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Gabrovo – Shipka Highway Project
Cost Benefit Analysis

Main Report




Prepared by: Edmund Salt
Consultant, Transportation

Checked by: Graham Powell
Regional Director, Transportation

Approved by: Martin Bright
Director, Transportation

Gabrovo – Shipka Highway Project, EU Cohesion Fund Application, Supporting Document

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Beaufort House, 94/96 Newhall Street, Birmingham, B3 1PB
Telephone: 0121 262 1900 Website: http://www.aecom.com

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Appendices
The Appendices to this report are contained in a separate document entitled '*Gabrovo-Shipka Highway Project, Cost Benefit Analysis, Appendices to Main Report*'.

1 Introduction

1.1 Introduction

This report presents the Cost Benefit Analysis (CBA) for the Gabrovo-Shipka Highway Project, which involves the construction of a road bypass west of the town of Gabrovo and a tunnel under Shipka Peak. The report explains the background to the project, and its context within the Gabrovo-Shipka corridor, before describing the relevant scheme details and options, as drawn from the previous Feasibility Study. The report then provides information on the transport model and forecasting, before reporting the results from the Cost Benefit Analysis and identifying the Preferred Options.

This report is structured as follows:

- **Chapter 2** describes the objectives of the project and how it meets national and international transport policy objectives, in particular how the project contributes to the pan-European and TEN-T policy framework;
- **Chapter 3** presents the details of the project, describing the scheme variants contained within the existing Feasibility Study and the process by which the Project Options have been assessed;
- **Chapter 4** sets out the traffic forecasting methodology and key assumptions;
- **Chapter 5** includes the traffic forecasts and traffic composition for the project;
- **Chapter 6** provides the background information on the estimation of project costs;
- **Chapters 7 and 8** describe the key inputs and methodology for the Economic and Financial CBA;
- **Chapter 9** presents the results of the Financial and Economic CBA for the preferred option;
- **Chapter 10** discusses the outcomes of sensitivity tests and the methodology and results of the risk analysis for the preferred option; and
- **Chapter 11** contains the summary and conclusions.

This report is principally concerned with the CBA for the Gabrovo-Shipka Highway Project, as this is the means through which the Preferred Options are indentified. The report does not include a Multi-Criteria Assessment or a review of environmental issues as these are outside the scope of this task.

2 Policy Context of the Scheme

2.1 Project Objectives

The proposed Gabrovo – Shipka Highway Project needs to be viewed within the context of the objectives of the Bulgarian Government and the regulatory framework of the EU. It is important that the scheme sits comfortably with, and satisfies, the appropriate policy drivers at a regional, national and international level to ensure the necessary approvals can be obtained to take the scheme through to implementation. An appreciation of the policy context is necessary to understand the justification for the scheme, in a strategic sense, complimenting the technical and financial assessments undertaken.

2.2 Scheme Location

National Context

As illustrated in **Figure 2.1,** Gabrovo is located in central Bulgaria to the northwest of the Central Balkan National Park. The national park itself is situated on the Balkan Mountain Range which spans the entire width of the country. The topography of central Bulgaria causes severance between northern conurbations, such as Gabrovo, and those in the south which results in poor transport connectivity for vehicular travel.

Figure 2.1 Location of Gabrovo, Bulgarian National Context

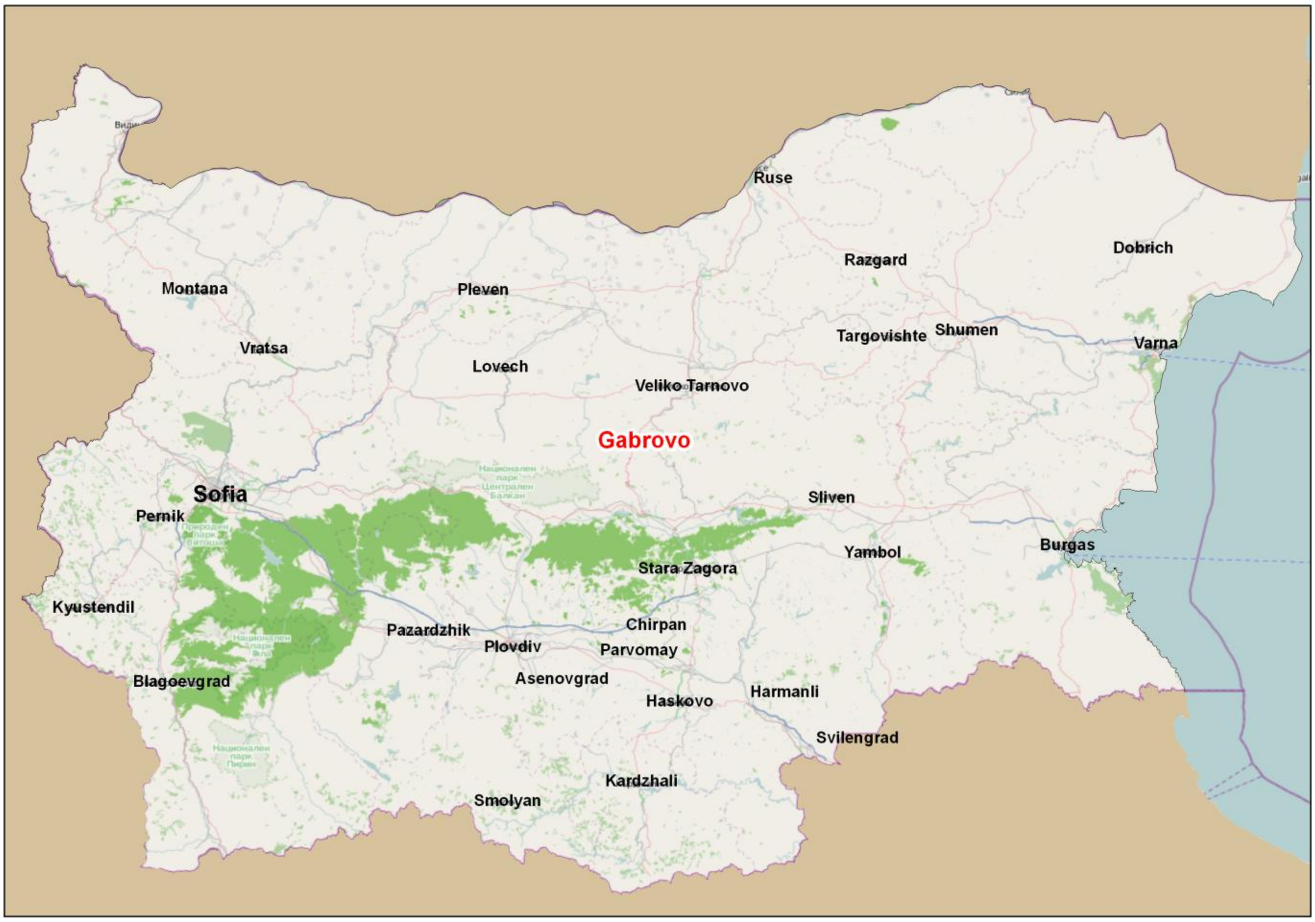


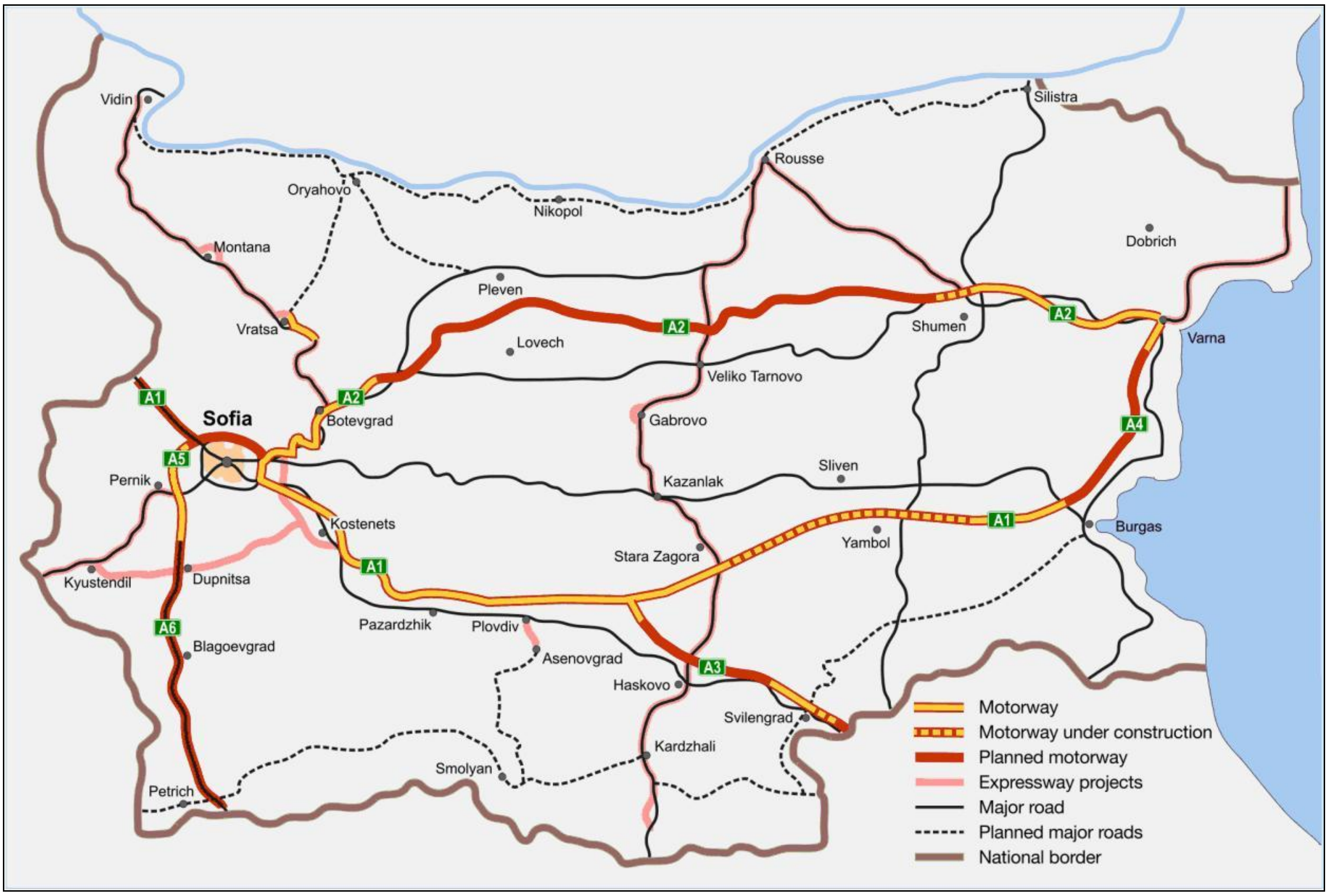
Figure 2.2 Gabrovo to Shipka Corridor

As illustrated in **Figure 2.2**, the town of Shipka lies immediately to the south of the Balkan Mountain Range. For the purposes of this report, the Gabrovo-Shipka corridor is defined as the length of the route between the two conurbations. The First Class Road I-5 is the primary route through the corridor, and an important link between the north and south of the country, however the poor quality and challenging alignment of the road currently results in slow journey times and delays through the corridor. Poor weather conditions also result in the section of the road along the Shipka Pass being closed during the winter months due to heavy goods vehicles becoming stuck (in 2008, a ban on 10 tonne vehicles was introduced on the pass which has had the effect of reducing the frequency of enforced closures).

Major Road Network in Bulgaria

The existing major road network in Bulgaria is displayed in **Figure 2.3**.

Figure 2.3 Motorway Network in Bulgaria



In 2011, the total length of completed motorway in Bulgaria was 437 km, including the Lyulin Highway (20km) which was completed in 2011. By 2013, it is envisaged that the total motorway network of Bulgaria will be 619 km with the completion of the Maritsa Motorway, Trakia Motorway and Vidin Bridge crossing. The Gabrovo-Shipka corridor is not part of the motorway network; however, it has been identified as a link of interest in terms of expressway projects. Expressway projects contribute to providing major road connections across Bulgaria through improved 1st class roads. In 2011, the total length of 1st class roads in Bulgaria was 2,961 km, of which the 86 km within the Gabrovo municipality made up 3%. Upon completion of the Gabrovo-Shipka bypass and tunnel, the amount of 1st class road network in the region would increase to 117 km.

Figure 2.4 Road Network within the Gabrovo-Shipka Corridor

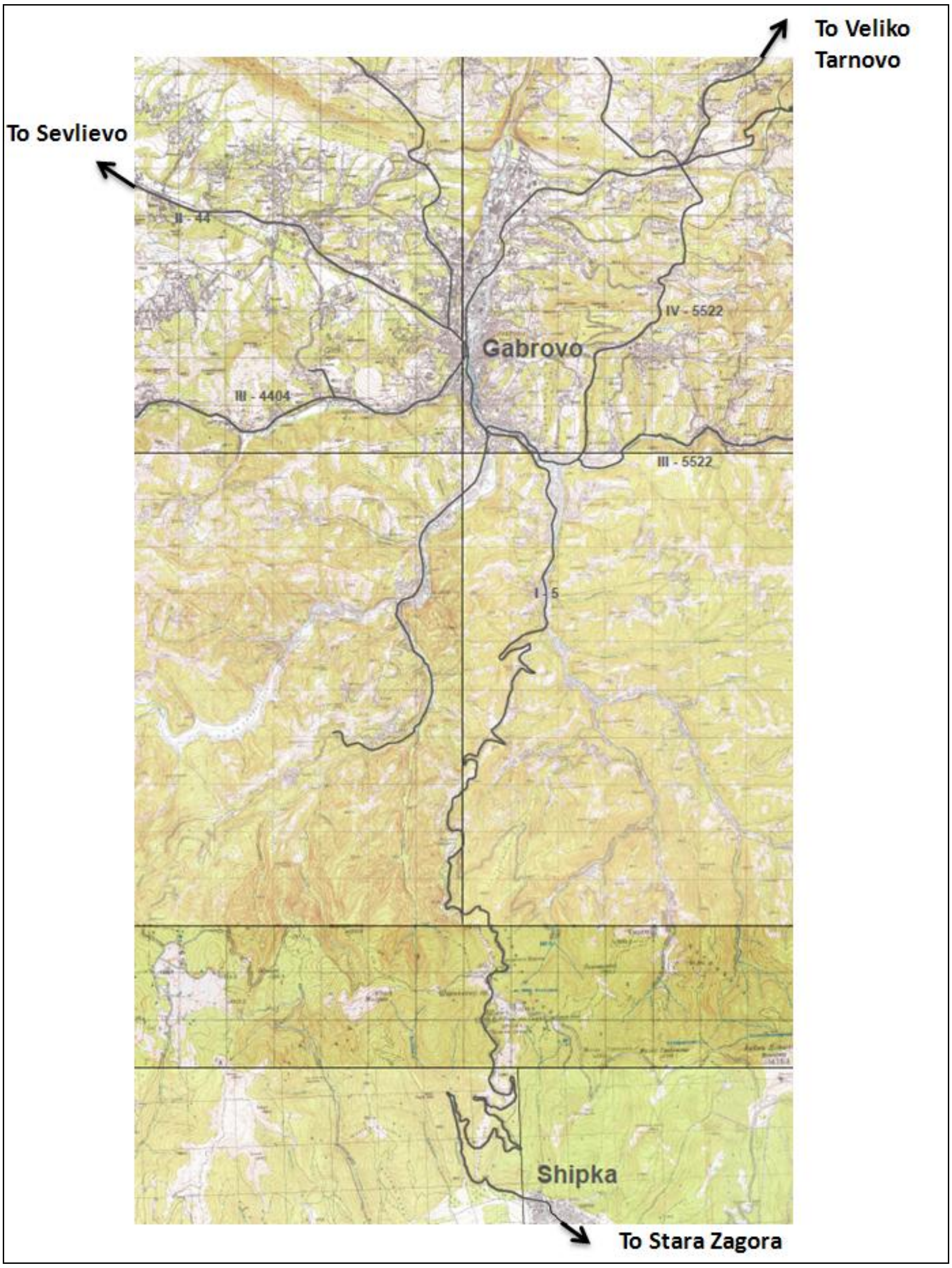


Figure 2.4 displays the road network within the Gabrovo-Shipka corridor, including the existing route of the I-5 between the two settlements. This illustrates the current role of the I-5 as the only direct connection between Gabrovo and Shipka which, as a result of its challenging alignment and periods of closure of the Shipka Pass, can cause severance along the north-south axis for transit traffic (as well as isolating residents of Shipka from Gabrovo and other conurbations to the north).

International Context

Bulgaria has a strategic geographical position within Europe, emphasised by the fact that five Pan European Corridors pass through the country: IV, VII, VIII, IX, and X. These Corridors are further described below and are shown on **Figure 2.5**.

- **Corridor IV**: Germany - Turkey: Dresden / Nurnberg – Prague – Vienna / Bratislava – Budapest – Arad – Bucharest –Constanta / Craiova – Sofia – Thessaloniki / Plovdiv – Istanbul;
- **Corridor VII**: The Danube River;
- **Corridor VIII**: Italy – Bulgarian Coast: Bari / Brindisi – Durres / Vlora – Tirana – Skopje – Sofia – Plovdiv – Burgas / Varna:

  plus the road link Ormenion – Svilengrad – Burgas, providing connection with Corridors IV, IX, and the Trans-European transport network;

  plus Byala / Gorna Oryahovitsa – Pleven – Sofia, providing connection with Corridors IV and IX; and

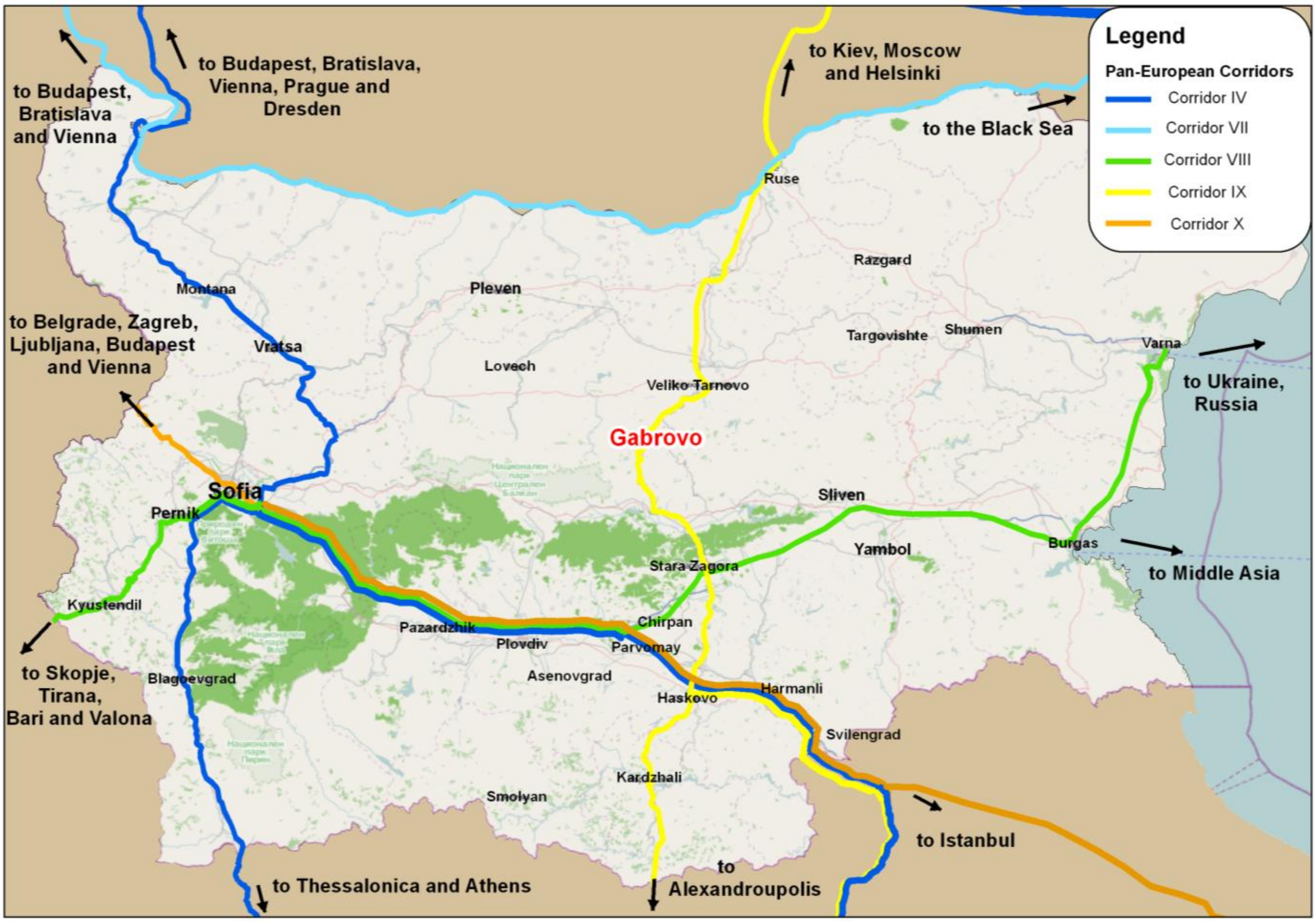
  plus Kafasan – Kapstiche / Kristalopigi, providing connection with the Trans-European transport network;
- **Corridor IX**: Finland – Russia – Romania – Bulgaria - Greece: Helsinki – Saint Petersburg – Moscow / Pskov – Kiev – Ljubasevka – Chisinau - Bucharest – Dimitrovgrad – Alexandruopolis

  Branch A: Odessa - Ljubasevka / Razdelna

  Branch B: Kiev – Minsk – Vilnius – Claipeda / Kaliningrad
- **Corridor X**: Austria - Greece: Saltsburg – Ljubljana – Zagreb – Belgrade – Nis – Skopje – Veles – Thessaloniki

  Branch C: Nis - Sofia (Dimitrovgrad – Istanbul through Corridor IV).

Figure 2.5 Pan - European Transport Corridors in Bulgaria

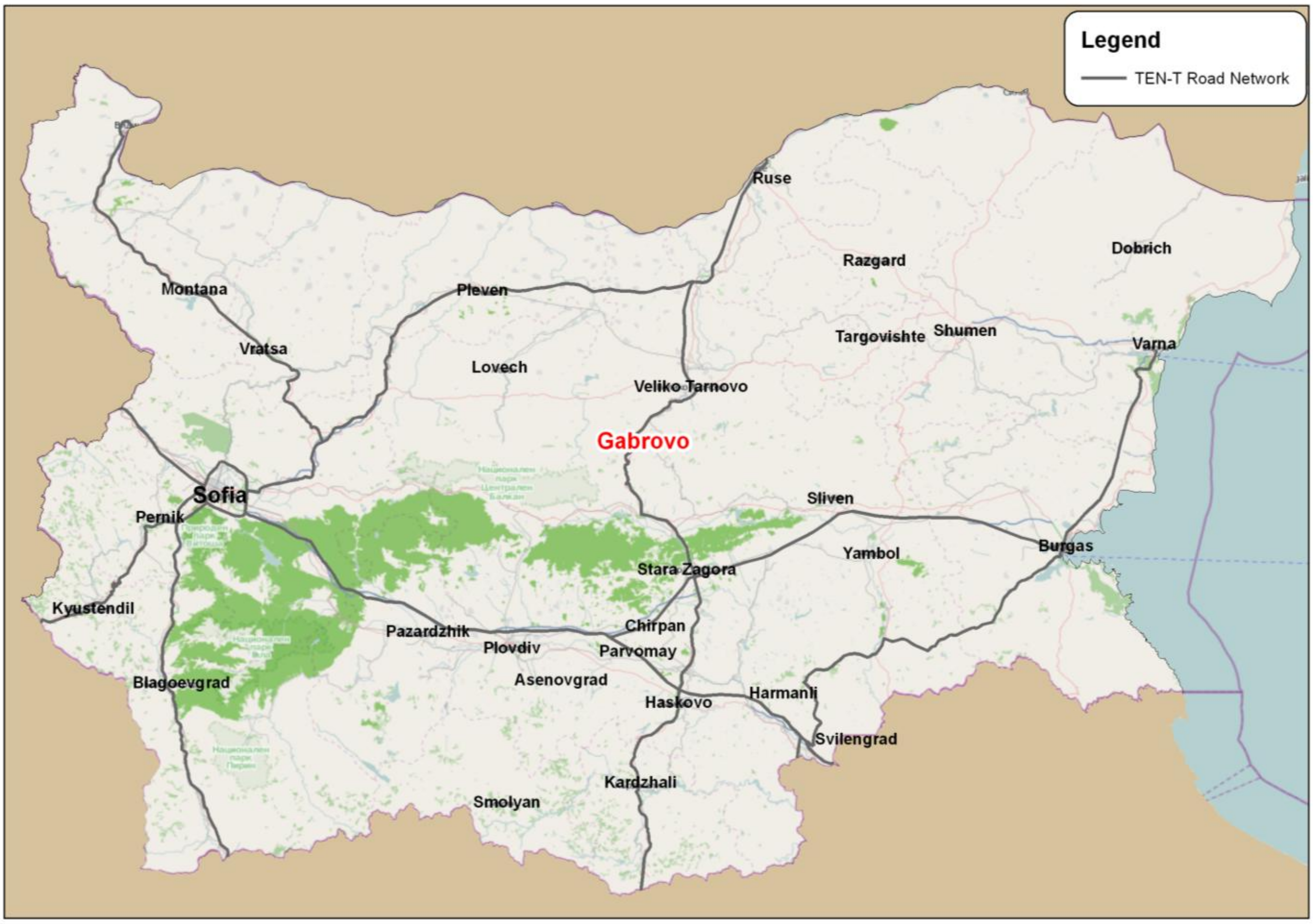


Gabrovo is located on PETC-IX, which runs north to south through Bulgaria, connecting Greece with Romania and Northern Europe. This Corridor has been identified as an essential contributor to the economic performance of Bulgaria and the overall economy of the region, principally through trade connections with northern and western Europe.

The Gabrovo – Shipka corridor is also part of the Trans European Transport Network (TEN-T). TEN-T aims to improve economic and social cohesion, by linking island, landlocked and peripheral regions within Europe's more central nations. This is done by interconnecting and interoperable national road, rail and maritime networks.

The Gabrovo – Shipka Corridor, shown in **Figure 2.6**, forms a key component of the TEN-T road network, also forming one of only two north-south connections of the network within the country.

Figure 2.6 Trans European Transport Road Network (TEN-T)



The fast and efficient transit of goods through the EU relies on high quality and integrated infrastructure provision. The Gabrovo corridor currently plays a key role in the movement of goods and people, not only across Bulgaria, but also from the Mediterranean to North-Eastern Europe. The recent global economic downturn means that the future economic growth of countries is going to be heavily reliant on the ability to efficiently import and export goods between countries, which are particularly important for Bulgaria given its strategic location within the EU.

2.3 EU Transport Policy

The policy context relevant to this scheme is potentially very broad. A concise summary has been provided below which identifies the key policy drivers, both nationally and internationally.

Creating a competitive Europe, leading to economic efficiency and increased social welfare, is the underlying theme of the guidance produced by the European Commission. The EU focuses on:

- Interventions in the development of the Trans European Network;
- Regulation and competition among and between modes;
- Setting of prices that include charging and the external costs;
- Overcoming the disadvantage experienced by peripheral regions as targeted by the Cohesion Fund; and
- Overcoming relative economic deprivation through the European Regional Development Fund.

The EU has recently released a new Transport White Paper, the main focus of which is ensuring equality in regulation, sustainable transport, intermodal transport, environmental and safety standards across the EU, rather than specific infrastructure provision. However, some of its objectives are applicable to the Gabrovo-Shipka project:

A fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services. The Gabrovo-Shipka Project is a key TEN-T route in a multi-modal corridor;

By 2050, move close to zero fatalities in road transport. In line with this goal, the EU aims at halving road casualties by 2020. Make sure that the EU is a world leader in safety and security of transport in all modes of transport. The improvement of the Gabrovo-Shipka Corridor would immediately reduce accident rates within the area.

Extend our transport and infrastructure policy to our immediate neighbours, including in the preparation of mobility continuity plans, to deliver closer market integration. The Gabrovo-Shipka Corridor acts as a key road connection between the EU and Greece.

2.4 National Policy

2.4.1 The National Strategic Reference Framework 2007-2013

This document forms the primary policy basis for Bulgaria covering the short and medium term period from 2007 to 2013. The National Strategic Reference Framework for Bulgaria is a major source of the principles used in the appraisal.

The framework sets out the link between a well developed and high quality transport network and the continued development and growth of the Bulgarian economy focusing on the importance of international trade to a small economy, especially where trade is with its EU partners.

The impact of poor transport on internal economic activity is demonstrated in relation to the faster developing large urban areas on one hand and the isolated small settlements with a potential for growth on the other. The key objectives from the framework are:

- Development of the competitiveness of the Bulgarian economy;
- Development of human resources and improvement of the social infrastructure;
- Improvement and development of basic infrastructure;
- Sustainable and balanced regional development.

2.4.2 The National Strategy for the Integrated Development of the Infrastructure of Bulgaria and Action Plan for the Period 2006-2015

The National Strategy was published in May 2006. It identifies the requirements for the delivery of all infrastructure within the country, not just transport, and hence provides the balanced view that is required when there is competition for financial resources within Bulgaria.

The framework demonstrates that the desire of the Bulgarian Government is to first analyse and assess the condition of the existing transport infrastructure, and then to use this to identify the main priorities in its development, maintenance and modernisation. The final stage is to specify the most important infrastructure projects with supporting funding and implementation plans.

The National Strategy defines eight major overarching **objectives** for transport:

- Build and develop the key transport infrastructure connections of national, cross-border and European importance and to improve the interoperability of the main railway lines;
- Develop the national road infrastructure and to integrate it into that of the EU Member States;
- Develop and improve the road network and to adjust it to the European norms and standards;
- Optimise the capacity and efficiency of the existing and new infrastructure;
- Modernise the infrastructure of the River Danube and sea waterways;
- Improve the conditions for navigation and promotion of intermodal transport;
- Develop and modernise airports and to adjust them to the requirements of the European Union in the field of the protection of the environment; and
- Promote public-private partnerships.

The National Strategy also identifies eight main national **priorities** for transport:

- Effective maintenance and modernisation of the transport infrastructure;
- Transparent and harmonised conditions for competitiveness and liberalisation of the transport market;
- Integration of the Bulgarian transport system into the EU transport system;
- Ensure adequate financing for the development and functioning of the transport sector;
- Limitation of the environmental and health impacts of transport;
- Development of intermodal transport;
- Adequate, qualitative and quantitative satisfaction of the transport needs; and
- Sustainable development of the public transport system.

