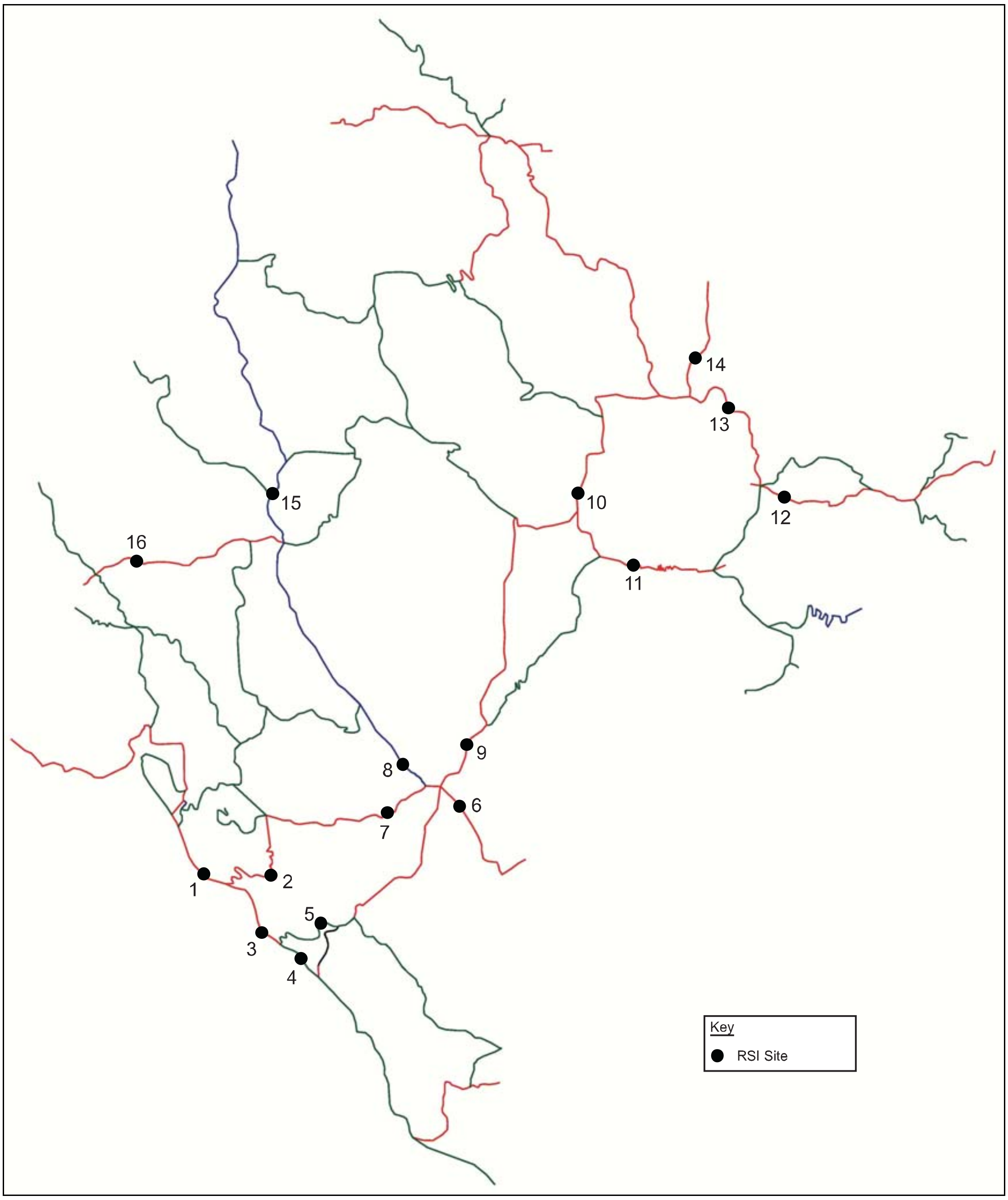
The 2007 Base Year model has been developed using VISUM. The model covers Montenegro and with neighbouring countries treated as external zones. The main features of the model are:

- AADT[1] model;
- 21 internal zones, based on Montenegrin municipalities and 9 external zones, representing neighbouring countries;
- 100 nodes;
- 254 links, covering a network of 1,840 kilometres of main and regional roads, and including information such as distance, capacity and flow-delay functions;
- 3 user classes, cars, light good vehicles and heavy good vehicles;
- Route choice using absolute value of time (derived from willingness to pay survey) and vehicle operating costs (derived from HDM-4) allowing testing of toll scenarios.

The Base Year matrices have been developed based on 16 Road Side Interviews (RSI) carried out across the network. RSI and counts outputs were processed to derive AADT traffic levels and O-D movements were cleaned to produce the prior matrices. Then counts were used to calibrate the model to base year observed traffic levels by carrying out matrix estimation. Figure 1 shows the extent of the modelled network and the location of the RSI.

[1] Average Annual Daily Traffic

Figure 1: Location of LB traffic surveys



Source: LB

The impedances and generalised costs formulas used in the model are (in Euros 2007):

- imp_{Cars} = (0.10 x km) + (2.23 x hour) + (1.31 x non-motorway hour) + (toll rate x km)
- imp_{LGV} = (0.14 x km) + (4.46 x hour) + (1.31 x non-motorway hour) + (toll rate x km)
- imp_{HGV} = (0.44 x km) + (4.46 * hour) + (1.31 x non-motorway hour) + (toll rate x km)

Post calibration, modelled flows showed a very correlation with observed flows, while the matrices integrity has not been significantly changed by matrix estimation.

1.2 Network forecasting

Following the successful calibration and validation of the VISUM model highway network and of the base year trip matrices for the Bar – Boljare motorway study, future networks have been developed.

A number of scenarios have been developed in discussion with the transport economist. All scenarios have been run for the base year and the three forecast years 2016, 2026 and 2036.

A Do Minimum (DM) scenario has been developed including the most likely developments outside the corridor of interest, shown in table 1.

Table 1: Proposed schemes for inclusion in Do Minimum

Number	Scheme	Years modelled
1	Part of the motorway from the connection to the highway Beograd - Bar to the border with Kosovo (Kosovo and Metohija): Andrijevica – Murino – Čakor - Bjeluha.	2026, 2036
2	Part of the Adriatic-Ionnian motorway: border with Bosnia and Herzegovina (in region of Nudola) – Grahovo–Cevo – Podgorica (bypass) – the tunnel through Dečić (border with Albania).	2026, 2036
3	Adriatic highway for fast motor vehicle traffic: Debeli brijeg (border with Croatia) – Herceg Novi (crossing over Bokokotorski Bay)– Tivat – Budva – Bar – Ulcinj – Fraskanjela region (Albanian state border).	2026, 2036
4	Šćepan Polje (border with Bosnia and Herzegovina) – Plužine – Nikšić – Podgorica.	2026, 2036

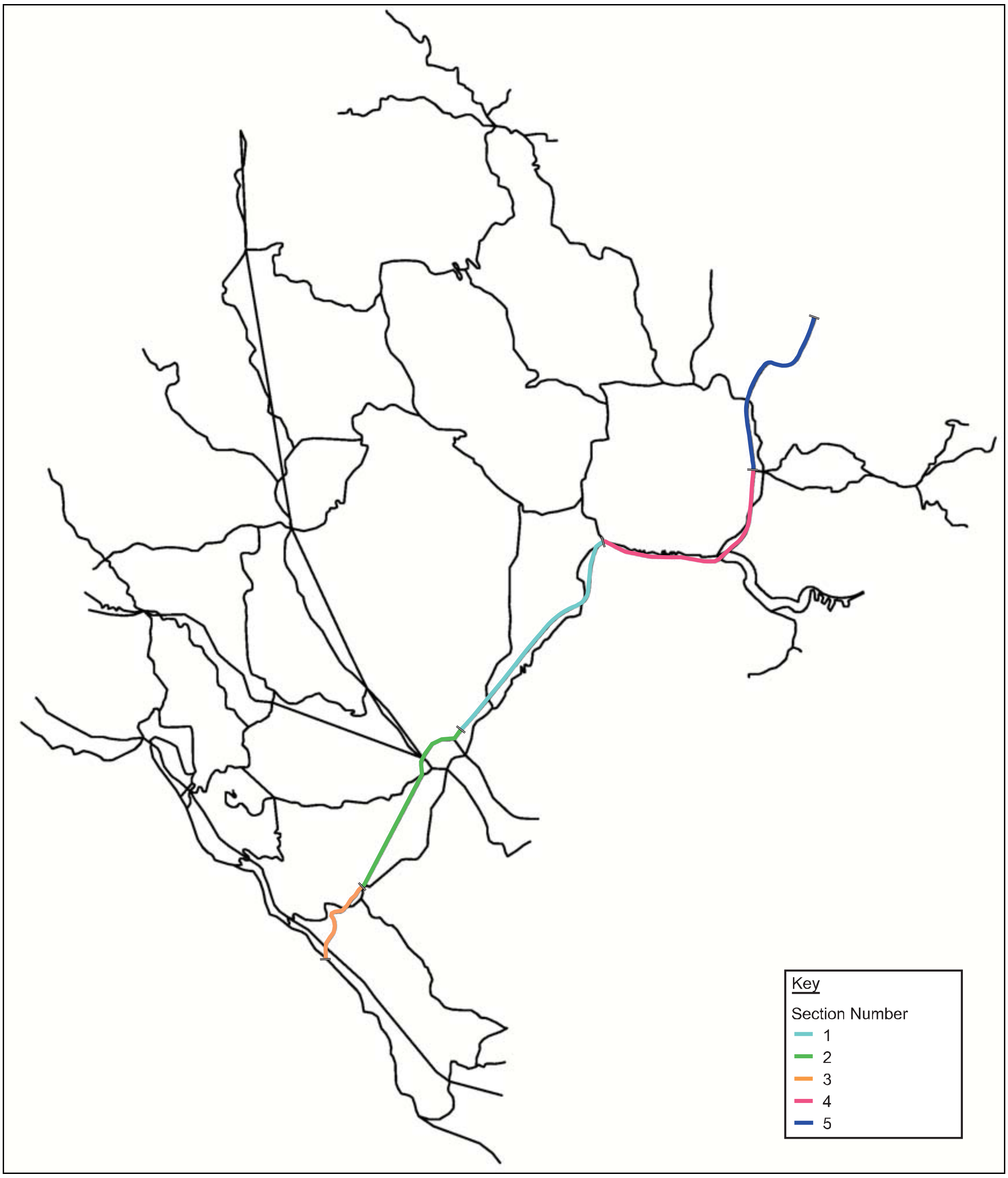
Source: Spatial Plan of Montenegro until 2020 and consultant's analysis

Then, the Do Something scenarios relating to the Bar – Boljare corridor, have been developed based on the DM, and have been assessed so as to fully understand the effects of introducing the differentiating elements of each scenario, for the proposed Bar – Boljare motorway. The sections composing the motorway and the years of opening have been assumed as follows:

- Smokovac – Matesevo 2013
- Smokovac – Virpazar 2015
- Matesevo – Berane 2015
- Berane – Boljare 2016
- Virpazar – Djurmani 2016

The location of these various sections is shown on Figure 2.

Figure 2: Location of new Bar – Boljare motorway sections



Source: Consultant's analysis

Thus in addition to the DM scenario, 10 scenarios have been developed, one per opening of a new section above plus one for each section on its own. Graphically, this can be summarised as follows:

Table 2: Proposed scenarios

	Virpazar - Coast	Smokovac - Virpazar	Smokovac - Matesevo	Matesevo – Berane	Berane - Boljare
DM					
S1			■		
S2		■			
S3	■				
S4				■	
S5					■
S6		■	■		
S7	■	■	■		
S8	■	■	■	■	
S9	■	■	■	■	■
S10	■	■			

■ Motorway section - Dual two

Source: Consultant's analysis

The proposed motorway sections have been coded as dual-2 links (2 lanes in each direction). Within the model, the motorway has been given the following characteristics:

- 2 lanes in each direction;
- Design speed of 100 kilometres per hour; and
- Capacity of 30,000 vehicles per day per direction.

In order to accurately represent driving behaviours of the three categories included in the model, maximum travelling speeds have been capped for each user class independently of road classification:

- Passenger car – maximum 120kph
- LGV – maximum 100kph
- HGV – maximum 80kph

Connections to Belgrade are not explicitly modelled, and only represented as centroid connectors as at the edge of the model and are existing in both the Do Minimum and Do Something networks. This underlies the assumption that the motorway from Belgrade to Boljare is assumed to be open by the time the northernmost section of the Bar – Boljare motorway between Berane and Boljare is completed. It should be noted that the only impact of this would be on traffic generation[2] which forms a relatively small element of the corridor demand.

1.3 Impedance and generalised costs

The same impedance formulations have been used for the forecast years as for the base year with only an increase in values of time in line with GDP growth using an elasticity of 0.7. The factors applied are given in table 3 and details can be found in the economic report.

[2] Trip generation/induction presented in section 8.5 of this report

Table 3: VOC and VOT growth factors

Year	VOC growth	VOT growth
2007	1.00	1.00
2016	1.00	1.40
2026	1.00	1.90
2036	1.00	2.26
2046	1.00	2.68

Source: Consultant's analysis

1.4 General methodology for demand forecasting

Forecast matrices have been developed for three different years, namely 2016, 2026 and 2036. A Do minimum forecast has been developed for each year, then for each scenario and year, induced traffic has been derived.

The methodology used includes growth and redistribution of the trips based on population as well as on GDP per capita (representing employment).

The method selected was to forecast future trip ends for origins and destinations and to apply a Furness using these figures to the base year matrix, to arrive at the forecast matrices.

1.5 Population forecasts

Any increases or decreases in population or in the distribution of population will have a direct influence on the amount of traffic and on traffic patterns.

The regional population forecast of LB was based on the draft of the so-called Physical Plan of Montenegro. This has subsequently been updated and renamed the Spatial Plan of Montenegro. The population forecast assumes that the spatial plan is fully implemented. A revised forecast based on the Spatial Plan adjusted to the years appropriate for use in the current review is shown in Table 4.

Table 4: population forecasts

Zone number	Zone name	2007	2016	2026	2036
1	HERCEG NOVI	33,264	33,788	34,684	35,295
2	TIVAT	13,789	14,152	14,611	14,869
3	KOTOR	23,116	23,502	24,137	24,562
4	BUDVA	16,366	17,441	18,387	18,711
5	BAR	40,822	42,644	44,462	45,246
6	ULCINJ	20,658	21,511	22,388	22,782
7	CETINJE	18,428	18,307	18,561	18,889
8	NIKSIC	76,892	80,641	84,261	85,746
9	DANILOVGRAD	16,588	16,736	17,115	17,417
10	PODGORICA	175,155	189,501	201,462	205,012
11	PLUZINE	4,257	4,222	4,277	4,352
12	SAVNIK	2,911	2,831	2,836	2,886
13	KOLASIN	9,911	9,825	9,950	10,126
14	ANDRIJEVICA	5,789	5,797	5,904	6,008
15	PLAV	14,187	15,085	15,884	16,164
16	ZABLJAK	4,187	4,150	4,202	4,276
17	MOJKOVAC	10,236	10,628	11,044	11,239
18	BERANE	36,119	38,601	40,759	41,477
19	ROZAJE	24,003	27,233	29,727	30,251
20	PLJEVLJE	36,072	36,678	37,671	38,335
21	BIJELO POLJE	51,535	54,466	57,156	58,163
Total Montenegro		**634,285**	**667,739**	**699,478**	**711,806**

Source: Spatial Plan of Montenegro until 2020, Table 11, and Consultant's analysis

Traffic to external zones is essentially traffic to Serbia. Forecasts of population in Serbia indicate that it is expected to remain more or less constant for the next 20 to 30 years (EPTISA 2007). Based on this assumption, population forecasts for all external zones have been assumed to be constant.

1.6 GDP per capita forecasts

Traffic is forecast to grow as GDP increases. The LB study based GDP forecasts on those of the Central Bank of Montenegro (CBCG) for the period 2006 - 2020[3]. The CBCG "most likely" scenario forecasts average growth in total GDP of 6.0 percent per year and 5.4 percent per year in terms of GDP per capita. This was assumed by LB to continue to 2021, with slightly lower growth rates thereafter in keeping with the greater level of uncertainty that is inherent in longer term forecasts. Thus the assumed rates of growth of GDP per capita were 3.6 percent per annum during the period 2022 to 2027 and 2.4 percent per annum between 2028 and 2037.

[3] Louis Berger SAS (2008) Technical Memorandum no. 13A, General Traffic Forecast - Revision

These rates are regarded as credible and, given the uncertainty associated with forecasting GDP, it is not considered necessary to change them. However, it is necessary to adjust them to average annual rates of growth for the time periods being used in the current review.

In the traffic model, traffic to and from external zones is predominantly traffic to and from Serbia. Recent traffic studies in Serbia have used a GDP forecast of 5.0 percent per year to 2020 and 4.0 percent thereafter (EPTISA). The resulting annual growth rates are shown in Table 5.

Table 5: Summary of GDP / capita forecast growth rates (percent per annum)

Period	Montenegro	External zones
2007 - 2016	5.4%	5.0%
2017 - 2026	4.5%	4.4%
2027 - 2036	2.5%	4.0%
2037 - 2046	2.4%	4.0%

Source: Consultant’s analysis

GDP growth in Montenegro is forecast to vary by region, and summarised in the table below. Further details on the derivation of these can be found in the economic report.

Table 6: Assumed regional differentials in economic development

Percentage growth in relation to the national average

-15%	0%	15%	30%
Northern region:	Central region:	Coastal region:	Capital area:
Pluzine Savnik Kolasin Andrijevica Plav Zabljak Mojkovac Berane Rozaje Pljevlje Bijelo Polje	Niksic Danilovgrad	Herceg Novi Tivat Kotor Budva Bar Ulcinj Cetinje	Podgorica

Source: Consultant’s analysis

1.7 Demand forecast

The general formula for each zone, and each attractions and production is as follows:

$$\text{Forecast trip end} = \text{existing trip end} \times \frac{\text{Future population}}{\text{existing population}} \times \text{GDP per capita growth} \times \text{Elasticity}$$

An elasticity of 1.2 has been assumed for cars in the growth in trip making with respect to the growth in GDP per capita while it has been assumed to be 1.0 for freight traffic. LB assumed an income elasticity of demand of 1.5 in 2007 for all traffic, declining to 1.3 by 2017. While it is true that high elasticities have been observed for short periods in neighbouring countries as they entered periods of change, an elasticity of 1.2 has typically been found to be appropriate for passenger cars in the central and east European region. Analyses of freight traffic in Europe have shown that on average freight traffic can be assumed to grow directly with GDP per capita (ie. with an elasticity of 1.0). These rates are supported by an analysis of growth in GDP and corresponding growth in passenger and freight transport based on IRF World Road Statistics for the UK, France and Germany for the period 1970 to 1990. Further analysis can be found in the economic report.

Further adjustments have been carried out focussing especially on the potentials the port of Bar and the development of the railway. These are presented in the following sections.

1.8 The port of Bar

The development of the port of Bar has been cited as a potential generator of traffic for the Bar – Boljare corridor. The port has therefore been considered separately in this review.

The port of Bar currently handles approximately 2 million tonnes of freight per year, an amount that has remained more or less constant during the period 2003 to 2007. In 2007 approximately 12 percent of freight was containerised; container traffic has increased from 8,633 TEU in 2003 to 27,095 in 2007. RO-RO traffic constitutes about 4 percent of total freight traffic. In 2006, about 80,000 passengers used the port.

Table 7: Port of Bar traffic 2003 – 2007

	Units	Year 2003	2004	2005	2006	2007
passengers	'000	n/a	n/a	66	80	n/a
freight loaded	mln. tonnes	n/a	n/a	1.24	1.06	n/a
freight unloaded	mln. tonnes	n/a	n/a	0.92	1.15	n/a
total freight	mln. tonnes	1.92	1.95	2.16	2.21	2.18
Of which:						
liquid bulk	mln. tonnes	0.37	0.46	0.39	0.39	0.45
dry bulk	mln. tonnes	1.03	0.98	1.04	0.79	0.54
general cargo	mln. tonnes	0.52	0.51	0.73	1.03	1.19
container traffic	TEU	8,633	11,434	12,258	17,854	27,095
container traffic	mln. tonnes	0.068	0.085	0.094	0.147	0.264
RO-RO traffic	mln. tonnes	n/a	n/a	0.08	0.09	n/a

Source: SEETO, MTMAT

The current capacity of the port is about 4.5 million tonnes per year, although with investment in equipment and infrastructure this could ultimately be increased to about 10 million tonnes per year. To achieve this level of increase in traffic, investment would also be needed in the road and / or rail links to the port. The Bar – Boljare motorway would be essential for the further development of the port. Serbian authorities[4] have indicated that their principal seaborne commerce would be transferred from Thessaloniki to Bar, once the motorway link from Belgrade to Bar is completed. Nevertheless, such a comment must be treated with a certain amount of caution, since the increasingly privatised commercial sector will be free to choose whichever port offers the most appropriate service. In parallel, upgraded rail infrastructure would influence the proportion of traffic using rail as opposed to road. Assuming necessary investments are made, capacity of the port could be reached by 2020 if traffic grows on average by 15 percent per year.

Analysis of the LB RSI surveys identified about 180 truck journeys per day between the port of Bar and the border with Serbia. Assuming full development of the port, from the current 2.1m tonnes pa to 10m tonnes pa, a quadrupling of the number of trucks to 720 per day could be expected by 2020, assuming the modal split between road and rail remains constant.