2.4.3 Project Objectives

The main objectives for the completion of the Gabrovo – Shipka highway project are:

- Improvement of the performance of a national level and Trans-European road network by increasing travel speeds and reducing the travel time and operating costs.
- To decrease the number of accidents as a result of decreased accident rates along the bypass.
- Eliminating capacity constraints. The truer alignments of the improvement will increase flow, resulting in an increased capacity.
- Accommodation of the forecasted increase in passengers and freight demand, both international and local, due to the development of the area and the national economy.
- Reduction of the exposure of people living in Gabrovo to air pollution, noise and traffic accidents.

The benefits achieved from the construction of the project will be assessed in relation to the following criteria:

Project contribution to foreseeable problems and objectives

Traffic Accidents

At-grade intersections and over-taking on a single carriageway road are primary reasons for traffic accidents. The new bypass and tunnel is expected to result in a reduction in accident rates by means of eliminating the dangerous locations of the existing route, such as the Shipka pass, creating homogenous traffic conditions (i.e. a route with continuous standards), introducing at-grade junctions and providing better design conditions. This will play a key role in the helping to reduce the number of injuries and fatalities on the highway network.

Improve Connectivity and Journey Times

The construction of the Gabrovo bypass and Shipka tunnel will enable traffic to travel along the corridor avoiding the sections of the route through Gabrovo town centre and over the Shipka Pass, which reduce speeds and increase journey times. The average traffic speeds along the existing I-5, through Gabrovo town centre ranges from 40 – 45 km/h. The existing I-5 travels through the centre of Gabrovo, so experiences delays due to crossings and speed restrictions. The sign-posted route via Gabrovo to the Shipka Pass, on the IV-5522, has slightly quicker journey speeds of approximately 50km/h. However, this route is hilly in the terrain can result in lower speeds for HGVs. The I-5, south of Gabrovo, has steep gradients and a challenging alignment, with average speeds of approximately 52km/h. In addition, the Pass is closed to vehicles during the year due poor weather and unsafe travel conditions.

Considering that the design speed of the proposed new bypass and tunnel section is 80 km/h, with grade separated intersections allowing for uninterrupted traffic flow, the average traffic speed is expected to increase. The transport model forecasts traffic speeds along the new bypass of between 70 and 78 km/h. This will lead to a significant reduction in the travel time across Bulgaria, with a year round North – South connection over the Shipka Pass. Journey time will improve within the town centre, as traffic volumes are reduced, thus easing congestion as a result of providing an improved alternative route.

2.4.4 The Bulgarian General Transport Master Plan

The Bulgarian General Transport Master Plan (BGTMP) was concluded in 2010 and has been approved by the Bulgarian Government. The main objective of the General Transport Master Plan was:

"the establishment of a strategic and coherent base of technical data, transport models and multimodal technical studies for project identification for long and medium term investment programming in the transport sector in Bulgaria. These technical studies should possess a high degree of consistency, through the appropriate elaboration of a transport master plan".

The primary goals of the BGTMP were to:

- Ensure the mobility of persons and goods under the best possible social and safety conditions, while supporting the achievement of the Community's objectives, particularly with regard to competition and environment, and contribute to strengthening of economic and social cohesion;
- Ensure the planning of high-quality infrastructure on acceptable economic terms;
- Include all modes of transport, taking into account their relative advantages;
- Allow the optimal usage of existing infrastructure capacity;
- Encourage operational harmonisation and intermodality between different modes of transport;
- Be feasible on a macro-economic level; and
- Contribute to the implementation of transport activities conforming to environmental requirements.

2.5 Operational Programme for Transport 2007 – 2013

The Operational Programme for Transport is one of seven operational programmes for Bulgaria, which are financed by the Structural and Cohesion Funds of the EU. It presents an ambitious strategy for investment in Bulgaria's transport infrastructure, the primary goal of which is the development of railway, road and water infrastructure, as well as the stimulation of development of mixed transport. The strategy is in line with the National Strategic Reference Framework for Bulgaria, which includes transport policy of the EU and established requirements for development of the Trans European Transport Network to achieve stability of the Bulgarian transport system, both nationally and internationally.

The operational programme is focused on several strategic priorities which contribute to the integration of the national transport network in the EU. Achieving those priorities will make a fundamental contribution towards stable and balanced economic growth in the country in the short and long term. The general goal of the OPT is to develop a stable transport system, with the specific goals of:

- Integration of the national transport system in the transport network of the EU; and
- Achieving a balance between different forms of transport.

The OPT consists of five priority axes:

- Priority Axis I – Development of railway infrastructure along the major national and Pan European transport axes;
- Priority Axis II – Development of road infrastructure along the major national and Pan European transport axes;
- Priority Axis III – Improvement of intermodality for passengers and freight;
- Priority Axis IV – Improvement of the maritime and inland water navigation; and
- Priority Axis V – Technical Assistance.

The road infrastructure is classed as Priority Axis II, whose objective is to construct and develop key road infrastructure connections that are on a national trans-border and hold European importance, as well as the improvement of the operative compatibility of the main national road arteries. Key for economic growth in Bulgaria is the opportunity to maximise its geo-strategic position as a transport bridge between western and central Europe, the Middle East and Asia, which this priority seeks to achieve.

The main goals for this axis to achieve the objective are:

- Construction of new and rehabilitation and modernization of the existing motorways with national and European importance across the Trans-European transport network. The Gabrovo-Shipka route forms part of PETC IX running north to south through Bulgaria ;
- Construction of new and rehabilitation and modernization of existing 1st class roads with national and European importance for the Trans-European transport network; and
- Construction, rehabilitation and modernization of road sections that connect the main road network of Bulgaria with these of the neighbouring countries; the Gabrovo-Shipka route forms part of the TEN-T network, directly linking Bulgaria with Romania in the north and Greece/Turkey in the south.

According to the priorities set in OP Transport, Priority Axis 2, as of 2013 the following indicators for impact are calculated and shown in **Table 2.1**

Table 2.1 OP Transport Priority Axis 2 Indicators

<table>
<tr><th>Impact Indicator</th><th>Base</th><th>Target (2013)</th></tr>
<tr><td>Time savings, thousand, hours/day</td><td>0</td><td>1336.4</td></tr>
<tr><td>Time savings, million EUR/day</td><td>0</td><td>1.23</td></tr>
<tr><td>Operating cost (VOC) savings – light vehicles, 1000km</td><td>0</td><td>41.62</td></tr>
<tr><td>Operating cost (VOC) savings – heavy vehicles, 1000km</td><td>254.99</td><td>98.39</td></tr>
<tr><td>Reduction of fatalities on road</td><td>1171 fatalities
-</td><td>585 fatalities
Reduction of 586 fatalities</td></tr>
<tr><td colspan="3">According to the priorities set in the OPT, Priority Axis 2 as of 2013 the following indicator for output relevant to the project is calculated:</td></tr>
<tr><th>Output Indicator</th><th>Base</th><th>Target</th></tr>
<tr><td>Built bypasses, km</td><td>0</td><td>42.3</td></tr>
</table>

2.6 Summary

The Gabrovo – Shipka route forms part of Pan European Corridor IX (PETC); a key link between Bulgaria's northern and southern borders with Romania and Greece and of economic significance to the European Union.

The Gabrovo-Shipka Highway project falls under a national priority for Bulgaria's Transport Sector. It meets national objectives as set out in the National Strategic Reference Framework 2007-2013, and the falls under Priority 2 of the Transport Sector's Roads and Motorways priorities, detailed in the National Strategy for the Integrated Development of the Infrastructure of Bulgaria and Action Plan for the Period 2006-2015. It was also subjected to comparative evaluation alongside many other projects as part of the Bulgarian General Transport Master Plan, and emerged from that evaluation process as a priority project. The project also falls under the Operational Programme for Transport 2007 – 2013 'Alternative Projects', wherein a budget is set aside for the construction of bypasses along the TEN-T network within the country.

3 Summary of Feasibility Study and Preferred Option Identification

3.1 Introduction

This chapter provides the background to the Gabrovo-Shipka Highway Project, setting out the scheme details and summarising the content of the existing feasibility study. From the information contained within the feasibility study it is then possible to identify the Project Options (comprising the variants described in **Section 3.2**) for which the Cost Benefit Analysis (CBA) will be undertaken.

For the purposes of this report, Project Options are grouped into three separate scenarios; the Gabrovo-Shipka bypass and tunnel, the Gabrovo Bypass only and the Tunnel only. The Preferred Option for each scenario will then be identified through the CBA of all of the options.

The scheme options were identified with the aid of a previously completed Feasibility Study of the project area.

3.2 Feasibility Study

The Feasibility Study used for the CBA of the Gabrovo-Shipka Highway Project was the "*Road III-5004 Gabrovo Bypass From km 0+000 to km 31+000" -* Intermediate Report, completed in 2008 by the Bulgarian contractor PATPROJECT ltd, based in Sofia. The study was carried out on the basis of separating the project corridor into five stages and identifying the possible design variants associated with these. The five stages identified are as follows:

- **First Stage**: from road I-5 to the interchange with II-44. The construction of the bypass started in 1977, and in 1983 the First Stage was completed and is currently in use today;
- **Second Stage**: from the interchange with road I-44 to Chehlevtzi Village (III-4404). Construction of the Second Stage ceased in 1993 for unknown reasons and is currently incomplete, lacking proper connections to the I-44 and III-4404;
- **Third Stage**: a new alignment from Chehlevtzi Village (road I-44) to Dyado Dyanko (road III-5006);
- **Fourth Stage:** a new alignment from road I-5006 to the 'Radetzky Quarter'. The Fourth Stage also includes a stage connection of 3.100km between Radetzky and the I-5 at km 160.000; and
- **Fifth Stage**: a new alignment from the stage connection to road I-5 in the vicinity of Shipka. This alignment includes the Shipka Tunnel.

The above mentioned design involves the rehabilitation of the First Stage and the reconstruction of the Second Stage. Stages Three, Four and Five require new alignments and, in the case of the latter, the construction of a tunnel under the Shipka Peak. For the construction of Stages Three, Four and Five the Feasibility Study identified a number of scheme variants which differ in alignment, length and highway design. The scheme variants are as follows;

Stage Three – Red Variant

This option crosses the Sinkevitza river gully and road III-404 Gabrovo-Gorna Rossitza with a 600m bridge. The alignment crosses road III-5006 (interchange), and then the Panicharka River with a 200m bridge.

The total length of the Red Variant is 5.518km and the design speed is 80kph. The Feasibility Study indicated that an additional lane (3m width) is needed in each direction for slow moving vehicles.

Stage Three – Blue Variant

This option crosses the Sinkevitza river gully and road III-404 Gabrovo-Gorna Rossitza with a 620m bridge. The alignment crosses the Bakoyski hill north to south with a 600m tunnel, then over the Dyado Dyanko quarter. The alignment crosses road III-5006 (interchange) and then the Panicharka River with a 200m bridge.

The total length of the Blue Variant is 5.071km and the design speed is 80kph. The Feasibility Study indicated that no additional lanes for slow moving vehicles were required.

Stage Four

This alignment is from Gabrovo's Dyado Dyanko quarter (road III-5006) to Radetzky quarter (a road junction for a stage connection). Depending on the option alignment for Stage 5, the length of this section varies for the Blue, Red and Violet alignments as 4.130km, 4.390km and 4.430km respectively.

Stage Five – Red Variant

This option passes on the eastern bank of the Kozyata River and, after crossing, passes through the Stara Planina Mountain in the north-south direction with a 3,180m tunnel. After the tunnel, the alignment crosses the Chernata River and enters another tunnel, 100m in length, on the eastern slope of the gully. The alignment then joins road I-5 and involves a reconstruction of the route before the junction with the Shipka Pass.

The total length of the Red Variant is 10.973km and the design speed is 80kph. The Feasibility Study indicated that an additional traffic lane for slow moving vehicles is required in both directions, starting at the beginning of the Fourth Stage just before the Shipka Tunnel. The crossing with road I-5 is via a three-leg junction.

Stage Five – Blue Variant

This option crosses the Kozyata River and follows the western bank before crossing the Stara Planina Mountain in the north-south direction with a 3,180m tunnel. After the tunnel, the alignment crosses the Byalata River then runs along the western bank of the Krivata River and joins road I-5.

The total length of the Blue Variant is 11.000km and the design speed is 80kph. The Feasibility Study indicated that no additional lanes for slow moving traffic are required.

Stage Five – **Violet Variant (long tunnel)**

This option begins at the end of stage four. After the crossing of the gully over the Malusha hydro-electric power station the alignment requires a tunnel, 7,050m in length, under the Stara Planina Mountain. The exit of the tunnel is located in the same place as the Red and Blue variants.

The scheme variants for the Gabrovo – Shipka Highway Project are summarised in **Table 3.1.**

Table 3.1 Scheme Variant Overview

Stage	Length (km)	Location	Design
1	7.800	Beginning of bypass to Junction II-44	Rehabilitation
2	3.880	Junction II-44 to Chehlevtzi village, III-4404	Reconstruction
3 (Blue)	5.071	III-4404 to Dyado Dyanko Interchange	New Alignment
3 (Red)	5.518	III-4404 to Dyado Dyanko Interchange	New Alignment
4a	3.870	Dyado Dyanko Interchange to Radetzky	New Alignment
4b (Blue)	0.260	Radetzky to Junction with stage connection (I-5)	New Alignment
4b (Red)	0.520	Radetzky to Junction with stage connection (I-5)	New Alignment
4b (Violet)	0.560	Radetzky to Junction with stage connection (I-5)	New Alignment
4c	3.130	Stage connection with I-5	New Alignment
5 (Blue)	10.763	Junction with stage connection & Shipka Tunnel	New Alignment
5 (Red)	10.273	Junction with stage connection & Shipka Tunnel	New Alignment
5 (Violet)	10.158	Junction with stage connection & Shipka Tunnel	New Alignment

3.3 Project Options

By combining the different variants for Stages 3, 4 and 5 (obtained from the Feasibility Study), the Project Options are created. The different combinations of variants result in a total of 15 Project Options. These are labelled alphabetically, from Option A to Option O, and are listed in **Table 3.2**, with the individual and cumulative lengths shown in **Table 3.3**.

The Project Options are then grouped into three scenarios for the CBA; the Gabrovo-Shipka bypass and tunnel, the Bypass only and the Tunnel only. For clarity, it is assumed that:

- Stages 1 to 5 comprise the Bypass and Tunnel;
- Stages 1 to 4 comprise the Gabrovo Bypass (connecting to the I-5 north and south of the town); and
- Stage 5 is the Shipka Tunnel.

Figure 3.1 illustrates the indicative alignment of all of the Project Options for the Gabrovo-Shipka Highway Project. It should be noted that the variants for Stage 4 do not change in alignment, only in length. Therefore, the plan only shows the Violet variant of Stage 4, as both the Red and Blue variants follow the same alignment.

Figures 3.2 to 3.16 illustrate Options A to O.

Figure 3.1 All Project Options

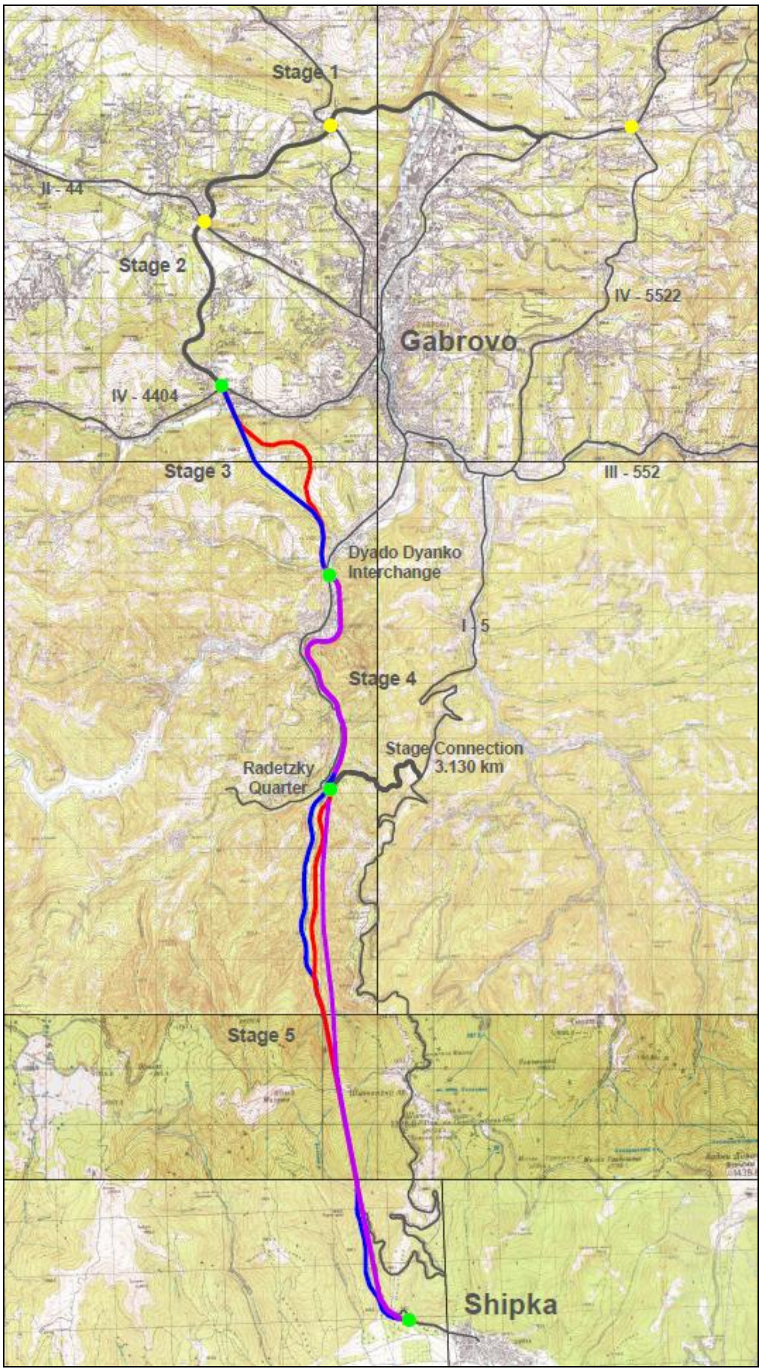


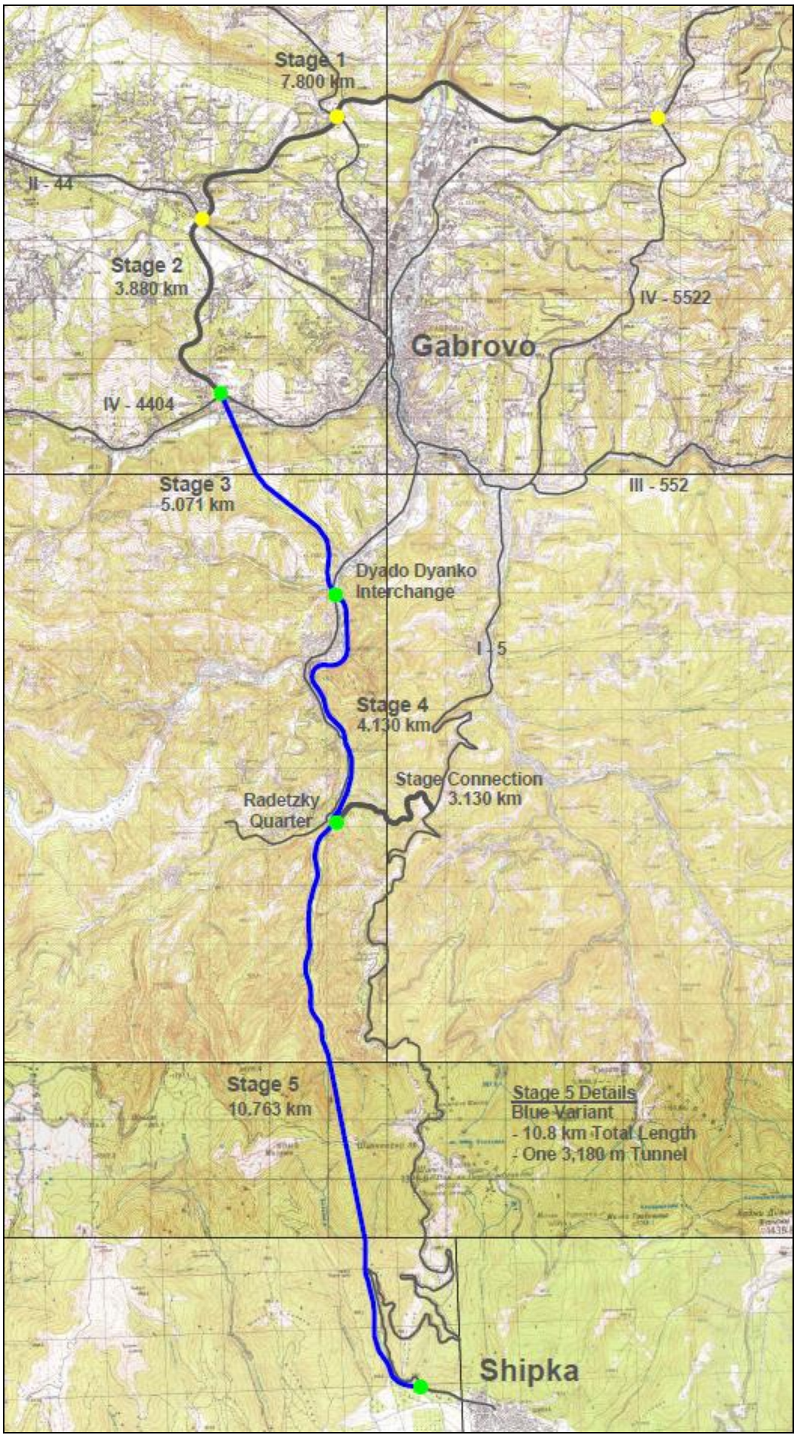
Table 3.2 Project Option Breakdown by Variant

Section	Stage						
	Option	1	2	3	4	Stage Connector	5
Bypass & Tunnel	A	✓	✓	Blue	Blue	✓	Blue
	B	✓	✓	Blue	Red	✓	Red
	C	✓	✓	Blue	Violet	✓	Violet
	D	✓	✓	Red	Blue	✓	Blue
	E	✓	✓	Red	Red	✓	Red
	F	✓	✓	Red	Violet	✓	Violet
Bypass Only	G	✓	✓	Blue	Blue	✓	
	H	✓	✓	Blue	Red	✓	
	I	✓	✓	Blue	Violet	✓	
	J	✓	✓	Red	Blue	✓	
	K	✓	✓	Red	Red	✓	
	L	✓	✓	Red	Violet	✓	
Tunnel Only	M					✓	Blue
	N					✓	Red
	O					✓	Violet

Table 3.3 Project Option Breakdown by Variant and Length

Section	Option	Length (km)						Total (km) excluding connector
		Stage 1	Stage 2	Stage 3	Stage 4	Stage Connector	Stage 5	
Bypass & Tunnel	A	7.800	3.880	5.071	4.130	3.130	10.763	**31.644**
	B	7.800	3.880	5.071	4.390	3.130	10.273	**31.414**
	C	7.800	3.880	5.071	4.430	3.130	10.158	**31.339**
	D	7.800	3.880	5.518	4.130	3.130	10.763	**32.091**
	E	7.800	3.880	5.518	4.390	3.130	10.273	**31.861**
	F	7.800	3.880	5.518	4.430	3.130	10.158	**31.786**
Bypass Only	G	7.800	3.880	5.071	4.130	3.130		**20.881**
	H	7.800	3.880	5.071	4.390	3.130		**21.141**
	I	7.800	3.880	5.071	4.430	3.130		**21.181**
	J	7.800	3.880	5.518	4.130	3.130		**21.328**
	K	7.800	3.880	5.518	4.390	3.130		**21.588**
	L	7.800	3.880	5.518	4.430	3.130		**21.628**
Tunnel Only	M					3.130	10.763	**10.763**
	N					3.130	10.273	**10.273**
	O					3.130	10.158	**10.158**

Figure 3.2 Option A (Bypass and Tunnel)

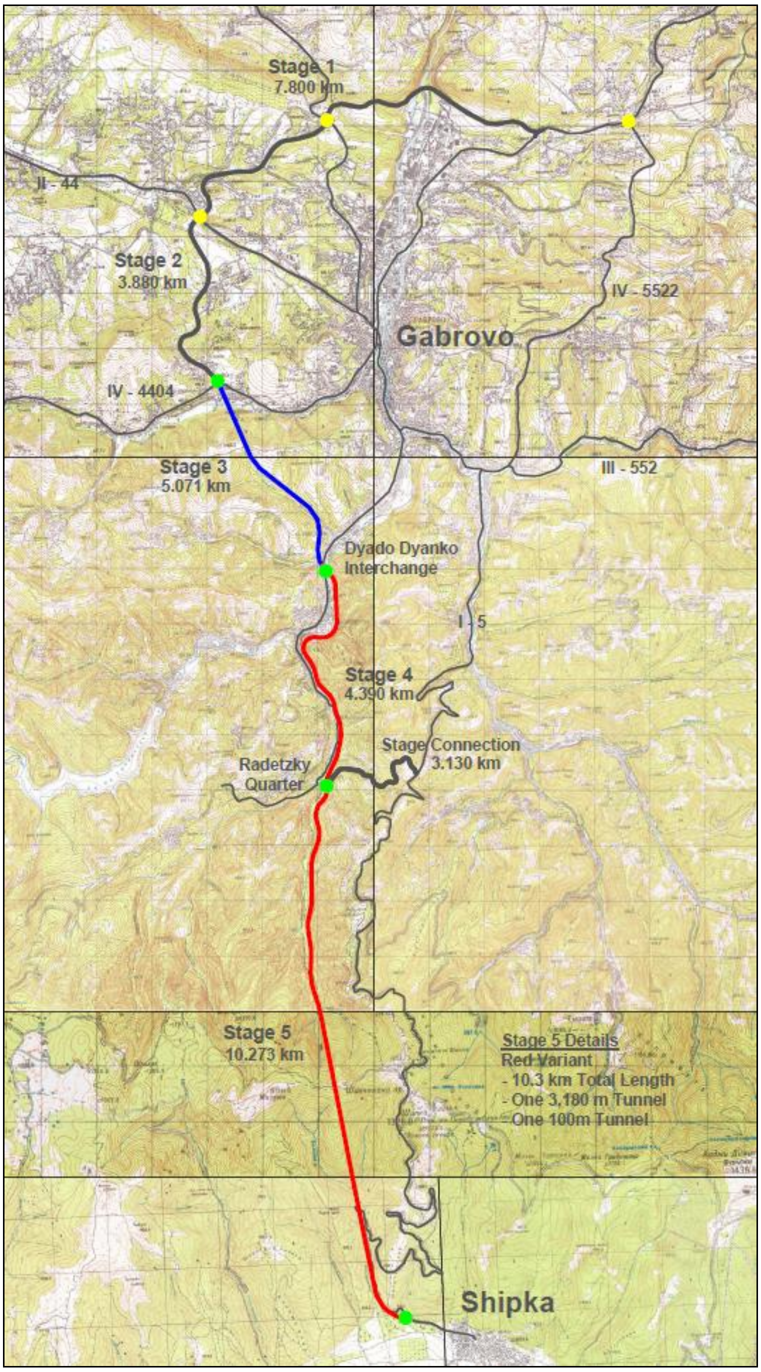


The alignment of Option A is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2 and the Blue variant of Stage 3. This variant crosses the Sinkevitza river gully and road III-404 Gabrovo-Gorna Rossitza with a 620m bridge. The alignment crosses the Bakoyski hill north to south with a 600m tunnel, then over the Dyado Dyanko quarter. The alignment crosses road III-5006 (interchange) and then the Panicharka River with a 200m bridge.

Option A then continues with the Blue variant of Stage 4 (4.130km in length) which crosses the Kozyata River and follows the western bank before crossing the Stara Planina Mountain in the north-south direction with a 3,180m tunnel. After the tunnel, the alignment crosses the Byalata River then runs along the western of the Krivata River and joins road I-5 via the stage connector.

The variants for Stages 4 and 5 are always consistent, so Option A is completed by the stage connector and the Blue variant of Stage 5 which crosses the Kozyata River and follows the western bank before crossing the Stara Planina Mountain in the north-south direction with a 3,180m tunnel. After the tunnel, the alignment crosses the Byalata River then runs along the western bank of the Krivata River and joins road I-5. The total length of Option A is 31.644km.

Figure 3.3 Option B (Bypass and Tunnel)

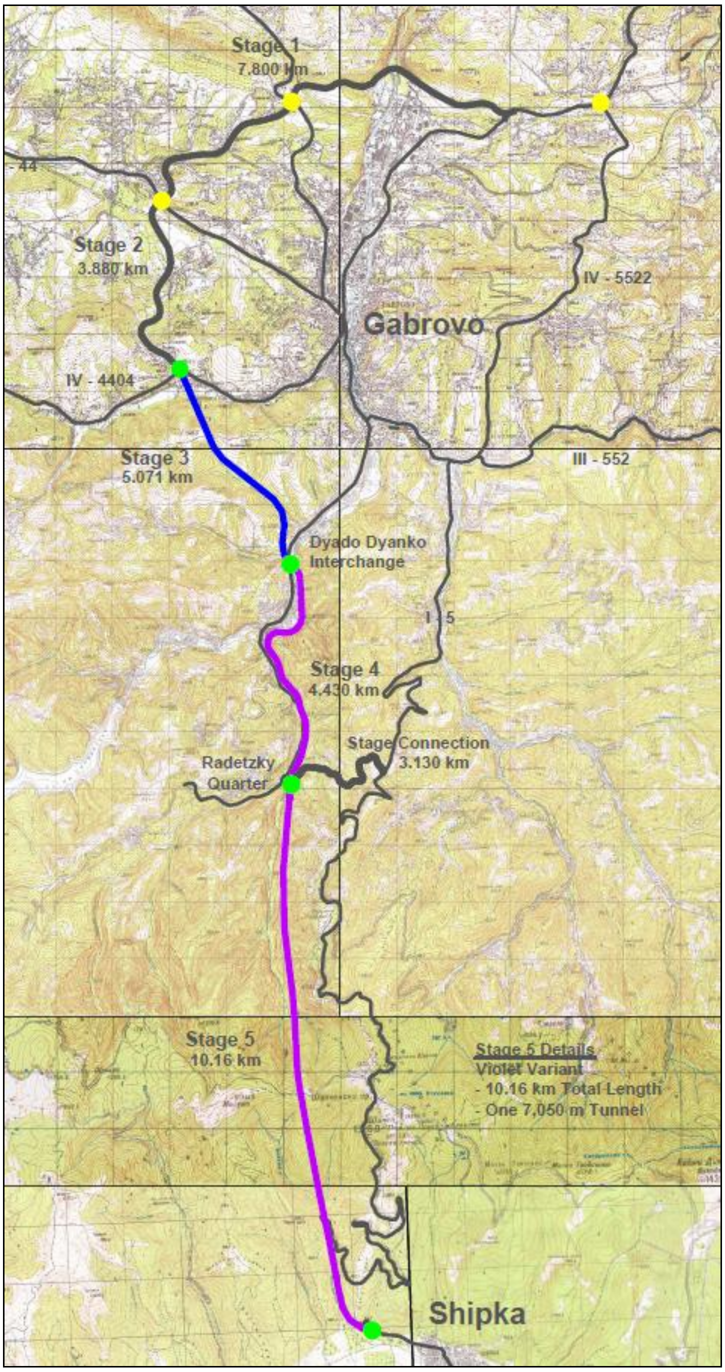


The alignment of Option B is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2 and the Blue variant of Stage 3 (as described in Option A). Option B then includes the Red variant of Stage 4 which follows the same alignment as the Blue variant, but is longer in length, at 4.390km.

After the stage connector, this option follows the Red variant of Stage 5 which passes on the eastern bank of the Kozyata River and, after crossing, passes through the Stara Planina Mountain in the north-south direction with a 3,180m tunnel. After the tunnel, the alignment crosses the Chernata River and enters another tunnel, 100m in length, on the eastern slope of the gully. The alignment then joins road I-5 and involves a reconstruction of the route before the junction with the Shipka Pass.

The total length of Option B is 31.414km.

Figure 3.4 Option C (Bypass and Tunnel)

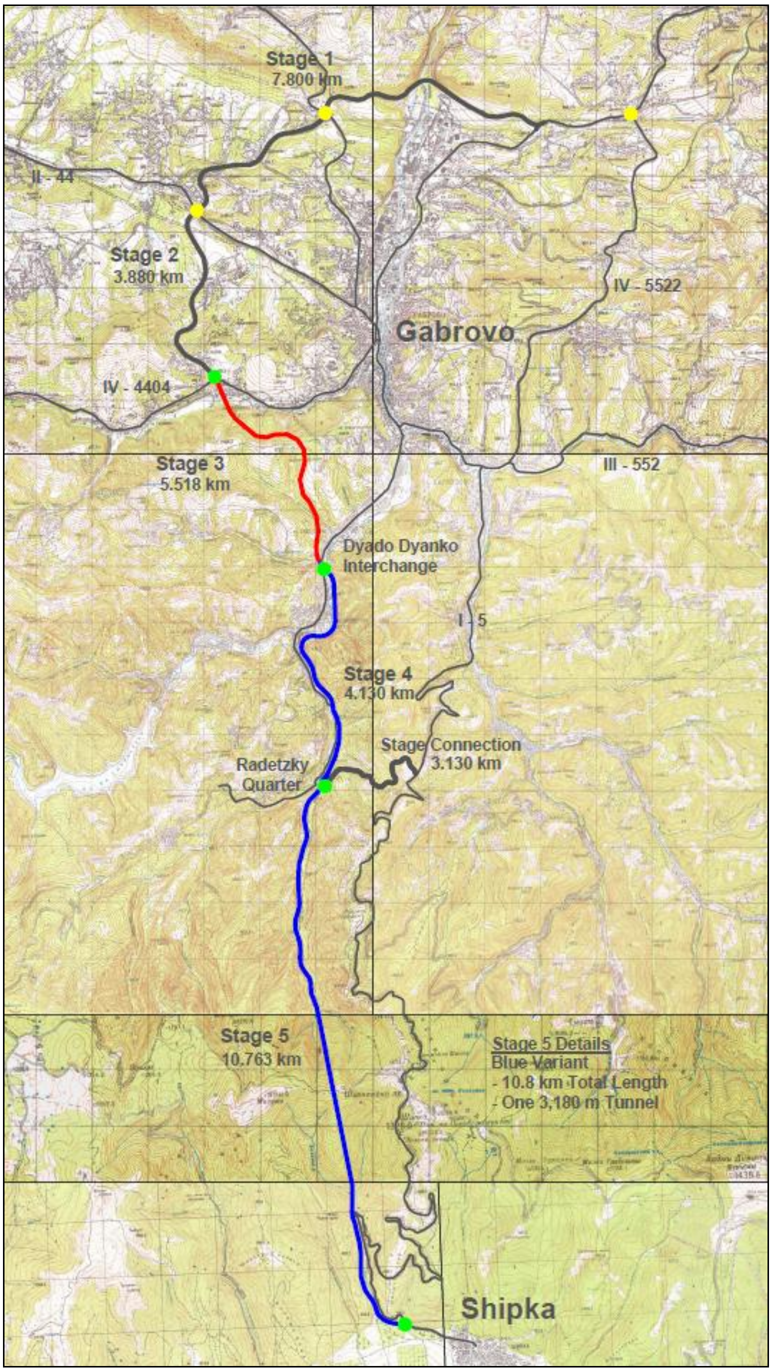


The alignment of Option C is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2 and the Blue variant of Stage 3 (as described in Options A and B). Option C then includes the Violet variant of Stage 4 which follows the same alignment as the Red and Blue variants, but is longer in length, at 4.430km.

After the stage connector, this option follows the Violet variant of Stage 5 which, after the crossing of the gully over the Malusha hydro-electric power station, requires a tunnel, 7,050m in length, under the Stara Planina Mountain. The exit of the tunnel is located in the same place as the Red and Blue variants.

The total length of Option C is 31.339km.

Figure 3.5 Option D (Bypass and Tunnel)

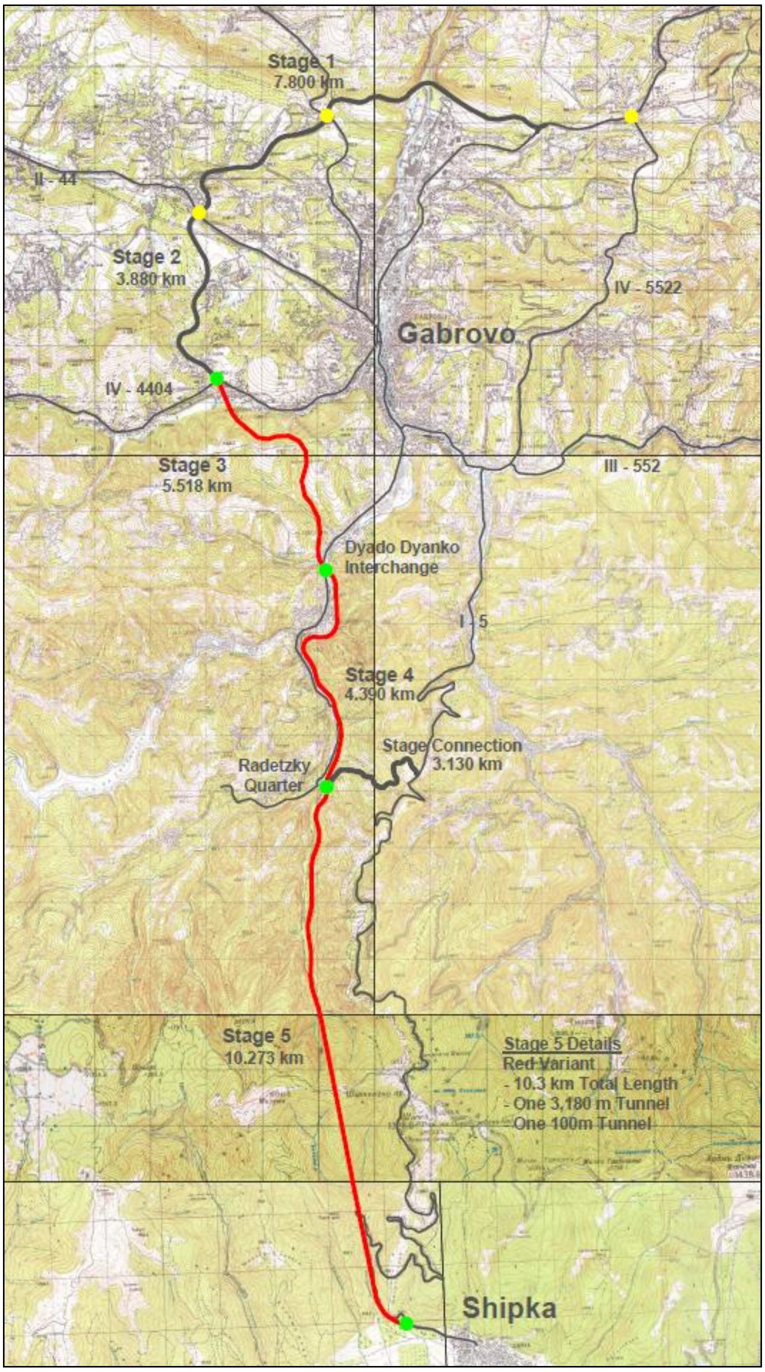


The alignment of Option D is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2 and the Red variant of Stage 3 which crosses the Sinkevitza river gully and road III-404 Gabrovo-Gorna Rossitza with a 600m bridge. The alignment crosses road III-5006 (interchange), and then the Panicharka River with a 200m bridge.

Option D then includes the Blue variant of Stage 4 and the Blue variant of Stage 5 (as described in Option A).

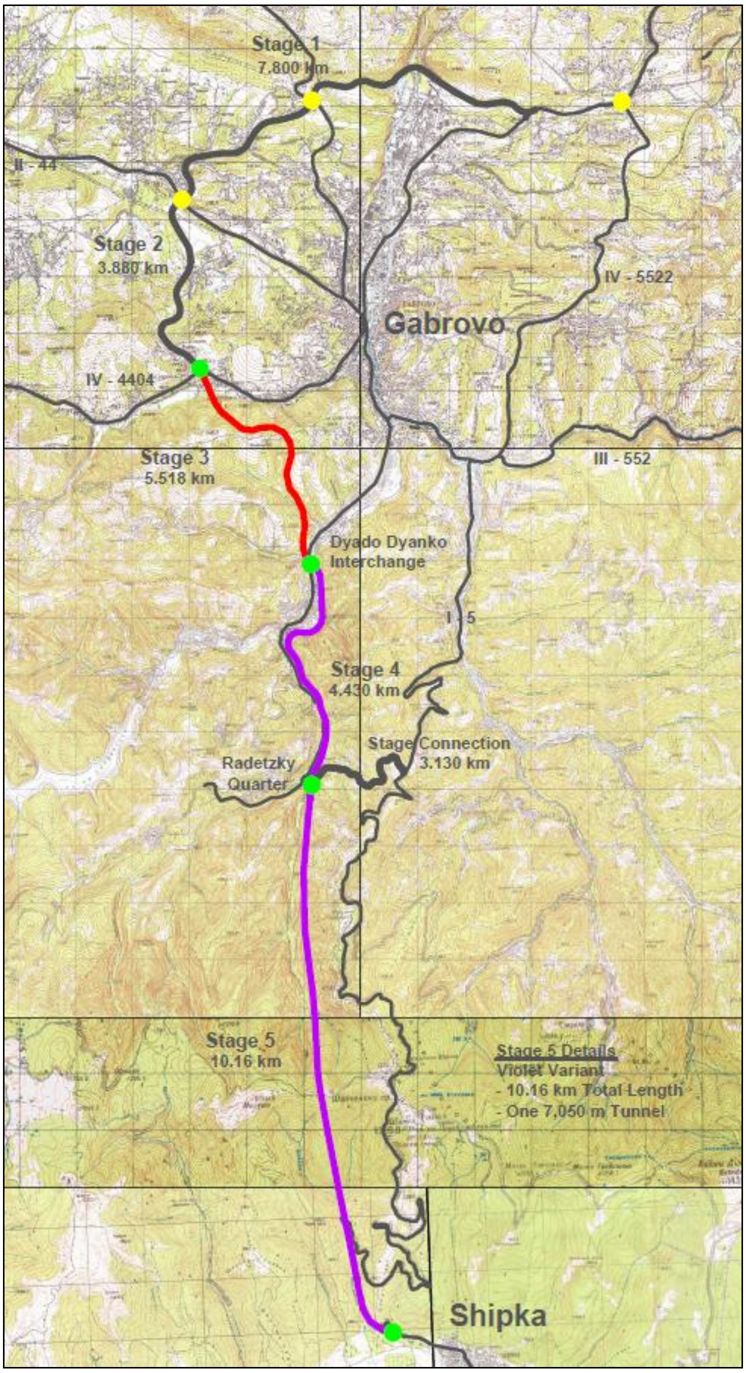
The total length of Option D is 32.091km.

Figure 3.6 Option E (Bypass and Tunnel)



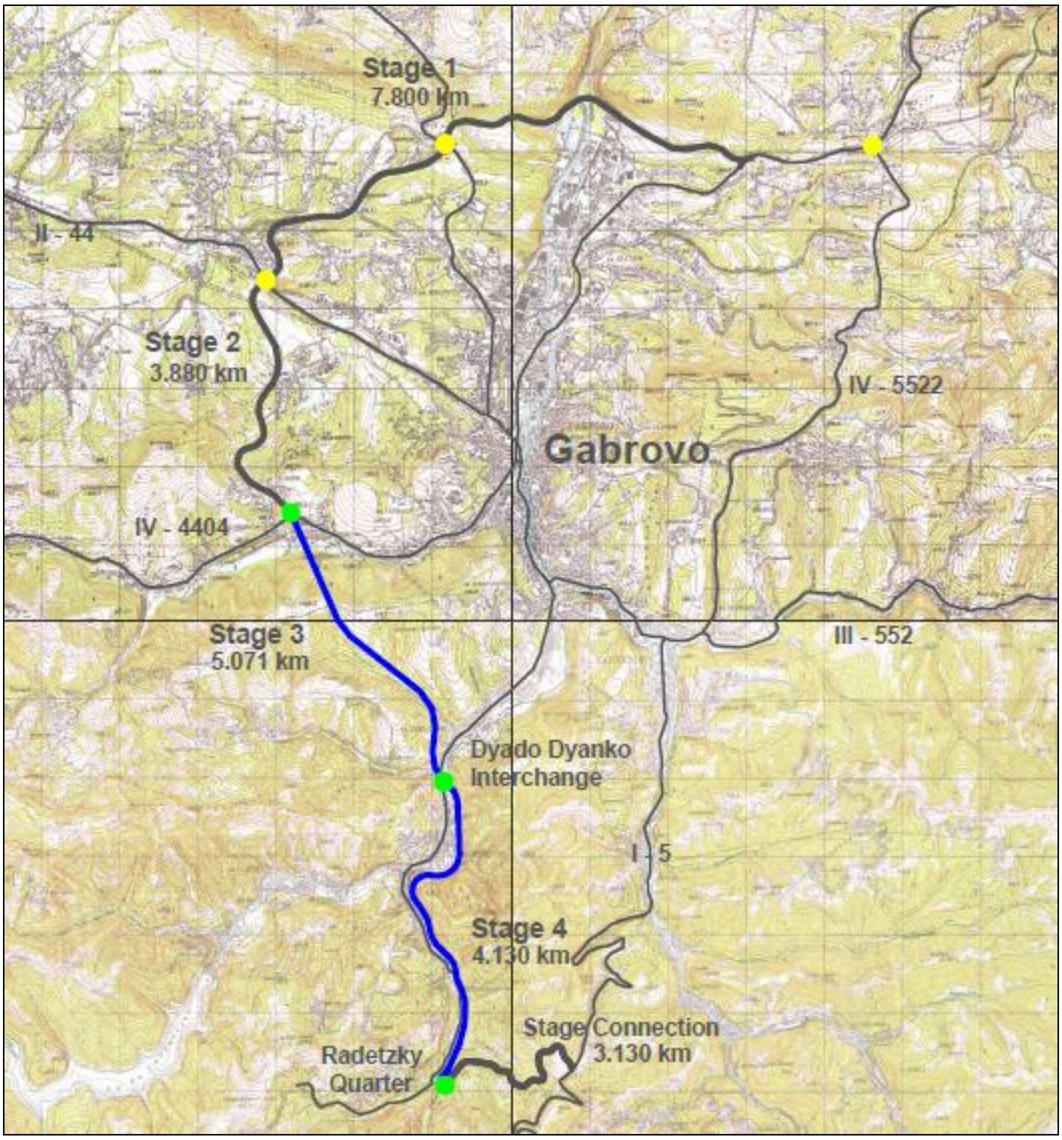
The alignment of Option E is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2 and the Red variant of Stage 3 (as described in Option D). Option E then includes the Red variant of Stage 4 and the Red variant of Stage 5 (as described in Option B). The total length of Option E is 31.861km.

Figure 3.7 Option F (Bypass and Tunnel)



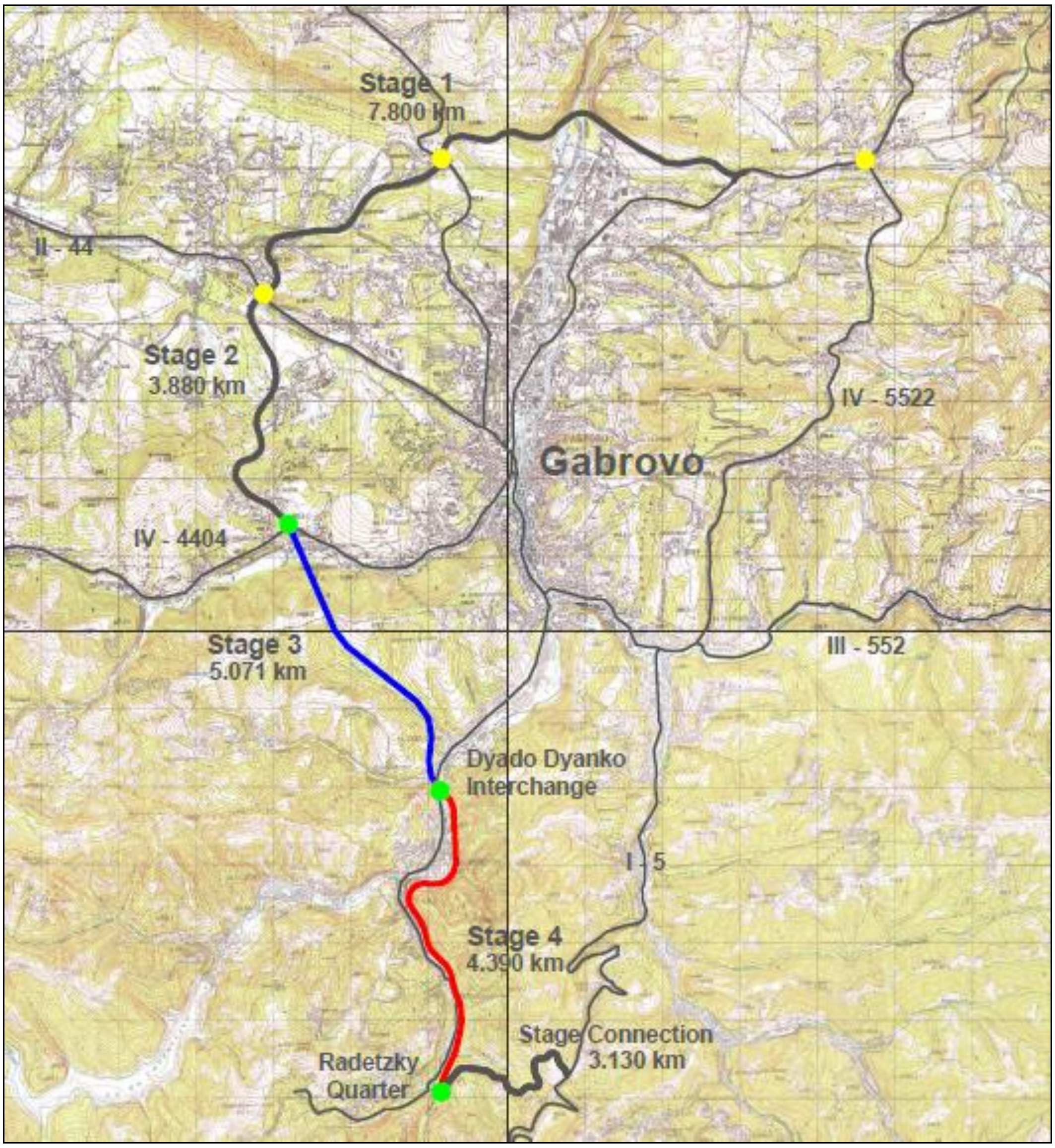
The alignment of Option F is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2 and the Red variant of Stage 3 (as in Options D and E). Option F then includes the Violet variant of Stage 4 and the Violet variant of Stage 5 (as described in Option C). The total length of Option F is 31.786km.

Figure 3.8 Option G (Bypass Only)



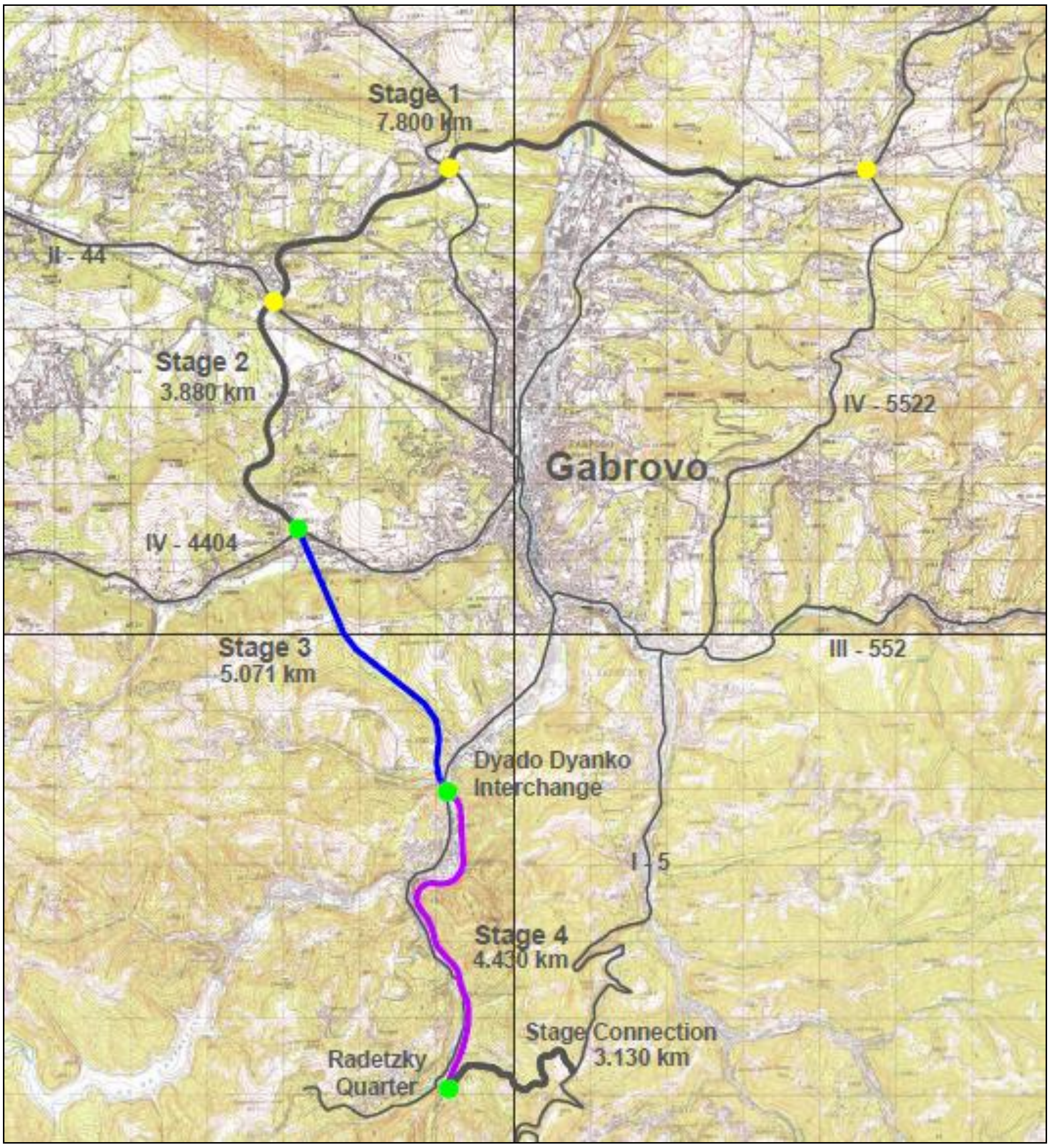
Option G is the first of the Project Options which relates to the Bypass element of the project only. The alignment is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2, the Blue variant of Stage 3 and the Blue variant of Stage 4 (as described in Option A). The stage connector then forms the final part of the bypass alignment, linking into the I-5 south of Gabrovo. The total length of Option G is 20.881km.

Figure 3.9 Option H (Bypass Only)



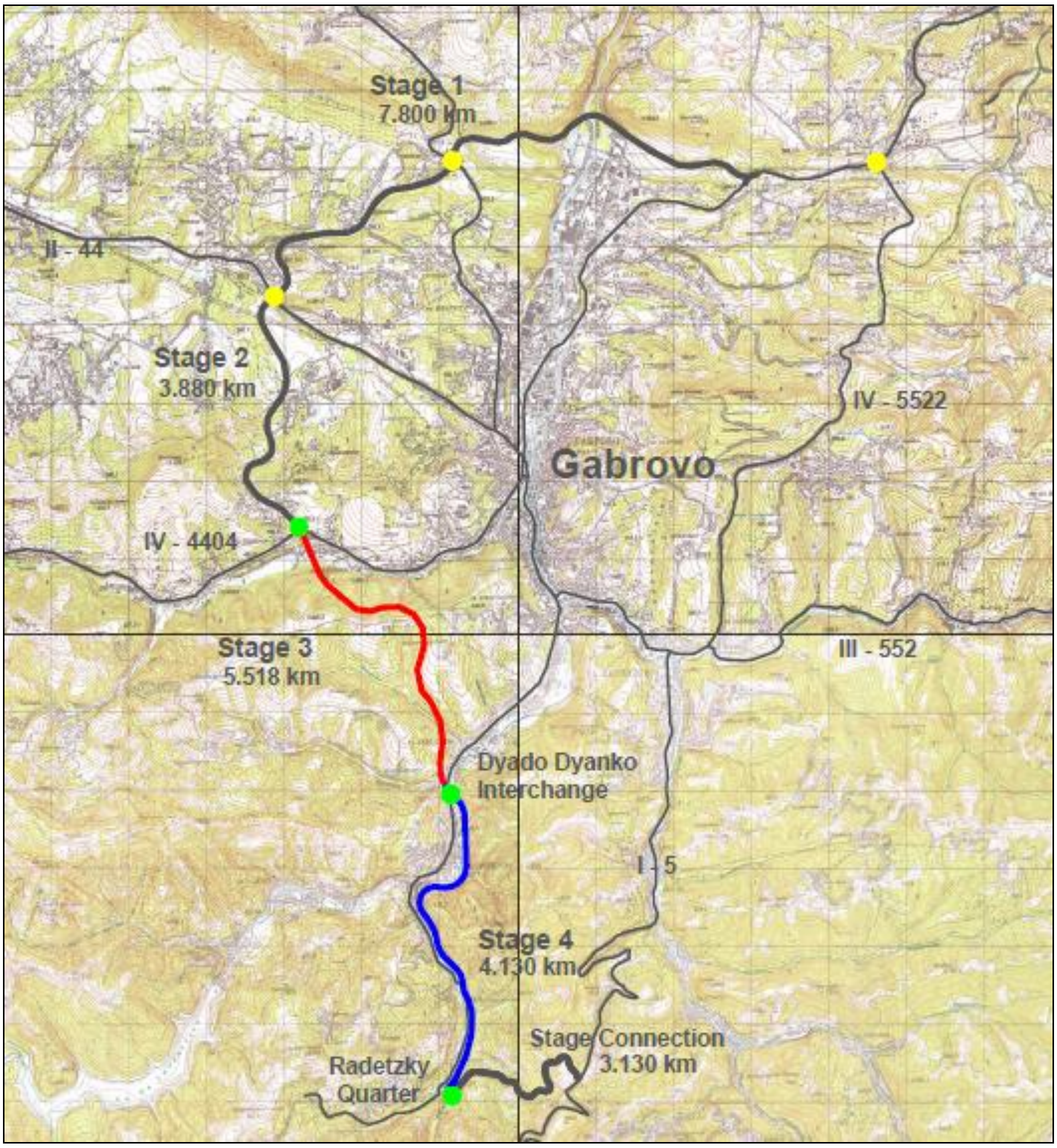
The alignment of Option H is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2, the Blue variant of Stage 3 and the Red variant of Stage 4 (as described in Option B). The stage connector then forms the final part of the bypass alignment, linking into the I-5 south of Gabrovo. The total length of Option H is 21.141km.