[4] Serbian Infrastructure Minister Velemir Ilic, announcement 19 March 2008.

Table 8: Volumes of trucks to / from Bar by corridor section (AADT)

Year Section	2007 Existing	2020 Growth	2020 Total
Bijelo Polje - Serbia	180	540	720
Berane - Bijelo Polje	230	690	920
Andrejevica - Berane	310	930	1,240
Kolasin - Andrejevica	330	990	1,320
Podgorica - Kolasin	330	990	1,320
Bar - Podgorica	540	1,620	2,160

Source: LB surveys and Consultant's analysis

The port of Bar may be expected to have above average growth. While the growth of general traffic will not be significantly more than other coastal zones, the growth of truck traffic will be significantly higher. This is considered explicitly in the traffic model by converting the link flows above into truck trips demand from and to the port of Bar (two way) as shown in table 9 and ensuring these are reached in the forecast matrices for years 2026 and 2036.

Table 9: Expected daily truck demand to / from Bar for 2020

Origin - Destination	2020 truck Demand
Bar - Serbia	720
Bar - Bijelo Polje	200
Bar - Berane	320
Bar - Andrejevica	80
Bar - Kolasin	0
Bar - Podgorica	840

Source: LB surveys and Consultant's analysis

If these targets are not reached in the forecast matrices, truck trip demand is increased to match these.

1.9 Development of the railway

It may be expected that investment will be made in the rail system and that traffic will be attracted to rail in the future. At the same time, however, investment will be made in the highway network, counteracting some or all of the additional attractiveness of the railway. Nevertheless, it is useful to consider the implications of a change in modal split. If it is assumed that the levels of traffic observed in 1989 are indicative of the maximum traffic that might be carried, the effect on traffic on the Bar – Boljare motorway may be estimated.

Between 1989 and 2007, the number of tonnes carried by rail fell from 4.50 million to 1.76 million, a fall of 2.74 million tonnes per year, or 7,500 tonnes per day, of which 5,000 tonnes were international freight. This is equivalent to about 200 loaded trucks per day, or 400 trucks per day in total, that could potentially be switched back from road to rail.

In 2007 the railway carried 1.2 million passengers, 40 percent of the 1989 patronage of about 3.0 million. Thus, about 1.8 million passengers have been lost, of which 57 percent (2,800 per day) were travelling internationally. This is equivalent to approximately 1,300 cars per day[5] switched back from road to rail.

If rail traffic were to grow at 5 percent per year, these modal shifts of trucks and cars from road to rail could be achieved by the year 2028.

Modal shifts from road to rail are included explicitly in the traffic model however the modal shifts were incorporated on the basis of intuitive assumptions. Because of changes in vehicle ownership, travel behaviour etc, it is assumed that by the year 2026 only half the potential transfers back to rail outlined in the paragraphs above occur. This has been modelled assuming a removal of 200 trucks and 650 cars per day from the Bar – Boljare highway corridor.

1.10 Final Do Minimum demand

Table 10 shows the matrix totals for the Do Minimum vehicle demand (excluding trip generation) for the various forecast years. This demand includes the correction for the port of Bar and for the railway as these are considered to be relatively independent from the introduction of the Bar – Boljare motorway (effects of the port of Bar might be increased and of the railway decreased due to the construction of the Bar – Boljare motorway and are considered as part of the model of induced traffic).

[5] Based on an occupancy of 2.14 persons per vehicle as presented in section 3.3 of this report.

Table 10: DM forecast demand and growth from 2007

Modes	Base 2007 Total	Intrazonal	Total Growth from 2007
Car	97,731	31,229	-
LGV	13,431	3,289	-
HGV	8,678	1,511	-
Total	**119,840**	**36,029**	**-**
	DM 2016		
Car	198,878	67,561	103.5%
LGV	23,777	6,239	77.0%
HGV	14,901	2,804	71.7%
Total	**237,556**	**76,604**	**98.2%**
	DM 2026		
Car	408,489	141,557	318.0%
LGV	48,889	13,080	264.0%
HGV	31,491	5,880	262.9%
Total	**488,869**	**160,517**	**307.9%**
	DM 2036		
Car	586,113	200,910	499.7%
LGV	70,129	18,521	422.1%
HGV	44,538	8,328	413.2%
Total	**700,780**	**227,759**	**484.8%**

Source: Consultant’s analysis

1.11 Model of induced traffic

Construction of a new motorway may lead to the generation of “induced traffic”, that is, traffic resulting from trips which would not have been made had the facility not been constructed.

In the current study, an estimate has been made of the amount of induced traffic which might be generated for each scenario for each forecast year. It represents, therefore, what might be expected to be the maximum amount of traffic induced.

A simple approach has been adopted which relates the traffic generated to the change in travel time resulting from the construction of the motorway for each origin - destination pair in the matrix. The form of the relationship is:

$Dem_{DS} = Dem_{DM} \times (c_1/c_0)^b$

where Dem_{DM} is the DM demand,

Dem_{DS} is the DS demand including generated traffic,

c_0 is the journey time without the motorway, or DM time skim

c_1 is the journey time with the motorway, or DS time skim and

b is an elasticity.

An elasticity of -0.24 has been assumed, which is the value recommended for off-peak inter urban trips in the UK[6]. This methodology has been used for other east European countries (Poland for example) to represent the expected trips generated due to the addition of new motorway links and hence reduced travel costs. The advantages of this technique are that it considers possible generation for all origin – destination pairs independently. Thus, origin – destination pairs away from the infrastructure improvements and not likely to use it will not produce any induced demand while origin – destination pairs directly close to the project will enjoy high induction. Furthermore, long distance trips where time savings are likely to be significant will benefit from greater induction than short distance trips for which time savings are minimal.

This induction of traffic in fact reflects three possible changes in behaviour towards travelling, these are:

- Trip distribution also called destination choice, or long term relocation of either or both home, work or shopping locations as the result of the motorway increasing accessibility to certain areas;
- Mode shift, which corresponds to people's willingness to change mode as the result of an improvement. For example trips being transferred form rail or air to road as the quality of travel improves thanks to the motorway;
- Trip frequency, or the willingness to travel as the result of transport infrastructure improvements. While before travelling from A to B was considered too long to be worthwhile new travel times make the trip possible.

In the case of the Bar – Boljare motorway, it is considered that the above approach accounts for 4 main factors:

- The possible further development of the port of Bar as road improvements to Podgorica and to Serbia would strengthen the position of the port of Bar;
- The possible transfer (mode shift) form rail to road as, even if the railway would have been improved, the Bar – Boljare motorway would bring significant time savings for long distance trips on the corridor;
- The possible development of the northern part of Montenegro which will be much more accessible from the coast and capital. Possible such developments include ski resorts in the mountainous areas and more accessible national parks close to the northern sections of the motorway; and
- The possible development of new settlements and extensions to urban areas along the corridor directly related to trip distribution.

1.12 Toll optimisation

Toll optimisation was carried out for cars on scenario 9 for year 2007 and 2036. Optimum toll revenue levels were found for toll rates of 7 Eurocents/km for year 2007 and 10 Eurocents/km for year 2036. Based on the optimised toll rate of 7

[6] Department of Transport (1997) Design Manual for Roads and Bridges, Traffic Appraisal Advice

Eurocents/km for cars, toll rates for other vehicle categories have been derived. The toll rates assumptions on the motorway are (except Sozina tunnel):

- 7.00 Eurocents/km for cars
- 12.25 Eurocents/km for LGVs
- 21.00 Eurocents/km for HGVs

The toll rates for the Sozina tunnel have been kept as the current levels.

Revision Schedule

Toll Study
February 2009

Rev	Date	Details	Prepared by	Reviewed by	Approved by
01	28 October 2008	Toll Study	**Colin Lawson Toll Systems Expert**	**Simon Roberts Technical Director**	**Martin Edge Director**
02	4 February 2009	Revised with updated traffic data and to reflect comments	**Colin Lawson Toll Systems Expert**	**Simon Roberts Technical Director**	**Martin Edge Director**

Scott Wilson
Scott House
Alencon Link
Basingstoke
Hampshire
RG21 7PP
UK
Tel +44 (0) 1256 310200
Fax +44 (0) 1256 310201

www.scottwilson.com

Table of Contents

EXECUTIVE SUMMARY

The Bar - Boljare Motorway is a proposed major new highway development in Montenegro. When complete, this Motorway will connect the port city of Bar in the South West of the country to Boljare on the border with Serbia. The Motorway is to be configured as a two lane divided highway and built to European Standards. It will take the form of a controlled access highway and toll fees will be charged for the use of the facility. It is intended, ultimately, that this Motorway will be a vital link in a planned arterial route connecting the port of Bar on the Adriatic Sea to Belgrade in landlocked Serbia and possibly beyond.

In the context of low initial traffic volumes, this report considers and evaluates the two options for toll systems for the Bar-Boljare Motorway, namely open and closed systems. An Open System usually means one in which all toll fees, with levels set according to vehicle type, are collected at a single point for the use of a particular stretch of road. Closed Systems are those in which the user is charged directly according to distance travelled. In this type of system, all entry and exit points to the road or network must be controlled.

This report also considers the different methods that are available for the collection of toll fees.

The report concluded that a fully manually operated closed system was most appropriate as it has the following advantages:

- Only two stops for the user, regardless of distance travelled;
- Equitable toll charges based on distance travelled on the facility;
- Simplicity of operation;
- Low initial costs;
- System throughput capability can be expanded by adding equipment in response to traffic growth;
- Flexibility for almost unlimited expansion of the tolled road network.

A further advantage of the standard Closed System is that the equipment is well proven and relatively inexpensive, and both equipment and operating costs can be managed by initial provision of minimal installations, gradually increasing the number of toll lanes in response to growth in traffic demand and increased toll revenue. During the design stage, care must be taken to provide sufficient land for the possible future needs for both entry and exit toll plazas.

None of the open system variants are considered to be appropriate.

This report recommends that a manual toll system, with 2 lanes in each direction be implemented. The possible means of payment include cash, pre-paid cards and credit card initially. Electronic Toll Collection (ETC) is not recommended initially as this would add significantly to the operating costs.

The optimum proposed toll is €0.11 per Km for cars, which may appear to be expensive, but the considerable savings achieved in travel time justifies this. Ultimately, the actual tolls applied to different classifications of vehicle will influence the number and type of vehicle using the Motorway. It is important that there is clarity regarding where responsibility lies for setting and adjusting toll rates.

It will be the responsibility of the toll system designer, together with the System Operator, to assess these traffic and revenue factors, along with social factors such as general acceptance and public expectation of the availability of some payment methods for other purposes, before deciding on the range of methods of payment, other than cash, to be incorporated in the initial system implementation.

1 INTRODUCTION

1.1 General

The BAR - BOLJARE MOTORWAY (BBM) is a major new highway development in Montenegro which will connect the port city of Bar in the Southwest of the country to BOLJARE on the border with SERBIA in the Northeast, serving, en route the capital city of Podgorica. The Motorway is to be configured as a two lane divided highway and built to European Standards. It will take the form of a controlled access highway and toll fees will be charged for the use of the facility. It is intended, ultimately, that this Motorway will be a vital link in a planned arterial route connecting the port of Bar on the Adriatic Sea to Belgrade in landlocked Serbia and possibly beyond. An approximate alignment of the Bar - Boljare Motorway is shown on the sketch map on the following page.

The purpose of this report is to discuss and develop guidelines for methods of toll collection to assist the Toll Operator in choosing a suitable system to be implemented for the completed Motorway and during phased construction & opening of the various sections. These will include recommendations for configuration of mainline and interchange tolling facilities within the constraints of the limited preliminary alignment and configuration information available at the time of production of this report.

Background information regarding existing design work was obtained from “The Feasibility Study for Two Highways in Montenegro” Final version, issued in August 2008 by Louis Berger SAS (LB), of France, and commissioned by the Project Owner, the Ministry of Transport, Maritime Affairs and Telecommunications (MTMAT). Some other documents by LB, generally Technical Memoranda produced in conjunction with the Feasibility Study, have also been available for reference.

The guidelines are developed utilising concepts of tolling accepted and in use worldwide. In particular we will strive to recommend a system of toll collection, which will be:

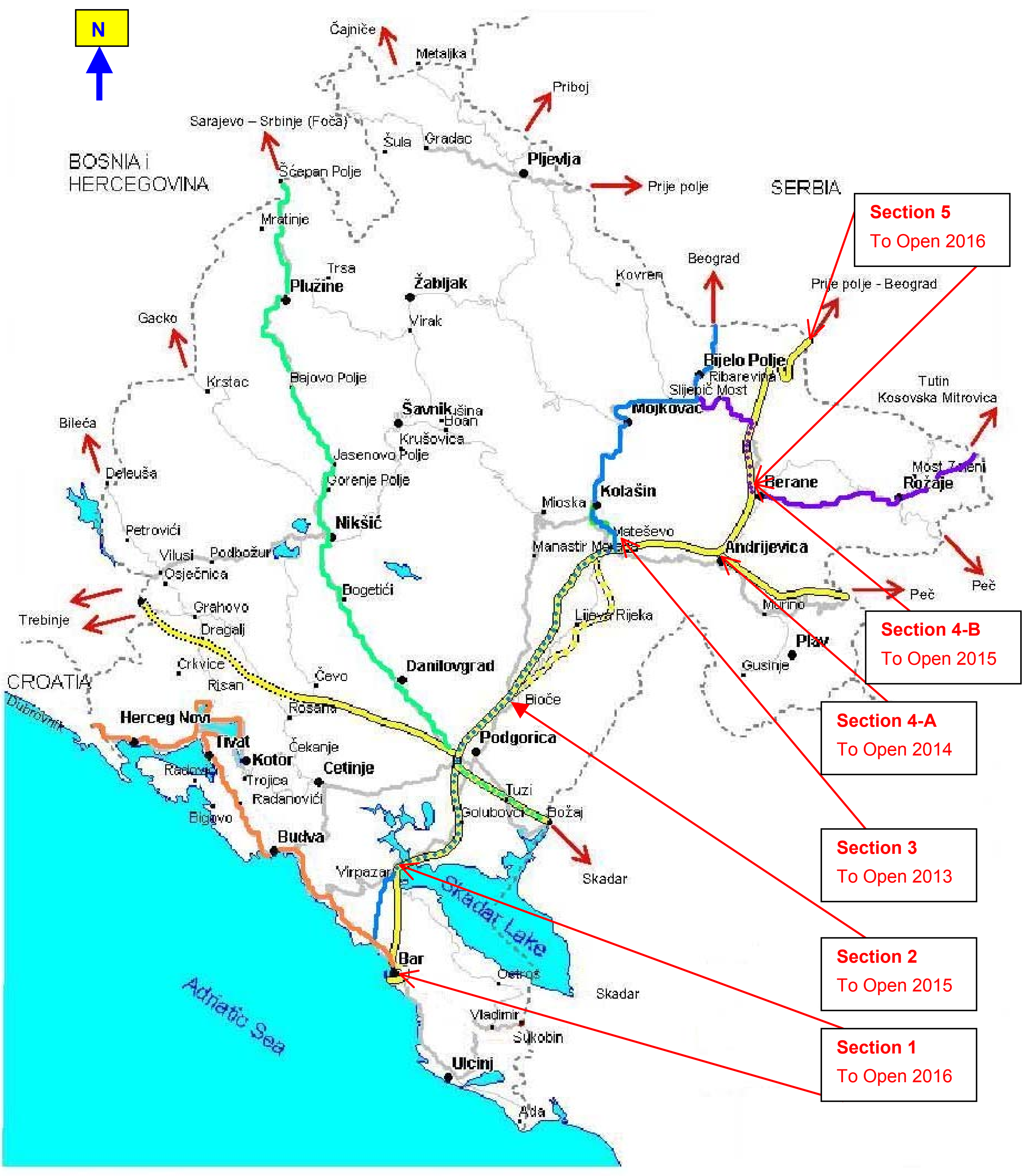
- Appropriate to the location and expected usage of the Motorway;
- Capable of expansion/change in collection methods as future conditions may dictate;
- Considerate of the possible incorporation of the Motorway into a larger future toll road network, within the country or extending beyond the borders of Montenegro;
- Efficient in use with minimal disruption to traffic flow;
- Cost effective in installation and operation.

1.2 Route Alignment and Description

The preliminary Route Alignment and Interchange positioning used in this Toll Study are taken from the Feasibility Study Final Report referenced above.

It is likely that the construction will take place in stages with opening to traffic of each stage on completion of construction. There are 6 stages envisaged, with overlapping construction phases leading to opening of all sections over a period of approximately 3 years between 2013 and 2016. The planned phases are shown on the following map and chart. Currently, as the details of the motorway alignment have not yet been completely finalized in all areas, the information should be considered preliminary and approximate, but will form the basis of tolling recommendations contained in this report.

Preliminary Route Alignment with Phased Construction / Opening Sections



Key

Section 1	**Bar (Djurmani) – Virpazar**	**Section 4-A**	**Matesevo - Andrijevica**
Section 2	**Virpazar – Farmaci - Smokovac**	**Section 4-B**	**Andrijevica - Berane**
Section 3	**Smokovac - Matesevo**	**Section 5**	**Berane – Boljare**

SECTION	ACTIVITY DESCRIPTION	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Section 1: BAR [DJURMAN] TO VIRPAZAR	General Design [completed]										
[11.2 kms]	Preliminary Design by GoM - MTMAT										
	Land Acquisition by GoM - MTMAT										
	Final Detailed Design by CONCESSIONAIRE										2016
	CONSTRUCTION by CONCESSIONAIRE										
Section 2: VIRPAZAR-FARMACI-SMOKOVAC	General Design [completed]										
[38 kms]	Preliminary Design by GoM - MTMAT										
	Land Acquisition by GoM - MTMAT										
	Final Detailed Design by CONCESSIONAIRE									2015	
	CONSTRUCTION by CONCESSIONAIRE										
Section 3: SMOKOVAC TO MATESEVO	General Design [completed]										
[41 kms]	Preliminary Design by GoM - MTMAT										
	Land Acquisition by GoM - MTMAT										
	Final Detailed Design by CONCESSIONAIRE							2013			
	CONSTRUCTION by CONCESSIONAIRE										
Section 4-A: MATESEVO TO ANDRIJEVICA	General Design [completed]										
[23 kms]	Preliminary Design by GoM - MTMAT										
	Land Acquisition by GoM - MTMAT										
	Final Detailed Design by CONCESSIONAIRE								2014		
	CONSTRUCTION by CONCESSIONAIRE										
Section 4-B: ANDRIJEVICA TO BERANE	General Design [completed]										
[11 kms]	Preliminary Design by GoM - MTMAT										
	Land Acquisition by GoM - MTMAT										
	Final Detailed Design by CONCESSIONAIRE									2015	
	CONSTRUCTION by CONCESSIONAIRE										
Section 5: BERANE TO BOLJARE	General Design [completed]										
[41 kms]	Preliminary Design by GoM - MTMAT										
	Land Acquisition by GoM - MTMAT										
	Final Detailed Design by CONCESSIONAIRE										2016
	CONSTRUCTION by CONCESSIONAIRE										

Note: the year columns appear under the spanning header ACTIVITY YEAR.

Table 1

Section 1 Bar (Djurmani) – Virpazar (11 Km.)

Scheduled to open to traffic 2016 (Part of Third Phased Opening)

The Bar – Virpazar Section starts at the port of Bar and includes two intermediate full directional interchanges with the E851 highway at Susanj and Djurmani. It then continues generally northward through the Sozina Tunnel to another full directional interchange at Virpazar. Though this Section, like the rest of the Bar - Boljare Motorway, is to be constructed as 4 lane dual carriageway divided highway, the 4.1 Km. Sozina Tunnel consists of a single tube with two way traffic. Each traffic lane is 3.85m. in width with no emergency lane. The Sozina Tunnel is currently tolled, with a fee of €2.50 for passenger cars in each direction. Fees are collected from vehicles travelling in both directions at a 4 lane barrier toll plaza situated at the north end of the tunnel.

Section 2 Virpazar-Farmaci-Smokovac (38 Km.)

Scheduled to open to traffic 2015 (Part of Second Phased Opening)

This Section starts at the Virpazar Interchange where it connects directly to Section 1. It then proceeds towards the capital city of Podgorica, where it forms a bypass to the west of the city. There are 3 intermediate full directional interchanges, at Bistrica, Farmaci with the Podgorica – Cetinje Road, and Gorica (Komani) with the Niksic Road. The northern end of the Section is at Smokovac where a further interchange will be constructed.

Section 3 Smokovac – Matesevo (41 Km.)

Scheduled to open to traffic 2013 (First Phased Opening)

This Section is scheduled to be the first part of the new Motorway construction to open to traffic. It will provide improved access to the capital to and from the north. The section starts at the northern end of the Podgorica Bypass Section, to which it will be directly connected, and proceeds generally North-Northeast to Matesevo where an interchange will be built leading to the town of Kolasin and, via the E80, to Mojkovac. Currently there are no intermediate interchanges planned for this section as it runs through quite mountainous terrain east of Road E65/E80 and there are few local roads in the area.

Section 4-A Matesevo – Andrijevica (23Km.)

Scheduled to open to traffic 2014 (Part of Second Phased Opening)

The proposed Motorway alignment curves towards the east a little before the Matesevo Interchange, and this Section continues to run east to Andrijevica where there is an interchange with the road leading to the eastern city of Plav and the borders with Serbia and Albania. There are no intermediate interchanges planned for this section.