Figure 3.10 Option I (Bypass Only)



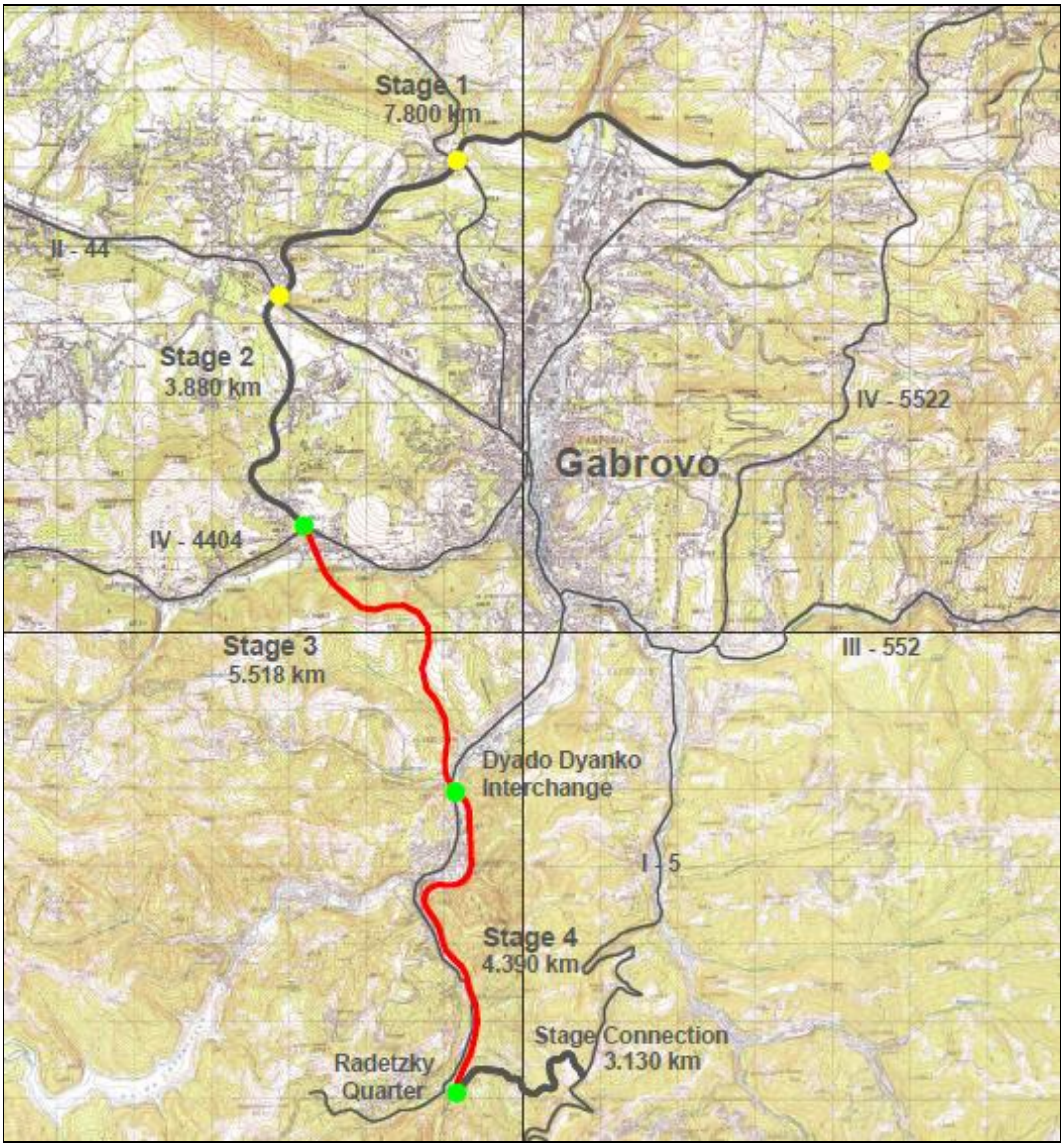
The alignment of Option I is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2, the Blue variant of Stage 3 and the Violet variant of Stage 4 (as described in Option C). The stage connector then forms the final part of the bypass alignment, linking into the I-5 south of Gabrovo. The total length of Option I is 21.181km.

Figure 3.11 Option J (Bypass Only)



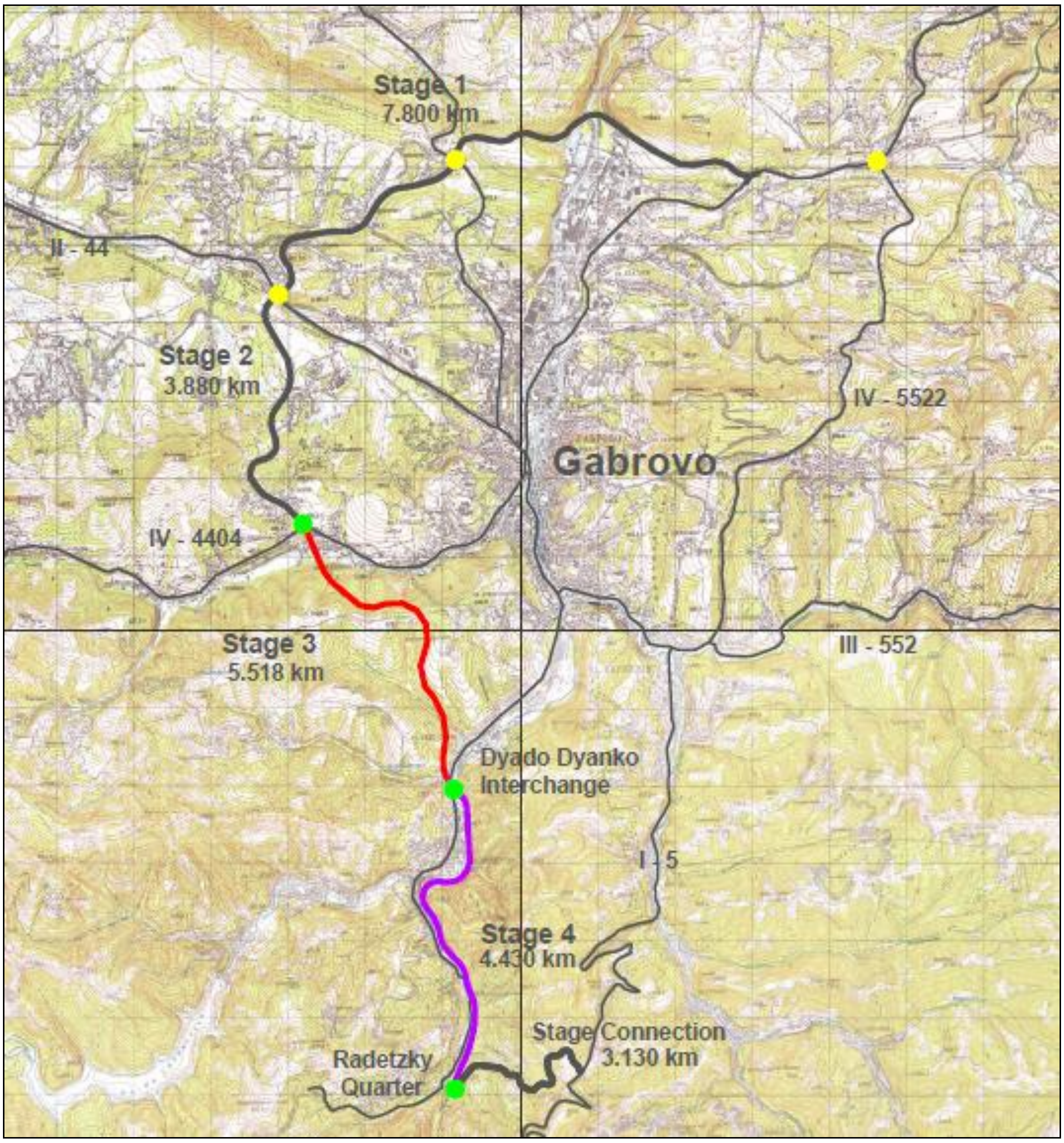
The alignment of Option J is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2, the Red variant of Stage 3 and the Blue variant of Stage 4 (as described in Option D). The stage connector then forms the final part of the bypass alignment, linking into the I-5 south of Gabrovo. The total length of Option J is 21.328km.

Figure 3.12 Option K (Bypass Only)



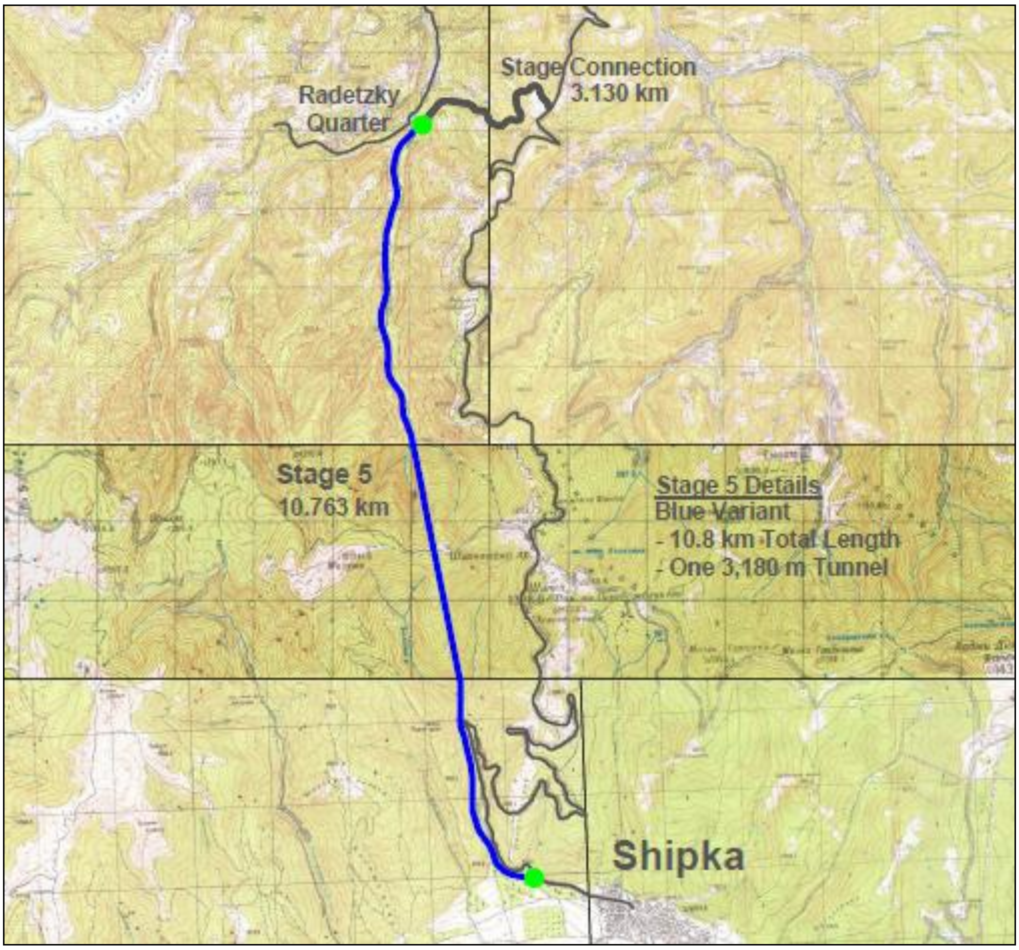
The alignment of Option K is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2, the Red variant of Stage 3 and the Red variant of Stage 4 (as described in Option E). The stage connector then forms the final part of the bypass alignment, linking into the I-5 south of Gabrovo. The total length of Option K is 21.588km.

Figure 3.13 Option L (Bypass Only)



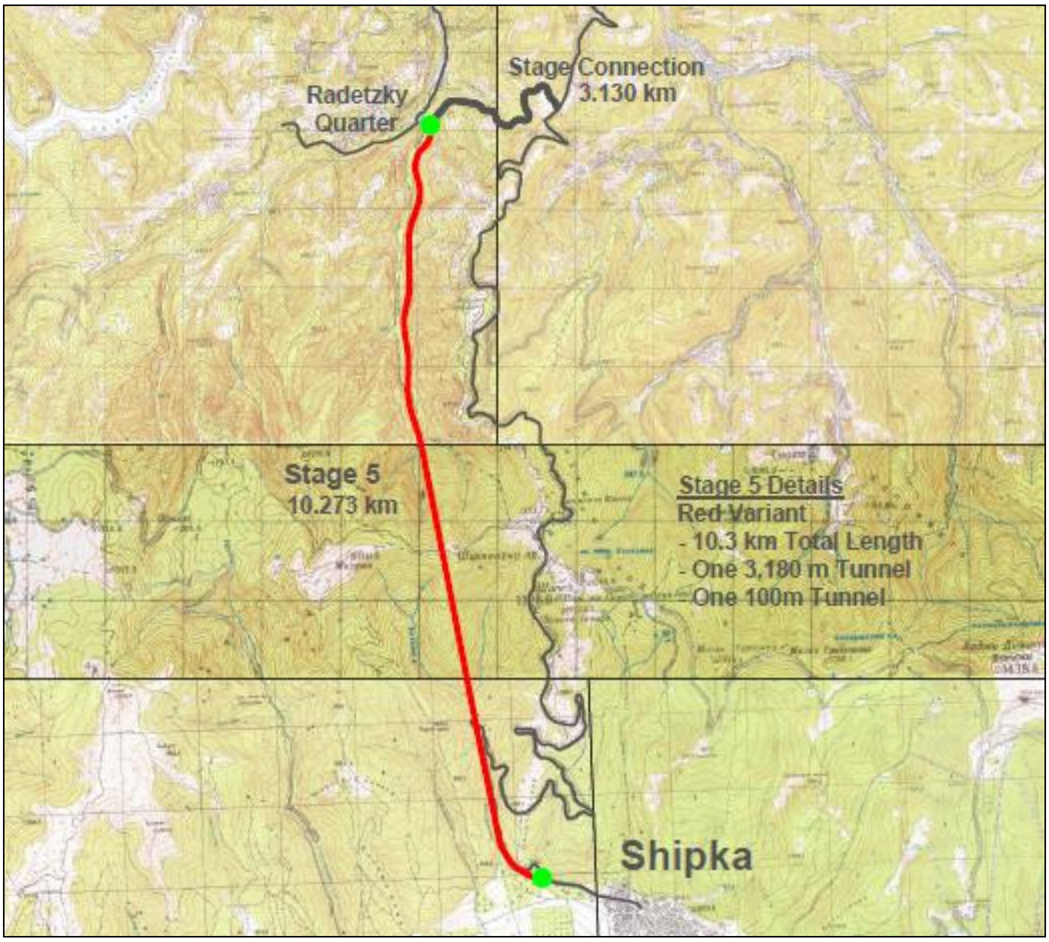
The alignment of Option L is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2, the Red variant of Stage 3 and the Violet variant of Stage 4 (as described in Option F). The stage connector then forms the final part of the bypass alignment, linking into the I-5 south of Gabrovo. The total length of Option L is 21.628km.

Figure 3.14 Option M (Tunnel Only)



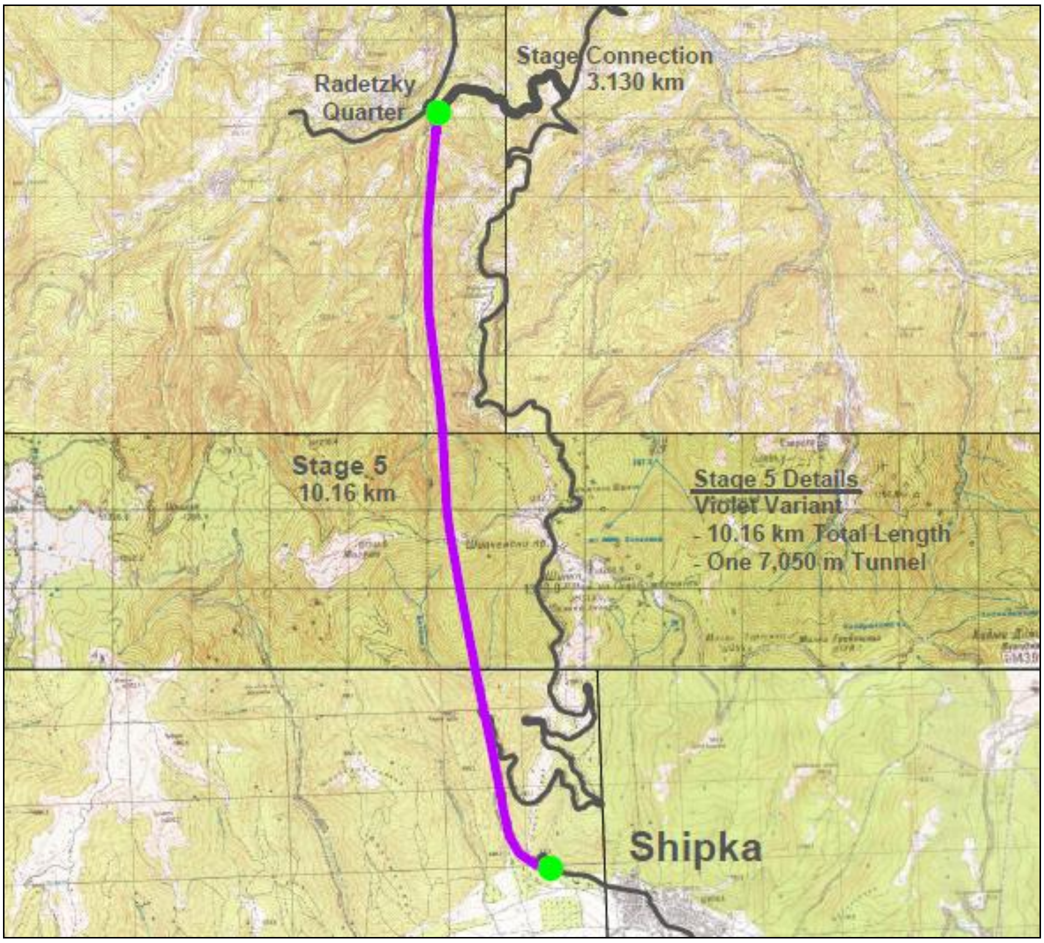
Option M is the first of the Project Options which relate to the Tunnel element of the project only. The alignment comprises the stage connector and the Blue variant of Stage 5 (as described in Options A and D) which joins the I-5 north of Shipka. The total length of Option M is 10.763km.

Figure 3.15 Option N (Tunnel Only)



The alignment of Option N comprises the stage connector and the Red variant of Stage 5 (as described in Options B and E) which joins the I-5 north of Shipka. The total length of Option N is 10.273km.

Figure 3.16 Option O (Tunnel Only)



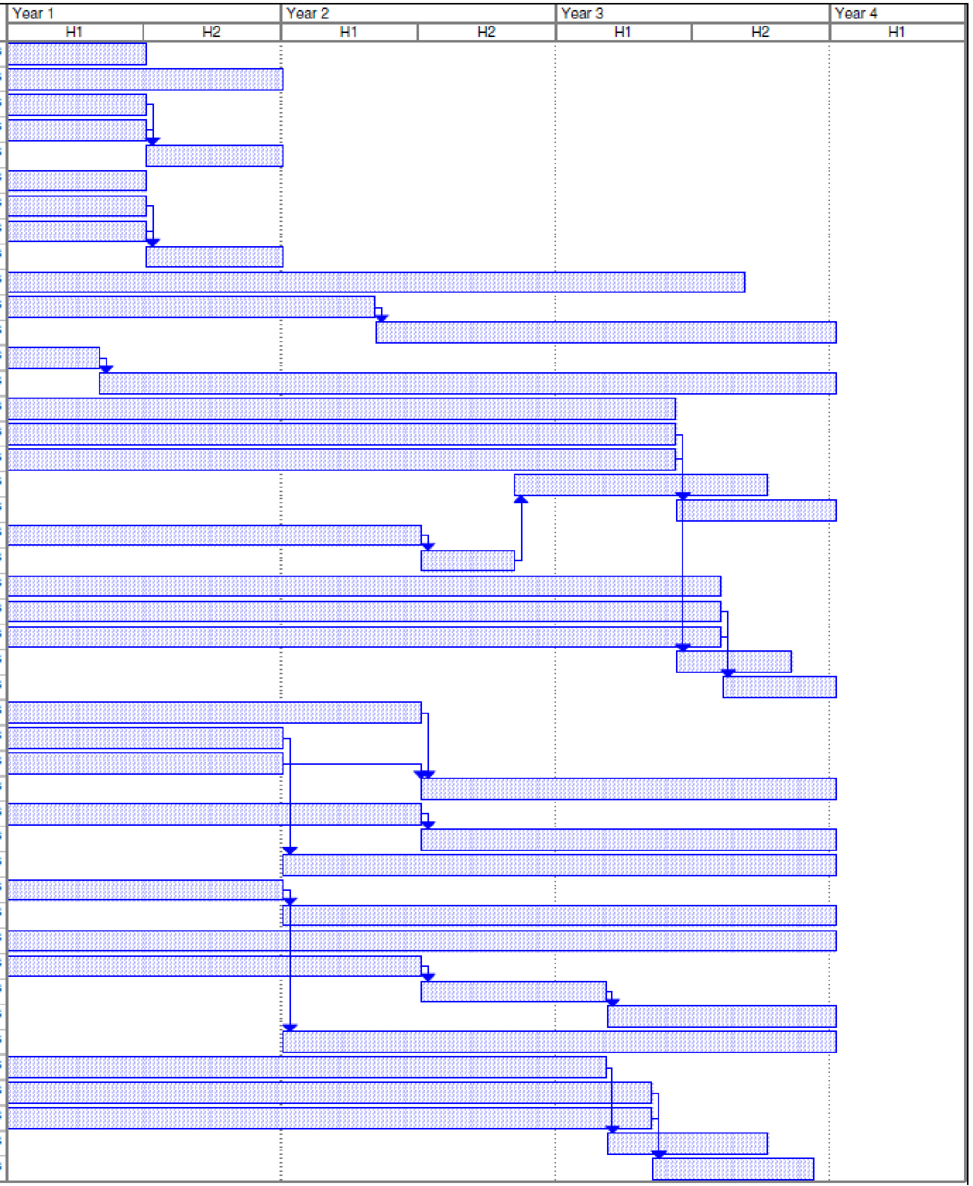
The alignment of Option O comprises the stage connector and the Violet variant of Stage 5 (as described in Options C and F) which joins the I-5 north of Shipka. The total length of Option O is 11.450km.

3.4 Timetable for Scheme Delivery

The scheme is due to be delivered and opened over a total period of 3 years. The timetable is reproduced in detail in the Gantt chart in **Figure 3.17**.

Figure 3.17 Gabrovo Project Timetable

ID	Section	Task	Quantity	Duration
1	**Stage 1**	Overpass km 1+760	Concrete - 51 m^3	132 days
2	km 0+000 to km 7+800	Bridge at km 2+300	Concrete - 258 m^3	264 days
3		Earth and Road Works	Excavation - 9400 m^3	132 days
4			Base Layer - 1000 m^3	132 days
5		Asphalt Works	Asphalt - 19200 tonnes	132 days
6	**Stage 2**	Overpass km 7+809	Concrete - 42 m^3	132 days
7	km 7+800 to km 11+680	Earth and Road Works	Excavation - 9900 m^3	132 days
8			Base Layer - 4070 m^3	132 days
9		Asphalt Works	Asphalt - 22452 tonnes	132 days
10	**Stage 3**	Bridge at km 11+780 L = 640m	Concrete - 8872.3 m^3, Girders x 96 - L = 38m	704 days
11	km 10+939 to km 16+010	Overpass km14+660 L = 165m	Concrete - 1987.5 m^3, Girders x 24 - L = 38m	352 days
12		Overpass km 15+500 L = 200m	Concrete - 2226.8 m^3, Girders x 30 - L = 39.6m	440 days
13		Bridge L = 19m		88 days
14		Tunnel L = 600m, km 12+420 - 13+020		704 days
15		The Prep work and small equipment	342 pcs	638 days
16		Earth Works	Excavation - 362749 m^3	638 days
17			Embankment - 181578 m^3	638 days
18		Road Works	Base Layer - 22139 m^3	242 days
19		Asphalt Works	Asphalt - 19547 tonnes	154 days
20	**Stage 4**	Tunnel km 17+270 to 17+420		396 days
21	km 16+010 to km 20+400	Overpass km 20+368 L = 20m	Concrete - 619 m^3, Girders x 10 - L = 20m	88 days
22		The Prep work and small equipment	894 pcs	682 days
23		Earth Works	Excavation - 496479 m^3	682 days
24			Embankment - 430623 m^3	682 days
25		Road Works	Base Layer - 39465 m^3	110 days
26		Asphalt Works	Asphalt - 34481 tonnes	110 days
27	**Stage 5**	Tunnel from km 20+500 to km 20+640 L = 140m		396 days
28	km 20+400 to km 30+673	Viaduct km 21+240 L = 78.3m	Concrete - 1312.20 m^3, Girders x 30 - L = 26.1m	264 days
29		Viaduct km 21+640 L = 104.3m	Concrete - 1620 m^3, Girders x 40 - L = 26.1m	264 days
30		Tunnel from km 22+340 to km 22+520 L = 180m		396 days
31		Viaduct km 21+640 L = 104.3m	Concrete - 2668.7 m^3, Girders x 70 - L = 26m	396 days
32		Tunnel from km 23+750 to km 23+880 L = 130m		396 days
33		Viaduct km 23+660 L = 156.6m	Concrete - 2503 m^3, Girders x 60 - L = 26m	528 days
34		Tunnel from km 23+760 to km 23+860 L = 80m		264 days
35		Tunnel from km 24+220 to km 24+380 L = 160m		528 days
36		Tunnel from km 24+440 to km 27+620 L = 3180m		792 days
37		Tunnel from km 27+820 to km 28+020 L = 200m		396 days
38		Tunnel from km 28+380 to km 28+440 L = 60m		176 days
39		Tunnel from km 28+940 to km 29+020 L = 80m		220 days
40		Tunnel from km 29+140 to km 29+400 L = 260m		528 days
41		The Prep work and small equipment	5286 pcs.	572 days
42		Earth Works	Excavation - 425300 m^3	616 days
43			Embankment - 419831 m^3	616 days
44		Road Works	Base Layer - 31506 m^3	154 days
45		Asphalt Works	Asphalt - 28163 tonnes m^3	154 days



3.5 Cost Benefit Analysis Appraisal

3.5.1 Introduction

This report has not considered multi criteria analysis of the various options but this chapter provides a high level comparison of the options based on the CBA results alone. This section will summarise the high level CBA results for all of the options. This will allow identification of the preferred options for the:

- Bypass and Tunnel;
- Bypass only; and
- Shipka Tunnel only.

It should be noted that an Economic Viability report entitled '*Road III-5004 "A Bypass around Gabrovo" – Interim Report*' was completed in 2009 by PATPROJECT ltd, based in Sofia. This report contains an economic analysis of the Gabrovo-Shipka Highway Project (using the same scheme variants as the Feasibility Study) using the HDM-4 software. This is not considered to be an appropriate tool with which to assess the economic viability of the various options which comprise the Gabrovo Bypass and Tunnel, and as a direct result this CBA report has been prepared.

The CBA results for each option for Net Present Value (NPV), Economic Internal Rate of Return (EIRR) and Benefit Cost Ratio (BCR) are summarised in **Table 3.4**. These results clearly show that the Bypass with Tunnel options and the Tunnel Only options have a high positive impact as they all yield a benefit cost ratio above 2. However, only one of the Bypass Only options yields a positive impact, whilst the remaining do not produce a positive impact in terms of their cost / benefits, as the cost benefit ratio for these options is less than 1.

The Bypass with Tunnel options, produce the highest benefit cost ratios, ranging between 3.86 and 5.54. For the Bypass and Tunnel Option, the preferred, from comparison of the CBA results is Option E. This option is the Red alignments for Stage 3 to 5. Although this option is not the shortest in terms of construction length, it does not involve a long tunnel (Option C), therefore for the costs are not as high whilst it yields a similar level of benefit.

The Tunnel Only options have two options with similar CBA results, but Option N yields slightly better results than Option M. Therefore, based on the CBA results alone, Option N should be seen as the preferred option for the Tunnel only. This option is the Red Alignment for Stage 5. Although this option is not the shortest alignment, it does not involve a long tunnel section, has lower costs than Option M, and yields sufficient journey time savings and accident benefits because the option has lower levels of congestion in Gabrovo centre. Therefore, the journey time and accident benefits from Option N as a result of the Tunnel are not offset unlike Option M benefits.

As mentioned, only one of the bypass only options produces a positive BCR (greater than one). The Option with the best CBA result is Option J, which is the Red and Blue alignment for Stage 3 and 4 respectively.

From comparison of the CBA results only, it can be concluded that the preferred options for the different construction combinations are:

- Bypass and Tunnel – Option E;
- Bypass Only – Option J; and
- Tunnel Only – Option N.

Table 3.4 Project Option Economic Indicators

Section	Option	Economic Indicator		
		NPV	EIRR	BCR
Bypass & Tunnel	A	398.14	24.43%	5.27
	B	408.84	25.06%	5.42
	C	371.50	19.31%	3.86
	D	392.09	24.97%	5.39
	E	402.47	25.68%	5.54
	F	390.43	20.47%	4.09
Bypass Only	G	-1.86	4.24%	0.92
	H	-2.03	4.22%	0.91
	I	-3.54	3.66%	0.86
	J	0.28	5.12%	1.01
	K	-1.28	4.34%	0.94
	L	-2.31	3.88%	0.89
Tunnel Only	M	219.52	19.61%	4.02
	N	221.42	19.88%	4.08
	O	183.92	14.32%	2.69

The following chapters will discuss these three preferred options only. The headline results for the other options are presented in the separate ***Appendices*** to this report.

4 The Transport Models

4.1 Model Background

The traffic analysis for the Gabrovo-Shipka Highway Project was carried out using the multi-modal model developed for the Bulgarian General Transport Master Plan (BGTMP). The following sections describe the development of that model.

The main objectives of the General Transport Master Plan project were set out in the Technical Specification prepared by the Bulgarian Ministry of Transport as being:

"the establishment of a strategic and coherent base of technical data, transport models, multimodal technical studies for project identification for long and medium term investment programming in the transport sector in Bulgaria. These technical studies should possess a high degree of consistency, through the appropriate elaboration of a transport master plan".

4.2 Overview of the Model

The Bulgaria Transport Model (BTM) is a large-scale inter-urban model comprising both elements of people movement and also the movement of freight. It is required to be able to test the impact of relatively large-scale improvements to the infrastructure available for inter-urban travel between Bulgarian cities and between Bulgaria and the rest of Europe. It is not required to represent in detail travel within towns and cities, but it is required to estimate and model transport in the rural areas of Bulgaria and the movement of international travellers into and out of Bulgaria by all modes.

The model is required to provide analysts with a sound estimate of patterns of existing demand and infrastructure (the Base Year case), to forecast likely changes in patterns of demand over time, and to predict the impact of and benefits associated with any proposed transport schemes. The models contain clear and logical linkages between economic/demographic change and overall transport demand.

4.2.1 Modes

The models constructed for the national transport plan include passenger and freight transport and comprise the following transport modes:

- Road (Car and motorcycle);
- Road (Truck);
- Road (Bus);
- Rail;
- Air; and
- Maritime and inland waterway.

4.2.2 Journey Purposes

Travellers are divided into six segments, by purpose and car availability, as follows:

- Commuting, with a car available;
- Business, with a car available;
- Leisure, with a car available;
- Commuting, with no car available;
- Business, with no car available; and
- Leisure, with no car available.

In addition, Heavy Goods Vehicles (HGVs) are modelled separately to the car segments.

4.2.3 Trip Types

Within the constraint that short distance travel within towns is not modelled, the following trip types are included:

- Journeys wholly within Bulgaria;
- International journeys with their origin or destination in Bulgaria; and
- Transit trips which currently travel through Bulgaria.

4.2.4 Interventions which can be modelled

The models are designed to be able to simulate the following impacts:

- Choice of destination (or entry/exit points for international trips);
- Choice of transport mode;
- Broad route corridor;
- Change in infrastructure provision;
- Changes in public transport services; and
- A range of policy scenarios relating to factors such as pricing for use of highways or public transport, and taxation changes.

The models also contain mechanisms for allowing trips to be suppressed if travel conditions worsen and for additional trips to be induced when conditions improve.

4.2.5 Model Years

Modelling has been undertaken for 2008, 2015, 2020, 2030 and 2040. The base 2008 model has been validated so that it reproduces existing demand to an appropriate level of accuracy.