Section 4-B Andrijevica – Berane (11 Km.)

Scheduled to open to traffic 2015 (Part of Third Phased Opening)

At Andrijevica the Motorway curves northward again for this short Section to Berane where an interchange will be constructed with the E80 highway. Again, there are no intermediate interchanges planned for this section.

Section 5 Berane – Boljare (41 Km.)

Scheduled to open to traffic 2016 (Final Phased Opening)

This Section to the border region between Montenegro and Serbia is scheduled to be the last stage completed. Its opening to traffic will mark the completion of construction and the opening of the entire Motorway to traffic. An intermediate interchange in this section is planned with the E80 road near Crnca, about halfway along the section, leading to the towns of Mojkovac and Bijelo Polje.

2. TOLL SYSTEMS METHODOLOGY

2.1 General

This section will describe in detail toll revenue collection methods available and examine their advantages and disadvantages, particularly as they may apply to the Bar – Boljare Motorway.

The basic purpose of any Toll Revenue Collection System is to ensure that the correct toll fees, as mandated by the Operating Authority or Government, are correctly charged to each vehicle passing through the system, properly accounted, and the revenue properly credited to the account of the authority designated to receive the fee. The system must provide an audit trail and means of cross-checking vehicles and fees collected to ensure accurate and transparent financial accountability at all times.

This is to be achieved in the most efficient manner, consistent with the specific application, and should not significantly inconvenience road users or interfere with traffic flows.

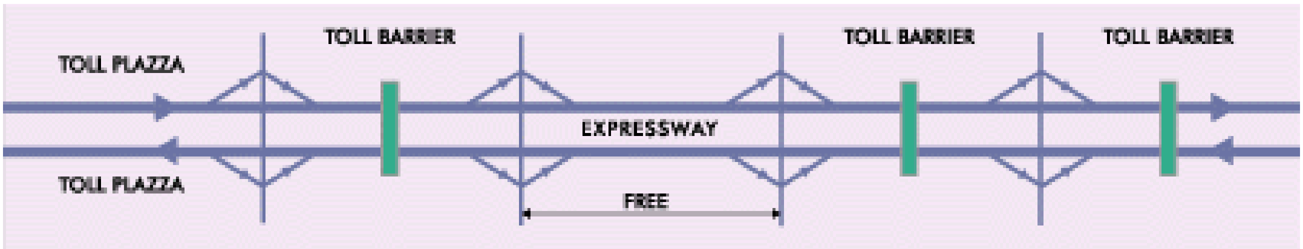
Internally, the toll revenue auditing system must accurately account for each toll fee collected, reporting this data to authorized operating staff separately from the physical accounting of the collected revenue, which should be undertaken by other staff. The results of both accountings should be made available only to senior staff responsible for the Toll Operator's financial management. The system operational design must minimize, to the greatest extent possible, opportunities to falsify data by operating staff. Data is normally collected on a transaction by transaction basis, the information being recorded and linked to the identities of the staff responsible for the operation, e.g. collectors and supervisors, in order to allow correct assignment of responsibility in the case of discrepancies between the two audit trails.

The basic tolling methods in general use can be split into two system principles. These are "**Open**" systems and "**Closed**" systems.

2.2 Open Systems

An Open System usually means one in which all toll fees, with levels set according to vehicle type, are collected at a single point for the use of a particular stretch of road or for a facility such as a bridge or a tunnel. Normally, a "Barrier" toll plaza is placed across the main line of the highway, at a strategic point which users can not avoid passing, to collect tolls from vehicles travelling in both directions. Traffic from several entrances may be channelled to the single collection point, after which drivers may have several choices of free exit. This 'classic' Barrier Toll Plaza approach is only generally practical where a road of medium length (say 20 to 40 Km.) requires relatively few entrance and exit points and a suitable, unavoidable location can be identified for toll collection. Occasionally on such Open configurations, where some, but very few, exits are unavoidable before the traffic reaches the barrier plaza, small 'satellite' plazas will be constructed on the exit slip roads. In these cases, the toll fees at the exit plaza will normally be less than those charged at the main line barrier.

TYPICAL OPEN SYSTEM



On longer roads, barrier toll plazas may be placed at distances of about 30 to 50 Km. Thus a vehicle will pay separately for the use of each section of the road, but there is no direct correlation between the toll fee and the distance travelled.

Depending on the placement of entry and exit points, Open Systems may be used to collect tolls from all vehicles using the road, or it may be permitted for vehicles to use some shorter stretches of the road between the toll plazas free of charge. For example, a toll road connecting two adjacent towns or a city to a facility such as an airport, may allow local free usage of parts of the road at each end, but charge by barrier toll collection for the longer journey between the extremities. Alternatively, in rural areas where there are few local roads, the tolled facility may be used to improve the local network by allowing free use for relatively short distances between existing local roads. In this case, barriers will be suitably placed at each end to 'seal' the system. Such use can provide economic advantages to the area, but accesses must be carefully planned to ensure that they do not present opportunities for longer distance traffic to bypass the barrier toll plazas.

At such facilities as bridges and tunnels a "Barrier" toll system is normally used. This is a type of Open System, sometimes known as a Passage System, where all vehicles using the facility are charged the toll fee at a single point. An example of this is the system currently in use at the Sozina tunnel. Other examples can be found worldwide, as this is the most common way to collect fees at such facilities, where users need to be charged to cover the costs of construction, operation and maintenance of the structures. Often, in such cases, if an alternate route is significantly longer, and if traffic studies show that most users return to their point of origin by use of the same facility, all toll revenue may be collected in one direction of travel only, to minimize equipment and operation costs. Examples of this are the Severn and Tamar Bridges in England and the Forth Road Bridge in Scotland before tolls were removed completely in 2007. Long distance travellers, such as tourists, may benefit from this, but the cost savings easily outweigh the small loss of revenue which this represents.

Another form of Open System is the "Pay on Entry" (or on Exit – though that is less common and less desirable) configuration. This is suitable for relatively small urban networks with several route choices within the network. On these systems, a flat fee is charged at each entry point for use of the entire network, without regard to ultimate exit points. Though tolls are not directly distance related in such systems, some discrimination between longer and shorter journeys can be made by charging reduced toll fees at entry points close to the centre of the network. An example of this type of system is inner expressway system in Bangkok, Thailand, which charges a single flat fee for use of all or any part of a fairly extensive inner city network of Expressways.

Generally, Open Systems, except for the special facility Passage Systems, are often perceived by users to be inequitable in terms of charges, when significant differences in journey length, representing greater advantages to longer distance users, are possible for payment of the same toll fee.

Within the Open System category, there are a number of variations in configuration which may be used to enhance the system, thereby enhancing fee equitability, 'tailoring' the system to meet as many initial objectives as possible and overcoming constraints, such as limited Right of Way availability, which may be a problem in developed urban areas. However, though these adjustments and mixtures may lead to a more ideal initial system, they may impose significant limitations on future expansion.

Open systems are generally at a disadvantage when a road network is expanded, or when two or more independent toll facilities are linked to form a larger area network. Such expansion is a normal infrastructure growth pattern which is intended to benefit users in terms of time and convenience, as well as improve overall traffic flow. However, the Open System toll approach can introduce user difficulties as fees become more inequitable in terms of journey length, or users are required to stop and pay several times within the expanded network, sometimes after quite short travel distances.

To summarise, the advantages of the Open Systems are:

- The barrier toll plaza approach normally involves the least cost for equipment and operation;
- Allows flexibility in land (RoW) usage for toll plazas, which can be positioned where convenient (except 'Pay-on-Entry);
- Only one stop for the user, except on long highways with multiple tolled sections;
- Fixed Fee operation means fees can be pre-advertised, and become familiar to users, generally promoting quicker throughput.

Disadvantages are:

- Perceived inequity of fees between short distance and longer distance users;
- Most suitable only for small networks, short highways such as town bypasses, and single facilities, such as bridges and tunnels;

- Unsuitable for expansion of the network (except in the case of linear highways where separately toll sections can be added – but this causes inconvenience to the user because of the need for multiple stops);
- "Pay on Entry" systems require temporary vehicle storage areas between the local feeder road and the toll booths to accommodate queues during short term vehicle arrival peaks. This is especially the case if arriving vehicles are controlled by local road traffic light systems, which can lead to batches of vehicles arriving almost simultaneously. Provision of sufficient Right of Way to achieve this may be problematic.

2.2.1 Open Systems Summary

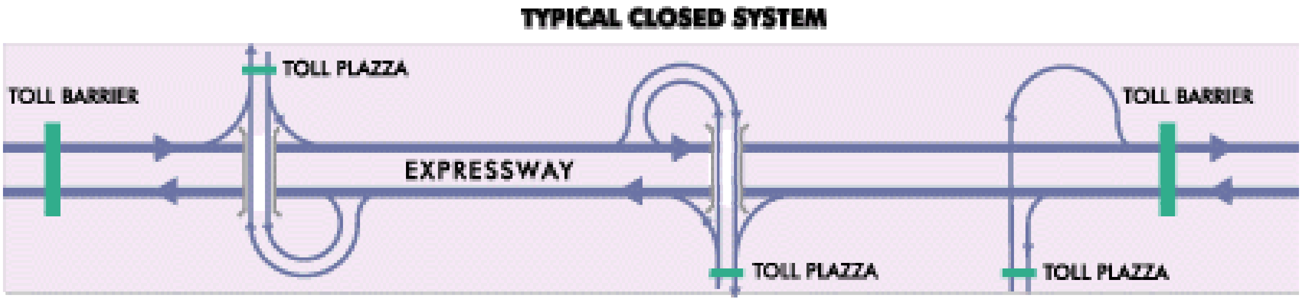
None of the variants of Open System configurations are considered to be suitable for application to the Bar - Boljare Motorway, which is linear and has a total length of over 165 Km. The above descriptions of Open Systems are therefore given for background only, and this type of system approach will be given no further consideration in this Toll Study.

2.3 Closed Systems

In the context of the Bar - Boljare Motorway, the Closed System would appear to present the best option for the implementation of toll collection. The linear design with relatively few intersections and overall length of over 165 Km. make it an ideal candidate for the implementation of this approach. For that reason detailed consideration of basic Closed System options for design and operation is given below. Particular consideration of the application to the Bar - Boljare Motorway will follow in Section 6 of this Toll Report.

2.3.1 System Philosophy

Closed Systems are those in which the user is charged directly according to distance travelled. In this type of system, all entry and exit points to the road or network must be controlled. Typically the user, on entry to the road or network, is given, or takes from an automatic dispenser, a ticket printed or encoded with toll plaza and vehicle details, generally referred to as a transit ticket. He can then travel to any destination served by the network without further impediment. On exit from the network the ticket is handed to a toll collector, read to establish the entry point, and the user charged the toll fee according to a pre-established table of charges related to the distance travelled and the class of the vehicle.



On a single intercity or interstate highway, or network of such highways, the toll would normally be directly related to the distance in kilometres travelled. The toll rates will normally represent a flat rate per kilometre, where a uniform benefit is perceived by the user. However, rates for specific journeys where there is not a uniform benefit along the route, for example, a section crossing a large suspension bridge or long tunnel, which are expensive to build and maintain, could be assigned a higher rate per kilometre. This can lead to different cost per kilometre for different journeys within the same road or network. These variations would be controlled by the Origin – Destination fee matrix used to assign tolls at the exit plazas. The fee rate for special structures might also take into account the distance and time saved over alternative routes which in the case of use of the structure could be very significant. The higher fee rate for the section would then be based on a combination of cost factors and the perception of the user's "willingness to pay" for the savings in time and fuel costs.

Closed toll systems represent the most equitable form of toll collection. They are in common use in many places including Europe, America, Australia, Japan and South East Asia. Their application to urban highways is not widespread despite the fact that integrated urban and inter-urban tolled highways represent an ideal solution. However, the Closed System can be used on large urban networks, divided into zones. In this case the toll fee will be related to the number of zones crossed on the journey. This is very much like the system of fares charged on most urban mass transit systems.

It is essential that a closed toll system implementation and operation be considered as a single project for the whole highway and planned accordingly. Where, as in the case of this project, there is a requirement to phase the opening in several sections, the operations either have to adapt to the interim requirements or be limited by the available facilities. These options are discussed further in Appendix A of this report.

One significant potential problem relating to the construction of facilities designed for closed toll system implementation, which must be given careful consideration early in the design stage, and particularly in interchange design, is the provision of sufficient area for both entry and exit toll plazas. This is especially true where toll plazas are required to be elevated, though that is unlikely in the case of the Bar – Boljare Motorway. In terms of a comparison of vehicle throughput rates (vehicles / toll lane / hour), exit toll lanes have the lowest figure (typically 250-350 vehicles/hour) and hence a higher number of lanes and space are required. By comparison entry lanes may achieve throughput rates of between 450 and 600 vehicles per hour depending upon the mode of ticket issuing. Therefore, approximately twice as many Exit Lanes are Required than Entry Lanes for the same volume of traffic.

A further important consideration in the civil works design for closed tolling is 'sealing' of the system within the tolled area including interchange areas, by RoW fencing, embankments, drainage ditches or other appropriate means, to prevent vehicles from entering or leaving the highway other than through the toll lanes. This sealing also extends to any rest areas or fuel stops provided within the tolled area, which must also prevent cross over of traffic between directions of travel.

It should be noted that at the beginning of a new construction project it is normally easier to acquire land for interchange and main line construction than it is to acquire additional land at a later date. Therefore, unless there are other overriding constraints, Right of Way should be made available sufficient for the construction of toll lanes to process the maximum levels of traffic which can be accommodated within the design of the highway, even if traffic in the first few years is light and all the toll lanes which will ultimately be needed are not initially built or equipped. This provision will ensure that toll collection can be easily expanded in response to future traffic growth.

2.3.2 Basic Closed System Operation

A journey within a closed toll system normally requires the user to stop upon entry to collect some form of identification ticket (transit ticket) and to stop again on exit where payment is made. Tickets can be issued at Entry lanes from either manual operators or automatic machines. This ticket is either printed and/or magnetically or otherwise encoded and typically contains the following information as a minimum:

a. Date and time of issue;

b. System identity and toll plaza identification;

c. Entry Lane number;

d. Operator ID (if any);

e. Class of vehicle;

f. The operating mode under which it was issued, normal, maintenance or emergency;

g. Operating Authority security code (a changing code to prevent counterfeiting).

Tickets are handed to collectors within Exit toll lanes for processing. The information contained on the ticket is transferred to the equipment by use of the encoding or, if printed, manually entered into the equipment using a keyboard. The equipment then calculates the toll fare from a matrix containing the fares for all possible journeys. In addition to the information contained on the tickets the arrival time can be added to any vehicle statistics required to give journey time/average speed, etc. This level of statistical information is very useful in transport planning and is not available on a continuous and automatic basis for open toll systems. It can also be used, in some cases, to counter attempts to commit transit ticket exchange fraud if there is no parking facility between entry and exit.

As a means of fraud prevention (by way of an opportunity to swap transit tickets) the segregation of traffic travelling in different directions has to be maintained throughout the main line. This is a particular consideration if rest areas or fuel stops are included in the alignment. These facilities should not be common to both directions of travel as drivers should remain segregated. To minimize interchange size as well as equipment and operation costs the 'Trumpet' configuration of interchange, in particular, normally utilizes the same entry lanes for traffic entering both directions of travel. The information contained on the transit ticket therefore identifies only the entry toll plaza but not the direction. This is the situation which can give rise to a 'ticket swap' fraud opportunity. If traffic can be segregated directionally before passing through the entry lanes, the direction of travel can be encoded or inferred from the lane number. However, the additional costs may not be justified to prevent the potential fraud.

2.3.3 Implementation Alternatives (Entry Lanes)

There are a number of possible alternatives in the implementation of the basic issuing of transit tickets and the checking of classification at the entrance or exit from toll lanes. These options are considered in detail and presented at Appendix A of this report.

The main options at entry lanes may be summarised as *pre-classification at entry lanes with vehicle class encoded upon transit tickets.*

a. *Manual pre-classification at entry lanes with vehicle class encoded on transit tickets;*

b. *Issuing of tickets at entry lanes from stand alone, dual height Automatic Ticket Issuing Machines (ATIM's), used with (a) above;*

c. *Issuing of tickets at entry lanes from dual height Ticket Issuing Machines (TIM's) installed within the side wall of the toll booth, used with (b) above;*

d. *Issuing of tickets at entry lanes with TIM's installed under the desk by booth operators, used with (b) above;*

e. *Streaming of vehicles and Issuing a pre-encoded ticket. That is, segregating traffic by class prior to entering the lane.*

2.3.4 Implementation Alternatives (Exit Lanes)

There are fewer options for alternative configurations at Exit lanes in Closed Toll Systems, since, with the exception of ETC and one other possible configuration described in (g) below, there are no viable alternatives to manual toll collection. Possible alternative Exit lanes configuration and options are:

a. *Pre-classification by Automatic Vehicle Classification (AVC) equipment on entrance to the lane;*

b. *Post classification by AVC equipment to check the registered transaction, including any amendments made by the toll collector changing the class of the vehicle;*

c. *No classification checks, i.e. totally reliant upon the classification at the Entry lane and manual classification at the Exit lane;*

d. *Processing of transit tickets by feeding them into a motorised reader;*

e. *Processing of transit tickets by swiping them through a reader or, for smart cards, a proximity reader;*

f. *Provision of Electronic Toll Collection (ETC) transceivers;*

g. *Automatic Lanes;*

h. *Provision of Video (or violation) Enforcement Systems (VES).*

Provision of Receipt Printers

For Closed system Exit lanes (or Open System toll collection lanes) the provision of a receipt printer is generally considered to be essential. The ability to issue a receipt may, in fact, be a legal requirement imposed on the System Operator. Except where the disposable transit ticket can be printed and used as a receipt, as noted above, receipt printers normally utilize paper roll stock with a capacity of over 2,000 receipts to avoid frequent changing of rolls. The roll stock may be pre-printed with the System Operator's details, logo etc. Data printed at the time of issue should, as a minimum, include:

- Operating Authority (if not pre-printed);
- Mandatory Tax (e.g. VAT) numbers (if not pre-printed);
- Issuing Plaza Identification;
- Date and Time of Issue;
- Issuing Toll Lane ID;
- Toll Collector ID;
- The Vehicle Class;
- The Toll Fee Paid;
- The Method of Payment;
- Receipt Number (6 Digit circulating).

Unless there is a mandatory requirement to the contrary, receipts should only be printed on demand, to avoid a litter problem and unnecessary depletion of ticket stock when patrons do not require a receipt.

2.3.5 Closed Systems Summary

The principle advantages of the Closed System are:

- Only two stops for the user, regardless of distance travelled;
- Equitable toll charges based on distance travelled on the facility;
- System throughput capability can be expanded by adding equipment in response to traffic growth;
- Flexibility for almost unlimited expansion of the tolled road network.

The advantages of Closed Systems increase as the length of the road or size of the network increases.

Disadvantages are:

- Equipment is more costly and complex since both Entry and Exit Toll Lanes are required.
- Operational costs are generally higher due to the use of entry and exit lanes, and the need to provide ticket stocks.
- Significantly more land is required for Exit Lanes.
- Closed Systems are generally unsuitable for short roads or small networks, not only due to the higher system and land costs.

.

These disadvantages may appear significant, but it should be considered that in applications where Closed System operation is most suited, Open Systems are generally not a viable alternative. The disadvantages of closed systems, such as land use, are problems that are recognised and resolved early in the life of a toll road construction project. However, the flexibility and the operational advantages of the closed system, which are exhibited throughout the many years of potential usage, significantly outweigh the disadvantages, on long toll highways such as the Bar – Boljare Motorway.

3 VEHICLE CLASSIFICATION AND TARIFFS

3.1 Vehicle Classification

A normal requirement of Toll System design is to utilise a classification system for vehicles, charging different fees for different types of vehicle in order to equitably apportion the tolls amongst the different types of road user.

The classification system is usually based on vehicles size, as measured by axle configuration and other clearly visible and measurable vehicle features. This method of differentiation is used because of the relative ease of automatic verification by sensors. Automatic Vehicle Classification (AVC) systems normally consist of various combinations of inductive loops, treadles and / or optical gates and beams to detect and check the various parameters of the vehicles used in differentiating classes for toll fee assessment. The AVC equipment measures parameters such as number of axles, presence of dual tyre axles, wheelbase (distance between axles) and vehicle height, or height above leading axle. Vehicle profiling by scanning the vehicle vertically as it passes an optical gate type of sensor to build an overall side profile, or by video cameras connected to a computer system programmed to recognize vehicle profiles can also be used. Inductive loops and / or optical gates are used to trigger the measurements and separate vehicles.

Traditionally, vehicle weight is often used to differentiate toll fees, as Governments frequently use this parameter for different taxation classification. However, dynamic weighing in a tolling environment is difficult, often inaccurate, expensive and maintenance intensive, and modern toll systems usually now avoid perpetuating this system. Generally, more complexity of measurements leads to more discrepancies, and should be avoided if possible. Similarly, any fee differentiation based on documents or stickers should be avoided, since there is no measurable parameter, unless the document is machine readable and can be recognised by equipment in the toll booth. Unfortunately, some such differentiation can be unavoidable, such as discounts for holders of Disabled Persons certificates (in the UK 'Blue Badges'). Special provisions normally have to be made through operating procedures to ensure correct accounting in such cases.