4.2.6 Model Outputs:

The outputs of the model are threefold:

- Demand levels, by origin, destination, mode and purpose;
- Assigned networks, containing traffic volumes on roads, passenger occupancies of public transport vehicles, and other network information; and
- Costs of travel by origin, destination, mode and purpose, including monetary costs and travel times.

The outputs are used to inform appraisal in terms of:

- operational performance of interventions –the demand for new infrastructure or services, and identification of capacity issues;
- economic and financial performance using the demand for new infrastructure or services, whether such demand is existing, diverted, generated, transit or national traffic; and travel); and
- environmental performance using particular vehicle kilometres from the network outputs.

4.3 An Overview of the Modelling Approach

The development of the Bulgaria Transport Model (BTM) is shown on **Figure 4.1**. It consisted of the following elements:

- A large-scale **data collection** exercise, including new surveys as well as collecting published information, all of which have formed the basis of a sound technical dataset;
- Based on the extensive data collected, a **large-scale multi-modal passenger transport model** - the Bulgaria Passenger Transport Model (BPTM) – was developed using the EMME transport planning software; the structure of this model is shown on **Figure 4.2**;
- Demand for **freight movements** by different transport modes (road, rail, water and air), for both domestic and international goods movements (Imports, Exports and Transit) are analysed using spreadsheet-based model – this is termed the Bulgaria Freight Transport Model (BFTM) Heavy goods vehicle (HGV) traffic volumes are then modelled as part of the highway model. This allows the impact of congestion, or infrastructure changes, on freight costs to be identified;
- **International travellers** are included within the BPTM, but are not subject to mode-choice or redistribution within the BPTM, because the model, being focussed on Bulgaria, is unable to fully represent all relevant factors. Interventions are considered externally;

- The analysis and forecasts of **air and maritime passenger travel** is undertaken by separate spreadsheet-based models; and
- A **Growth Model**, which forecasts likely changes to patterns of and level of demand over time, based on changes in the economy, population and land-use, to provide initial estimates of future-year demand;

Figure 4.1 Structure of the Bulgaria Transport Model (BTM)

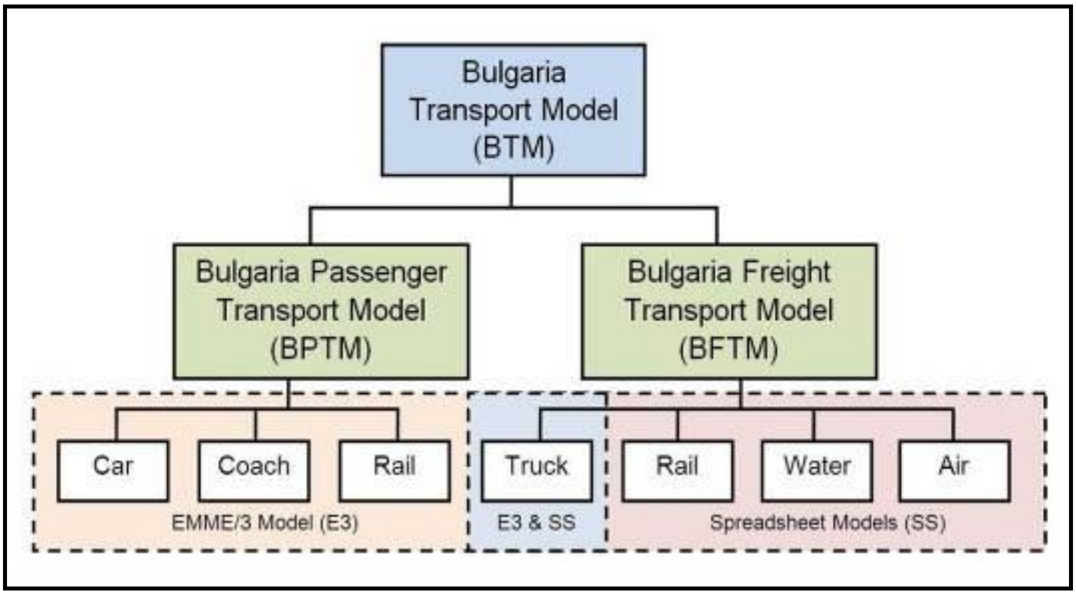
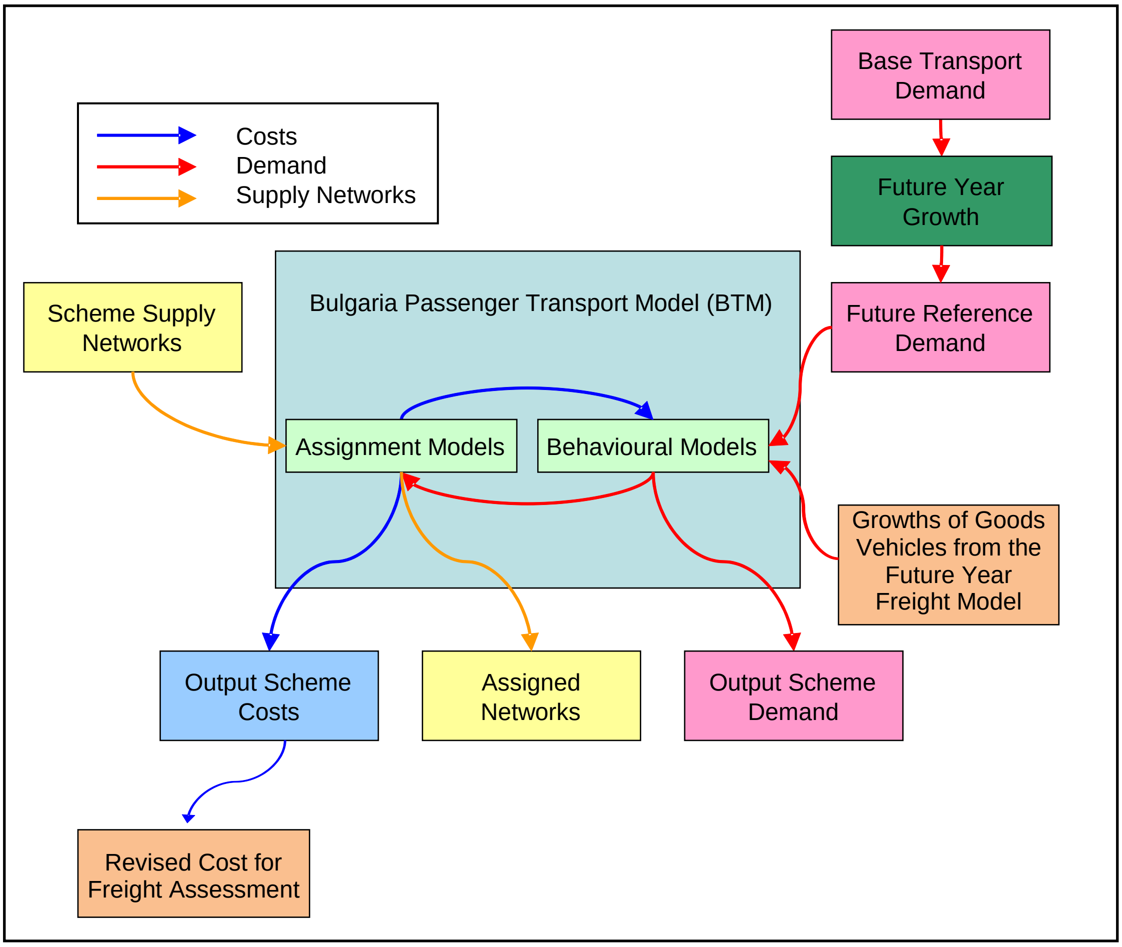


Figure 4.2 Bulgaria Passenger Transport Model (BPTM) Structure



4.3.1 Survey data

New survey data were collected as described in the following sections.

4.3.1.1 Origin-Destination Surveys

- Roadside interviews and traffic counts at 41 sites on main roads around Bulgaria, as well as traffic counts alone at a further 26 sites. These include all major border-crossings;
- Passenger interviews and boarding and alighting counts at six key coach stations; and
- Passenger interviews and boarding and alighting counts at six key rail stations.

The questionnaires were designed to obtain the same essential basic information from drivers in relation to the trips that they were making. The pertinent information collected was as follows:

- Vehicle type;
- Number of occupants in vehicle;
- Purpose of travel;
- Where the vehicle was coming from (origin & border crossing if applicable); and
- Where the vehicle was going to (destination & border crossing if applicable).

Drivers of both cars and trucks were interviewed. The truck driver's questionnaire was more detailed asking for information on the load being transported.

In all, around 30,000 vehicle interviews were carried out. About 2,700 coach passenger interviews and around 2,300 rail passenger interviews were also carried out.

4.3.1.2 Stated Preference Surveys

Stated preference surveys were also conducted. These were designed to identify the likely response of travellers to various improvements to the transport system by asking respondents to select one of a number of alternative journeys as the one that seemed best to them, in a number of different scenarios. These surveys were used to derive 'willingness to pay' or 'value of time' factors appropriate to Bulgaria, which is important since these are likely to be significantly different from the values appropriate to other European countries.

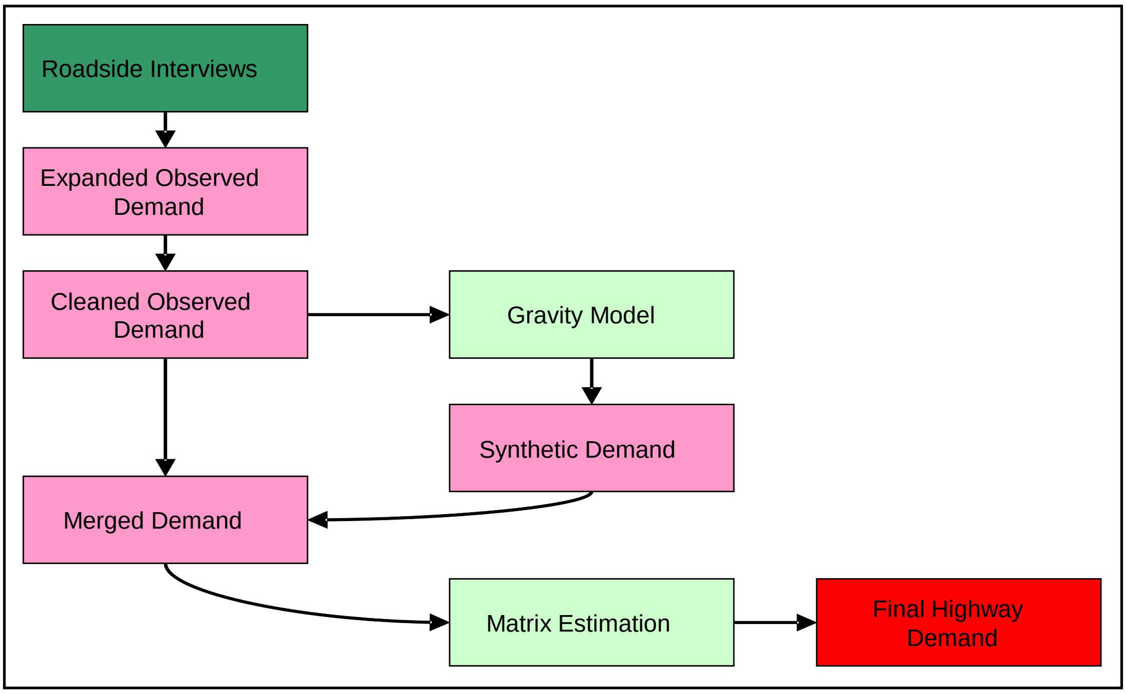
4.3.2 Car and Freight Trip Matrix Development

Trip matrices for highway travel for the BPTM are intended to represent all ground travel by personal vehicle, as well as all road-based freight travel that passes through Bulgaria for at least part of its journey. These include journeys wholly within Bulgaria, international journeys with their origin or destination in Bulgaria (including trips using ferries crossing the River Danube), and transit trips. Trips wholly external to Bulgaria which do not pass through Bulgaria for any part of the journey (e.g. Romania to Russia) are not included.

Separate matrices have been constructed for each traveller purpose. Four highway trip matrices have been built for the Bulgaria Transport model, these representing Business, Commuting and Leisure car travellers and Freight traffic.

The overall process of trip matrix development is summarised in **Figure 4.3**.

Figure 4.3 Matrix Building Process



4.3.3 Numbers of Journeys in 2008

The final highway demand matrices are summarised in **Table 4.1**.

Table 4.1 Highway Demand Matrices Summary

Vehicle Type	Segment	Person Total	Vehicle Total	Average Person Trip Length (Km)
Car	Commuting	893,464	495,543	10.2
	Business	955,561	533,535	20.5
	Leisure	694,354	300,066	27.8
	All	**2,543,378**	**1,329,144**	**18.9**
Freight	HGV	54,099	54,099	90.1
	LGV	33,604	33,604	57.4
	All	**87,703**	**87,703**	**77.6**

4.4 Road network

The road classifications are outlined in **Table 4.2**. In addition, the total length in km of roads of each class has been calculated, and this compared with a statistic from the BIS Yearbook. It can be seen that these match very closely, except for motorways, the total length of which in Bulgaria has increased significantly in the intervening three years. The Bulgaria highway network contains 3,246 nodes, and 7,604 links.

Table 4.2 Link Classifications

Link Type	Total Length	Yearbook, 2005	Number of links
Class 1 Road	2,946 km	2,969 km	1,231
Class 2 Road	4,063 km	4,012 km	1,563
Class 3 Road	11,609 km	11,969 km	4,676
Motorway	442 km	331 km	134
Total Roads	**19,060km**	**19,218km**	**7,604**

4.5 Assignment Procedures

Travelling vehicles are assigned to the highway network in two groups, or user classes. Light vehicles (including cars of all kinds and light goods vehicles) are distinguished from heavy (that is, freight goods) vehicles.

Traffic is assigned at a 12-hour level, that is, the input demand matrix and the flows on the network represent traffic over the course of a 12 hour day.

Vehicles are assumed to choose paths through the networks that minimise their total cost. Total cost is considered to include both travel time and fuel cost. Non-fuel-based vehicle operating costs are not included. Fuel costs are calculated separately for light and heavy vehicles.

4.5.1 Values of Time

An understanding of how travellers are willing to trade off time against money is also required. This is achieved by use of values of time, which can be used to convert monetary costs to a time equivalent. The behavioural models use time in minutes for calculations, so all costs must be expressed in minutes.

Values of time vary by purpose, and have been taken from “Requirements for preparation of CBA in Transport sector”. They are illustrated below.

Table 4.3 Values of Time (in 2008 prices)

Purpose	Value of Time per person (eurocents per minute)
Business	19.77
Leisure	7.30
Commuting	7.30

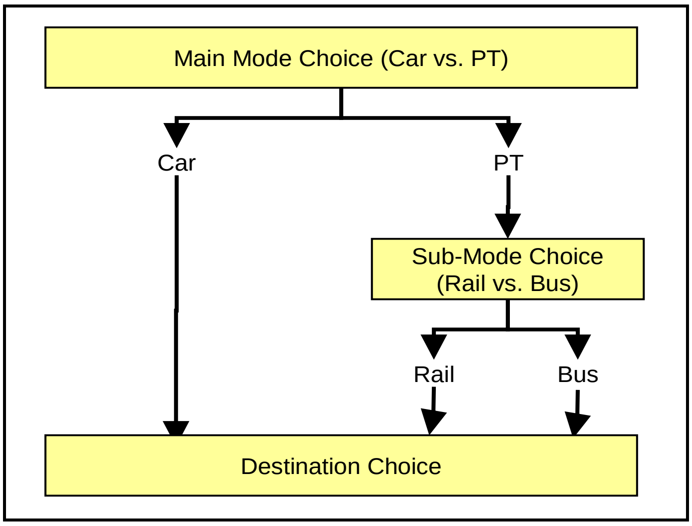
4.6 Mode Choice and Distribution Models

The basic concept of the behavioural models is that:

- $D_o = f(D_I, \Delta C)$, where
- D_o is output demand;
- D_I is input reference demand;
- ΔC is generalised cost change from base (that is, base-year) to test (that is, whatever scenario is to be tested); and
- $f()$ represents a function of the contents of the bracket.

The models are constructed so that if ΔC=0, then $D_o = D_I$, i.e. if there is no change to transport costs and patterns of demand do not change. **Figure 4.4** illustrates the process. Firstly, one set of equations divides trips between car and public transport, and then secondly another set divides public transport trips between rail and bus. Finally, a third set determines the destination of all trips.

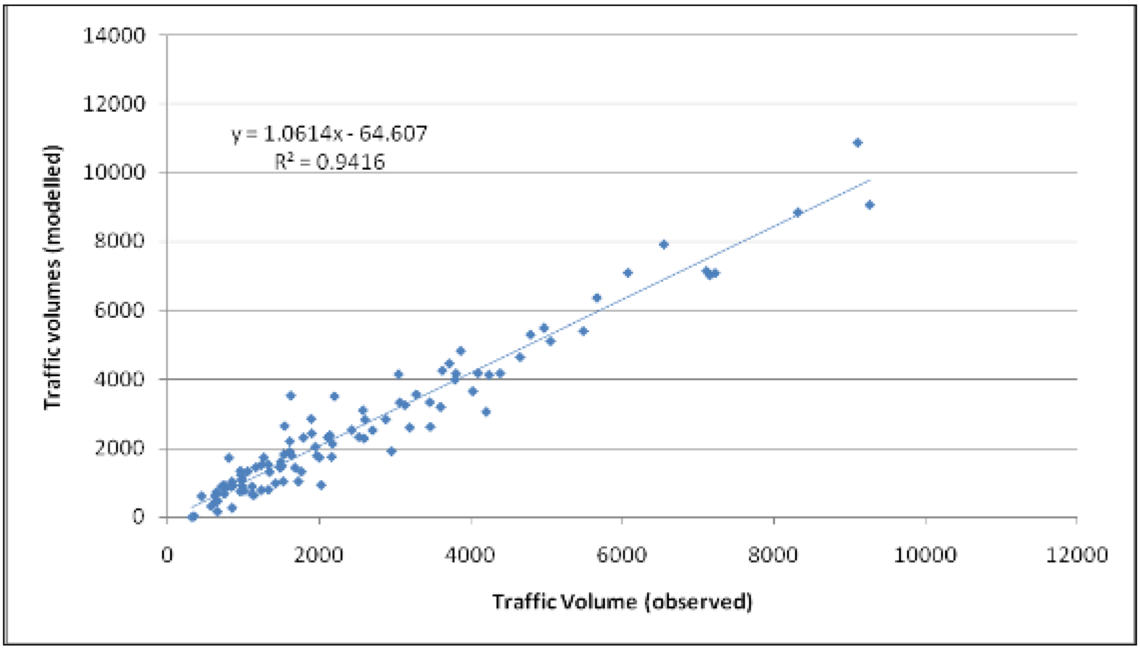
Figure 4.4 Behavioural Model Structure



4.7 Model Validation

We have access to such data, in the form of AADT (average annual daily traffic) counts conducted on 114 stretches of road in 2007 (source: Central Roads and Bridges Laboratory). Although these data are not directly comparable with our model (being a different year and 24 hour rather than 12 hour volumes), it is possible to estimate 2008, 12 hour, vehicle traffic from them and compare with that modelled. This comparison is shown in **Figure 4.5**.

Figure 4.5 Assigned Volumes versus AADT Counts



Another useful validation exercise is to compare real vehicle journey times with those in the model. Journey time surveys were conducted across Bulgaria along key routes and corridors. The figures below plot the observed journey times with those in the model. There are five plots as shown in **Figure 4.6**, one for each survey that was carried out, as well as a plot of the routes covered. The Gabrovo corridor was included in these surveys, on the Varna – Varna loop which highlights a very good level of validation. Subsequent journey time surveys were undertaken along the corridor as discussed in ***Chapter 4.12***, to provide additional detail on the corridor and adjacent routes.

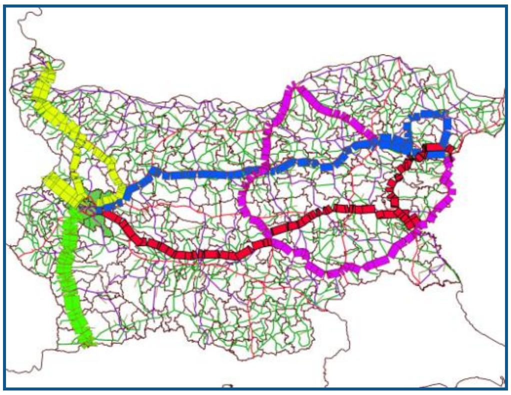
All of the plots show very a good comparison between modelled and observed journey times. This implies that journey times are accurately and realistically represented in the model.

Figure 4.6 Modelled Assignment Times versus Surveyed Times

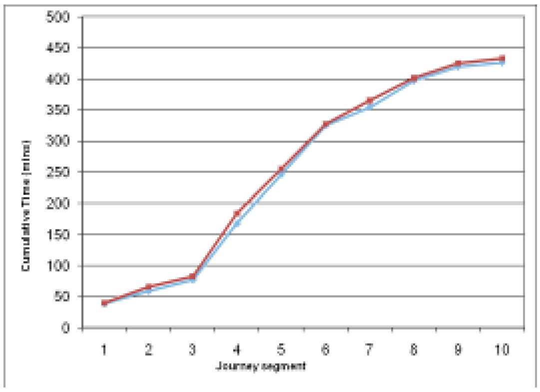
Journey time surveys

Observed journey

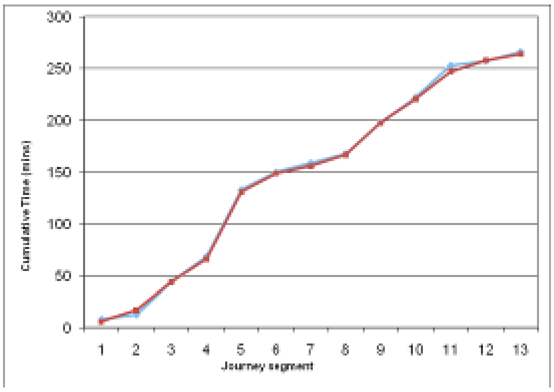
Modelled journey



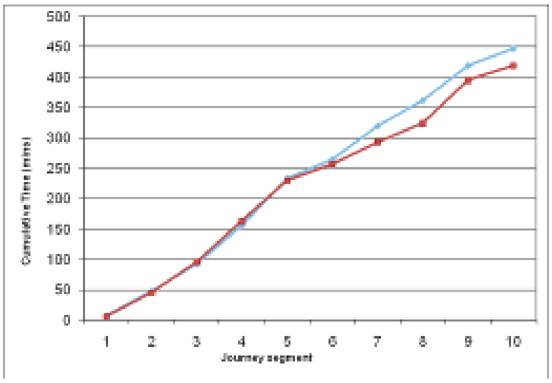
Routes



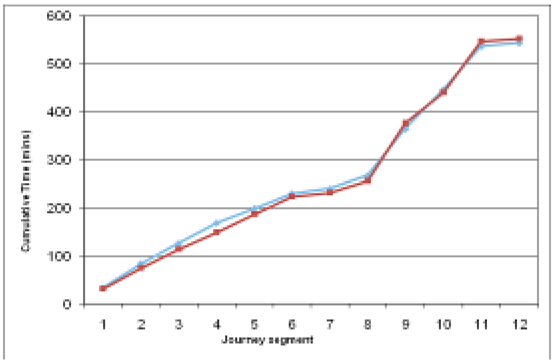
Sofia to Kalotina and Vidin



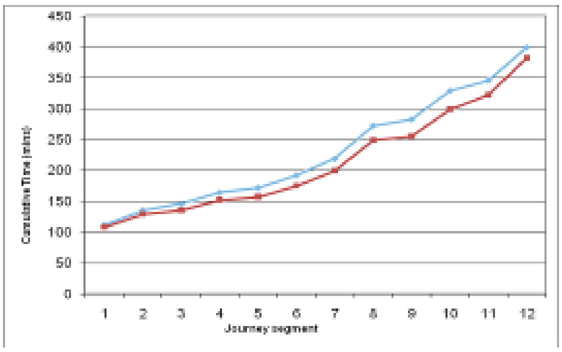
Sofia to Kulata



Sofia to Varna



Varna to Varna via Ruse and Stara Zagora



Varna to Sofia via Burgas

4.8 Freight Modelling

This section summarises the source of data available for, and used in, the construction of the Bulgaria Freight Transport Model (BFTM). Key sources of data for modelling freight transport include:

- Roadside interviews and traffic counts at 41 sites on main roads around Bulgaria, as well as traffic counts alone at a further 26 sites. These include all major border-crossings;
- Road and rail network topologies from MapInfo layers acquired from the GIS Company; "GfK GeoMarketing";
- Demographic data from National Statistics Institute (NSI) year book, 2007;
- Rail freight statistics provided by BDZ, 2007;
- Statistics of GVA by commodity group and by Bulgaria region, from the Eurostat website;
- Statistics of GVA by commodity group and freight demand of other countries, from Eurostat website;
- Statistics of GDP from Bulgaria National Statistics Institute (NSI) website, 2007;
- Statistics of GDP from the Economist website for countries other than Bulgaria, accessed January 2009;
- Statistics on empty running and back-loading, from Eurostat website;
- Statistics of freight movement by commodity type from NSI website, 2007;
- Information on imports, exports, and transit freight movements through Bulgaria sea ports (Varna and Burgas) and ports along the River Danube, provided by the Bulgaria Ministry of Transport, 2003 to 2007;
- Information on competing ports (Thessaloniki and Constanta), from Eurostat website;
- Information on current air freight tonnages, from Eurostat website;
- Boeing (2008) World Air Cargo Forecast, http://www.boeing.com/commercial/cargo/ Accessed 24/03/2009;
- Airbus Global Market Forecast (2008) http://www.airbus.com/en/corporate/gmf/ Accessed 24/03/2009; and
- Conway, Peter (2006) Europe's New Frontier, Air Cargo World, http://www.aircargoworld.com/archives/features/2_jul06.htm, accessed 24/03/2009.

4.9 Freight Demand

Base year freight demand has been estimated separately for road, rail, ports and water freight via the River Danube. The freight demand segments and modes that have been considered in the freight model include the following:

- Road freight transport – Domestic and International (including Imports, Exports and Transit);
- Rail freight transport – Domestic and International (including Imports, Exports and Transit);
- Road and rail traffic to/from the sea ports (including Imports, Exports and Transit);
- Sea freight via the Ports; and
- Water freight via the River Danube.

4.10 Air Freight

4.10.1 Estimated 2008 Base Year GVA by Commodity Group

The 2008 Base Year level of GVA by commodity group is estimated within each of the nine Bulgarian regions for which freight has been modelled. These are summarised in **Table 4.4**.

Table 4.4 GVA by Commodity Group (Euro Million), Estimate for 2008

Region	Agriculture	Industry	Wholesale, Retail and Transport	Other Services
North Western	291	459	281	641
North Central	261	506	354	620
North Eastern	250	513	557	699
Sofia & Region	89	1,516	1,977	2,585
Blagoevgrad	99	209	82	199
Other South Western	72	198	62	199
South Central	388	841	571	977
Stara Zagora	71	481	125	230
Other South Eastern	179	528	359	503
Total	**1,700**	**5,251**	**4,368**	**6,653**

4.10.2 Base Year Tonnage by Commodity Group

Table 4.5 shows the estimated split of tonnage and HGV trips by industry type for the 2008 base year.

Table 4.5 Estimated Percentage Split by Commodity Group, 2008

	Agriculture	Industry	Wholesale, Retail, and Transport	Other Services
Tonnage	9%	77%	8%	5%
HGV Trips	7%	70%	17%	6%

Domestic road freight trips in 2008 are estimated at 54,000 HGV equivalent units in a 12-hour weekday.

Table 4.6 Base Year Domestic Road Freight Demand, Average 12 Hour Weekday, HGV Equivalent Units

		Destination								
		North Western	North Central	North Eastern	Sofia & Region	Blagoevgrad	Other South Western	South Central	Stara Zagora	Other South Eastern
Origin	North Western	3,091	498	71	1,364	168	50	297	56	137
	North Central	513	2,103	380	272	3	3	201	164	443
	North Eastern	81	646	3,126	44	13	2	205	41	832
	Sofia & Region	1,323	319	35	11,143	662	900	921	217	172
	Blagoevgrad	168	3	7	779	832	190	118	3	95
	Other South Western	54	4	2	1,001	228	326	147	17	5
	South Central	289	188	118	891	113	155	4,815	999	376
	Stara Zagora	64	164	32	253	3	20	978	473	486
	Other South Eastern	160	474	820	133	48	3	414	336	4,545

4.10.3 International Road Freight - Imports

Table 4.7 lists the estimated 2008 import freight demand by road freight. The country of origin is shown.

Table 4.7 Base Year Road Freight – Import, Average 12 Hour Weekday, HGV Equivalent Units

	Destination									
		North Western	North Central	North Eastern	Sofia & Region	Blagoevgrad	Other South Western	South Central	Stara Zagora	Other South Eastern
Origin	North Western	126	151	79	84	9	0	53	15	23
	North Central	31	9	89	281	197	15	125	0	17
	North Eastern	49	1	1	17	10	57	12	0	7
	Sofia & Region	29	121	7	28	0	0	170	27	51
	Blagoevgrad	16	17	4	29	0	2	14	11	0
	Other South Western	12	1	3	30	11	4	6	15	0
	South Central	0	17	0	1	0	0	2	0	0
	Stara Zagora	0	9	0	11	0	0	18	0	0
	Other South Eastern	0	4	0	9	0	0	2	7	0

International Road Freight - Exports

Table 4.8 presents the estimated 2008 export freight demand by road freight. The country of destination is shown.

Table 4.8 Base Year Road Freight – Export, Average 12 Hour Weekday, HGV Equivalent Units

Origin	Destination											
		Romania	Greece	Macedonia	Turkey	Germany	Italy	Ukraine	Russia & Baltic	Western Europe	Eastern Europe	Central Europe	Middle East
	North Western	101	33	67	47	14	16	0	0	1	11	17	0
	North Central	186	13	1	164	28	1	29	10	6	3	7	0
	North Eastern	86	177	1	16	6	3	0	0	0	0	2	0
	Sofia & Region	94	255	13	38	39	34	1	14	2	26	21	0
	Blagoevgrad	6	178	8	0	0	11	0	0	0	0	0	0
	Other South Western	1	10	29	0	2	4	0	0	0	0	0	0
	South Central	68	107	27	216	15	10	2	13	4	12	8	5
	Stara Zagora	23	0	0	36	12	19	0	0	2	0	0	0
	Other South Eastern	41	23	10	62	0	0	0	0	0	0	0	0

Table 4.9 Base Year Road Freight –Transit Traffic, Average 12 Hour Weekday, HGV Equivalent Units

Origin	Destination											
		Romania	Greece	Macedonia	Turkey	Germany	Italy	Ukraine	Russia & Baltic	Western Europe	Eastern Europe	Central Europe	Middle East
	Romania	0	8	3	65	0	0	0	0	0	1	0	2
	Greece	16	0	3	0	6	0	1	2	3	6	8	0
	Macedonia	5	3	0	6	0	0	0	0	0	0	0	0
	Turkey	71	0	7	0	41	8	5	9	6	33	16	3
	Germany	0	4	0	39	0	0	0	0	0	4	0	12
	Italy	0	0	0	8	0	0	0	0	0	0	0	0
	Ukraine	0	1	0	8	0	0	0	0	0	0	0	0
	Russia & Baltic	0	1	0	10	0	0	0	0	0	0	0	0
	Western Europe	0	4	0	5	0	0	0	0	0	2	0	0
	Eastern Europe	1	3	0	40	6	0	0	0	2	0	0	1
	Central Europe	0	7	0	16	0	0	0	0	0	0	0	2
	Middle East	3	0	0	3	13	0	0	0	0	1	1	0

4.11 Traffic Model Forecasting Parameters

4.11.1 Economic Growth Assumptions

This section discusses the economic and population factors which are the key drivers of future year traffic levels. They key inputs which drive future year traffic levels are:

- GDP and GDP per head; and
- Population.

Table 4.10 summarises the GDP and population growth assumptions which have been adopted for the traffic forecasts. These are sourced from the Economist Intelligence Unit (EIU), a respected body for producing independent economic forecasts.

The forecasts highlight the impact of the global economic downturn on Bulgaria, with actual GDP in 2009 falling by 4.9%. The EIU are forecasting a slight increase in GDP for 2010, followed by increases between 2.5% and 3.9% through to 2015. These forecasts are significantly below those made before the global economic downturn.

The population of Bulgaria has been reducing due to net outward migration and this trend is forecast to continue throughout the period of our forecasts. This leads to a significantly higher rate of GDP / head growth than GDP. Both GDP growth and population growth are taken from the same source (the EIU) so that there is internal consistency between GDP and GDP / head in the forecasts.

Table 4.10 Bulgaria GDP Growth Forecast 2008-2030

Year	GDP Growth Forecast	GDP Per Head	Population(d)
2008	6.20%(a)	6.80%(a)	-0.56%
2009	-4.90%(a)	-4.40%(b)	-0.52%
2010	0.30%(b)	0.90%(b)	-0.59%
2011	2.50%(b)	3.10%(b)	-0.58%
2012	3.50%(b)	4.20%(b)	-0.67%
2013	3.90%(b)	4.50%(b)	-0.57%
2014	3.80%(b)	4.40%(b)	-0.57%
2015	3.60%(b)	4.20%(b)	-0.58%
2016 - 2040	3.00%(c)	3.90%(c)	-1.06%

(a) Actual, source Economist Intelligence Unit

(b) Forecast, March 2011 Economist Intelligence Unit

(c) Forecast, July 2010 Economist Intelligence Unit Long Term Forecast

(d) *Calculated based on Actual and Forecast GDP and GDP per head*

International trade makes up a considerable proportion of freight traffic in Bulgaria, growth in exports and transit demand is linked to the GDP of Bulgaria's trading partners. GDP figures for all major trading nations have been updating using World Economic Outlook Database figures up to 2015.

Table 4.11 GDP Growth Forecasts, % Growth per Annum and Cumulative Forecasts for 2015 and 2030[1]

Country	2008	2009	2010	2011	2012	2013	2014	2015 +	2015	2030
Greece	2	-2	-2	-1.1	0.2	1	0.5	1.4	-1%	21%
Macedonia	4.8	-0.7	2	3	4.5	4	4	4	24%	123%
Turkey	0.7	-4.7	5.2	3.4	3.6	3.8	4	4	17%	110%
Germany	1.2	-5	1.2	1.7	2	1.8	1.6	1.2	4%	25%
Italy	-1.3	-5	0.8	1.2	1.5	1.4	1.3	1.3	0%	21%
Romania	7.4	-7.1	0.8	5.1	5	4.9	4.5	4.1	22%	122%
Ukraine	2.1	-15.1	3.7	4.1	5.1	5.1	5.1	4	9%	96%
Russia	5.6	-7.9	4	3.3	3.7	4.1	4.4	5	18%	145%
France	0.3	-2.2	1.5	1.8	2	2.1	2.2	2.2		
Spain	0.9	-3.6	-0.4	0.9	1.5	1.6	1.8	1.7		
Holland	2	-4	1.3	1.3	1.7	1.8	1.8	1.8		
Western Europe	0.4	-2.4	1.4	1.7	2.0	2.1	2.2	2.1	7%	48%
Serbia	5.5	-2.9	2	3	5	5.5	5.5	5		
Moldova	7.8	-6.5	2.5	3.6	5	5	5	4		
Albania	7.8	2.8	2.3	3.2	3.6	4.2	4.7	5		
Eastern Europe	6.1	-3.5	2.1	3.1	4.9	5.3	5.4	4.8	26%	153%
Austria	2	-3.6	1.3	1.7	1.8	2	2.1	2.2		
Poland	5	1.7	2.7	3.2	3.9	4	4	4		
Slovenia	3.5	-7.3	1.1	2	2.8	3	3.9	3.8		
Hungary	0.6	-6.3	-0.2	3.2	4.5	4	3.5	3		
Czech Republic	2.5	-4.3	1.7	2.6	3.5	3.5	3.5	3.5		
Croatia	2.4	-5.8	0.2	2.5	3	3	3	3		
Central	2.8	-4.2	1.3	2.3	2.9	3.0	3.2	3.2	12%	78%

[1] World Economic Outlook Database (WEOD) to 2015, FM estimate thereafter

Europe										
Iran	2.3	1.8	3	3.2	3.2	3.2	3.2	3.2		
Syria	5.2	4	5	5.5	5.6	5.6	5.6	5.6		
Middle East	3.5	2.7	3.8	4.2	4.2	4.2	4.2	4.2	30%	142%

4.11.2 Regional GDP Changes

Cumulative GDP growth for 2015, 2020, 2030 and 2040 on 2008 is calculated for each region in Bulgaria, based on the overall national growth rates as shown in **Table 4.11**, and a forecasting approach based on industrial sectors by region. The model inputs for each of the forecast years are shown in **Table 4.12**.

Table 4.12 Cumulative GDP Growth by Bulgarian Region

Bulgarian Region	2015 Cumulative GDP growth on 2008	2020 Cumulative GDP growth on 2008	2030 Cumulative GDP growth on 2008	2040 Cumulative GDP growth on 2008
North Western	0.3%	4.4%	8.0%	9.1%
North Central	7.6%	19.4%	41.1%	59.6%
North Eastern	15.3%	37.6%	83.7%	129.3%
Sofia & Region	31.2%	68.6%	152.8%	246.1%
Blagoevgrad	19.3%	40.3%	85.6%	139.9%
Other South Western	0.3%	4.4%	8.0%	9.1%
South Central	23.4%	54.5%	127.4%	212.7%
Stara Zagora	15.3%	34.3%	75.0%	118.5%
Other South Eastern	19.3%	45.8%	104.4%	167.9%

4.11.3 Regional Population Changes

Population forecasts have been split based on planning regions and the principles set down in the Operational Plan for Regional Development that future growth will be concentrated within Sofia and the agglomeration areas.

The process adopted considers Sofia first, as the economic hub of the country. Following on from this forecasts for other regions within Bulgaria have been undertaken separately for the agglomeration areas of the large cities, agglomeration areas of medium-size cities and rural areas as defined within the Operational Plan for Regional Development. Forecasts for the country as a whole, as given in **Table 4.13**, have been used as a control total to determine growth rates within the rest of the country.

This leads to the following regional forecasts in **Table 4.13**.

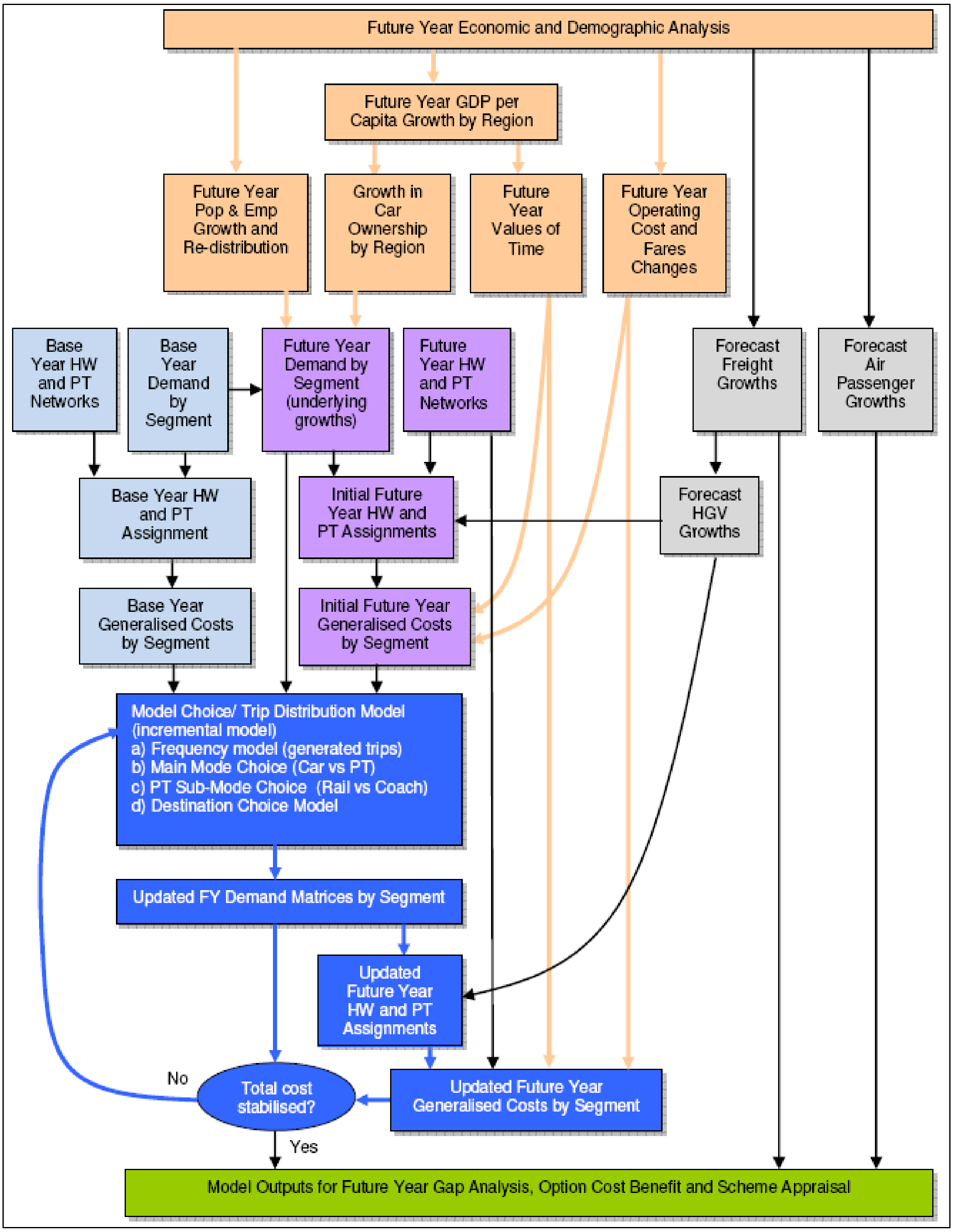
Table 4.13 Total Population Growth Forecast for Bulgarian Regions

Regions	2015	2020	2030	2040
North Western	-5%	-10%	-21%	-31%
North Central	-5%	-10%	-21%	-32%
North Eastern	-5%	-10%	-20%	-30%
Sofia & Region	0%	-3%	-8%	-14%
Blagoevgrad	-6%	-12%	-23%	-34%
Other South Western	-6%	-11%	-22%	-34%
South Central	-5%	-10%	-20%	-30%
Stara Zagora	-4%	-8%	-17%	-26%
Other South Eastern	-5%	-10%	-20%	-29%
Bulgaria	-4%	-9%	-18%	-27%

4.11.4 Translation of Growth Forecasts for Model Input

The multi-stage Bulgarian National Transport Model forecasts transport demand using the assumptions set out in the preceding section. This is illustrated in **Figure 4.7**, which summarises how the various socio-economic assumptions and inputs are used to determine demand.

Figure 4.7 BTM Demand Forecast Model Methodology



The demand forecasting process considers the change in economic development, change in demographic data, change in car ownership, change in transport infrastructure provision and change in travel cost to forecast the transport demand for each mode of transportation.

An initial estimate of new demand by mode is generated using a growth model, prior to consideration of any network, income, fuel price, or public transport fare changes. This is derived from population and car-ownership changes. Demand is assumed to be linearly proportional to population; so that a 5% fall in population results in a 5% fall in trips. Transport demand is assumed to also vary with car ownership, which is taken into account in the model with an elasticity relating car ownership levels to car trips. The model also has a growth elasticity to determine the change in PT trips. GDP is used together with car ownership forecasts to determine total passenger kilometres.

Growth elasticises (derived from the base year calibrated validated model) are used to determine the change in transport demand resulting from a change in the unit cost of transport for each mode. For example, as income increases, car owning households are likely to drive more, whilst those in non-car households are likely to travel further by public transport.

Changes to the transport networks will also affect demand. New or improved infrastructure can result in new trips being generated or a change in the distribution of trips (e.g. people will be able to access a greater range of destinations within the same amount of time), and may also result in mode switching. Increased congestion may also have an impact, for example suppressing trips or limiting the range of destinations that can be reached in a given amount of time. Trip assignment is also affected, for example people may switch from an existing route to a new and improved route. The model process takes into account of all of these factors through the calculation of a generalised cost of travel.

4.11.5 Vehicle ownership

A vehicle ownership model has been developed for application in the transport model. It is based on the general trend observed in European countries in the last 25 years. The following is the relationship calibrated for the use in model:

$Car\ Ownership = 39.311.GDPpc^{0.293}-172.0$

Using this relationship vehicle ownership is calculated within the model run process using GDP growth inputs by region.

4.11.6 Existing and Future Demand

The tables below show the forecast do-minimum scenarios for domestic passenger transport demand by mode (international travellers are not included in these tables).

Car demand is forecast to increase by 19% from 2.5 million (inter-urban) trips per day to 3 million in 2040.

Public transport demand is forecast to decrease, with rail demand declining by 19% by 2040 and coach demand by 14%.

Reflecting the assumed redistribution of population in Bulgaria, with the lowest rates of population decrease in Sofia, the forecasts are for relatively higher traffic growth in the south west region than are forecast in other regions (note that the division by region reported here refers to the origin of a trip).

Table 4.14 Domestic Car Trip Totals, Do Minimum Case (12-Hour Weekday)

Region	2008	2015	2020	2030	2040
North Central	140,736	138,024	136,250	129,979	121,035
North East	312,697	313,934	315,872	317,480	316,338
North West	36,946	35,959	35,146	32,818	30,007
South Central	421,803	435,720	449,793	466,452	468,169
South East	110,121	112,294	114,184	116,340	116,440
South West	1,521,074	1,650,069	1,743,556	1,884,996	1,975,416
Total	**2,543,378**	**2,686,001**	**2,794,802**	**2,948,065**	**3,027,404**

Table 4.15 Domestic Rail Trip Totals, Do Minimum Case (12-Hour Weekday)

Region	2008	2015	2020	2030	2040
North Central	9,761	9,279	8,842	7,926	6,974
North East	7,943	7,711	7,503	7,048	6,548
North West	7,076	6,700	6,363	5,664	4,953
South Central	20,942	20,246	19,598	18,164	16,559
South East	3,995	3,853	3,745	3,509	3,249
South West	21,839	21,864	21,506	20,643	19,628
Total	**71,556**	**69,652**	**67,557**	**62,954**	**57,912**

Table 4.16 Percentage Trip Growth from 2008 to 2015, 2020, 2030 and 2040, By Mode

Region	Total Percentage Growth (%)											
	2008 to 2015			2008 to 2020			2008 to 2030			2008 to 2040		
	Car	Coach	Rail	Car	Coach	Rail	Car	Coach	Rail	Car	Coach	Rail
North Central	-1.9%	-4.8%	-4.9%	-3.2%	-9.1%	-9.4%	-7.6%	-18.1%	-18.8%	-14.0%	-27.6%	-28.6%
North East	0.4%	-2.2%	-2.9%	1.0%	-4.1%	-5.5%	1.5%	-8.3%	-11.3%	1.2%	-12.8%	-17.6%
North West	-2.7%	-5.1%	-5.3%	-4.9%	-9.6%	-10.1%	-11.2%	-19.2%	-20.0%	-18.8%	-29.0%	-30.0%
South Central	3.3%	-3.1%	-3.3%	6.6%	-6.0%	-6.4%	10.6%	-12.6%	-13.3%	11.0%	-20.0%	-20.9%
South East	2.0%	-2.2%	-3.6%	3.7%	-4.3%	-6.2%	5.6%	-8.8%	-12.2%	5.7%	-13.9%	-18.7%
South West	8.5%	1.2%	0.1%	14.6%	0.1%	-1.5%	23.9%	-2.8%	-5.5%	29.9%	-6.5%	-10.1%
Overall	**5.6%**	**-1.3%**	**-2.7%**	**9.9%**	**-3.5%**	**-5.6%**	**15.9%**	**-8.4%**	**-12.0%**	**19.0%**	**-14.0%**	**-19.1%**

4.11.7 Value of Time (VOT)

Base VOTs are 19.77 eurocents/minute for business and 7.3 eurocents/minute for commuting and leisure[2]. Forecast year VOTs are calculated based on GDP per capita growth and an income elasticity of 0.7, as per the CBA guidelines[3]. **Table 4.17** summarises the derivation of the forecast year VOTs.

[2] Requirements for Preparation of CBA in Transport Sector (December 2008)
[3] *ibid*.

Table 4.17 Derivation of Forecast Year Values of Time

Year	GDP growth factor	Population	GDP per capita growth factor	VOT growth factor (0.7 elasticity)	Business VOT (eurocents/min)	Commuting/ Leisure VOT (eurocents/min)
2008	1	7,760,892	1	1	18.65	6.88
2015	1.13	7,450,456	1.18	1.12	20.91	7.72
2020	1.30	7,088,281	1.42	1.28	23.86	8.81
2030	1.71	6,363,931	2.09	1.67	31.21	11.52
2040	2.25	5,639,582	3.10	2.21	41.21	15.21

4.11.8 Vehicle Occupancy

The base values for vehicle occupancy were taken from the roadside interview (RSI) surveys, with annual indicative reductions based on the UK's Department for Transport's guidance in WebTAG. **Table 4.18** gives the values used in the base and forecast years.

Table 4.18 Vehicle Occupancy

Year	Business Vehicle Occupancy	Commuting Vehicle Occupancy	Leisure Vehicle Occupancy
2008	1.791	1.803	2.314
2015	1.759	1.779	2.274
2020	1.737	1.762	2.247
2030	1.694	1.729	2.193
2040	1.651	1.696	2.139

Extrapolating to 2040, gives values of 1.651, 1.696 and 2.139 for business, commuting and leisure respectively. These are above the values in the Technical Specification which suggests a minimum value of 1.5 for occupancy of passenger cars over time. Using this lower value would, of course, increase the number of cars in the forecasts. Bus occupancy values are not used as a model input, but are provided as a model output following the assignment.

4.11.9 Fuel price

The base year value is set at 128 eurocents/litre. This is assumed to fall by 11.5% in the period 2008-2015 to 113 eurocents/litre (due to high 2008 prices) and rise by 14% in the period 2015-2040 to 129 eurocents/litre for an average car.

4.11.10 Vehicle efficiency

Fuel efficiency in the model base year of 2008 is assumed to be the same as the UK in 2002. For 2015, fuel efficiency is assumed to be the same as the UK in 2009. The assumption for 2030 is that fuel efficiency in Bulgaria will be identical with that in the UK. This represents an 8.3% increase in vehicle efficiency by 2015, a 23.3% increase by 2030 and a 33.3% increase by 2040.

4.11.11 Rail and bus fares

It is assumed that there is no change in rail and bus fares from the base year to 2015 (3.31 eurocents/km for rail and 5.88 eurocents/km for coach) and 1% annual growth after 2015. This results in an overall growth factor of 1.268 in public transport fares from 2008 to 2040.

4.11.12 Freight Modal Share

The freight modal share is affected by the relative attractiveness of each mode and the relative cost. The main variables when calculating the operating cost of each mode are the fuel price and the labour price. For fuel price growth from 2008 to 2015 and 2030, actual figures for growth from 2008 to 2010 have been compared to predictions in the model, this comparison confirmed that the growth factors in the model remain consistent. Growth in labour price also remains unchanged since this is linked closely to GDP which, by 2015, remains the same as in previous work.

4.11.13 Average Loads

The average load per vehicle in 2005 in EU countries, for both national and international transport, was 13.1 tonnes. This represented an increase of 6.5% since 2000. The load carried on international journeys was, for most countries, greater than that on national journeys, and increased with increasing distance. **Table 4.19** summarises these data.

Table 4.19 Average Vehicle Loads Tonnes EU, 2000 - 2005

Average Loads over time					
2000	2001	2002	2003	2004	2005
12.3	12.3	12.4	12.8	13.0	13.1
Average Load by distance (km)					
0-50	0-50	50-150	150-500	>500	Total
	11.3	11.1	11.8	13.6	12.2

Source: Statistics in Transport 117/2007 Transport, Eurostat

No data was provided for Bulgaria in respect to average loads. Hungary was the nearest EU country for which data was available, where the average vehicle loads were 13.9 tonnes. The Gabrovo corridor is part of the PETC network, serving as a main strategic route for transit traffic, so 14 tonnes per vehicle was judged as a reasonable estimate for freight vehicles.

4.11.14 Back Loading

Back loading, where a goods vehicle carries a payload on its return journey, affects the growth in road freight and the opportunity for shifting to rail or water. According to current figures in the Eurostat database, the opportunity for additional back loading has decreased from 30% to 28%. This implies that the road sector is becoming slightly more efficient which in turn yields fewer opportunities for converting road movements to rail and water.

4.11.15 Larger Good Vehicles

The weight limit for goods vehicles in Bulgaria is near the upper threshold of EU standards and there has been a move towards greater enforcement to reduce overloading. Since the previous work there have been no significant developments which would affect the size of vehicles or compliance in Bulgaria and as such no changes relating to this have been made in the model.

4.12 2008 Model Performance in the Gabrovo Corridor

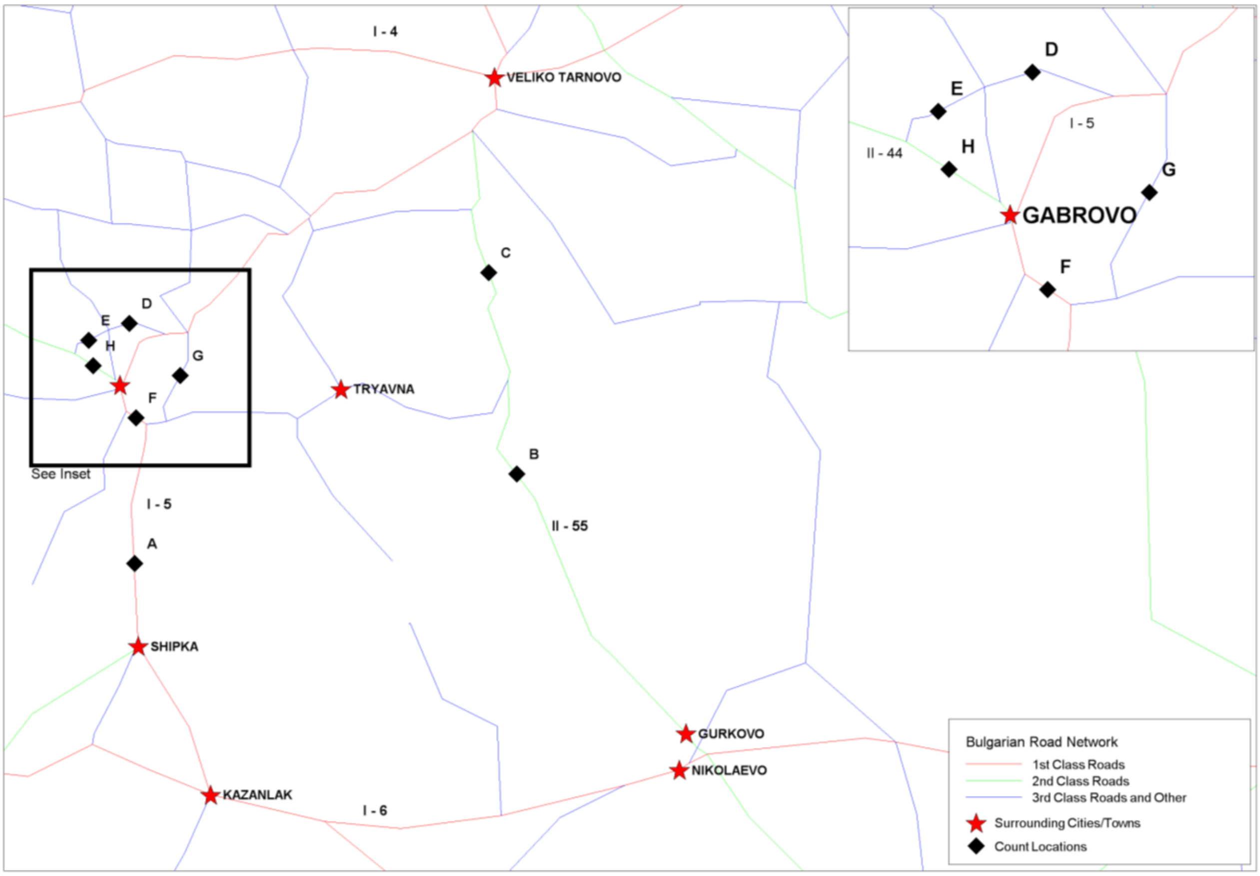
4.12.1 Flow Validation

Table 4.20 summarises the 2008 validation at count locations along the Gabrovo corridor and on roads approaching and leaving the corridor. Count locations were also recorded on parallel roads to the corridor to provide an indication of traffic on competing routes. **Figure 4.8** illustrates the locations referred to in the table. Modelled flows with a GEH statistic of less than 5 can be considered as acceptable and reflecting observed flows. The GEH statistic is a statistical formula used in traffic engineering to compare two numbers. The flow validation on the Gabrovo corridor is very good for the count sites located on the existing route, with GEH values less than 5, highlighting a good level of validation.

Table 4.20 2008 Base Model Validation in the Gabrovo Corridor

Count Location	Observed 12 hour 2 – way flow (pcus)	Modelled 12 hour 2 – way flow (pcus)	Difference	GEH	Location
A	1906	2222	316	2.0	I-5,Shipka Pass
B	2846	2800	-46	0.3	II-55,Raykovtsi
C	1616	2055	439	3.0	II-55,Vaglevtsi
D	576	766	190	2.1	IV-5004, Bypass East
E	1440	1305	-135	1.1	IV-5004, Bypass West
F	5424	4632	-792	3.2	I-5, south of Gabrovo
G	1008	1335	327	2.5	IV-5522, Orlovtsi
H	5148	5239	91	0.4	II-44,west of I-5

Figure 4.8 2008 Base Model Validation Count Locations in the Gabrovo Corridor



4.12.2 Journey Time Validation

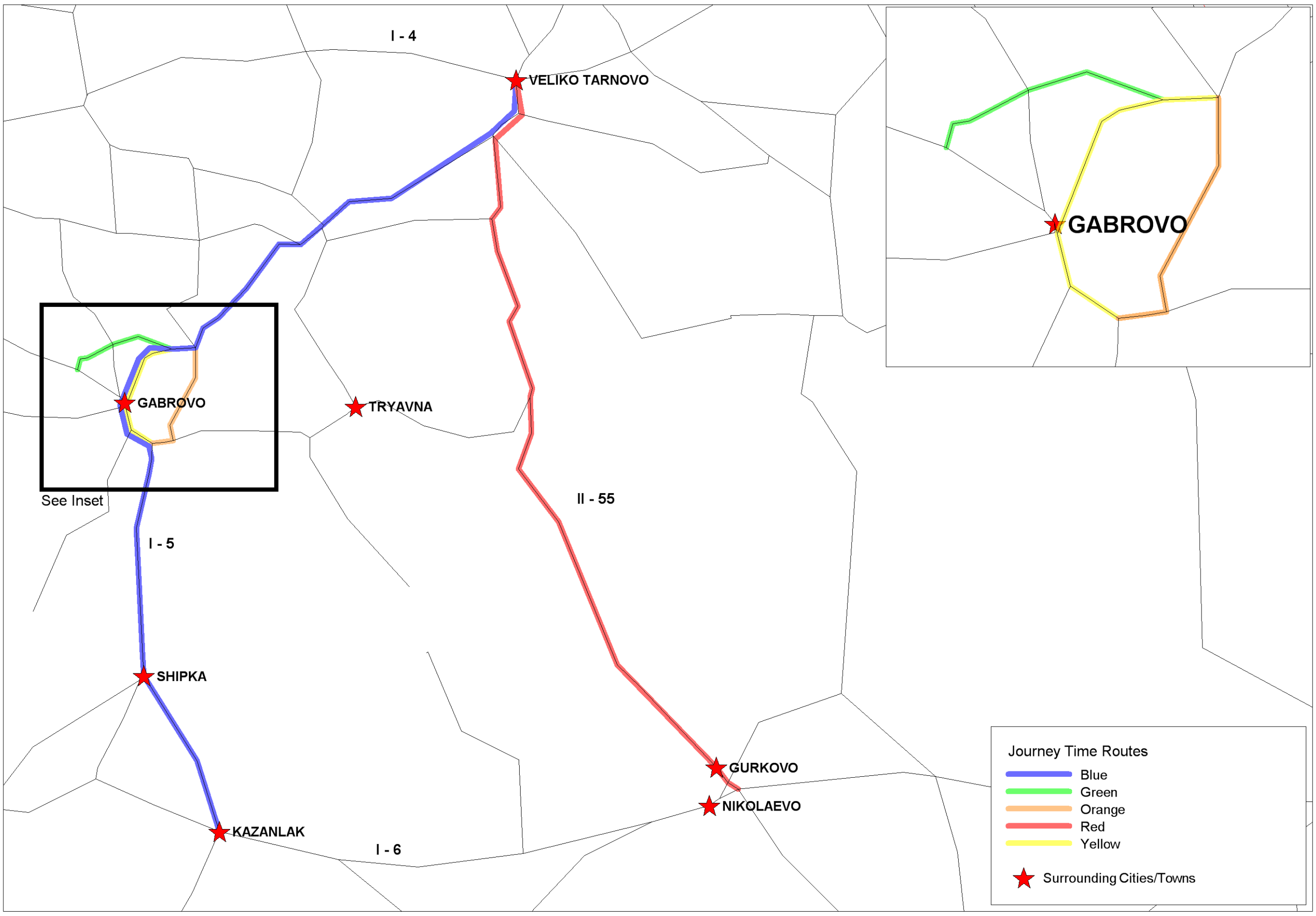
As discussed in ***Chapter 4.7***, the Gabrovo corridor was included in the network-wide journey time surveys undertaken to validate the entire model network. In August and September 2011, additional journey time surveys were undertaken in the Gabrovo area to enable a comparison of the modelled and observed journey times, providing additional detail in the corridor. Several different routes were surveyed to provide coverage along the corridor and on the surrounding network. Surveys were undertaken along strategic routes on the I-5, between the junction with the I-4 at Veliko Tarnovo and junction with the I-6 at Kazanlak, as well as the II-55 between the junction with the I-4 at Veliko Tarnovo and the I-6 at Gurkovo. Within Gabrovo, surveys were undertaken along the I-5, through the centre of the town and on the surrounding roads of the IV-5004 and IV-5522. The routes that were surveyed are shown in **Figure 4.9**, with surveys being undertaken in both directions on a neutral weekday.