The principle drawback of AVC is that it generally cannot distinguish between vehicles which use effectively identical chassis. Medium sized goods trucks and passenger buses, for example, usually fall into this category. To counter this, in most systems, though buses may be assigned a different classification for statistical purposes, the toll fee charged is the same for trucks and buses or other types of vehicle with the same axle configuration.

The vehicle classification system should be as simple as possible and based on easily discernable vehicle characteristics which can be verified by sensors. Although the initial toll system implementation recommended does not include Automatic Vehicle Classification, it may be decided in the future to install AVC and the classification system chosen should be suitable for its adoption. One basis on which classes for tariff differentiation are defined is the wear and tear the vehicle causes to the road. On this basis, axle loads of small vehicles, in the range up to about 1 to 1.5 tonnes per axle cause very little damage, medium vehicles with main axle weights up to 3 or 4 tonnes cause greater damage, and the greatest damage is caused by heavy trucks with axles weights in the region of 8 tonnes or more.

The simplest system of classification is therefore to use axle and wheel configuration. The LB Study for traffic uses 6 classes defined below:

1. Private Car
2. Light Delivery Vehicle and Microbus
3. Bus (>30 seats)
4. Small Truck (2 Axle)
5. Medium Truck (>2 Axle) - [Implies 3-4 Axle]
6. Heavy Truck (5 Axles or more)

This can give rise to some anomalies, but is generally reasonable as a basis. It is noteworthy that neither the LB Study nor any other available study has considered motorcycles. Assuming that these are not to be banned, they must be given consideration for toll collection purposes.

Considering all the above, a reasonable classification system for tariff differentiation would be:

1. Motorcycles and 3 wheeled vehicles;
2. 2 Axle 4 wheel vehicles (car, light delivery vehicles and microbuses);

3. 2 Axle 6 wheel vehicles (rear axle dual tyred) (small trucks and buses);
4. 3 Axle Vehicles (Medium Trucks and some buses);
5. 4 Axle and more (heavy trucks, including medium trucks with trailer and articulate vehicles).

Tariff Band	Vehicles
1	Motorcycles* and 3 wheeled vehicles
2	Private Cars (2 Axle - 4 Wheel) Light Commercial Vehicles (2 axle – 4 wheel) Minibuses (2 axle – 4 wheel)
3	Small Commercial Vehicle (2 axle – 6 wheel) Buses (2 axle – 6 wheel)
4	Medium Trucks or Heavy Buses (3 axle)
5	Heavy Trucks (4 axle and over, including trucks with trailers)

Table 3.2 Tariff Band

* Motorcycles often cause problems where AVC is used, particularly light motorcycles, scooters etc. Axle detectors may detect only one axle if the front wheel is lightly loaded, or up to 3 in the case of a motorcycle with sidecar. Special consideration in the design may be necessary if motorcycles are common and charged a toll fee. If motorcycles are free of charge, as is the case in some systems, consideration should be given to special bypass lanes, with width restricted to prevent use by larger vehicles. If the Bar – Boljare Motorway Initial System is implemented without AVC, there will be no such problem, but it should be considered if AVC is introduced at a later date.

It is sometimes necessary, for purposes of compiling traffic statistics to differentiate between some of the types of vehicle covered by these classifications. So, for example Class 2 could be sub-classified into cars, light commercial vehicles and microbuses, and Class 3 into commercial vehicles and buses. However, the toll fee would be the same for each of the sub-classes. It is not normally thought necessary to subdivide the types of heavier vehicle. A practical classification system, therefore, may be:

Tariff Band	Class	Vehicles
1	1	Motorcycles and 3 wheeled vehicles
2	2 3 4	Private Cars (2 Axle - 4 Wheel) ** Light Commercial Vehicles (2 axle – 4 wheel) Minibuses (2 axle – 4 wheel)
3	5 6	Small Commercial Vehicle (2 axle – 6 wheel) Buses (2 axle – 6 wheel)
4	7	Medium Trucks or Heavy Buses (3 axle)
5	8	Heavy Trucks (4 axle and over, including trucks with trailers)

Table 3.2 Vehicle Classification

** A special case may be made for cars towing trailers such as caravans, or they may be included in Band 4, in accordance with policy set by the System Operator. If the former, and if AVC is introduced, the lack of a dual tyred axle must be used to validate the classification.

3.2 Vehicle Tariffs

The Traffic Study Report dated February 2009 (Chapter 9.1) identified that the optimum initial toll rate will be €0.11 per kilometre for private cars. However, a weighting needs to be applied for other tariff bands. This should reflect not only the 'wear and tear' factor but also the perceived value of motorway use in comparison with alternative routes. The weighting may also be used to reflect Government policy to either attract or discourage certain classes of vehicle from using the Motorway.

Generally, the greatest benefit from the use of a high quality highway is derived by long distance heavy transport, for which savings on time and fuel costs are most significant. We would therefore propose for consideration the following:

Tariff Band	Weighting Factor Range	Toll Rate Range (€ / Km.)
1	0 – 0.5***	Free – 0.05***
2	1	0.11
3	1.5 – 2.0	0.16 – 0.22
4	2.0 – 3.0	0.22 – 0.33
5	2.5 – 4.0	0.28 – 0.44

Table 3.2 Proposed vehicle weighting

*** If motorcycles are given free passage, special restricted width bypass lanes should, ideally, be provided at both Entry and Exit lanes. If processed through standard lanes, motorcycles without transit tickets at the Exit lane should be charged a penalty fee. In all cases, motorcycle passage should trigger the storage of VES Violation data together with the transaction details.

Special fees for over-height, over-width or overweight vehicles, normally escorted loads, should be considered.

These suggested weighting factors would be consistent with weighting factors used in other systems although they are lower than the weightings applied at Sozina tunnel which are as shown below: .

Tariff Band	Vehicle Type	Weighting Factor Range	Toll Rate Range (€)
1	Car/motorbike	1	2.5
2	Cars + trailer/ vans	1.6	4
3	Small bus 7-20 seats	2	5
4	Trucks < 5t	3	7.5
5	Trucks > 5t	3.8	9.5
6	Large buses	4.8	12
7	Large trucks with trailer	7.2	18

Table 3.3 Vehicle classification and tolls at Sozina tunnel

The actual tariffs themselves presumably reflect the significant cost savings to road users compared to the alternative route. However, the weightings seem to discriminate strongly against larger vehicles. This could be as part of a policy decision to discourage larger vehicles or may reflect their willingness to pay.

We understand that the operators of Sozina tunnel intend to reduce the number of vehicle classifications from seven (as Table 3.4 below) to five:

Tariff Band	Vehicle Type
1	Cars
2	Cars + trailer/ vans
3	2 axle trucks
4	Buses/3 axle trucks
5	Trucks > 3 axles

Table 3.4 Proposed vehicle classification at Sozina tunnel

For short travel distances, a minimum fee is normally charged. In the case of the Bar-Boljare Motorway, it is uncertain at present what the shortest possible journey would be. However, it would be reasonable to propose that a minimum charge equal to a 10Km. journey should be imposed, if some interchanges are less than that distance apart.

When constructing the tariff tables for use at each interchange, it is also normal to round the actual calculated, distance based toll, to an amount which is easy to pay in commonly available currency. Usually the rounding is downward, which is perceived as fair by users. In the case of Euro based tolls, and with a rate per Kilometre of €0.11 or higher for other classes, it would seem reasonable to round down tolls in effective units of €0.2 (20 €c), representing 2.5 Km of travel for a light vehicle, though €0.1 would also be possible. Larger rounding units may be deemed appropriate for heavy vehicles.

4 METHODS OF PAYMENT OF TOLL FEES

The available methods of payment of toll fees have largely been covered in Appendix C of this report. However, it may be useful to summarize them here and mention some other alternatives.

Methods of payment are largely independent of the type of system employed, at least as far as traditional Open and Closed systems are concerned, but are somewhat dependent upon the amount of toll to be levied. It is important to note that the Method of Payment (MOP) employed directly affects the throughput capacity of an Open System lane or a Closed System Exit lane as does simultaneous availability of different MOP's and any operational requirements such as the issue of receipts.

4.1 Main Methods:

4.1.1 Cash Payment

Cash payment using notes and/or coins is still the most common form of payment. In general, toll fees in Open Systems should be set at rates which allow payment by single coins or notes or in multiples of the values of commonly circulated coins and notes. This will minimize change giving and speed throughput at the toll plazas. It also allows the use of Automatic Coin Machines (ACM) in some Open systems. For the same reason, distance related tolls at Closed System Exit lanes should be rounded up or down such that increments in tolls for various classes of vehicles can also be paid in whole values of common notes or coins. Although based on a rate per kilometre, the actual fees at Exit lanes are not calculated but are determined using fee matrices based on entry plaza and class for each exit plaza. This allows rounding of the fees so that amounts which are difficult to pay in the local currency are avoided. This also allows the application of minimum fees, which most toll system operators impose. Thus, journeys of typically 20 Km. or less are charged the same minimum fee regardless of actual distance travelled. It is for this reason that shorter toll roads normally operate a single fee per class Open System rather than a Closed System.

4.1.2 Voucher Payment

Payment by vouchers/tickets has been commonly used in the past but is increasingly less popular as methods of payment utilising modern technologies become more prevalent. Under this system, prepaid vouchers, are usually issued for the value of the toll applicable to the class of vehicle. They counter the problems associated with multiple coin/ note cash payment and change giving, and have usually been offered at a discount rate to encourage use, as it can improve plaza throughput. Whilst relatively inexpensive to set up and operate, strict control over the handling of vouchers is necessary as they introduce possibilities for fraud which are not as easy to detect as with other MOP's. They are also only useful in fixed fee Open Systems. However, a form of voucher may remain useful to cover warrants for public service or military vehicles, or for the Operator's own maintenance vehicles. The vehicle number or driver ID would be recorded on use to validate the transaction. Such warrants effectively exempt the vehicle from toll payment and therefore may be used in Open or Closed systems. Actual tolls or fixed fees under contract may be paid later, depending on the contractual agreement between the System Operator and the organisation owning the vehicle.

4.1.3 Operator Specific Stored Value Cards

Some Operators offer, as an alternative to or a replacement for, vouchers, Stored Value or Stored Journey cards, which may use either magnetic stripe or smart card technology as convenient. The Stored Journey cards allow a number of passages through an Open system, much as purchase of a book of vouchers does, but can not be used in Closed systems. The Stored Value cards are more flexible, and can be used in Closed systems to pay variable, distance related tolls. In both cases, warning needs to be given to the user when the number of journeys or value remaining on the card reaches a low threshold. This is usually achieved by an additional message on the Fare Indicator sign normally fitted in payment lanes. The choice of magnetic card or smart card technology often depends largely on the use of other similar cards in the system. Magnetic cards are cheaper and can be read with swipe readers, which are also inexpensive and often already fitted to toll booths for reading operator ID cards. Smart cards are more expensive, but can store more data. The user may be charged a premium to cover the card cost or the card may be sponsored, with advertising printed on it.

In closed systems where smart cards are used as transit tickets, the Stored Value smart card may be used to replace the transit ticket, and the entire calculation and payment at the Exit lane performed in a single operation. This capability is not possible if magnetic cards are used since not enough data storage is available on the magnetic stripe.

If a Toll System Operator has several roads within its jurisdiction, the Stored Value cards can normally be used on all the Operator's toll roads.

The Stored Value Smart Card, operationally, has much in common with ETC payment in mixed systems. It is cheaper to implement and operate than ETC, but involves slower transactions, though this penalty in mixed toll lanes, i.e. those not dedicated to ETC, may not be significant.

4.1.4 Credit or Debit Cards

Standard credit cards issued by banks, and backed by international operators, Visa, MasterCard or others, may also be used. There is normally a service charge for vendors, in this case the toll System Operator, who may consequently limit their acceptance to transactions over a certain monitory threshold. In toll lanes this might restrict their use to only the higher fees of longer Closed Systems journeys, though they can be used for manual or automatic top-up of Stored Value cards or ECT accounts.

Another disincentive to use in toll lanes is that normal 'instant' verification, such as used at retail point-of-sale terminals, is still too slow for toll booth transactions, often taking up to 30 seconds for verification, and requiring PIN entry by the card holder or signature on a printed receipt. For use in a toll lane, the Operator must take some risk by accepting the card without verification, other than basic card information which can be read in the lane, and automatically processing the cards in batch modes, using what is known as 'Customer not Present" mode, one or more times per day, depending on the number of cards accepted.

This process would normally be handled automatically by a 'Back Office' administration computer system connected to the Operator's bank or to a card clearing facility. If the Toll Operator has a Central Administration facility, with a central computer continuously on line to all the Toll Plaza computer systems, bank credit / debit card clearing would normally be handled by that system for all Exit Plazas in the system, and for Stored Value Card or ETC Account top-up.

In the event that a credit / Debit card payment for transit fee is refused, the Operator must have sufficient detail, including VES evidence to trace the user and collect the fee. Some form of legislation may be needed to allow the Operator to do that. Refusal in the case of automatic top-up simply results in a top-up failure to be redressed by the customer.

4.2 Other Methods Considered:

4.2.1 Electronic Road Pricing (ERP)

4.2.2 Fixed Fee Leasing (Vignette))

4.2.3 Electronic Toll Collection (ETC)

4.2.4 Automatic Number Plate Recognition (ANPR)

4.2.5 Electronic Purse (or Wallet)

4.2.6 Off Line Payments

The operation of these options are fully described in Appendix C.

4.3 Summary

In conclusion, we consider that during the early life of the motorway, toll payment should be collected as cash, by credit/debit card or pre-paid cards. The use of vouchers as a general method of payment is not recommended but could be used as a possible “warrant” for vehicles such as the Concessionaire’s own vehicles, public service vehicles (eg Police, Fire etc) or other exempted Government vehicles. Due to low traffic volumes initially, ETC is not recommended but could be considered at some point in the future when traffic volumes have increased. Vignettes are not recommended because they are inequitable for low and high use patrons, may require additional means of toll collection and may result in additional costs to the state. This type of system is generally being replaced by ETC systems.

4.4 Effects of Methods of Payment on Toll Lane Throughput

The effects of the various methods of payment and toll methodologies on peak toll lane vehicle throughput are summarised in the table below. The figures are approximate and should be taken as a guide for relative performance only. Specific Toll Plaza conditions, toll rates and methods of payments will affect actual achievable throughput. The throughput figures are given in Equivalent Passenger Car Units (PCUs) per hour in order to take account of the mix of vehicle classes without knowing the particular percentages of light, medium and heavy vehicles. To calculate pcu, the weighting generally used is:

- Cars, vans and minibuses = 1
- Medium Trucks and Buses = 1.5
- Heavy Trucks = 2

In some particular systems, where conditions such as gradients may be considered outside norms, larger equivalences may be used for heavier vehicles.

Toll Method / MoP	Open System PCU / Hr.	Closed System Exit PCU / Hr.
Manual - Cash (correct money) / Voucher / ETC (Mixed)	450 - 600	275 – 375
Manual - Cash (change given)	400 - 550	250 – 325
Manual - Cash (change and receipt on demand given)	300 - 400	200 – 250
Manual - Prepaid Card, Credit / Debit Card	500 - 600	350 – 450
Auto – Prepaid Card, C / DC - Standard Transit Ticket*- HSB	500 - 600	300 - 400
ETC - Dedicated Lane - Standard Transit Ticket* - HSB	900 – 1,100	600 – 700
ETC – Dedicated Lane – Tag as Transit Ticket* - HSB	900 – 1,100	800 – 1,000
ETC - Dedicated Lane, No Barrier	> 1,200**	> 1,200**

Table 4.2 Toll lane throughputs

HSB = High Speed Barrier

* N/A to Open System.

** Near through-lane speed with guided lane width restriction.

5 OPERATING AND MAINTENANCE COSTS

5.1 Toll System Operating Costs

Operating costs will consist primarily of staff wages and salaries, costs of consumables and overheads such as communications, heating and lighting. The major cost will be staffing.

The table below is an estimate of approximate staffing required by the recommended toll plaza configuration with the expected low traffic flow:

Staff	Remarks	Number of Staff Required per plaza
Toll Lane Operators	Core of 2 persons per 2 x 8 hour shifts. Third night shift may be one person and there may be split shifts during the day to cover peaks. Temporary or part time staff in Summer if needed	Permanent 6 to 8 Some part time for split shift, summer months and emergency cover
Toll Supervisors	1 per 3 x 8 hour shift plus rotation staff	4
Staff Supervisors / Traffic Supervisors	1 per 2x 8 hour shift. Not generally needed at night. Rotation staff	3
Plaza Manager	1 - but may be responsible for 3 to 4 toll plazas	4 to 5 for total system
Administration	2 per standard day shift.	2
Cleaning Staff	May be contracted or team covers all toll plazas	-
TOTAL	Includes additional staff detailed below	17 - 20

Table 5.1 Toll plaza staffing levels

Additional staff includes 3 to 4 administrative staff at the central facility and an Operations Director with one or two assistants, secretarial and general office staff – possibly 2 to 4 in total. Because of the need to transport staff and consumables etc between plazas and a central administration facility / depot some vehicles and drivers would presumably be necessary. But in this area there is overlap with other functions such as toll system Maintenance, motorway maintenance, motorway patrols etc. so it is difficult to assign a cost for toll system operations only.

We understand that at Sozina tunnel, toll booth operatives cost the Employer €10,000 to €12,000 per annum. On this basis labour costs associated with system operation, which comprises the majority of the operating costs, would be expected to be in the region of about €170,000 to 240,000 per plaza. This assumes that the total staff levels are between 17 and 20 per plaza. For the section between Smokovac and Matesevo (where only two toll plazas would be required initially) the annual cost of operating the toll booths would be between €340,000 and €480,000.

Consumables are few in the type of closed system toll recommended. Primarily receipt printer stock and, if disposable, transit ticket stock. Receipt printer roll stock would be about €10 per roll for production of about 2,500 receipts. As receipts are printed on demand, usage at exit lanes would be expected to be 3 – 4 rolls per week per lane. Transit ticket would depend on type. Smart Card costs are now in the region of 0.2 Euro each but average life cycle is over 2,500 uses. If disposable ticket stock were to be used, costs would be expected to be similar to receipts. Other consumables would be similar to a small office.

If the cost of civil works is excluded, the approximate cost of provision of the minimal closed toll system for the whole Motorway would be expected to be between €10,000,000 and €14,000,000. The cost per plaza is estimated to be between €900,000 and €1.3m each. For the section between Smokovac and Matesevo (where only two toll plazas would be required initially) the cost of the toll infrastructure (excluding civils works) would be between €1.8m and €2.6m.

5.2 Toll System Maintenance Costs

Maintenance Costs comprise primarily maintenance staff and spares. The initial system cost estimates (described in 5.1) include a purchase of spare parts, based on about 5% of the equipment hardware cost, which is considered normal, and totaling approximately €350,000 to €500,000 for the full Motorway. The costs also include 1 year warranty maintenance, in which period the contractor would be responsible for replacement of any spare parts at his own expense. After the first year of operation, the spare parts usage can be expected to average 10% to 20% of the inventory, or a maximum in the region of €100,000, at present day prices.

Maintenance can be accomplished by awarding a maintenance contract to the equipment / system supplier or to a third party maintenance organization. In practice, it is usually impractical to contract the supplier, unless his base of operations is close to the project. Similarly, few third party organizations have the skill to maintain a toll system, with its requirement for 24 hour, seven day operation, and subsequent necessary short response times to call outs.

Consequently, the optimum solution is usually for the System Operator to provide and train his own staff for first line maintenance (call out response and replacement of modules on site). The System supplier can be contracted to provide technical support by telephone or web site, and to repair replace faulty modules (second line maintenance). A local third party organization, if convenient, can be contracted to repair standard components, mainly computer systems, including, usually, attendance at site. Cost will reflect the number and location of systems and the call out response times specified.

In this system, the Operator's own maintenance staff will need to be the first line response covering the 13 systems, spread over 160Km of the motorway. It is unnecessary to place permanent maintenance staff at each toll plaza, but because of the distance and need for quick response, it would be logical to designate probably 3 plazas in the upper, central and lower thirds of the motorway as maintenance depots. Each one would keep stocks of the most commonly used spare parts, with larger items, such as spare toll booths, at the centrally positioned depot. Some coverage would be needed for response over a 24 hour period, though all routine maintenance and most repair work would be expected to be done during the day. Although this may have to be adjusted in the light of experience, adequate staffing would probably consist of 2 maintenance engineers at each of the three depots during 2, 8 hour day shifts and 2 at the central depot only during the night shift. This would lead to a total maintenance staffing requirement of 18 to 20 engineers / technicians to cover all shifts with rotation, with some overtime as necessary to complete the work. Since the engineers may be called to deal with faults simultaneously, allowance should be made for two vehicles (vans are appropriate) at each depot, with one or two heavier vehicles available if necessary. Again, as with operations, there can be sharing of facilities with other motorway maintenance and transportation functions in this regards.

Costs of maintenance contracts with the System supplier and a local organization, if used, would need to be included. These are difficult to estimate but we have assumed that an allowance of about €100,000 would be reasonable.

Maintenance Costs would be comparatively small. Using the above figures, labour costs would be expected to be in the region of €100,000 per annum with costs of spare parts and service contracts in the region of €200,000 to €300,000 per annum. Other cost, such as operating costs of at least 6 vehicles and administrative costs of maintenance (very small because tasks such as inventory control and spare parts ordering / repair etc, is normally done by the maintenance engineers, leaving only accounting functions, which can be included in operational administrative overheads).