Table 4.21 shows the comparison of modelled and observed journey times and indicates that the model journey times match observed to an acceptable level. Modelled journey times that are within 15% of those observed can be considered acceptable, so the figures demonstrate that the model performs well in the corridor and adjacent roads in terms of replicating journey times. Within the corridor, the modelled journey times reflect the observed conditions extremely well, with times within 10% of the observed. However, as the model generally over-estimates the journey times along the existing strategic routes, it may overestimate the likely benefits of the scheme as more trips re-route onto the new road to avoid the existing slower sections.

Table 4.21 Comparison of Modelled and Observed Journey Times in the Gabrovo Corridor and Surrounding Roads

Route	Direction	Modelled Time (mins : secs)	Observed Time (mins : secs)	Difference (%)
Blue	Northbound	94:36	90:54	+4
	Southbound	95:00	90:36	+5
Red	Northbound	59:42	54:24	+10
	Southbound	59:42	52:48	+13
Green	Eastbound	9:30	10:03	-5
	Westbound	9:30	9:36	-1
Yellow	Northbound	17:54	17:53	+0
	Southbound	17:54	19:41	-9
Orange	Northbound	10:30	11:22	-8
	Southbound	10:30	10:04	+4

Figure 4.9 Journey Time Survey Routes



4.13 Development of the Without Project Network

The ‘without project’ (Do Minimum) network has been created to include all major committed transport infrastructure up to 2015. All the forecast year ‘without project’ networks are the same. The ‘with project’ (Do Something) outputs are compared against the ‘without project’ model to isolate the impacts of the future year option. This enables a fair evaluation of the scheme.

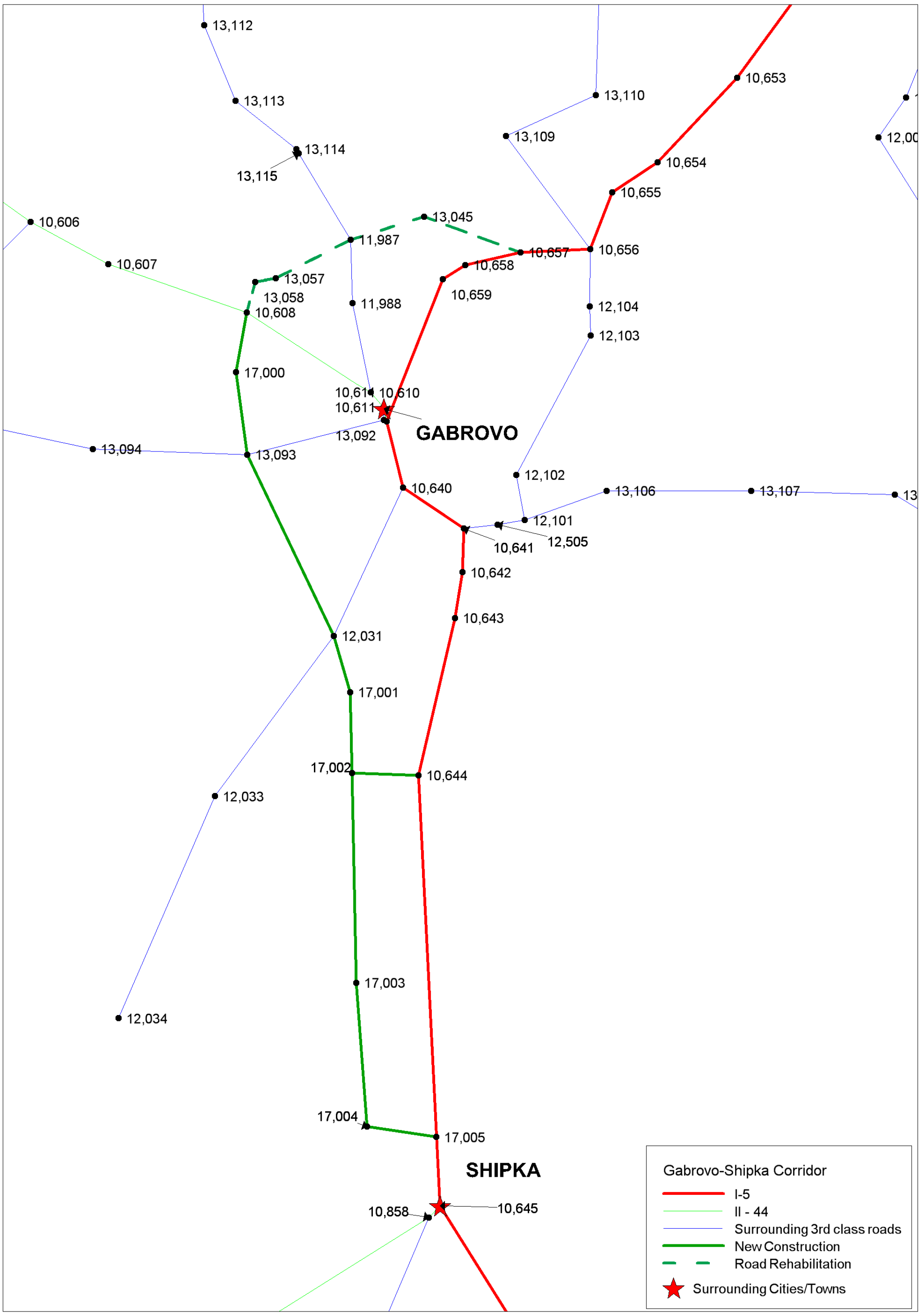
The ‘without project’ network includes committed schemes in Bulgaria, including the Vidin Road Bridge and Lyulin Highway (Sofia to Pernik). These two schemes are unlikely to have any significant impact on the Gabrovo corridor. The ‘without project’ scheme also includes the completion of the Trakia motorway, and anticipated four highway schemes identified for completion under the Operational Programme for Transport, 2007 – 2013; namely the Maritsa

Motorway, Hemus Motorway, Struma Highway and Kardzhali-Podkova Highway. These schemes, and particularly the latter, are likely to have some impact on the traffic along the Gabrovo corridor.

4.14 Development of the With Project Networks

The ‘with project’ network has been created to include all of the Do Minimum committed schemes and the new highway network identified in the different options. The ‘with project’ network is shown diagrammatically in **Figure 4.10.** The new section is shown in green, with the numbers representing the node numbers along the corridor, used in the model.

Figure 4.10 With Project Network Development – Gabrovo Corridor



5 Traffic Forecasts

5.1 Description of the Forecast Traffic Conditions

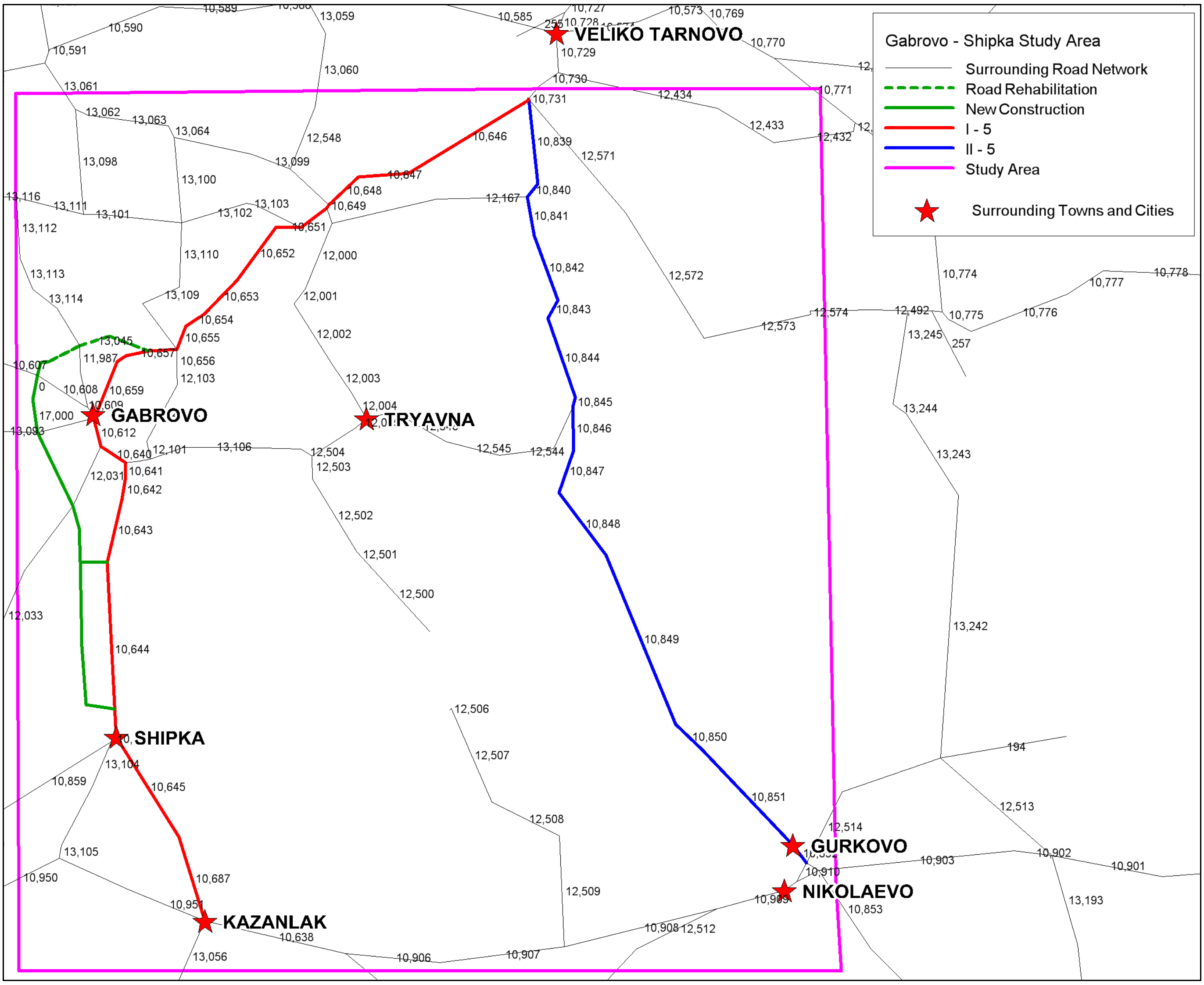
This section of the report focuses on the traffic forecasts. Information is provided on:

- Traffic flows;
- Traffic speeds;
- The composition of the traffic flow in terms of vehicle types;
- Typical trip lengths for traffic using the route;
- The composition of the traffic flows in terms of international and local traffic; and
- The proportion of generated traffic produced by the scheme (where generated traffic includes induced (new) trips, those switching from other modes and redistributed trips).

The interpretation of this data does require some care. The traffic model represents inter-urban traffic movements and was calibrated and validated for these movements. This level of modelling is entirely appropriate for evaluating strategic proposals, such as the Gabrovo-Shipka scheme, designed to cater for inter-urban traffic. The model, therefore, does not include short distance traffic on links within built-up areas. This means that, while the flows shown on inter-urban links are a realistic forecast, the flows on urban links may well be lower than those actually achieved on outturn. Similarly, the transfer of traffic to the Gabrovo bypass and Shipka tunnel is correctly represented, but the residual flows on links within built-up areas may be underestimated, meaning that percentage reductions in urban areas are overstated.

Figure 5.1 shows the correlation between node and link references in the tables in the Gabrovo corridor, and their location in the project. The figure also presents the node and link references in the wider study area used in the analysis of the wider scheme benefits. The traffic forecast analysis is performed only in the Gabrovo corridor, for links in the immediate vicinity of the new road.

Figure 5.1 Gabrovo Highway Study Area Corridor Node and Link References



5.2 Forecast Traffic Flows, and Composition

5.2.1 Bypass and Tunnel Preferred Option E

Tables 5.1 to 5.4 summarise the traffic flows and traffic composition in the Gabrovo corridor for the base year (2008) and for four forecast years (2015, 2020, 2030 and 2040), for both the ‘with’ and ‘without project’ options for Option E. The last nine rows of the tables represent the new scheme links; the preceding four rows represent sections of the existing road that are improved. The remaining preceding rows represent sections of the existing road within the core study area corridor. No data is presented for 2015 'with' project because it is expected that the 'with' project construction will not be complete until 2020.

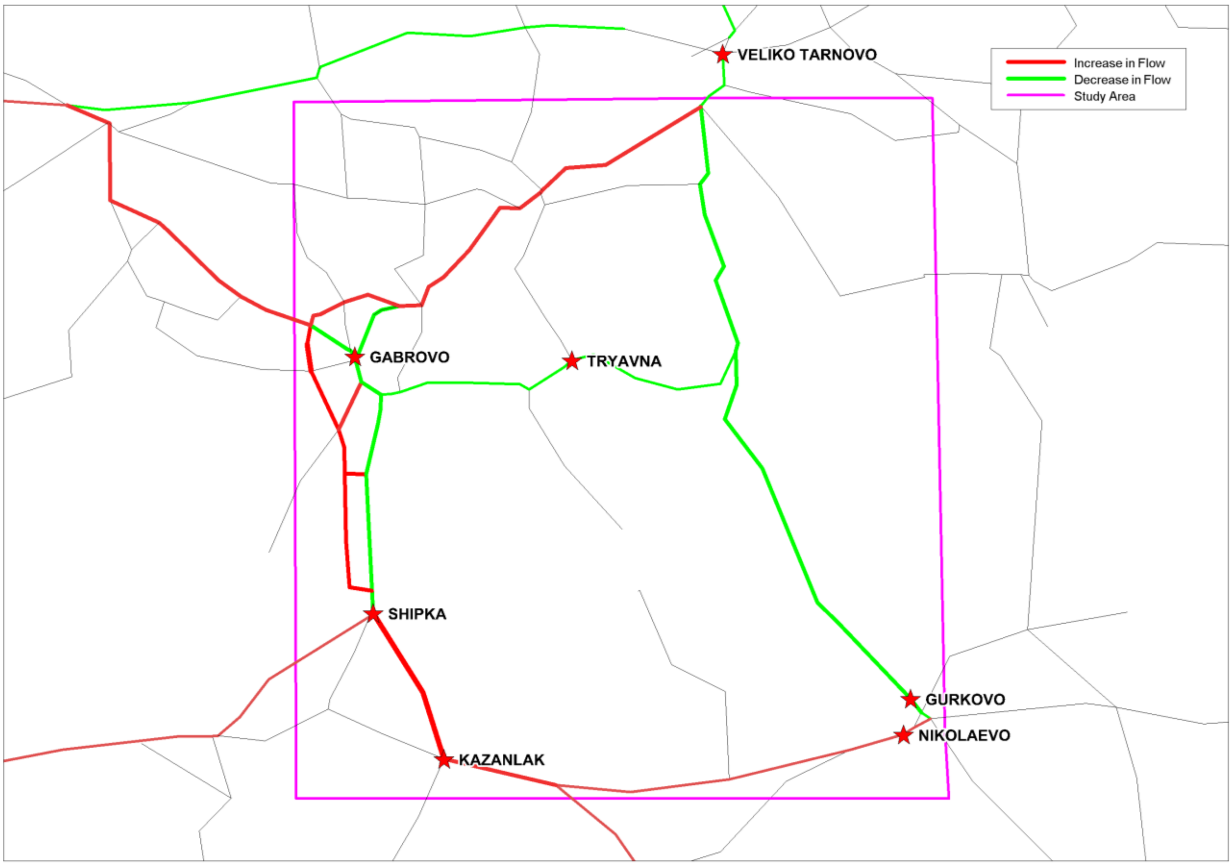
Considering the data in **Table 5.1**, a comparison against the base year for typical links along the existing road without the project shows growth of 18% approaching Gabrovo and 4% on the pass between 2008 and 2015. The growth from 2008 to 2020 is typically 24% and 8% whilst for 2030 the growth is between 33% and 39% approaching Gabrovo and for 2040 the growth is between 39% and 46%. On the pass, the growth is typically 17% and 22% in 2030 and 2040 respectively.

The traffic flows show a logical pattern along the route, with flows decreasing in Gabrovo as a result of the majority of through traffic diverting onto the bypass and tunnel. For example, in 2030, forecast flows are 5,233 on the link in Gabrovo centre without the project, decreasing to 677 with the project. Of course, in reality there will be a small volume of residual local traffic on these links. The pattern of relief to the existing road (I-5) is logical also, bearing in mind that the model contains medium and long-distance interurban traffic. For example, the relatively high flow of 4,700 vehicles on link 10656 – 10657 is associated with traffic from Veliko Tarnovo: by contrast, the zero flows between 10644 and 17005 are a result of the new Stage 5 tunnel section.

Figure 5.2 presents the change in flow across the study area in 2020 as a result of the bypass and tunnel being implemented. Across the wider study area, the switch in traffic is largely from the adjacent II-55, which provides a parallel altern**a**tive to the I-5 in the without project scenario. Traffic which previously used the II-55 to travel between Veliko Tarnovo and south of Shipka, has switched to use the new bypass and tunnel despite the longer journey. The new bypass and tunnel section also provides improved access for movements between the north and south of Gabrovo, For example, there is an increase in demand along the II-35 to/from Pleven, north-west of Gabrovo to/from Plovdiv and Karlovo, south of Gabrovo, which accounts for a significant amount of the demand on the new tunnel section.

Tables 5.2 to **5.4** show the composition of the traffic in the immediate vicinity of Gabrovo and the Shipka Pass in the base and future years for both the 'with' and 'without' project scheme scenarios.

Figure 5.2 Change in flow across the wider study area in 2020 – Option E



Increase in traffic demand is represented by red, decrease by green with the thickness of the line representing the magnitude of the change in flow.

Table 5.1 Traffic Flow in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	2,554	3,024	-	3,164	5,347	3,547	7,182	3,740	7,834
I-5	10657	10658	1,788	2,126	-	2,215	2,164	2,378	2,313	2,494	2,418
I-5	10658	10659	1,788	2,126	-	2,215	2,164	2,378	2,313	2,494	2,418
I-5	10659	10611	1,788	2,126	-	2,215	2,164	2,378	2,313	2,494	2,418
I-5	10611	10612	9,205	11,510	-	11,914	9,085	12,433	9,566	12,693	9,414
I-5	10612	10640	4,631	4,930	-	5,071	3,060	5,233	3,281	5,371	3,068

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10640	10641	4,631	4,930	-	5,071	660	5,233	677	5,371	678
I-5	10641	10642	4,379	4,551	-	4,723	1,254	5,101	128	5,323	129
I-5	10642	10643	4,379	4,551	-	4,723	1,254	5,101	128	5,323	129
I-5	10643	10644	4,379	4,551	-	4,723	1,254	5,101	128	5,323	129
I-5	10644	17005	4,379	4,551	-	4,723	0	5,101	0	5,323	0
I-5	17005	10645	4,379	4,551	-	4,723	11,863	5,101	13,109	5,323	14,093
IV-5522	10656	12104	1,334	1,223	-	1,315	1,131	1,505	0	1,583	0
IV-5522	12104	12103	1,334	1,223	-	1,315	1,131	1,505	0	1,583	0
IV-5522	12103	12102	1,334	1,223	-	1,315	1,131	1,505	0	1,583	0
IV-5522	12102	12101	1,334	1,223	-	1,315	1,131	1,505	0	1,583	0
III-552	12101	12505	3,149	3,003	-	3,159	1,913	3,325	805	3,399	807
III-552	12505	10641	3,149	3,003	-	3,159	1,913	3,325	805	3,399	807
IV-5006	10640	12031	0	0	-	0	2,400	0	2,604	0	2,390
IV-4404	10612	13092	0	0	-	0	0	0	0	0	0
IV-4404	13092	13093	0	0	-	0	0	0	0	0	0
II-44	10611	10610	7,417	9,384	-	9,699	6,921	10,055	7,252	10,199	6,996
II-44	10610	10609	5,239	6,717	-	6,896	4,488	7,173	4,625	7,195	4,618
II-44	10609	10608	5,239	6,717	-	6,896	4,488	7,173	4,625	7,195	4,618
Minor Rd	11987	11988	2,151	2,720	-	2,858	3,226	3,226	3,479	3,384	4,009
Stage 1	13045	11987	766	898	-	949	3,183	1,169	4,869	1,246	5,416
Stage 1	11987	13057	1,305	1,745	-	1,835	4,589	1,978	6,383	2,074	7,338
Stage 1	13057	13058	1,305	1,745	-	1,835	4,589	1,978	6,383	2,074	7,338
Stage 1	13058	10608	1,305	1,745	-	1,835	4,589	1,978	6,383	2,074	7,338
Stage 2	10608	17000	-	-	-	-	8,209	-	10,377	-	11,574
Stage 2	17000	13093	-	-	-	-	8,209	-	10,377	-	11,574
Stage 3	13093	12031	-	-	-	-	8,209	-	10,377	-	11,574
Stage 4	12031	17001	-	-	-	-	10,609	-	12,981	-	13,964
Stage 4	17001	17002	-	-	-	-	10,609	-	12,981	-	13,964
Connector	10644	17002	-	-	-	-	1,254	-	128	-	129
Stage 5	17002	17003	-	-	-	-	11,863	-	13,109	-	14,093
Stage 5	17003	17004	-	-	-	-	11,863	-	13,109	-	14,093
Stage 5	17004	17005	-	-	-	-	11,863	-	13,109	-	14,093

Table 5.2 Car Traffic Composition in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Traffic Composition (% Car)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	62%	75%	-	76%	83%	77%	68%	76%	66%
I-5	10657	10658	62%	76%	-	76%	76%	76%	76%	75%	75%
I-5	10658	10659	62%	76%	-	76%	76%	76%	76%	75%	75%
I-5	10659	10611	62%	76%	-	76%	76%	76%	76%	75%	75%
I-5	10611	10612	71%	82%	-	82%	83%	82%	83%	81%	86%
I-5	10612	10640	49%	67%	-	66%	62%	64%	61%	62%	67%
I-5	10640	10641	49%	67%	-	66%	85%	64%	85%	62%	86%
I-5	10641	10642	48%	66%	-	65%	7%	64%	72%	61%	72%
I-5	10642	10643	48%	66%	-	65%	7%	64%	72%	61%	72%
I-5	10643	10644	48%	66%	-	65%	7%	64%	72%	61%	72%
I-5	10644	17005	48%	66%	-	65%	-	64%	-	61%	-
I-5	17005	10645	48%	66%	-	65%	70%	64%	69%	61%	67%
IV-5522	10656	12104	31%	50%	-	50%	0%	49%	-	48%	-
IV-5522	12104	12103	31%	50%	-	50%	0%	49%	-	48%	-
IV-5522	12103	12102	31%	50%	-	50%	0%	49%	-	48%	-
IV-5522	12102	12101	31%	50%	-	50%	0%	49%	-	48%	-
III-552	12101	12505	36%	54%	-	54%	34%	51%	83%	50%	83%
III-552	12505	10641	36%	54%	-	54%	34%	51%	83%	50%	83%
IV-5006	10640	12031	-	-	-	-	55%	-	55%	-	61%
IV-4404	10612	13092	-	-	-	-	-	-	-	-	-
IV-4404	13092	13093	-	-	-	-	-	-	-	-	-
II-44	10611	10610	74%	84%	-	84%	85%	83%	85%	83%	90%
II-44	10610	10609	74%	83%	-	84%	86%	83%	87%	83%	87%
II-44	10609	10608	74%	83%	-	84%	86%	83%	87%	83%	87%
Minor Rd	11987	11988	72%	81%	-	81%	82%	81%	82%	82%	75%
Stage 1	13045	11987	62%	75%	-	75%	88%	77%	65%	76%	62%
Stage 1	11987	13057	81%	85%	-	85%	89%	85%	71%	86%	65%
Stage 1	13057	13058	81%	85%	-	85%	89%	85%	71%	86%	65%
Stage 1	13058	10608	81%	85%	-	85%	89%	85%	71%	86%	65%
Stage 2	10608	17000	-	-	-	-	83%	-	72%	-	68%
Stage 2	17000	13093	-	-	-	-	83%	-	72%	-	68%
Stage 3	13093	12031	-	-	-	-	83%	-	72%	-	68%
Stage 4	12031	17001	-	-	-	-	77%	-	69%	-	67%
Stage 4	17001	17002	-	-	-	-	77%	-	69%	-	67%
Connector	10644	17002	-	-	-	-	7%	-	72%	-	72%
Stage 5	17002	17003	-	-	-	-	70%	-	69%	-	67%
Stage 5	17003	17004	-	-	-	-	70%	-	69%	-	67%
Stage 5	17004	17005	-	-	-	-	70%	-	69%	-	67%

Table 5.3 HGV Traffic Composition in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Traffic Composition (% HGV)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	12%	12%	-	12%	7%	13%	23%	15%	26%
I-5	10657	10658	20%	12%	-	12%	12%	13%	14%	16%	16%
I-5	10658	10659	20%	12%	-	12%	12%	13%	14%	16%	16%
I-5	10659	10611	20%	12%	-	12%	12%	13%	14%	16%	16%
I-5	10611	10612	16%	8%	-	9%	7%	10%	8%	11%	6%
I-5	10612	10640	37%	22%	-	23%	27%	26%	29%	30%	25%
I-5	10640	10641	37%	22%	-	23%	4%	26%	4%	30%	5%
I-5	10641	10642	36%	22%	-	23%	80%	26%	12%	30%	14%
I-5	10642	10643	36%	22%	-	23%	80%	26%	12%	30%	14%
I-5	10643	10644	36%	22%	-	23%	80%	26%	12%	30%	14%
I-5	10644	17005	36%	22%	-	23%	-	26%	-	30%	-
I-5	17005	10645	36%	22%	-	23%	22%	26%	24%	30%	27%
IV-5522	10656	12104	52%	35%	-	36%	88%	40%	-	43%	-
IV-5522	12104	12103	52%	35%	-	36%	88%	40%	-	43%	-
IV-5522	12103	12102	52%	35%	-	36%	88%	40%	-	43%	-
IV-5522	12102	12101	52%	35%	-	36%	88%	40%	-	43%	-
III-552	12101	12505	49%	33%	-	34%	54%	39%	6%	41%	6%
III-552	12505	10641	49%	33%	-	34%	54%	39%	6%	41%	6%
IV-5006	10640	12031	-	-	-	-	33%	-	35%	-	31%
IV-4404	10612	13092	-	-	-	-	-	-	-	-	-
IV-4404	13092	13093	-	-	-	-	-	-	-	-	-
II-44	10611	10610	15%	8%	-	8%	6%	9%	6%	10%	3%
II-44	10610	10609	15%	7%	-	7%	3%	8%	3%	10%	4%
II-44	10609	10608	15%	7%	-	7%	3%	8%	3%	10%	4%
Minor Rd	11987	11988	13%	7%	-	7%	6%	7%	7%	7%	14%
Stage 1	13045	11987	20%	12%	-	12%	4%	12%	27%	13%	31%
Stage 1	11987	13057	6%	3%	-	3%	2%	3%	20%	3%	27%
Stage 1	13057	13058	6%	3%	-	3%	2%	3%	20%	3%	27%
Stage 1	13058	10608	6%	3%	-	3%	2%	3%	20%	3%	27%
Stage 2	10608	17000	-	-	-	-	10%	-	21%	-	26%
Stage 2	17000	13093	-	-	-	-	10%	-	21%	-	26%
Stage 3	13093	12031	-	-	-	-	10%	-	21%	-	26%
Stage 4	12031	17001	-	-	-	-	15%	-	24%	-	27%
Stage 4	17001	17002	-	-	-	-	15%	-	24%	-	27%
Connector	10644	17002	-	-	-	-	80%	-	12%	-	14%
Stage 5	17002	17003	-	-	-	-	22%	-	24%	-	27%
Stage 5	17003	17004	-	-	-	-	22%	-	24%	-	27%
Stage 5	17004	17005	-	-	-	-	22%	-	24%	-	27%

Table 5.4 LGV Traffic Composition in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Traffic Composition (% LGV)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	6%	7%	-	7%	7%	6%	5%	6%	4%
I-5	10657	10658	6%	7%	-	6%	6%	6%	6%	5%	5%
I-5	10658	10659	6%	7%	-	6%	6%	6%	6%	5%	5%
I-5	10659	10611	6%	7%	-	6%	6%	6%	6%	5%	5%
I-5	10611	10612	6%	6%	-	6%	6%	6%	6%	5%	6%
I-5	10612	10640	4%	6%	-	5%	4%	5%	4%	4%	4%
I-5	10640	10641	4%	6%	-	5%	8%	5%	7%	4%	7%
I-5	10641	10642	5%	6%	-	6%	1%	5%	6%	5%	5%
I-5	10642	10643	5%	6%	-	6%	1%	5%	6%	5%	5%
I-5	10643	10644	5%	6%	-	6%	1%	5%	6%	5%	5%
I-5	10644	17005	5%	6%	-	6%	-	5%	-	5%	-
I-5	17005	10645	5%	6%	-	6%	4%	5%	3%	5%	3%
IV-5522	10656	12104	5%	6%	-	6%	0%	5%	-	4%	-
IV-5522	12104	12103	5%	6%	-	6%	0%	5%	-	4%	-
IV-5522	12103	12102	5%	6%	-	6%	0%	5%	-	4%	-
IV-5522	12102	12101	5%	6%	-	6%	0%	5%	-	4%	-
III-552	12101	12505	4%	6%	-	6%	3%	5%	7%	4%	7%
III-552	12505	10641	4%	6%	-	6%	3%	5%	7%	4%	7%
IV-5006	10640	12031	-	-	-	-	3%	-	3%	-	3%
IV-4404	10612	13092	-	-	-	-	-	-	-	-	-
IV-4404	13092	13093	-	-	-	-	-	-	-	-	-
II-44	10611	10610	6%	6%	-	6%	6%	6%	6%	5%	6%
II-44	10610	10609	8%	8%	-	8%	9%	7%	9%	6%	8%
II-44	10609	10608	8%	8%	-	8%	9%	7%	9%	6%	8%
Minor Rd	11987	11988	8%	9%	-	9%	9%	9%	9%	9%	8%
Stage 1	13045	11987	6%	7%	-	7%	7%	7%	4%	7%	4%
Stage 1	11987	13057	10%	10%	-	10%	8%	10%	6%	10%	5%
Stage 1	13057	13058	10%	10%	-	10%	8%	10%	6%	10%	5%
Stage 1	13058	10608	10%	10%	-	10%	8%	10%	6%	10%	5%
Stage 2	10608	17000	-	-	-	-	5%	-	4%	-	3%
Stage 2	17000	13093	-	-	-	-	5%	-	4%	-	3%
Stage 3	13093	12031	-	-	-	-	5%	-	4%	-	3%
Stage 4	12031	17001	-	-	-	-	4%	-	3%	-	3%
Stage 4	17001	17002	-	-	-	-	4%	-	3%	-	3%
Connector	10644	17002	-	-	-	-	1%	-	6%	-	5%
Stage 5	17002	17003	-	-	-	-	4%	-	3%	-	3%
Stage 5	17003	17004	-	-	-	-	4%	-	3%	-	3%
Stage 5	17004	17005	-	-	-	-	4%	-	3%	-	3%

5.2.2 Bypass Only Preferred Option J

Considering the data in **Table 5.5**, results of the 'with' project scenario, traffic flows show a decrease in Gabrovo centre as a result of the majority of through traffic from the west (II-44) diverting onto the bypass at Stage 2 to avoid travelling through the centre. For example, in 2030, forecast flows are 12,433 on the link in Gabrovo centre without the project, decreasing to 9,881 with the project. The pattern of relief to the existing road (I-5) for traffic from the north is unaffected. The route using the IV-5522 via Orlovtsi to bypass Gabrovo still maintains a similar volume of traffic with and without the project. In 2030, the without the project flow is 1,505, decreasing to 1,463 in the 'with' project situation. The bypass route does provide some relief for traffic to bypass Gabrovo, but this is generally for traffic from the west, as traffic from the north remains on the existing II-55 road network to the east

Tables 5.6 to **5.8** show the composition of the traffic in the base and future years for both the 'with' and 'without project' scheme scenarios.