5.3 Operating and Maintenance Cost Summary

The initial cost of toll installation and subsequent operating and maintenance costs are summarised in the table below. For the Smokovac to Matesevo section (2 toll plazas), the annual operating and maintenance costs would be in the range €400,000 and €560,000. For the entire Motorway, the annual operating and maintenance costs would be approximately €3m.

	Cost range /plaza (€)	
Initial cost of toll installation (excluding civils work)	900,000	1,300,000
Annual Maintenance cost	30,000	40,000
Annual Operations cost	170,000	240,000
TOTAL per toll plaza (€)	**200,000**	**280,000**

Table 5.3 Range of Operating and Maintenance Costs (per plaza)

6 PARTICULAR RECOMMENDATIONS FOR TOLL SYSTEM IMPLEMENTATION

The Bar - Boljare Motorway, when completed, will be two carriageway divided highway having two traffic lanes in each direction, with the exception of the existing Sozina Tunnel, which is bidirectional with a single traffic lane in each direction. The total length of the motorway will be approximately 167 Km. and, as outlined at the time of this report, will have 13 Interchanges including the terminal points at Bar and Boljare. According to current information, all interchanges will be of 'trumpet' type concentrating toll facilities for both directions of travel at a single location at each interchange.

6.1 Recommendations in relation to Traffic Flow for Toll System Design

In examining traffic flow for the purposes of Toll System design, it is necessary to have a reasonable estimate of peak hourly flow, by direction of travel, at each toll station. The LB Feasibility Study and our own Traffic Study Report (January 2009) does not provide peak hour flows. However, the purpose of this Toll Study is to make general recommendations for toll system implementation, so approximate figures are sufficient to achieve this objective.

To ascertain if the original LB counts were reasonable we also undertook additional traffic counts at three similar location sites. These figures are summarised in table 6.1.1. The Feasibility Study also indicates very significant seasonal differences, the January – February winter averages being about half the annual averages and the July – August summer averages being up to twice the annual averages, so for worst case summer peak traffic these figures should be doubled.

Summary of Additional Traffic Counts undertaken in 2008
Result in estimated AADT for 2008

	Count Location		
Vehicle Type	SW1 (Podgoricia - Golubovci)	SW2 (Kolasin and Mojkovac)	SW3(Bioce)
Car	18,591	4,247	4,380
LGV	1,367	516	585
HGV	1,050	710	730
Total	21,008	5,473	5,695

Table 6.1.1 Traffic Counts 2008

From the above, we may convert the traffic flow to equivalent Passenger Car Units (PCU), which is more useful for toll purposes, as follows:

Vehicle Type	PCU Factor	SW1 (Podgoricia - Golubovci)	PCU	SW2 (Kolasin and Mojkovac)	PCU	SW3(Bioce)	PCU
Car	1	18,591	18,591	4,247	4,247	4,380	4,380
LGV	1.5	1,367	2,051	516	774	585	878
HGV	2	1,050	2,100	710	1,420	730	1,460
Total		21,008	22,742	5,473	6,441	5,695	6,718

Table 6.1.2 Passenger Car Units (PCU) 2008

The above figures represent total estimated average daily traffic, both actual and equivalent PCU, aggregated over both directions of travel in each section. For toll calculations, it is normal to assume that about 90% of daily traffic is concentrated in a 16 hour day, and that the remaining 10% travel during 8 night time hours (usually considered to be 10 p.m. to 6 a.m.). That may not apply well for heavy commercial traffic, as such traffic tends to avoid peak hour travel if possible. However, the above figures show a preponderance of cars and other light vehicles, so the 'rule of thumb' formula may reasonably be applied. It is also generally assumed that Peak Hour Traffic, which toll plazas should be designed to handle without queuing (except for acceptable, very short 'mini-peaks' of no more than about 3 to 5 minutes), represents about 10% of the 16 hour total. Though there is no current indication that there would be traffic peak hours on the BBM, but the assumption should still be made in considering toll plaza size (number of lanes). This leads to the following table:

Count Location	Total Average Daily PCU	Daily Average PCU by direction	16 Hour PCU by direction	Ave Hourly PCU by Direction	Peak Hour PCU by Direction
SW1 (Podgoricia - Golubovci)	22,742	11,371	10,234	640	1,023
SW2 (Kolasin and Mojkovac)	6,441	3,221	2,898	181	290
SW3(Bioce)	6,718	3,359	3,023	189	302
Total	35,901	17,951	16,155		

Table 6.1.3 Peak Hour Flows (2008)

* **Note** Totals have no meaning in these columns as they would simply sum simultaneous traffic flows in the individual sections.

As noted, the above figures are derived from traffic surveys carried out in 2008. However, for the design of toll facilities and recommendation of initial equipment installation and installation phasing, it would be necessary to consider likely traffic flow both in the opening year and up to about 10 years after full opening, which represents the average life of equipment before replacement. The projected peak hour flows are included in table 6.1.4 below. For estimates of ultimate toll plaza sizes, if the same toll collection methodology is to be continued, either the theoretical capacity of the road or traffic estimates up to 25 – 30 years after opening should be used.

Section	AADT	Peak PCU	AADT	Peak PCU	AADT	Peak PCU	AADT	Peak PCU
	2007		2017		2027		2037	
Durmani-Virpazar	7,799	252	15,928	515	24,407	790	39,852	1,289
Virpazar-Smokovac	7,339	237	11,098	359	20,212	654	32,515	1,052
Smokovac-Matesevo	7,014	227	8,044	260	16,124	522	23,919	774
Matesevo-Berane	4,659	151	3,591	116	7,901	256	14,805	479
Berane-Boljare	5,011	162	8,299	268	15,218	492	29,443	953

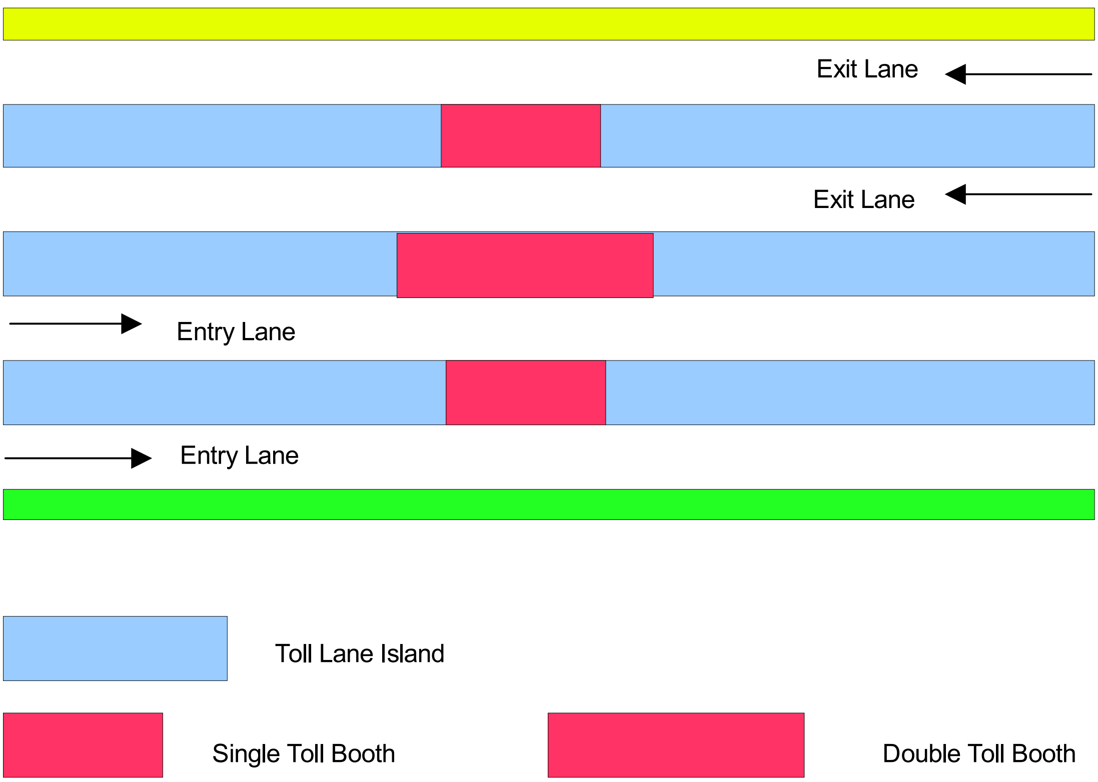
Table 6.1.4 Projected Peak Hour Flows for Years 2007, 2017, 2027 and 2037

A minimal Toll Plaza configuration catering for both directions of traffic in a closed system will consist of two Entry Lanes and Two Exit Lanes. These are the minimum numbers required to provide redundancy in case of failure of one set of lane equipment of each type.

In the manually operated closed system proposed, an entry lane can be expected to process about 600 pcu/hr and an exit lane 300 to 350 pcu/ hr.

The projected peak hour figures for 2017 (Table 6.1.4 refers) suggest that the fully manual toll collection system remains viable because the maximum peak pcu (515) is consistent with the capacity of a fully manual toll collection system operating on 2 lanes. However, the peak pcu figures for 2027 (up to 790) suggest that either additional toll lanes or an electronic toll collection system (ETC) may be required for the increased demand. The average life of toll equipment is about ten years. At this time, the need for additional toll lanes and/or different toll equipment should be considered based on anticipated traffic flows for the forthcoming ten years.

Initially, to reduce operating costs and due to low traffic volumes, it is recommended that the below configuration should be implemented using one 'double ended' central toll booth fitted with both Entry and Exit lane equipment and two standard booths , one for Entry and one for Exit traffic.



Four Lane Toll Plaza Configuration with Central 'Double' Booth

Using this configuration, at night and other times of low traffic throughput, it is possible for one operator to service both Entry and Exiting traffic. During most periods it is likely that two operators using the central booth will be sufficient, using the outer two booths only at peak times. In winter months it may be found unnecessary to open any but the inner lanes using the single booth. In Summer, if demand dictates the necessity, it would be possible to hire temporary or part time operators to service the peak traffic.

6.2 Recommendations for Methods of Toll Collection

In Section 2 (and Appendix B) of this Toll Report, various available methods of toll revenue collection are discussed, and some general comments on their suitability for this application made. In this section we will assess, comment on and make specific recommendations as to the suitability of these methodologies for application to the Bar - Boljare Motorway.

6.2.1 Open System

Due to the total length of the Bar - Boljare Motorway, at least in excess of 165 Km. and the positioning of interchanges, there is no configuration of a standard Open Toll System which offers any advantage in this application. An Open System approach would require up to 12 'Barrier' toll plazas on the main line, which is an unacceptable concept. No further consideration will, therefore, be given to implementation of a traditional Open System approach.

6.2.2 Closed System

Of all the possible methods of toll revenue collection available, the flexibility of installation and payment options, equitability of fees and convenience to users offered by **Closed System** tolling makes the Bar – Boljare Motorway an obvious and ideal candidate for application. The length of the motorway and interchange positioning dictates that distance related tolling is the only option which is equitable to users, and the prediction of relatively low traffic, at least in the early years, means that the Operator can benefit from the flexibility of closed tolling which allows gradual expansion, and therefore investment, in line with traffic growth. Also, the construction of Entry and Exit Plazas on slip roads or ramps will allow unimpeded travel on the main line of the Motorway, to the benefit of journey times and the comfort and convenience of motorists.

A further advantage of the standard Closed System is that the equipment is well proven and not expensive, and both equipment and operating costs can be managed by initial provision of minimal installations, gradually increasing the number of toll lanes in response to perceived growth in traffic demand. Expansion would be achieved by the addition of identical, equipment and toll booths, or the addition of facilities such as ETC lanes, to cater for traffic growth limited only by the traffic capacity of the Motorway. As long as sufficient land is made available at the toll plaza sites for future additional lanes, this flexibility can greatly ease the cash flow burden of the Operator, since the system will already be generating revenue when expansion is needed.

The System software and operating procedures would normally not need any alteration and the computers controlling the Plaza functions, and Central Administration Systems if included, would probably not require upgrading to cope with the additional toll lane throughput. If not initially a part of the System, a Central Administration facility, on line to all the toll plazas, could be added at a later date.

As noted above, initial indications are that the Motorway will be quite lightly used in the first few years of operation, but there may be significant traffic growth in the future.

For simplicity of operation and to minimize maintenance costs, it is recommended that both Entry and Exit lanes should be manually operated. Though it has to be defined by the final toll system designer on data available at that time, it appears likely that initial installations will be small, possibly consisting of two Entry Lanes and two Exit lanes per toll plaza. Two is considered a minimum because of the need for some redundancy to cover equipment failures, but possibly only one booth of each type will be in operation at any given time. In small, relatively lightly used installations such as these, equipment such as an Automatic Ticket Issuing Machine (ATIM) or automatic Exit lanes give rise to a disproportionate maintenance load, and any savings in toll booth operating staff costs tend to be outweighed by maintenance staff needs and additional spares holding requirements.

Having manual operation of both Entry and Exit lanes can also allow operation without Automatic Vehicle Classification (AVC) equipment, as explained briefly in section 2.3.4 (c) and in detail in Appendix C. This also represents a significant saving in equipment costs, maintenance costs and spares holding.

Because of the inherent flexibility of Closed Systems, equipment such as ATIMs and AVC can be included in later additions, if considered useful and viable, without affecting the basic operation of toll revenue collection or system software, as any additional capability needed, for example, for generation of ATIM reports and AVC integration in lane processors, would normally be specified and built into standard customized software for later activation.

Options for Transit Tickets

If the recommended manual closed system is chosen for implementation, options for transit ticket type must be considered. The most flexible and durable type of transit ticket is the Contactless Smart Card. Due to their many varied uses the cost of cards is reasonable in comparison with their probable life cycle, and they are available from many manufacturers. The ability to store large amounts of data also makes them flexible in use. We consider that this option represents the best solution for transit tickets in this application. However, the designer should consider the economics of magnetic card use to determine whether there could be any advantages.

Operation in both cases would be similar. In the manual Entry lane booth, after classification of the vehicle by the operator the transit ticket (Smart Card) would be issued from an exchangeable cassette stack in a Ticket Issuing Machine (TIM) built into the operator's desk. It would be automatically encoded with the issuing information and verified before being taken by the operator and given to the driver. An 'end of transaction' button pressed by the operator would send a signal to allow the vehicle to leave the lane.

In the Exit lane the transit ticket (Smart Card) would be returned to the collector and inserted into a reader for calculation of the fee due. After receipt of the correct payment, the ticket would be captured by the reader and stored in a removable cassette, suitable for immediate reuse in an Entry lane TIM or handling by a sorting machine, as appropriate to the chosen method of operation. The Entry data would be erased before storing or in the sorting machine if used.

6.2.3 Vignette Systems

The Vignette system could, in theory, be applied to tolling on the Bar - Boljare Motorway, but it would appear to be a far from ideal solution. It is primarily a road tax, and suitable for road networks where few, if any, alternative roads are available. Under these circumstances it is most suitable only for local residents, as is the case for other centralized payment systems, as special arrangements have to be made for travellers from outside the network area. It is not suitable for a single road such as the Bar – Boljare Motorway, though it can be applied where it permits travel on many first class highways, such as in the case of national vignettes in Austria. For the Operator, the Vignette System requires most of the investment to be made at the beginning of the project. It is therefore not ideally suited for roads where usage may be low or unpredictable. As noted above, a special type of vignette, entitling the user to toll fee discounts, could be considered for local residents for use in conjunction with Closed System tolling. A fuller description of the system forms Section 1.2 of Appendix C of this report.

6.2.4 Electronic Road Pricing – ETC / V-Toll - Open Road Tolling (ORT)

Open Road Electronic Road Pricing, using GPS On-Board-Units (OBU) or any means other than Electronic Toll Collection (ETC) using transponders (tags) with Video tolling / Automatic Number Plate Recognition (ANPR) back up are primarily aimed at large busy road networks or single installations where very high traffic volumes need to be processed without causing delays and traffic congestion. Such 'high-tech' systems are expensive and difficult to administer, with a great deal of the technology and effort aimed at preventing and punishing fraud attempts by users. This is not considered feasible for a single linear Motorway such as the Bar – Boljare Motorway, and so will be given no further consideration

Also like other systems where 'stop-and-pay is not an option, it can be difficult to accommodate foreign or casual traffic. For this reason most current ORT systems are operated in conjunction with stop-and-pay options. For the Bar – Boljare Motorway, there would appear to be no advantage in introducing Open Road

Tolling as traffic flow is likely to be fairly low and the equipment and administrative costs are unlikely to be justified. without causing.

6.3 Recommendations for Methods of Toll Payment

In Section 4 of this toll report, various possible methods of payment of toll fees were discussed, together with their suitability, in general terms, to Open and Closed toll system applications. In this section the suitability of each of these Methods of Payment to the Bar – Boljare Motorway will be considered. For this purpose, it is assumed that the recommended manually operated closed toll system will be implemented.

6.3.1 Overview

There are various factors which influence the methods of payment which may be adopted. Amongst the most important are the expected traffic volume, the ratio of regular 'commuter' or commercial usage to casual or infrequent travellers, and the actual amounts of individual toll fees, that is, whether average fees are perceived as low or high.

In the case of the Bar – Boljare Motorway, the overall expected usage would not appear to be very high initially. However, there is currently no indication of the ratio of regular to casual users, which would greatly influence the introduction of prepaid cards or ETC, as these depend on people's willingness to participate in the scheme and invest in a prepayment account. Regular users perceive a benefit, especially if discounts are offered, but infrequent users are more likely to decide that paying by each journey is more advantageous to them.

The proposed level of toll fees is discussed in Section 3 of this report, the proposed toll rate for cars being €0.11per Km..

Toll rates will have a significant influence on the introduction of more complex and administratively expensive methods of toll collection such as ETC and, to a lesser extent, credit cards and stored value cards. Not only do these add to installation and operating costs, but, at low toll rates, there is less incentive for patrons to participate in a prepayment scheme, which generally requires a minimum initial payment of about 10 times the average toll fee charged, and a minimum level to top up at about two or three times the average payment.

It will therefore be the responsibility of the final toll system designer, together with the System Operator, to assess these traffic and revenue factors, along with social factors such as general acceptance and public expectation of the availability of some payment methods for other purposes, before deciding on the range of methods of payment, other than cash, to be incorporated in the initial system implementation.

As pointed out in Section 2 and elsewhere in this report, the manually operated closed toll system has the flexibility to include additional methods of payment at a later stage, in response to traffic demand and changes in toll rates, as the motorway usage and economic situation develops. It is therefore possible for the system designer to specify that the capability to utilize particular methods of payment, such as stored value cards and, especially, ETC, with minimum additional equipment and software modification, must be included in the initial system supply, even if the options are not initially made available to users, so that they can easily be introduced at the appropriate time.

Notwithstanding the above, summarized below are the methods of payment, with consideration of their applicability to the Bar – Boljare Motorway, for further consideration by the toll system designer and System Operator at the time of final design and specification.

6.3.2 Cash Payment

The recommended manually operated closed system concept is based on cash as the primary method of payment. It is understood that the Euro will be the basic currency for toll payments. However, the designer and System Operator should consider the likelihood or otherwise of travellers wishing to use other currencies and, if needed, the system should be designed with the ability to accept and account for foreign currency transactions.

6.3.3 Voucher Payment

Traditional monetary value voucher payment has no place in a closed toll system. However, a voucher payment capability should be retained to cater for special vouchers issued by the System Operator for use by police / military or other emergency or public service vehicles, or, perhaps primarily, the Operator's own vehicle fleet. Operationally, the availability of a 'Voucher' method of payment, with the physical evidence of the special voucher and a record of the vehicle number and organization of the owner, offers a viable alternative to an "Exempt" passage facility, often included in toll system designs, which is undesirable and open to misuse. It is also a practical consideration that, on occasion, patrons arrive at the toll booth with insufficient money to pay the toll. Operational procedures must be defined to handle these incidents, but, to allow and account for the passage within the system, the patron may be issued a Non-Payment Voucher (for later payment to the Operator), and the voucher transaction recorded.

6.3.4 Credit / Debit Card Payment

The acceptance of payment by international Credit / Debit cards has become an expectation by most people for all manner of goods and services, even for quite low value transactions. It is therefore necessary for the Operator and designer to give careful consideration to their use for toll payments in this system, despite some drawbacks for the System Operator, as discussed in section 4.1.4 of this toll report. If not included in the system, significant problems could arise, especially in the case of foreign travellers. However, as noted above, the toll rates in effect need to be taken into account. Because of handling difficulties, and because banks and Credit Card companies often impose a surcharge to cover their overheads, Toll Operators generally limit credit / debit card use to fee payment only above a certain minimum. In the case of low toll rates, the majority of payments may not reach a level where credit / debit card payment can be accepted economically.

It is therefore recommended that, at an early stage in the design process, the Operator discuss the technical and financial aspects of card usage with their bankers and/or available credit card clearing houses and consider whether the acceptance of credit cards is viable. If not, or if only viable for payments over a minimum amount, the Operator should attempt to inform potential patrons of the limitations through signing prior to entry plazas and by advertising, in order to minimize confusion and delays at Exit lanes.

6.3.5 Stored Value Cards and ETC Payment

There are significant similarities between Stored Value Card and ETC payment, so they can be considered together. Both methods involve prepayment by users, generally by setting up a prepayment account to be topped up as the balance becomes depleted, though stored value cards can be sold without the need to register user and vehicle details.

As noted above, the major factor which needs to be determined when deciding whether ETC or stored value cards should be made available to patrons is the extent to which users are prepared to participate in the schemes. They are only likely to appeal to regular users. Transport fleet operators, if regularly using the tolled facility, also welcome prepaid schemes as they make their accounting simpler and avoid having to provide cash to drivers for toll payments, or recompense them afterwards.

To an extent, the stored value card schemes can often be considered as a 'pilot' for a later ETC scheme, if initial interest does not appear to justify the expense of installation of ETC equipment.

The stored value card is a very convenient method of payment for regular users and facilitates quicker, simpler transactions at the Exit toll booths. The scheme is cheap to administer and requires little in the way of special equipment. As noted above, the cards can either be topped up to any convenient value above a minimum, or sold in a range of fixed values through stores, post offices or at toll plazas. In the latter case a means has to be provided to reclaim any residual value on the cards, insufficient to pay a complete toll. This could be done by rebate, credit on next purchase or 'serial' use, where the value remaining on an old card could be used and the remainder of the fee taken from a new card or in cash. In general, the disposable fixed value magnetic card is the simplest and cheapest type to implement, its use can be compared with phone cards sold in many outlets.

Stored value cards would most likely be of a contactless smart card type if top-up is available, and, of necessity, if also used as transit tickets, as noted in Section 4.1.3 above. Magnetically encoded cards may be used if sold as fixed value disposable cards. As well as the System Operator's information, any type of card could carry advertising to offset costs, but the fixed value disposable cards are probably most suited to this.

The use of an ETC tag for payment of tolls requires registration, and normally establishment of a prepayment account. The transponder tags are quite expensive as is the equipment to interrogate the tags, verify account data and accurately deduct and account the toll fees. The system also adds significant administrative overhead in registering and handling accounts, top-ups and statements. To justify this additional expense, it is necessary to attract a large number of regular users to participate in the scheme. However, its ease and speed of use, especially if a dedicated lane can be provided, is attractive and beneficial to regular users and the reduction in cash handling and cash flow benefit of prepayment is attractive to the System Operator.

It has previously been noted that, like the stored value smart card, the ETC Tag also has the benefit of potentially being used to replace the transit card for ETC scheme customers.

It is recommended that the eventual designated System Operator for the Bar – Boljare Motorway, the MTMAT or a Concessionaire, conduct a survey to establish the level of initial user interest in participation in prepaid Stored Value or ETC Schemes in due time for the inclusion of the results in the toll system design. The offer of toll fee discounts should be considered to encourage use.

Based on user interest, the viability of inclusion or otherwise of Stored Value or ETC payment in the initial system implementation can be decided.

Although somewhat dependent on actual numbers of participants, average journey lengths and fee rates, which will determine the amount of revenue which will be collected in this way, it is frequently considered that, to justify the expense and administrative cost of ETC, greater than 30% of traffic should be registered in the scheme. For this reason, unless daily commuters are known to form a significant percentage of users, initial targets of ETC schemes are often transport fleet operators, where a single contract covers many vehicles. It is not currently known whether transport fleets will be major users of the motorway, but the connection to the port of Bar would indicate the possibility of potentially high use by such entities.

If interest is sufficient to justify ETC implementation, it can be further determined whether ETC only lanes at some or all Plazas should be built. To justify this, greater than 40% of traffic is often considered a minimum for economic viability. However, these figures are subjective, and depend on actual conditions and Operator policy.

It should be noted that ETC only lanes, for safety and efficiency of use, are generally longer than normal 'stop-and pay' lanes, and consideration must also be given to weaving distances to allow safe separation of non-stop ETC traffic from 'stop-and-pay' traffic at the approach side of toll plazas. The decision to build them, or allow for their later addition, must, therefore, be made in sufficient time for inclusion in civil works designs.

If the survey indicates that there is insufficient initial interest to justify ETC implementation, the cheaper Stored Value Card schemes should be considered. These, particularly the sale of fixed value cards which is normally the simplest and cheapest, can be used to generate further interest in prepayment and the convenience of cashless transactions. Subsequently, if growth in use is significant, the stored value schemes can be phased out to be replaced by an ETC scheme, which is more suited to higher traffic throughput as demand increases.

In either case of 'smart card' stored value cards or ETC, it has been noted that the transit ticket can, theoretically, be dispensed with, as entry data can be encoded on the card or tag. However, in the case of the stored value card this is not recommended as it complicates operation at both Entry and Exit lanes and adds little to the speed or convenience of vehicle passage. It is also not recommended for ETC if the Exit lanes cater only for mixed methods of payment. The additional equipment at Entry lanes can not, in this case, be justified. However, it can be considered for implementation if dedicated ETC Exit lanes are provided. In this case the simpler Exit lane operation justifies a slight increase of complexity at manual Entry lanes, and fully automatic ETC Entry lanes can also be provided.

6.3.6 Electronic Purse Payment

The Electronic Purse card or mobile phone variant is described in the Section 4.2.2 of this report. As noted there, if a commercial application of the Electronic Purse concept achieves popular usage in the project area, there is no basic reason why it should not be used as a method of payment for the Bar – Boljare Motorway. Suitable readers and software would have to be obtained from the operator of the EP system, and integrated into the Lane Processor software. If this can be done, the method could be used. Unlike Credit / Debit cards, an account status does not have to be verified, so additional off line processing is unnecessary. This is a matter which should be considered by the toll system designer and the System Operator at the appropriate time.

Appendix A Phased Construction and Opening

It is currently understood that the Bar – Boljare Motorway will be constructed in phases, in accordance with the Design and Construction Schedule shown as Table 1 on page 4 of this toll report, and that each phase will be opened to traffic on completion.
Normally, in the case of phased construction and opening of a major road, several non-contiguous sections may first be opened, for economic reasons to do with the construction or for reasons of satisfying urgent traffic demands. In these cases interim toll solutions may have to be applied to the various sections prior to the implementation of the final toll system as the road is completed.

Phasing of construction and opening of toll facilities is very much dependent on the length of completed sections and the time lag between initial openings and gradual opening of other sections until the road is complete. If possible, permanent toll installations are built on main lines or interchanges, but occasionally temporary facilities must be provided and later removed.

If the ultimate system is to be a closed system, Exit toll plazas may be built and operated temporarily in flat fee “Open” mode on short sections. Entry plazas or lanes are then added later and brought into use when sections are joined to make road segments long enough to require the introduction of distance related tolls.

In some cases short sections may be opened initially free of charge, with tolls only introduced when longer segments are joined and opened.

However, in the case of the Bar – Boljare Motorway, if built in accordance with the current schedule, such interim solutions will be unnecessary.

The diagrammatic maps on the following two pages show the approximate planned phased opening sections.

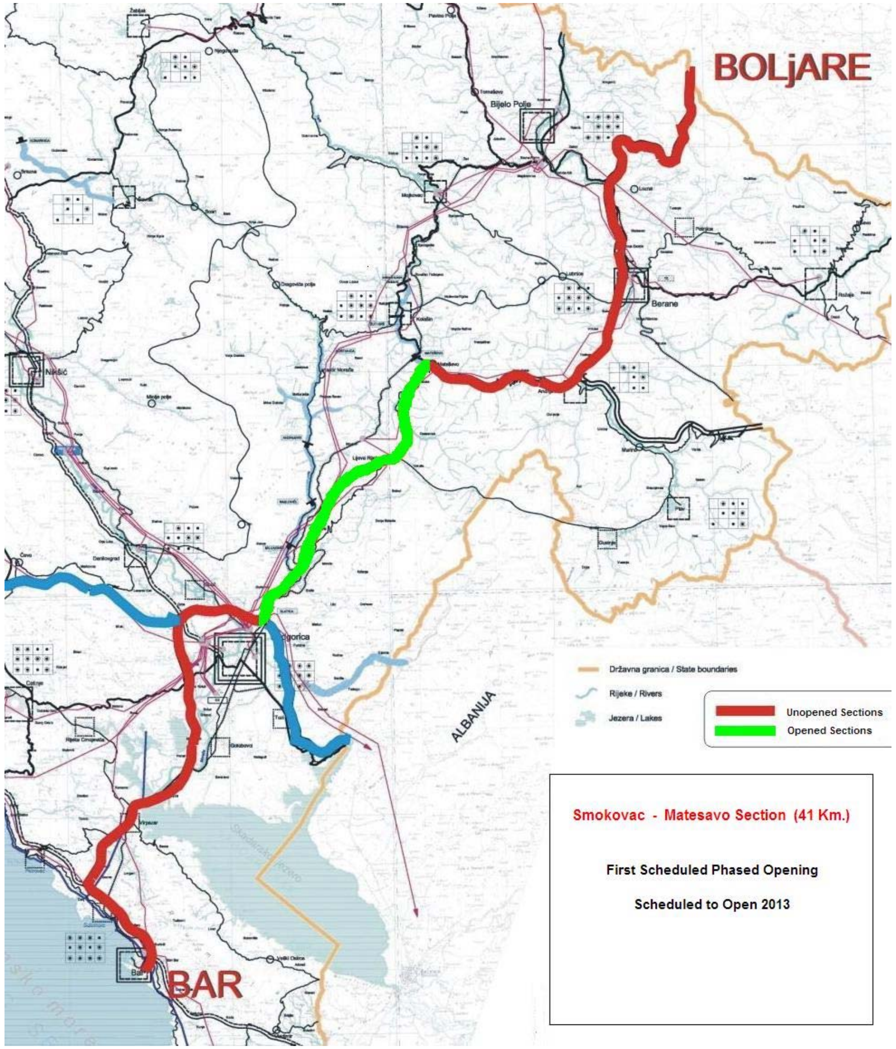
The Planned opening phases are:

Phase	**Between**	**Construction Section Nos.**	**No. of Interchanges**	**Total Continuous Length**	**Opening Date**
First	Smokovac - Matesevo	3	2	41 Km.	2013
Second	Virpazar - Andrijevica	2, 3, 4A	7	102 Km.	2015
Third	Bar - Berane	1, 2, 3, 4A, 4B	11	124 Km.	2016
Final	Bar - Boljare	ALL	13	165 Km.	2016

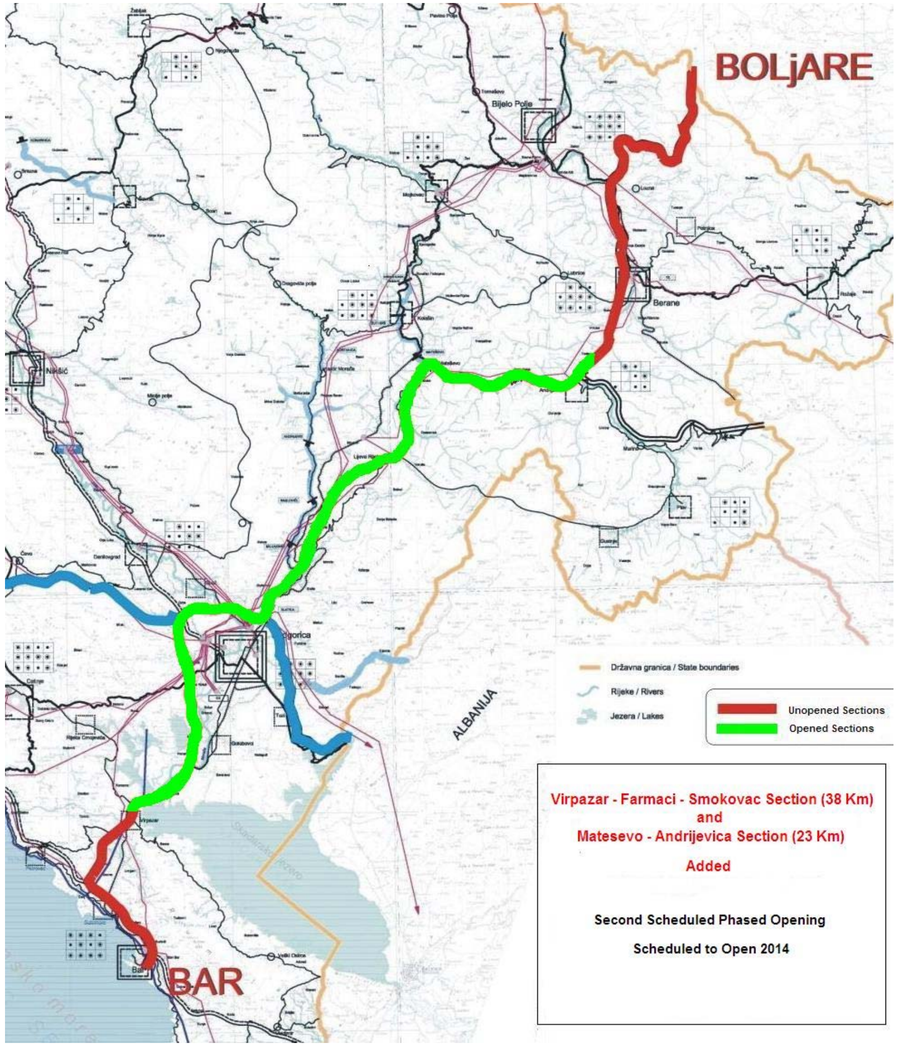
It can be seen that starting with the first phase, the Smokovac – Matesevo section, scheduled to open in 2013, the additional sections are contiguous and extend the motorway both north and south to complete and open the entire project within a time frame of 3 years. For a highway construction of this size and complexity, that time span from completion of the first segment to final completion can be considered normal progress.

Bar – Boljare Motorway Phased Opening

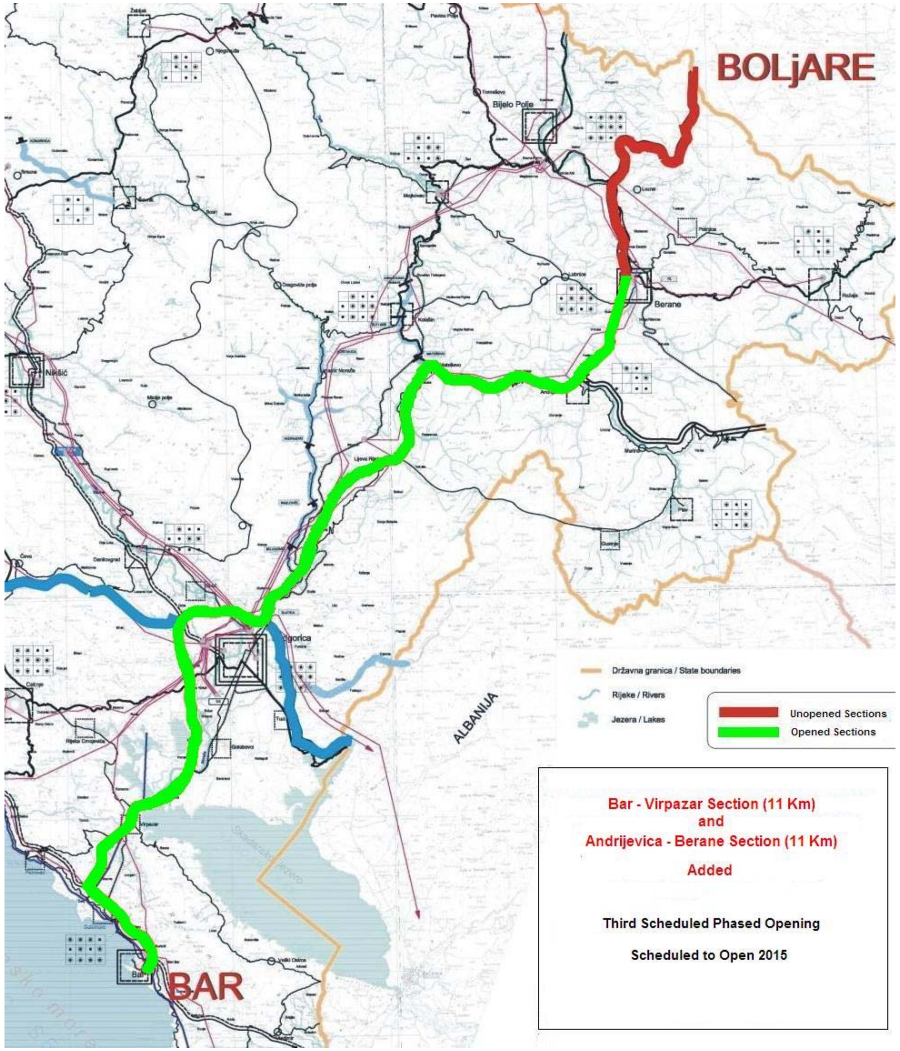
Phase 1 - Total Length 41 Km.



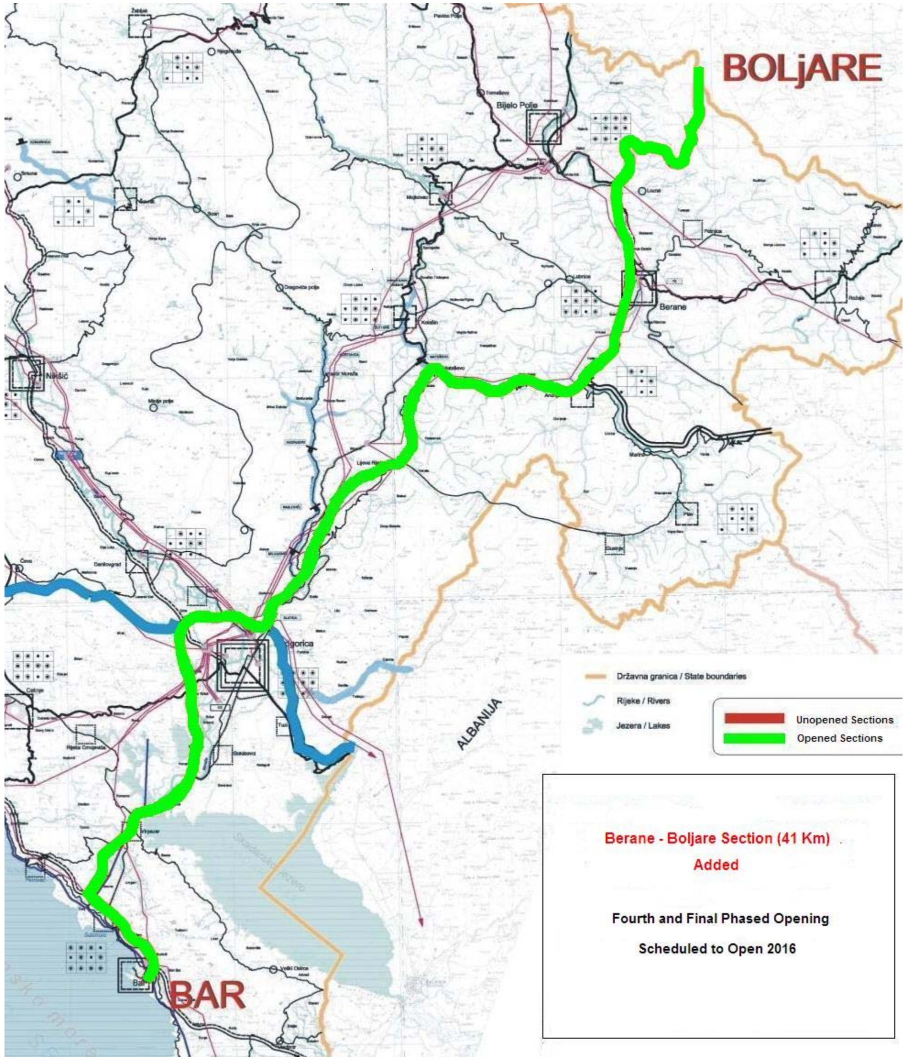
Phase 2 - Total Length 102 Km.



Phase 3 - Total Length 126 Km.



Phase 4 (Final) - Total Length 165 Km.



Assuming that Closed System tolling is to be implemented, there is only one decision to be influenced by the phased opening schedule, and that is the nature of tolling employed on the first section before the second two northern and southern sections are added 1 year later, after which, full closed system operation is needed.

Since the section, in the current plan, contains no intermediate interchanges, all toll fees will be the fixed for each class of vehicle as the distance travelled will be fixed. Unless there are changes in this plan, it would be logical to equip only the Exit lanes at the Smokovac and Matesevo interchanges and charge flat fees, with clear signing at the entry lanes to ensure that users are aware that they must stop and pay on exit. Later, when the second two sections are opened with 5 additional interchanges and a total continuous main line of about 102 Km., will it be necessary to full implement the Closed System configuration.

However, another possible option will be to open the first section under full Closed System operation with entry and exit control using transit tickets. This is only to be considered because of the short one year term of interim operation. The advantage of doing this is that it can act as a ‘trial run’ of the closed system charging, ticket handling and staff training in a ‘scaled down’ situation prior to the second phase full scale operation covering tolling at 7 interchanges. This trial run period will allow operations staff to become familiar with transit ticket handling, particularly recycling, which is a critical part of the closed system operation. It will also allow operating staff to be trained in operation of both Entry and Exit lane equipment and procedures, and allow administrative staff to become familiar with reports and operational procedures whilst the quantity of data to be processed by the system and the staff is at a minimum.

No other impacts on the recommended toll system implementation are foreseen due to phased construction and opening.

Appendix B Implementation Alternatives

1.1 Implementation Alternatives (Entry Lanes)

There are a number of possible alternatives in the implementation of the basic issuing of transit tickets and the checking of classification at the entrance or exit from toll lanes.

The main options at entry lanes include:

a. *Automatic pre-classification at entry lanes with vehicle class encoded upon transit tickets.*

This is complex and, though apparently attractive, has many drawbacks so is not to be recommended for a number of reasons vis:

- The Classification Structure (See section 3 of this report) must be suitable for differentiation using physical parameters which are conveniently measured by sensors in the toll lane;
- the Entry lanes must be very long, so as to fully enclose the longest vehicle prior to its arrival at the Ticket Issuing point;
- Following from the above, a queuing system mechanism must be built in to the automatic pre-classification system to allow several shorter vehicles to be within the lane and the correct ticket issued. This is prone to error and can lead to serious collection problems;
- In case of such errors, photographic evidence of the entry transaction may be needed, and available for viewing at the Exit lane to ensure that no intentional fraud is being attempted and that the correct toll fee is collected. This is complex and expensive, and only possible if all Entry and Exit lanes are in communication with a central system at all times.

b. *Manual pre-classification at entry lanes with vehicle class encoded on transit tickets.*

This option has several advantages. It does not have the disadvantages of Automatic Pre-classification and can lead to simpler Exit lane configurations, as a second “blind” manual classification at the Exit lane can avoid the necessity of installing post-classification sensors at the Exit lane, thus offering savings in both equipment costs (including spares and replacements) and maintenance work. (see section 1.4 (c) below.)

The disadvantage of manual pre-classification is that, at the Entry lane, an operator must be employed and toll booth provided equipped with heating and ventilation to provide a proper working environment. However, the advantages generally outweigh this, and equipment costs are not significantly different.

c. *Issuing of tickets at entry lanes from stand alone, dual height Automatic Ticket Issuing Machines (ATIM's), used with (a) above.*

This has the same disadvantages as (a) above unless the Classification system can be simplified to only vehicle height over the first axle.

d. *Issuing of tickets at entry lanes from dual height Ticket Issuing Machines (TIM's) installed within the side wall of the toll booth, used with (b) above.*

This only eliminates the need for interaction between the Entry lane operator and the vehicle driver, whilst increasing the cost of equipment and level of difficulty for drivers taking ticket. This would generally lead to slower throughput. Nevertheless, it is used in some installations. The advantage is that at off-peak times, the TIM can be switched to Automatic Mode and used as (c) above, but most likely as (f) below, with the lane reverting to ‘Cars Only’ mode.

e. *Issuing of tickets at entry lanes with TIM's installed under the desk by booth operators, used with (b) above.*

This is, in fact, the most common and preferable implementation of (b), and has the advantage of personal communication between the operator and the patron. It prevents any confusion on the part of the patron and leads to quick transactions, as drivers do not have to manoeuvre their vehicles close to the booth to collect the ticket. Lane throughputs of 600 – 700 vehicles per hour are quite easily achievable using this method of ticket issuing, compared to about 450 to 550 vph for TIM operation described in (d). In countries where labour rates are not a major factor in comparison to toll rates and overall toll revenues, this would be the preferred method of ticket issuing to maximize throughput and efficiency of toll operations.

f. *Streaming of vehicles and Issuing a pre-encoded ticket. That is, segregating traffic by class prior to entering the lane.*

This can lead to large Entry Plazas, and requires long weaving distances at the approach to the Entry lanes. Normally a partial version is used for ‘Cars Only’ lanes, or for ‘Buses Only’ lanes to speed throughput. If private cars represent a significant majority of traffic, such lanes, used with height restriction barriers, can save on operating costs. As mentioned above in (d), manual lanes equipped with TIM can be switched to automatic mode in off-peak times to reduce labour requirements. The most common application of this would be to switch to ‘Cars Only’ mode. To prevent larger vehicles using the lane in this mode, a movable height restriction barrier can be swung over the lane during this mode of operation. The concept is illustrated by the two photographs below, taken at the Dublin Port Tunnel in Ireland. The DPT is an Open System, but the principle is the same.

All the above make the assumption that classification has to form part of the information encoded or printed onto the transit ticket. However, it is possible for the transit tickets to have no class information. In this case the classification is carried out only at the Exit lanes, as it would be in an open system. A post-classification system would be needed to check the toll collector's selection. As the amounts of money are larger for the closed toll system transactions, any potential fraud in this area is more significant. It is therefore better practice to include class information on the transit ticket. At the exit lane the toll collector enters his assessment of the class of the approaching vehicle and a comparison is made between the collector classification and that carried on the transit ticket. To account for errors caused by a discrepancy between the toll collector selected class and that contained on the ticket there must be a mechanism to re-classify a vehicle. This would be an unusual occurrence, possibly requiring supervisor authority and would be clearly logged in the toll collectors shift details. (See also section 1.4 (c) below). The method can facilitate statistical assessment of operators' performance at both Entry and Exit lanes.

The following 3 options are applicable to all the above basic methods of Transit Ticket issuing:

1. *Use of post classification system to check the validity of the issued ticket.*

   This is an option which can be used to augment any of the above basic ticket issuing methods. It is, however, normally used only in conjunction with manual classification. Clearly, it has no application to streamed single class lanes, unless it is possible for other vehicles to pass through the lane, in which case alarms can alert plaza staff to the occurrence.

   In the event of a post-classification discrepancy being alarmed, the System Operator must define an Operational Procedure to be followed, since a valid ticket has already been issued to the transiting motorist.

2. *Use of automatic barriers to control the egress from the entry lane, following issue of tickets.*

   Even though all toll lanes are normally equipped with red and green traffic lights to control egress from the toll lanes, the use of high speed barriers, though not strictly necessary, is recommended for automatic lanes, largely because of user familiarity (e.g. at car parks) but is not generally needed for manual lanes. In Open Toll Systems, such barriers may be used to prevent revenue loss, but in Closed System Entry Lanes there is no such loss, and the difficulty will lie with the user if he exits the lane without a ticket, as normal procedure at Exit lanes is to charge the maximum possible fee for 'lost' tickets. If automatic barriers are not used, it would be normal to fit sensors (usually inductive loops) to detect a vehicle leaving the lane without taking a ticket, and operational procedures should be devised to cope with this situation. For dual use lanes, automatic barriers may be activated in Automatic modes of operation, but remain raised in Manual modes.

3. *Use of barriers at entry lanes to close lanes which are not available for use.*

   The use of "Lane Closed" barriers positioned at the entry to lanes in recommended for all toll lanes, whether Closed System Entry, Exit or Open System lanes, in order to prevent user confusion and as a safety feature to protect maintenance staff working in the toll lane. Although overhead signs are usually used to show the lane's Open or Closed status, these are best seen at a distance and experience has shown that "Lane Closed" barriers are also needed. The barriers may be manually operated or remotely controlled (with suitable safety precautions) at the discretion of the System Operator. Though manually operated barriers are cheaper and simpler in operation, there are sometimes Health and Safety considerations for staff concerned with the operation of the barrier if the operator might be exposed to oncoming traffic in order to close or open the barrier. For this reason, if manually operated barriers are chosen, the toll lane design should include a safe walkway within the protected toll island to access the barrier mechanism.

The following 4 options concern the choice of ticket stock.

a. *Use of new roll stock or pre-cut tickets, made from thin card, contained within magazines.*

b. *Use of plasticized, reusable transit tickets contained within magazines and issued through an automatic encoder.*

c. *Use of plasticized, reusable transit tickets contained within magazines and issued by swiping them through an encoder.*

d. *Use of semiconductor 'Smart' cards as transit tickets.*

Generally, the final choice will be a function of operational economics at the recommendation of the system designer at the time of final design and implementation. Numbers of transit tickets used may be high and their cost must be taken into account as consumable items. Most existing older systems use magnetically encoded tickets. Smart cards are in use on newer systems. Much will depend on expected usage. At higher system throughputs, throw away type tickets become less attractive than re-usable tickets. Throw away tickets have the cheapest unit cost, but they can only be used once. Plasticized reusable tickets are more expensive, but still cheaper than smart cards and they have a theoretical life of typically 500-1000 cycles. The cost of contactless smart cards is, however, dropping due to the many uses to which they are currently put, and their life cycle is much greater due to their more robust fabrication. All reusable tickets require sorting, checking, cleaning and re-distribution and have potential problems caused by distortion, exposure to sunlight when in use, and general mishandling, but, again, smart cards are more robust. Throw away type tickets may carry printing to reflect some or all of the encoded information. Re usable tickets designed for a large number of cycles can not carry this printed information. To assist recognition of either throw away or re-usable tickets, they may be pre-printed or colour coded to identify them with their issuing plaza. If this is done there is no need to print on the tickets at the time of issue as all the 'basic' information to collect the correct toll is visible on the ticket, and by observation of the vehicle, in the case of a reading error at the exit lane. However, recycling re-usable tickets to their original issuing plaza represents yet another handling overhead, and it is better to have uniform tickets which can be issued from any plaza. Tickets can then be re-issued where collected, with some transportation to other locations to balance the numbers of tickets available.

1.2 Electronic Toll Collection (ETC) Transit Option.

All the above options for implementation of Closed System Entry lanes are applicable to any method of payment which may be applied to the system. However, if Electronic Toll Collection (ETC) using Radio Frequency (RF) transponders carried in the vehicle, is implemented, one other Entry lane configuration is possible. Other aspects of ETC use are covered in various sections of this report. However, briefly, if sufficient regular users are prepared to subscribe to prepaid ETC accounts for viability of the scheme, the vehicles are issued with a transponder, often referred to as a 'Tag' for convenience, which is normally attached to a vehicle's windscreen. These tags are encoded with vehicle and account details, and interrogated by transceivers positioned at toll lanes or elsewhere. When interrogated by a valid coded signal, the tag transmits the encoded details which are received by the transceiver and used to verify the validity of the account, and the identity of the vehicle. This is also known as a form of Automatic Vehicle Identification or AVI.

Some 'tags' have the ability to receive and store data transmitted from the transceiver, as well as transmit their stored data. This type of tag can be used in Closed toll systems both to act as a transit ticket and method of payment at the Exit lane.

At Entry lanes, a dialogue takes place between the transceiver and the transponder. On arrival at the Entry Lane, the tag is first interrogated and its data concerning the vehicle identity and class is verified against the ETC database. Data similar to that encoded on transit tickets is then transmitted to the tag and stored within it. The tag validates the data by predefined stored protocols and transmits acknowledgement of the receipt and verification of the data. The vehicle then continues its journey to the desired Exit.

At the Exit lane, similar transceivers again interrogate the tag, and retrieve both the vehicle identification data and the data stored at the Entry lane which identifies the point of origin of the journey within the

Closed system. The appropriate toll fee is then deducted from the prepaid account and a coded 'End of Transaction' message, which may include details of the fee, the Exit lane and the date and time of the exit transaction, for long term storage in the tag, if the type of tag contains sufficient storage to retain this data throughout its operating life. On receipt of a valid 'End of Transaction' message, the transit data stored in the tag is deleted.

This type of Entry and Exit transaction is potentially very fast, and vehicles can proceed without stopping, even in mixed manual lanes. However, high speed Automatic Lane Barriers would be recommended to ensure that vehicle processing is complete before the vehicle leaves the lane. If there is sufficient demand, special lanes may be provided which allow passage without significantly reducing speed. In all lanes, but especially in 'ETC only' lanes, Video Enforcement Cameras may be used to ensure that vehicles transiting without valid tags can be recorded and prosecuted. At Closed System Entry lanes, such attempts at fraudulent use are less likely, as once inside the controlled area, it is quite easy to apprehend to offending vehicle, so expensive VES recording equipment may be avoided if system policing is efficient. At Exit lanes or in Open Systems, such equipment is essential.

1.3 Interoperability of ETC Schemes

A significant advantage of ETC schemes, whether used only as a method of payment in Open or Closed systems or for fully automated passage in a Closed system or 'free flow', OTR system (see Appendix B section 1.4), is the potential for use of the same tag on many toll facilities. Where the ETC System Operator is the same, this presents no problems. In Norway, one of the pioneers of Electronic Toll Collection in Europe, the national AutoPASS scheme allows subscribers to use the tag on 25 toll installations positioned throughout the country. However, attempts are being made to create Interoperability Standards so that tags issued by any Operator can be used in a wide range of systems. In the UK, the Department for Transport (DfT) engaged in the development of the "Open Minimum Interoperability Specification Suite" (OMISS), later changed to the "DRSC Charging Application Specification" (DCAS). Neither specification was fully developed, as the DfT decided to postpone the project pending the development of the European Interoperability Standard, currently under development by the European Union. This standard is due to be completed and published by 2010. After publication, any ETC scheme implemented in Europe will gain significant benefits by compliance with the standard. As the Bar - Boljare Motorway is expected to commence initial operation in 2013, and may introduce ETC at that time or later, the technology should be designed to comply with the European Standard, if available.

1.4 Implementation Alternatives (Exit Lanes)

There are fewer options for alternative configurations at Exit lanes in Closed Toll Systems, since, with the exception of ETC and one other possible configuration described in (h) below, there are no viable alternatives to manual toll collection. Possible alternative Exit lanes configuration and options are:

a. *Pre-classification by Automatic Vehicle Classification (AVC) equipment on entrance to the lane.*

   The same drawback to the use of automatic pre-classification at Exit lanes as those noted for Entry lanes apply. It is complex and has no advantages. It is therefore not to be recommended.

b. *Post classification by AVC equipment to check the registered transaction, including any amendments made by the toll collector changing the class of the vehicle.*

   This is commonly used and has several advantages. Violation alarms can be generated, with details displayed to collectors and supervisors, in the cases where the AVC equipment detects a different class of vehicle to that entered by the collector, or where it differs from the class encoded on the transit ticket.

c. *No classification checks, i.e. totally reliant upon the classification at the Entry lane and manual classification at the Exit lane.*

This is the option briefly referred to under Entry lane alternative (b). The system relies on minimizing errors by, in effect, two independent classification procedures. For this to be effective, the classification made at the Entry lane can not be printed on the transit ticket. Typically the operation is as follows. The toll collector at the Exit lane makes his own class assessment and enters the transit ticket into the reader. If the two classes agree, the transaction proceeds and the toll fee is collected. If the two classifications do not agree, the toll collector is normally first requested by the system to re-verify his manual classification. If the corrected classification then is the same as that encoded on the transit ticket, the transaction is allowed to proceed normally, but the discrepancy is recorded and appears on the collectors shift report produced by the central computer. If the collector verifies his classification assessment, the transaction is locked and the shift supervisor notified by alarm at his supervisory terminal. Then visually, either directly or by CCTV monitoring, the supervisor must verify the class of the vehicle and enter this into the system. The transaction then proceeds with the fee calculated and collected according to the final classification entered by the supervisor. Details of all classifications Manual Exit, Supervisor's and encoded on the transit ticket, along with details of the issuing Entry toll plaza, lane and operator ID are recorded and included on the shift report. If Video Enforcement is in operation, the still and video images are also permanently stored and retrieval references included in the transaction report details.

This procedure has two significant advantages over automatic classification systems. Firstly, the installation of AVC sensors is avoided. AVC systems rely on measurements of physical parameters of vehicles (see section 2.5 of this report), the most common of which are number of axles, presence of one or more dual tyred axle, and wheelbase or configuration of axles. Though other methods exist, such as optical profiling, the simplest and most common method of making these measurements is by axle pads or 'treadles' installed in the road surface. Whilst significant improvements have been made over the years, in the design of treadles, they are still subject to a very harsh environment, suffering not only physical stresses imposed by axle loads, including heavy braking and accelerating, but also chemical attack by oil and various exhaust gasses and, in cold climates salt and other chemicals spread to counteract icing. The systems therefore tend to be maintenance intensive and have limited life or MTBF. A minimal AVC system will include at least 6 to 8 treadles and typical routine replacement is 12 months or less. The cost of each treadle is about US$350 or about US$2,100 to 2,800 per lane. The AVC system may also include other expensive components, such as Optical Gates for vehicle separation. Whilst having longer life, these are also expensive, costing around US$2,800 per set. Clearly, a system which avoids maintenance and replacement expenses of this order, whilst still offering high confidence of accurate toll fee collection, should be seriously considered.

The second advantage offered by this approach to Closed System tolling is that it allows the use of classification systems which do not rely purely on measurable vehicle parameters. In the AVC approach, for example, it is impossible to automatically differentiate reliably between a two axle, 6 wheel bus and a two axle, 6 wheel truck, which may use an identical chassis. Some systems do assign these vehicles to different classes, for purposes of production of traffic statistics, but charge the same toll fee for the two classes, so that the AVC systems can still be used to verify accurate fee collection and accounting. However, if two such overlapping classes are required to be charged different fees, the AVC system can not verify the transaction, making its use entirely redundant, as accounting accuracy can not be verified by the automatic system. In practice, toll systems using AVC are constrained to differentiate toll fees between vehicles with measurable differences.

d. *Processing of transit tickets by feeding them into a motorised reader.*

e. *Processing of transit tickets by swiping them through a reader or, for smart cards, a proximity reader.*

The above options (d) and (e) can be considered together. Generally, option (e) should not be used. It is not reliable, particularly with softer paper stock or damaged tickets, and is not suitable for re-usable tickets. Neither does it offer any significant speed advantage.

Motorised readers can capture the ticket and, if necessary print on it to cancel it. In the case of 'throw away' stock, the transit ticket is often printed on exit, with fee, date and time, and returned to the user as a receipt, thus fulfilling the function of a receipt printer and relieving the Operator of the need to dispose of large quantities of used tickets.

In the case of reusable tickets, especially of smart card transit tickets, the tickets, once verified and at the end of the transaction, after the toll fee has been collected, can be captured by the motorised reader to a cassette, which may be used directly in ticket issuing machines or fed into sorting, cleaning and verification machinery, which readies the cards for re-issue.

f. *Provision of Receipt Printers.*

For Closed system Exit lanes (or Open System toll collection lanes) the provision of a receipt printer is generally considered to be essential. The ability to issue a receipt may, in fact, be a legal requirement imposed on the System Operator. Except where the disposable transit ticket can be printed and used as a receipt, as noted above, receipt printers normally utilize paper roll stock with a capacity of over 2,000 receipts to avoid frequent changing of rolls. The roll stock may be pre-printed with the System Operator's details, logo etc. Data printed at the time of issue should, as a minimum, include:

- Operating Authority (if not pre-printed);
- Mandatory Tax (e.g. VAT) numbers (if not pre-printed);
- Issuing Plaza Identification;
- Date and Time of Issue;
- Issuing Toll Lane ID;
- Toll Collector ID;
- The Vehicle Class;
- The Toll Fee Paid;
- The Method of Payment.
- Receipt Number (6 Digit circulating)

Unless there is a mandatory requirement to the contrary, receipts should only be printed on demand, to avoid a litter problem and unnecessary depletion of ticket stock when patrons do not require a receipt

g. *Provision of Electronic Toll Collection (ETC) transceivers.*

If the ETC toll collection option is implemented, Transceivers should be fitted in suitable positions in all Exit lanes. In the case where the option is not used to replace the transit ticket for journey validation (see Entry Lane Option above) the transceiver antenna should be automatically activated after the ticket is read, the toll fee calculated and displayed to the patron. The toll fee will then be automatically deducted from the patron's prepaid account and the green traffic light activated to allow the vehicle to leave the lane.

In the case where the ETC tag is also used for journey verification, the ETC antenna may be activated as soon as the vehicle has been classified by the collector. The vehicle class is part of the data read from the tag, and should be compared with the collector's classification in the same way as the data from a transit ticket. When the class is verified the toll fee will be calculated, displayed to the patron and the collector, and deducted from the prepaid account, after which the green traffic light will allow the patron to leave the lane.

Where the vehicle is not equipped with a valid ETC tag, acknowledgement of receipt of the payment by other means should de-activate the ETC transceiver antenna.

In all cases, the receipt printer should be active, so that the patron may receive a receipt if so desired.

h. *Automatic Lanes*

Under certain circumstances, the inclusion in a Closed toll system of Automatic Exit lanes can be considered. The obvious case is the use of ETC, where the ETC tag is also encoded at Entry and used to replace the transit ticket, and the level of ETC scheme participation is high enough to justify the construction of Automatic ETC lanes at some or all Exit plazas.

However, Automatic Exit lanes are also possible if Operator Specific Stored Value Cards or standard Credit / Debit Cards are used. (See sections 2.6.3 and 2.6.4 for explanations of these methods of payment). In these cases the transit ticket must be machine readable, allowing an automatic reader to be installed in the lane to first read the transit ticket inserted by the driver, then accept the Stored Value Card or Credit / Debit card for payment. In the case of ‘Smart Card’ type Stored Value Cards, the card can, like the ETC tag, also be used as the transit ticket. In this case, a single insertion of the card could be used to complete the transaction.

A disadvantage of the Automatic Ticket / Card reading equipment is that the driver must position the vehicle for ease of insertion and retrieval of cards. Experience has shown that this causes user problems, particularly if a queue of vehicles forms behind an inexperienced user, but regular patrons can be expected to become quite efficient in the use of the system.

As with Automatic ETC lanes, the percentage of Stored Value Card and Credit Card users must be sufficient to justify the costs of provision of the dedicated lane. However, Credit / Debit Card facilities could be incorporated with ETC lanes for use of either. It is very unlikely that Stored Value cards would be used with ETC lanes, as the two are alternative options and it is unlikely that both would be implemented. However, if ETC tags or cards issued by another Operator were to be accepted, this alternative would also be possible.

Ancillary equipment in automatic lanes would be expected to include On-Demand Receipt Printers, Automatic Exit Barriers, Automatic Post-classification equipment and Video Enforcement cameras, if used elsewhere on the toll plaza.

i. *Provision of Video (or Violation) Enforcement Systems (VES).*

VES, originally “Violation Enforcement Systems” but, since they most commonly use still and video images for enforcement, now the term is generally interpreted as “Video Enforcement Systems”. VES Systems normally consist of at least one, but preferably two or three video cameras suitably placed in the toll lane to take both video and still images of the front and rear of vehicles, to show clearly vehicle type, characteristics such as colour, and, most importantly number plates. The third camera may be needed positioned to record video data when a violating vehicle leaves the lane, as the field of view of the first rear facing camera may be obscured by succeeding vehicles.

Automatic Number Plate Recognition (ANPR) can also be integrated, but for application only to the detection and prosecution of violating vehicles in Closed System Exit lanes it may not be economically viable.

The VES system provides evidence, using still images of the front and rear of vehicles and short video clips, to link an attempt to leave the toll lane without proper registration of the toll to a particular vehicle. This may later be used to identify the vehicle owner and recover the toll fee. It is beyond the scope of this report to go into the detail of VES System design, but the optimum positioning of the cameras is vitally important and, if the system is to be included, this needs to be given careful consideration in the design of the toll lanes, including the civil works. It is a common error to allow the design and construction of civil works to proceed before any consideration is given to the geometric layout of equipment in the toll lane. This can place difficult and unnecessary constraints on the toll system designer, and ultimately compromise the effectiveness of the toll operations. Systems particularly susceptible are AVC and VES systems.

Appendix C Methods of Toll Collection

1. Other Methods of Toll Collection

Other methods of toll collection which do not rely on the use of conventional Open or Closed toll plazas, are in use in various locations, though most can be regarded as special cases of either the open or closed systems. Some of these systems, particularly full ETC and most recently Video tolling are most suited to urban or sub-urban highways with very high traffic flow, where the ability to handle large volumes of traffic at speed is an overriding consideration. A further advantage is a reduction of man-power for toll collection (though maintenance and administrative staffing requirements are normally increased), and reduction or elimination of cash handling and its attendant need for security. In this section of the report these will be discussed in general terms. Their suitability for possible application to toll collection on the Bar - Boljare Motorway will be considered later in the report. These systems are considered separately below, but, in practical applications it is likely that some of these techniques will be mixed.

1.1 Electronic Road Pricing (ERP)

Electronic Road Pricing is, in fact, a generic term which can be used to cover any system by which fees are paid by Automatic Identification of Vehicles without the need for drivers to pay specific fees at the point of use. However, in this section, ERP is intended to describe systems where all vehicles entering a certain area are identified by sensors, which may include wireless transponder interrogation, CCTV or ANPR at the boundary of the area and randomly at points within the controlled area. Vehicles entering and using the area must have paid and registered with the scheme, or, usually, may purchase a daily ticket. Generally, such schemes are used as congestion mitigation methods in central urban areas, where the fee is designed to discourage unnecessary journeys. ERP may only apply at certain times of day and/or only on weekdays. Examples of this type of ERP can be found in Singapore, London, Oslo and several other cities.

A wider area ERP system can be found in Switzerland and Germany, which use a Vehicle Positioning System to track movements of HGVs throughout the country. On-board Global Positioning System (GPS) Equipment is used in conjunction with the vehicle tachometer and roadside transceivers to levy a Heavy Vehicle Fee to all Heavy Goods Vehicles, dependent on distance travelled within the entire country. In this case it is intended to raise revenues to maintain the road system and reduce pollution. Vehicles conforming to higher Euro anti-pollution standards are charged lower fees. In systems such as these, the On Board Units (OBU) are permanent fittings and not detachable from the vehicle. Initial purchase and fitting of the units is quite expensive at around US$200.

Generally, ERP systems such as described above, with the exception of Electronic Toll Collection (ETC), a specific type of ERP described below, are not ideally suited to single toll road applications, as they do not differentiate fees by distance, and therefore are inequitable to short distance users. The Vehicle Positioning System based systems do allow distance related charging, but are very expensive and difficult to administer, and as such should be considered as ‘overkill’ solutions for single toll roads. However, some variants are used, such as the Vignette system described below.

1.2 Fixed Fee Leasing (Vignette) Systems

Vignettes are usually small, coloured stickers affixed to motor vehicles passing through highways and freeways in some countries of the European Union. The affixing of a vignette sticker on a motor vehicle indicates that the respective road toll has been paid. Different classes of vehicle are subject to different payments, which the design of the sticker will show. Stickers are often valid for a year. They may also be a form of tax on the vehicles even if the driver doesn't drive on highways or freeways, and they are usually constructed in such a way that detaching and reattaching is impossible without destruction, ensuring that people can't use the same toll sticker on more than one car. In some cases monthly, weekly or daily Vignettes are available, mostly for the use of tourists or other non-regular users.

The general concept is that, during the period of validity of the Vignette, the vehicle may be used without restraint on the network of roads for which the Vignette is valid. In most cases, the Vignette is used as a form of road tax, and covers a whole network of roads in an area or even a whole country. It is designed to shift the burden of road network maintenance and expansion from the taxpayer to the road user.

Enforcement is dependent on efficient policing and high fines for violators, which, along with the possibility of inspection randomly and at any time, act as a deterrent to attempts to avoid payment.

In Austria, for example, Vignette stickers are required for all motorways and expressways under federal administration which can be recognized by the prefixes A and S in front of the number. The prices for cars (weighing less than 3.5 tons) are €7.70 for 10 days, €22.20 for 2 months, and €73.80 for one year. Motorcyclists have to pay €4.30, €10.90, and €29.00 respectively.

On motorways and roads, the stickers are controlled by the police and employees of the federal motorway administration ASFINAG. Penalties for attempted avoidance are very severe. As a fine, a substitute toll of €110 must be paid by travellers without a Vignette sticker, and €220 fine if the sticker has been altered (e.g., foil in between the windscreen and the toll sticker). This substitute toll allows the use of A and S networks on the day of payment and on the following day. If substitute toll is not paid, the traveller is subject to a complaint at the administration authority of the county, which may lead to a penalty fee between €400 and €4,000. Furthermore, personal valuables (including the car) can be confiscated from foreigners to guarantee the payment of the penalty.

In addition to the compulsory Vignette sticker for general motorway and expressway use in Austria, further tolls per each single usage must be paid on certain motorway and expressways (e.g. cost-intensive sections in the Alps). Additional Tollgates are installed on these roads. This demonstrates that the Vignette system alone is not a complete replacement for a traditional toll system where expensive bridge or tunnel sections must be built and maintained. Rather it is a road tax system designed to reduce, but not necessarily eliminate, the need for traditional toll collection.

Heavy vehicles are also subject to separate, mileage-dependent motorway tolls via technology involving onboard and external monitors.

In Bulgaria, Vignette stickers are required for all types of roads, except for the streets inside cities, towns, and villages, as well as city ring roads. Three types of Vignettes are available:

- K1 - Road vehicle 1st category: all freight vehicles with more than two axles, road trains, special construction equipment, auto cranes, special trailers for transport of heavy or oversized cargo, and other special motor vehicles.
- K2 - Road vehicle 2nd category: all passenger transport vehicles with more than 8 seats excluding the driver's seat and all freight vehicles with two axles, as well as construction equipment, auto cranes, special trailers for transport of heavy or oversized cargo, and other special motor vehicles, all of them with two axles.
- K3 - Road vehicle 3rd category: all passenger transport vehicles with no more than 8 seats.

Weekly, monthly, and yearly stickers are sold. Starting 2007, daily K1 and K2 stickers were introduced. Monthly and weekly stickers are valid for a given period of time, which need not coincide with calendar weeks and months. A yearly sticker is valid from January 1 until January 31 next year (13 months).

Prices change every year. In 2007, a yearly K3 sticker cost €67, a monthly sticker cost €13, and a weekly sticker cost €5.

Vignettes may not always take the form of stickers, or stickers may be augmented in other ways. When purchasing a Vignette, the vehicle owner must give vehicle details, including the vehicle registration number (license number). At various positions on the controlled road system, cameras, such as described under Video Enforcement Systems above, integrated with optical character recognition (OCR) and Automatic Number Plate Recognition (ANPR) software, may be installed to check whether the vehicle has a valid Vignette by interrogating the Vignette registration database. If not found, a visual record including still photographs and video may be retained for later enforcement and collection of fees and fines. If the country has a facility for on-line vehicle registration checks, the system may automatically check the national vehicle registration database to provide the name and address of the owner of the violating vehicle. Whilst transiting the Vignette controlled system, the vehicle may pass several VES/ANPR installations, making it almost impossible to avoid detection if no valid Vignette is registered as having been issued to the vehicle

In single toll road applications, such as the Bar – Boljare Motorway, the Vignette system could be used. However, the apparent cost savings may not be so great as expected. The savings on toll plaza installations and operation costs have to be offset against the need for an efficient Point of Sale network, particularly for casual users and visitors purchasing short term Vignettes, and the cost of VES/ANPR installations and visible policing patrols to identify/deter violation attempts. A further “Back Office” administrative cost is incurred in follow up of violations to collect fees and fines. This must be done, and publicised, if potential violators are to be deterred.

The system could be convenient to local frequent users who may buy long term Vignettes. However, the cost of these must be comparable to an average cost of toll fees which would otherwise be paid, in order to maintain the toll road Operator’s level of income. If the number of users who would be prepared to purchase long term vignettes forms a significant percentage of all users, a better approach would be the introduction of prepaid stored value transit cards, using either magnetic or smart card technology, or ETC Tags, to attract this same group of users.

The greatest disadvantage of the Vignette system in toll road applications is that it is period based rather than usage based. Thus producing inequitable contributions across the user base between heavy, long distance and lighter, short distance users. The purchase of a vignette gives no indication of use of the road network. Some purchasers may use the system extensively on a daily basis, while others may only use a part of the system two or three times per week. Not only is this inequitable to the user, but there is no direct correlation between the overall use of the system and the income produced. This makes it very difficult to match the income of a toll Operating Authority to costs such as loan repayments, operation and maintenance. In local road networks, where the Vignette system is, in effect, a road tax, the vignette prices may be set, by experience, statistically, and like most taxes, the revenue produced is just one contribution to the Local Authority’s annual revenue and budget. However, for a dedicated toll authority, and especially for a Concessionaire, control and predictability of the revenue stream is essential.

It should also be noted that, for a new project, unlike traditional Closed System tolling, the full investment cost of vignette sales infrastructure, enforcement systems and administration needs be made prior to opening of the project road or network. Costs can not be spread by installation of additional equipment in response to increases in usage, as they can using Closed System tolling, as everything need to be in place and operational on opening day.

Similarly, operation costs are quite fixed from the beginning. The administrative costs relating to sales and enforcement would not be expected to vary greatly with traffic growth. Initial cash flow, at least, may therefore, be quite poor.

1.3 Electronic Toll Collection (ETC)

Electronic Toll Collection (ETC) has the potential to replace “Stop and Pay” revenue collection in both Open and Closed System equivalent modes, though it is still most commonly used in conjunction with other methods of payments on mixed toll plazas. ETC is the basis of most ‘Free Flow’ or ‘Open Road Tolling’ (ORT) systems in Europe, North America and many other systems throughout the world. In Europe, Norway is a major user and pioneer of ETC with a nationwide system named AutoPASS. AutoPASS is implemented at both fully automated Toll Plazas and in dedicated lanes at mixed plazas. Some are configured as Urban Rings to control entry to inner cities, such as Oslo and Bergen.

It is worthy of note that ‘free flow’ ETC is still most often an option offered alongside traditional ‘Stop and Pay’ facilities to ease congestion at toll plazas and allow regular commuters a quicker passage.

In all cases, users must register their names, addresses and vehicle details with the Operating Authority and install a transponder tag in the vehicle in such position as to be able to reliably respond to interrogation by RF Transceiver. Transmissions are encrypted and the encryption keys securely pre-programmed into the tags to prevent fraudulent use and unauthorized access to, or alteration of, data stored in the tags. Normally payments are deducted from prepaid accounts, though, in some cases, post-billing is done on a monthly basis.

In a ‘Free Flow’ Closed System configuration, the tag details would be recorded at entry, and data usually written to write enabled fields within the tag. At exit, the tag details would again be read and either by comparison through a central database which holds records of the entry or, more commonly from the data encoded in the tag at entry, the fee calculated and deducted from a prepaid account or recorded for later billing. The entry data within the tag are then erased to be reused for the next journey. In an Open System configuration, the tag is identified and the fixed fee is deducted when the vehicle passes a single point equipped with transceivers, normally mounted on gantries above the road and clearly marked. In longer systems or networks several such payment gantries may be used, with fees deducted at each one.

Whilst modern equipment is capable of processing vehicles at through lane speeds, streaming into lanes, which also slows the vehicle somewhat, is the most common configuration. This system increases reliability of reading, since it ensures that the vehicle transponder is well aligned in the ‘footprint’ of the transceiver antenna and vehicles tags can not be masked by other larger vehicles.

Violation Enforcement is a vital key to the success of non-stop ETC toll systems. This is achieved through the use of multiple VES cameras and ANPR systems, necessitating a significant ‘back office’ administrative expense in tracking and reclaiming fees from violators.

The disadvantage of this type of system is the difficulty of dealing with casual users, especially foreign vehicles. In mixed use plazas there is no problem because vehicles not registered in the ETC scheme can pay by other means. However, in totally automatic systems it is necessary to provide a means by which visitors can register and obtain a valid tag. In Norway, visitors are often directed to stop at an adjacent petrol station where temporary registration is available.

It should be noted that, currently, in the peak July-August tourist season, according to the findings of the Louis Berger SAS Feasibility Study, Average Daily Traffic at the Sozina tunnel is about 3 times the Winter average, and approximately twice the averages of the preceding and following two month periods (May-June and September- October). The LB report also notes that “*The high seasonal variation for Sozina tunnel is very consistent with the seasonal variations elsewhere in the corridor reported by Crnagoraput*”. The LB report does not attempt to break down this traffic between foreign and domestic, but it would appear likely that there is a high percentage of foreign registered vehicles in the make-up of the extra traffic. Expansion of the passage of goods traffic through the port of BAR can also be expected to contribute to an increase in foreign registered vehicles. Again according to the LB Study, the port is currently operating at less than 50% of its capacity and “*the Serbian authorities have indicated that their seaborne commerce would be transferred from Thessaloniki to Bar, once the complete motorway link from Belgrade to Bar is ready.”* This increase in commercial transportation through the port has the potential to significantly increase all traffic on the motorway and particularly the percentage of foreign registered vehicles, probably mainly Serbian and Italian. This would represent significant logistical problems in dealing with foreign vehicles in an ETC based ORT system.

1.4 Automatic Number Plate Recognition (ANPR) Systems (Including Video Tolling - V-Toll)

Generally speaking, ANPR/V-Toll is not used as a primary method of toll collection, but mainly as a Vehicle Identification system in conjunction with VES, Vignette, ETC or Congestion Charge systems, as described above in this report.

Whilst the technology is well proven and in use worldwide for law enforcement, its reliability and accuracy for as a primary tolling solution is doubtful. In countries such as the UK, vehicle number plate design has, for many years, been aimed at producing clear contrast and sharp images of numerals by use of reflective white or yellow background and black numbers. It is also an offence to have excessively dirty of obscured number plates, and offending vehicles risk apprehension at any time by police patrols. In that environment, reading accuracy is quite high. However, misreads do occur, particularly in bad weather, such as snow and heavy rain. Due to reading angles, there are sometimes reflections, for instance from wet roads, even when auxiliary infra-red illumination is used, which can cause misreads. In some countries where license plates are not specifically designed for ANPR, where numbers are smaller or contrast between number and background is less, and plates may be dirty or otherwise obscured, or even missing, without great fear of prosecution, the accuracy of ANPR is further reduced. This may not be a great drawback for enforcement systems, where occasional failures to read the number of a violating vehicle does not lead to significant loss of revenue. In area control also, such as congestion charging or vignette enforcement the vehicle may pass several ANPR check points, so misreading at one is not too important. However, in toll systems, vehicles normally are identified at a single point, or each point passed represents a unit of revenue. Single misreads therefore translate to loss of revenue. ANPR / V-toll is generally not acceptable as a primary and only means of toll collection for this reason.

In some systems, such as Highway 6 in Israel and Route 407 ETR in Ontario, Canada on which the Israeli system is based, and two recently opened toll roads in the United States, the TX121 near Dallas, Texas, and the Tampa Crosstown Expressway in Florida, ANPR/V-Toll is used as a secondary collection system, the primary system being ETC using RF Tags. In the first two examples, users who, for whatever reason, do not want to subscribe to the ETC tag system, can register their vehicle license numbers with the Operating Authority, which registers the number in its database. The methodology is as follows. When entering the tolled area or passing various additional toll stages within it, the vehicles are interrogated by ETC Transceivers. Number plates of only those vehicles not fitted with a transponder are scanned by ANPR cameras. If registered in the database, the vehicle owner is identified and billed for usage at the end of the month. In the American examples prior registration for V-toll is not required, but the principle is similar. In all cases, the toll rate applied is higher than that applied to vehicles in the ETC scheme. If not in the database, the vehicle number is identified through the national vehicle registration database and the owner billed for the passage. In this case, the toll rate applied is much higher, by about 30 to 40%, to cover additional overhead and to discourage this type of usage. Texas users also pay a $1 additional billing fee under the ANPR/V-Toll system.

It is worthy of note that in both Ontario and Israel, and in the United States, the number of foreign users is likely to represent an extremely small percentage of all vehicles. An inherent problem with all ‘free flow’ systems is that if violators are of foreign origin it is usually impossible to trace them by any economical means to collect tolls and fines, unless they are apprehended whilst still within the controlled area. Foreign registered vehicles therefore represent a potential loss of revenue for the System Operator. Where such vehicles represent an extremely small percentage of total patronage, this is acceptable, but for a road such as the Bar - Boljare Motorway, which connects a port of arrival for foreign vehicles (Bar) to other countries, (Serbia, Albania and beyond) foreign vehicles could make up a significant percentage of traffic, and, in a 'free flow' system, a significant potential for loss of revenue.

The likelihood of significant numbers of foreign vehicles travelling the BBM corridor, due to tourist and commercial traffic is set out in section 2.4.3 above. This factor would have a significant bearing on the potential use of any tolling system which does not offer a 'stop-and-pay' option at a toll plaza, and needs to be fully assessed before a final choice of system type or equipment configuration is made.

1.5 Electronic Purse (or Wallet)

The Electronic Purse or Wallet is a concept which has been much publicised but has, so far, met with limited success in attracting users, with some notable exceptions. It is usually a stored value contactless, passive RFID smart card which can be used to purchase normally small items in retail stores or vending machines or pay for transport, such as bus and train fares, meals or services. Use of a PIN number is not normally required. It can usually be topped up and contains relatively small amounts of money, such that if lost or stolen no great financial loss ensues. Reporting of a loss, such as is required in the case of bank credit / debit cards, is unnecessary.

Current developments have integrated the Electronic Purse concept with mobile phones using Universal SIM (USIM) cards, which combine the functions of SIM Cards and Smart Cards. If an Electronic Purse card or mobile phone scheme achieves popularity in the project area, there is no reason why it should not be accepted as a method of payment in toll systems.

1.6 Off Line Payments

For completeness, a summary is given here of types of payment of tolls under which actual revenues is received by the Operating Authority other than directly at the toll booths.

Most of the above methods of payment fall into the category of prepayments except cash, Bank Credit / Debit cards and ANPR/V-Toll, where users are not pre-registered.

Prepayment is very beneficial to the Operating Authority's cash flow, and generally should be promoted amongst regular users such as commuters and, especially, fleet operators, such as haulage companies and passenger bus service operators. The advantages to individual commuters are less than to fleet operators, but increased speed of passage through the toll lane can be considered advantageous to regular users. For fleet operators, centralized payment is easier to account, and avoids the necessity of giving drivers advances for payment of toll fees or reimbursing toll fees. Since it is to the advantage of the Toll Authority to encourage prepayment, discounts are frequently offered as incentives.

The alternative Off-Line Payment System is Post Billing.

Post Billing is similar to the Prepayment in operation, except that the patron company must generally enter into a contract with the Operating Authority and be billed, typically, on a monthly basis, for tolls accumulated by their vehicles. There are disadvantages to the Operating Authority in this method, as the Authority must undertake the administrative overhead associated with producing and delivering the bills, and typically will not receive payment for up to 3 months after billing. Whilst revenue is reasonably assured from corporate users, there is a significant risk associated with individual users that payment may not be collected. The Authority's cash flow is therefore adversely affected. Unlike prepayment, which can be implemented simply by collecting an initial account payment on registration, post billing requires a secure means of recording each transaction, such as magnetic card, smart card or ETC. For these reasons, post billing is not generally popular amongst Toll Authorities, and is seldom considered for offer to individual users, due to the disproportionate overhead expended in collection of the tolls.

The use of standard bank credit / debit cards at toll booths is not considered to be post-billing because the revenue is normally received in a short time from the bank or card company. However, there is a risk if cards are rejected, as noted above.

The methods of payment falling under the category of true post billing are unregistered ANPR / V-Toll or registered ANPR / V-Toll where no advance payment is collected and ETC with no advance payment.. In the case of users such as municipal bus companies, there may be no alternative to a post billing contract, but the nature of the client is a reasonable guarantee of eventual payment.