Table 5.5 Traffic Flow in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	2,554	3,024	-	3,164	3,306	3,547	3,558	3,740	3,745
I-5	10657	10658	1,788	2,126	-	2,215	2,216	2,378	2,380	2,494	2,497
I-5	10658	10659	1,788	2,126	-	2,215	2,216	2,378	2,380	2,494	2,497
I-5	10659	10611	1,788	2,126	-	2,215	2,216	2,378	2,380	2,494	2,497
I-5	10611	10612	9,205	11,510	-	11,914	9,358	12,433	9,881	12,693	10,121
I-5	10612	10640	4,631	4,930	-	5,071	2,524	5,233	2,687	5,371	2,809
I-5	10640	10641	4,631	4,930	-	5,071	2,524	5,233	2,687	5,371	2,809
I-5	10641	10642	4,379	4,551	-	4,723	2,304	5,101	2,518	5,323	2,559
I-5	10642	10643	4,379	4,551	-	4,723	2,304	5,101	2,518	5,323	2,559
I-5	10643	10644	4,379	4,551	-	4,723	2,304	5,101	2,518	5,323	2,559
I-5	10644	17005	4,379	4,551	-	4,723	5,065	5,101	5,503	5,323	5,662
I-5	17005	10645	4,379	4,551	-	4,723	5,065	5,101	5,503	5,323	5,662
IV-5522	10656	12104	1,334	1,223	-	1,315	1,306	1,505	1,463	1,583	1,453
IV-5522	12104	12103	1,334	1,223	-	1,315	1,306	1,505	1,463	1,583	1,453
IV-5522	12103	12102	1,334	1,223	-	1,315	1,306	1,505	1,463	1,583	1,453
IV-5522	12102	12101	1,334	1,223	-	1,315	1,306	1,505	1,463	1,583	1,453
III-552	12101	12505	3,149	3,003	-	3,159	3,012	3,325	3,278	3,399	3,337
III-552	12505	10641	3,149	3,003	-	3,159	3,012	3,325	3,278	3,399	3,337

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
IV-5006	10640	12031	0	0	-	0	0	0	0	0	0
IV-4404	10612	13092	0	0	-	0	0	0	0	0	0
IV-4404	13092	13093	0	0	-	0	0	0	0	0	0
II-44	10611	10610	7,417	9,384	-	9,699	7,141	10,055	7,500	10,199	7,624
II-44	10610	10609	5,239	6,717	-	6,896	4,707	7,173	4,872	7,195	4,875
II-44	10609	10608	5,239	6,717	-	6,896	4,707	7,173	4,872	7,195	4,875
Minor Rd	11987	11988	2,151	2,720	-	2,858	3,227	3,226	3,480	3,384	3,640
Stage 1	13045	11987	766	898	-	949	1,089	1,169	1,178	1,246	1,248
Stage 1	11987	13057	1,305	1,745	-	1,835	2,064	1,978	2,253	2,074	2,357
Stage 1	13057	13058	1,305	1,745	-	1,835	2,064	1,978	2,253	2,074	2,357
Stage 1	13058	10608	1,305	1,745	-	1,835	2,064	1,978	2,253	2,074	2,357
Stage 2	10608	17000	-	-	-	-	2,761	-	2,985	-	3,103
Stage 2	17000	13093	-	-	-	-	2,761	-	2,985	-	3,103
Stage 3	13093	12031	-	-	-	-	2,761	-	2,985	-	3,103
Stage 4	12031	17001	-	-	-	-	2,761	-	2,985	-	3,103
Stage 4	17001	17002	-	-	-	-	2,761	-	2,985	-	3,103
Connector	10644	17002	-	-	-	-	2,761	-	2,985	-	3,103

Table 5.6 Car Traffic Composition in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Traffic Composition (% Car)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	62%	75%	-	76%	76%	77%	77%	76%	76%
I-5	10657	10658	62%	76%	-	76%	76%	76%	76%	75%	75%
I-5	10658	10659	62%	76%	-	76%	76%	76%	76%	75%	75%
I-5	10659	10611	62%	76%	-	76%	76%	76%	76%	75%	75%
I-5	10611	10612	71%	82%	-	82%	83%	82%	84%	81%	83%
I-5	10612	10640	49%	67%	-	66%	54%	64%	52%	62%	50%
I-5	10640	10641	49%	67%	-	66%	54%	64%	52%	62%	50%
I-5	10641	10642	48%	66%	-	65%	52%	64%	51%	61%	48%
I-5	10642	10643	48%	66%	-	65%	52%	64%	51%	61%	48%
I-5	10643	10644	48%	66%	-	65%	52%	64%	51%	61%	48%
I-5	10644	17005	48%	66%	-	65%	67%	64%	66%	61%	64%
I-5	17005	10645	48%	66%	-	65%	67%	64%	66%	61%	64%
IV-5522	10656	12104	31%	50%	-	50%	50%	49%	48%	48%	44%
IV-5522	12104	12103	31%	50%	-	50%	50%	49%	48%	48%	44%
IV-5522	12103	12102	31%	50%	-	50%	50%	49%	48%	48%	44%
IV-5522	12102	12101	31%	50%	-	50%	50%	49%	48%	48%	44%
III-552	12101	12505	36%	54%	-	54%	52%	51%	50%	50%	48%
III-552	12505	10641	36%	54%	-	54%	52%	51%	50%	50%	48%
IV-5006	10640	12031	-	-	-	-	-	-	-	-	-
IV-4404	10612	13092	-	-	-	-	-	-	-	-	-
IV-4404	13092	13093	-	-	-	-	-	-	-	-	-
II-44	10611	10610	74%	84%	-	84%	86%	83%	86%	83%	86%
II-44	10610	10609	74%	83%	-	84%	87%	83%	87%	83%	87%
II-44	10609	10608	74%	83%	-	84%	87%	83%	87%	83%	87%
Minor Rd	11987	11988	72%	81%	-	81%	82%	81%	82%	82%	82%
Stage 1	13045	11987	62%	75%	-	75%	77%	77%	77%	76%	76%
Stage 1	11987	13057	81%	85%	-	85%	86%	85%	86%	86%	86%
Stage 1	13057	13058	81%	85%	-	85%	86%	85%	86%	86%	86%
Stage 1	13058	10608	81%	85%	-	85%	86%	85%	86%	86%	86%
Stage 2	10608	17000	-	-	-	-	80%	-	80%	-	78%
Stage 2	17000	13093	-	-	-	-	80%	-	80%	-	78%
Stage 3	13093	12031	-	-	-	-	80%	-	80%	-	78%
Stage 4	12031	17001	-	-	-	-	80%	-	80%	-	78%
Stage 4	17001	17002	-	-	-	-	80%	-	80%	-	78%
Connector	10644	17002	-	-	-	-	80%	-	80%	-	78%

Table 5.7 HGV Traffic Composition in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Traffic Composition (% HGV)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	12%	12%	-	12%	11%	13%	13%	15%	15%
I-5	10657	10658	20%	12%	-	12%	12%	13%	13%	16%	16%
I-5	10658	10659	20%	12%	-	12%	12%	13%	13%	16%	16%
I-5	10659	10611	20%	12%	-	12%	12%	13%	13%	16%	16%
I-5	10611	10612	16%	8%	-	9%	7%	10%	8%	11%	9%
I-5	10612	10640	37%	22%	-	23%	32%	26%	35%	30%	39%
I-5	10640	10641	37%	22%	-	23%	32%	26%	35%	30%	39%
I-5	10641	10642	36%	22%	-	23%	31%	26%	35%	30%	40%
I-5	10642	10643	36%	22%	-	23%	31%	26%	35%	30%	40%
I-5	10643	10644	36%	22%	-	23%	31%	26%	35%	30%	40%
I-5	10644	17005	36%	22%	-	23%	21%	26%	24%	30%	27%
I-5	17005	10645	36%	22%	-	23%	21%	26%	24%	30%	27%
IV-5522	10656	12104	52%	35%	-	36%	37%	40%	41%	43%	47%
IV-5522	12104	12103	52%	35%	-	36%	37%	40%	41%	43%	47%
IV-5522	12103	12102	52%	35%	-	36%	37%	40%	41%	43%	47%
IV-5522	12102	12101	52%	35%	-	36%	37%	40%	41%	43%	47%
III-552	12101	12505	49%	33%	-	34%	36%	39%	39%	41%	44%
III-552	12505	10641	49%	33%	-	34%	36%	39%	39%	41%	44%
IV-5006	10640	12031	-	-	-	-	-	-	-	-	-
IV-4404	10612	13092	-	-	-	-	-	-	-	-	-
IV-4404	13092	13093	-	-	-	-	-	-	-	-	-
II-44	10611	10610	15%	8%	-	8%	6%	9%	6%	10%	7%
II-44	10610	10609	15%	7%	-	7%	3%	8%	3%	10%	4%
II-44	10609	10608	15%	7%	-	7%	3%	8%	3%	10%	4%
Minor Rd	11987	11988	13%	7%	-	7%	6%	7%	7%	7%	7%
Stage 1	13045	11987	20%	12%	-	12%	10%	12%	11%	13%	13%
Stage 1	11987	13057	6%	3%	-	3%	3%	3%	3%	3%	3%
Stage 1	13057	13058	6%	3%	-	3%	3%	3%	3%	3%	3%
Stage 1	13058	10608	6%	3%	-	3%	3%	3%	3%	3%	3%
Stage 2	10608	17000	-	-	-	-	13%	-	14%	-	17%
Stage 2	17000	13093	-	-	-	-	13%	-	14%	-	17%
Stage 3	13093	12031	-	-	-	-	13%	-	14%	-	17%
Stage 4	12031	17001	-	-	-	-	13%	-	14%	-	17%
Stage 4	17001	17002	-	-	-	-	13%	-	14%	-	17%
Connector	10644	17002	-	-	-	-	13%	-	14%	-	17%

Table 5.8 LGV Traffic Composition in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Traffic Composition (% LGV)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	6%	7%	-	7%	7%	6%	6%	6%	6%
I-5	10657	10658	6%	7%	-	6%	6%	6%	6%	5%	5%
I-5	10658	10659	6%	7%	-	6%	6%	6%	6%	5%	5%
I-5	10659	10611	6%	7%	-	6%	6%	6%	6%	5%	5%
I-5	10611	10612	6%	6%	-	6%	6%	6%	6%	5%	5%
I-5	10612	10640	4%	6%	-	5%	5%	5%	5%	4%	4%
I-5	10640	10641	4%	6%	-	5%	5%	5%	5%	4%	4%
I-5	10641	10642	5%	6%	-	6%	6%	5%	5%	5%	4%
I-5	10642	10643	5%	6%	-	6%	6%	5%	5%	5%	4%
I-5	10643	10644	5%	6%	-	6%	6%	5%	5%	5%	4%
I-5	10644	17005	5%	6%	-	6%	5%	5%	5%	5%	4%
I-5	17005	10645	5%	6%	-	6%	5%	5%	5%	5%	4%
IV-5522	10656	12104	5%	6%	-	6%	6%	5%	5%	4%	4%
IV-5522	12104	12103	5%	6%	-	6%	6%	5%	5%	4%	4%
IV-5522	12103	12102	5%	6%	-	6%	6%	5%	5%	4%	4%
IV-5522	12102	12101	5%	6%	-	6%	6%	5%	5%	4%	4%
III-552	12101	12505	4%	6%	-	6%	5%	5%	5%	4%	4%
III-552	12505	10641	4%	6%	-	6%	5%	5%	5%	4%	4%
IV-5006	10640	12031	-	-	-	-	-	-	-	-	-
IV-4404	10612	13092	-	-	-	-	-	-	-	-	-
IV-4404	13092	13093	-	-	-	-	-	-	-	-	-
II-44	10611	10610	6%	6%	-	6%	6%	6%	6%	5%	5%
II-44	10610	10609	8%	8%	-	8%	9%	7%	8%	6%	8%
II-44	10609	10608	8%	8%	-	8%	9%	7%	8%	6%	8%
Minor Rd	11987	11988	8%	9%	-	9%	9%	9%	9%	9%	9%
Stage 1	13045	11987	6%	7%	-	7%	7%	7%	7%	7%	7%
Stage 1	11987	13057	10%	10%	-	10%	10%	10%	10%	10%	10%
Stage 1	13057	13058	10%	10%	-	10%	10%	10%	10%	10%	10%
Stage 1	13058	10608	10%	10%	-	10%	10%	10%	10%	10%	10%
Stage 2	10608	17000	-	-	-	-	5%	-	5%	-	4%
Stage 2	17000	13093	-	-	-	-	5%	-	5%	-	4%
Stage 3	13093	12031	-	-	-	-	5%	-	5%	-	4%
Stage 4	12031	17001	-	-	-	-	5%	-	5%	-	4%
Stage 4	17001	17002	-	-	-	-	5%	-	5%	-	4%
Connector	10644	17002	-	-	-	-	5%	-	5%	-	4%

5.2.3 Tunnel Only Preferred Option N

The data in **Table 5.9** show traffic flows that followa logical pattern along the route, with flows transferring from the existing I-5 road to the new tunnel section. For example, in 2030, forecast flows are 5,101 on the link representing the Shipka Pass without the project, decreasing to 0 with the project. The likely benefits that the new tunnel section will deliver are emphasised by an increase in demand using the tunnel. This increase in demand is due to a shift in traffic from the parallel II-55 to the east. In 2030, the flow with the project is 10,048, an increase of 97% on the without project.

As a direct result of this increase in demand using the new tunnel, the traffic flow through Gabrovo has also increased as more traffic is generated from surrounding towns and cities and from Gabrovo itself into the corridor. In 2030, the flow in the centre of Gabrovo shows an increase from 12,433 without the project to 14,024, with the project. The flow on the alternative class IV road to the east also shows an increase in flow. In 2030, the flow is 1,505 without the project increasing to 3,165 with the project, highlighting the shift in traffic from the parallel route due to the benefits delivered by the new tunnel section. However, this option does not generate or attract as much additional demand as Option E which has both the tunnel and bypass in place.

Tables 5.10 to **5.12** show the composition of the traffic in the base and future years for both the ‘with’ and ‘without project’ scheme scenarios.

Table 5.9 Traffic Flow in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	2,554	3,024	-	3,164	3,124	3,547	3,354	3,740	3,523
I-5	10657	10658	1,788	2,126	-	2,215	2,175	2,378	2,328	2,494	2,436
I-5	10658	10659	1,788	2,126	-	2,215	2,175	2,378	2,328	2,494	2,436
I-5	10659	10611	1,788	2,126	-	2,215	2,175	2,378	2,328	2,494	2,436
I-5	10611	10612	9,205	11,510	-	11,914	13,200	12,433	14,024	12,693	14,508
I-5	10612	10640	4,631	4,930	-	5,071	6,886	5,233	7,435	5,371	7,851
I-5	10640	10641	4,631	4,930	-	5,071	6,886	5,233	7,435	5,371	7,851
I-5	10641	10642	4,379	4,551	-	4,723	9,253	5,101	10,048	5,323	10,789
I-5	10642	10643	4,379	4,551	-	4,723	9,253	5,101	10,048	5,323	10,789
I-5	10643	10644	4,379	4,551	-	4,723	9,253	5,101	10,048	5,323	10,789
I-5	10644	17005	4,379	4,551	-	4,723	0	5,101	0	5,323	0
I-5	17005	10645	4,379	4,551	-	4,723	9,253	5,101	10,048	5,323	10,789
IV-5522	10656	12104	1,334	1,223	-	1,315	2,906	1,505	3,165	1,583	3,489
IV-5522	12104	12103	1,334	1,223	-	1,315	2,906	1,505	3,165	1,583	3,489
IV-5522	12103	12102	1,334	1,223	-	1,315	2,906	1,505	3,165	1,583	3,489
IV-5522	12102	12101	1,334	1,223	-	1,315	2,906	1,505	3,165	1,583	3,489

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
III-552	12101	12505	3,149	3,003	-	3,159	3,690	3,325	3,971	3,399	4,295
III-552	12505	10641	3,149	3,003	-	3,159	3,690	3,325	3,971	3,399	4,295
IV-5006	10640	12031	0	0	-	0	0	0	0	0	0
IV-4404	10612	13092	0	0	-	0	0	0	0	0	0
IV-4404	13092	13093	0	0	-	0	0	0	0	0	0
II-44	10611	10610	7,417	9,384	-	9,699	11,024	10,055	11,695	10,199	12,072
II-44	10610	10609	5,239	6,717	-	6,896	8,222	7,173	8,671	7,195	8,908
II-44	10609	10608	5,239	6,717	-	6,896	8,222	7,173	8,671	7,195	8,908
Minor Rd	11987	11988	2,151	2,720	-	2,858	1,835	1,978	1,978	2,074	2,074
Stage 1	13045	11987	766	898	-	949	2,802	2,882	3,024	3,004	3,163
Stage 1	11987	13057	1,305	1,745	-	1,835	949	1,169	1,026	1,246	1,087
Stage 1	13057	13058	1,305	1,745	-	1,835	949	1,169	1,026	1,246	1,087
Stage 1	13058	10608	1,305	1,745	-	1,835	1,835	1,978	1,978	2,074	2,074
Connecto r	10644	17002	-	-	-	-	9,253	-	10,048	-	10,789
Stage 5	17002	17003	-	-	-	-	9,253	-	10,048	-	10,789
Stage 5	17003	17004	-	-	-	-	9,253	-	10,048	-	10,789
Stage 5	17004	17005	-	-	-	-	9,253	-	10,048	-	10,789

Table 5.10 Car Traffic Composition in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Traffic Composition (% Car)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	62%	75%	-	76%	75%	77%	76%	76%	75%
I-5	10657	10658	62%	76%	-	76%	76%	76%	76%	75%	75%
I-5	10658	10659	62%	76%	-	76%	76%	76%	76%	75%	75%
I-5	10659	10611	62%	76%	-	76%	76%	76%	76%	75%	75%
I-5	10611	10612	71%	82%	-	82%	81%	82%	81%	81%	81%
I-5	10612	10640	49%	67%	-	66%	69%	64%	69%	62%	68%
I-5	10640	10641	49%	67%	-	66%	69%	64%	69%	62%	68%
I-5	10641	10642	48%	66%	-	65%	64%	64%	63%	61%	61%
I-5	10642	10643	48%	66%	-	65%	64%	64%	63%	61%	61%
I-5	10643	10644	48%	66%	-	65%	64%	64%	63%	61%	61%
I-5	10644	17005	48%	66%	-	65%	0%	64%	0%	61%	0%
I-5	17005	10645	48%	66%	-	65%	64%	64%	63%	61%	61%
IV-5522	10656	12104	31%	50%	-	50%	56%	49%	53%	48%	50%
IV-5522	12104	12103	31%	50%	-	50%	56%	49%	53%	48%	50%
IV-5522	12103	12102	31%	50%	-	50%	56%	49%	53%	48%	50%
IV-5522	12102	12101	31%	50%	-	50%	56%	49%	53%	48%	50%
III-552	12101	12505	36%	54%	-	54%	61%	51%	59%	50%	56%
III-552	12505	10641	36%	54%	-	54%	61%	51%	59%	50%	56%
IV-5006	10640	12031	-	-	-	0%	0%	0%	0%	0%	0%
IV-4404	10612	13092	-	-	-	0%	0%	0%	0%	0%	0%
IV-4404	13092	13093	-	-	-	0%	0%	0%	0%	0%	0%
II-44	10611	10610	74%	84%	-	84%	82%	83%	82%	83%	82%
II-44	10610	10609	74%	83%	-	84%	81%	83%	81%	83%	81%
II-44	10609	10608	74%	83%	-	84%	81%	83%	81%	83%	81%
Minor Rd	11987	11988	72%	81%	-	85%	85%	85%	85%	86%	86%
Stage 1	13045	11987	62%	75%	-	84%	84%	84%	84%	84%	84%
Stage 1	11987	13057	81%	85%	-	75%	75%	77%	75%	76%	74%
Stage 1	13057	13058	81%	85%	-	75%	75%	77%	75%	76%	74%
Stage 1	13058	10608	81%	85%	-	85%	85%	85%	85%	86%	86%
Connector	10644	17002	-	-	-	-	64%	-	63%	-	61%
Stage 5	17002	17003	-	-	-	-	64%	-	63%	-	61%
Stage 5	17003	17004	-	-	-	-	64%	-	63%	-	61%
Stage 5	17004	17005	-	-	-	-	64%	-	63%	-	61%

Table 5.11 HGV Traffic Composition in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Traffic Composition (% HGV)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	12%	12%	-	12%	12%	13%	13%	15%	16%
I-5	10657	10658	20%	12%	-	12%	12%	13%	13%	16%	16%
I-5	10658	10659	20%	12%	-	12%	12%	13%	13%	16%	16%
I-5	10659	10611	20%	12%	-	12%	12%	13%	13%	16%	16%
I-5	10611	10612	16%	8%	-	9%	10%	10%	11%	11%	12%
I-5	10612	10640	37%	22%	-	23%	21%	26%	23%	30%	25%
I-5	10640	10641	37%	22%	-	23%	21%	26%	23%	30%	25%
I-5	10641	10642	36%	22%	-	23%	27%	26%	30%	30%	32%
I-5	10642	10643	36%	22%	-	23%	27%	26%	30%	30%	32%
I-5	10643	10644	36%	22%	-	23%	27%	26%	30%	30%	32%
I-5	10644	17005	36%	22%	-	23%	0%	26%	0%	30%	0%
I-5	17005	10645	36%	22%	-	23%	27%	26%	30%	30%	32%
IV-5522	10656	12104	52%	35%	-	36%	35%	40%	39%	43%	44%
IV-5522	12104	12103	52%	35%	-	36%	35%	40%	39%	43%	44%
IV-5522	12103	12102	52%	35%	-	36%	35%	40%	39%	43%	44%
IV-5522	12102	12101	52%	35%	-	36%	35%	40%	39%	43%	44%
III-552	12101	12505	49%	33%	-	34%	29%	39%	32%	41%	37%
III-552	12505	10641	49%	33%	-	34%	29%	39%	32%	41%	37%
IV-5006	10640	12031	-	-	-	0%	0%	0%	0%	0%	0%
IV-4404	10612	13092	-	-	-	0%	0%	0%	0%	0%	0%
IV-4404	13092	13093	-	-	-	0%	0%	0%	0%	0%	0%
II-44	10611	10610	15%	8%	-	8%	10%	9%	11%	10%	11%
II-44	10610	10609	15%	7%	-	7%	10%	8%	11%	10%	11%
II-44	10609	10608	15%	7%	-	7%	10%	8%	11%	10%	11%
Minor Rd	11987	11988	13%	7%	-	3%	3%	3%	3%	3%	3%
Stage 1	13045	11987	20%	12%	-	9%	9%	11%	10%	11%	10%
Stage 1	11987	13057	6%	3%	-	12%	12%	12%	13%	13%	15%
Stage 1	13057	13058	6%	3%	-	12%	12%	12%	13%	13%	15%
Stage 1	13058	10608	6%	3%	-	3%	3%	3%	3%	3%	3%
Connector	10644	17002	-	-	-	-	27%	-	30%	-	32%
Stage 5	17002	17003	-	-	-	-	27%	-	30%	-	32%
Stage 5	17003	17004	-	-	-	-	27%	-	30%	-	32%
Stage 5	17004	17005	-	-	-	-	27%	-	30%	-	32%

Table 5.12 LGV Traffic Composition in the Gabrovo Corridor in the Base and Forecast Years, with and without the project

Road	i Node	j Node	Traffic Composition (% LGV)								
			2008	2015		2020		2030		2040	
			Base	Without	With	Without	With	Without	With	Without	With
I-5	10656	10657	6%	7%	-	7%	7%	6%	6%	6%	6%
I-5	10657	10658	6%	7%	-	6%	6%	6%	6%	5%	5%
I-5	10658	10659	6%	7%	-	6%	6%	6%	6%	5%	5%
I-5	10659	10611	6%	7%	-	6%	6%	6%	6%	5%	5%
I-5	10611	10612	6%	6%	-	6%	6%	6%	5%	5%	5%
I-5	10612	10640	4%	6%	-	5%	5%	5%	4%	4%	4%
I-5	10640	10641	4%	6%	-	5%	5%	5%	4%	4%	4%
I-5	10641	10642	5%	6%	-	6%	4%	5%	4%	5%	3%
I-5	10642	10643	5%	6%	-	6%	4%	5%	4%	5%	3%
I-5	10643	10644	5%	6%	-	6%	4%	5%	4%	5%	3%
I-5	10644	17005	5%	6%	-	6%	0%	5%	0%	5%	0%
I-5	17005	10645	5%	6%	-	6%	4%	5%	4%	5%	3%
IV-5522	10656	12104	5%	6%	-	6%	4%	5%	3%	4%	3%
IV-5522	12104	12103	5%	6%	-	6%	4%	5%	3%	4%	3%
IV-5522	12103	12102	5%	6%	-	6%	4%	5%	3%	4%	3%
IV-5522	12102	12101	5%	6%	-	6%	4%	5%	3%	4%	3%
III-552	12101	12505	4%	6%	-	6%	5%	5%	4%	4%	4%
III-552	12505	10641	4%	6%	-	6%	5%	5%	4%	4%	4%
IV-5006	10640	12031	-	-	-	0%	0%	0%	0%	0%	0%
IV-4404	10612	13092	-	-	-	0%	0%	0%	0%	0%	0%
IV-4404	13092	13093	-	-	-	0%	0%	0%	0%	0%	0%
II-44	10611	10610	6%	6%	-	6%	6%	6%	5%	5%	5%
II-44	10610	10609	8%	8%	-	8%	7%	7%	6%	6%	6%
II-44	10609	10608	8%	8%	-	8%	7%	7%	6%	6%	6%
Minor Rd	11987	11988	8%	9%	-	10%	10%	10%	10%	10%	10%
Stage 1	13045	11987	6%	7%	-	2%	2%	2%	2%	2%	2%
Stage 1	11987	13057	10%	10%	-	7%	7%	7%	7%	7%	7%
Stage 1	13057	13058	10%	10%	-	7%	7%	7%	7%	7%	7%
Stage 1	13058	10608	10%	10%	-	10%	10%	10%	10%	10%	10%
Connector	10644	17002		-	-	-	4%	-	4%	-	3%
Stage 5	17002	17003		-	-	-	4%	-	4%	-	3%
Stage 5	17003	17004		-	-	-	4%	-	4%	-	3%
Stage 5	17004	17005		-	-	-	4%	-	4%	-	3%

5.3 Trip Length Distributions

5.3.1 Bypass and Tunnel Preferred Option E

A select link analysis was undertaken for representative links within the Gabrovo Corridor for both the 'with' and 'without' project scenarios for three of the four forecast years (2020, 2030 and 2040), (2015 is not shown as the project is not expected to be complete until 2020).

The representative links chosen were along the I-5 on the Shipka Pass and the new Stage 5 section (link 10644-17005 and 17003-17004 respectively). The results in terms of trip length frequency distribution are presented in **Figures 5.3** to **5.5** for car trip lengths. Examination of **Figures 5.3** to **5.5**, shows that when the bypass and tunnel section is in place, traffic is attracted into the corridor. The switch in traffic is largely from the adjacent II-55, which provides a parallel alternative to the I-5 in the without project scenario. Traffic which previously used the II-55 to travel between Veliko Tarnovo and south of Shipka, has switched to use the new bypass and tunnel despite the longer journey.

There is also an increase in the number of trips in each distance band, with a significant increase in longer distance trips, over 180 km. This can be accounted for because the new bypass and tunnel has generated additional traffic compared to the without project scenario, as discussed in ***Chapter 5.5***. The new bypass and tunnel also provides improved access for movements north-south of Gabrovo, which contributes to the significant increase in longer distance trips, over 180km. These movements include an increase in demand along the II-35 to/from Pleven, north-west of Gabrovo to/from Plovdiv and Karlovo, south of Gabrovo.

Figure 5.3 Trip Length Frequency Distribution for Car Trips in 2020

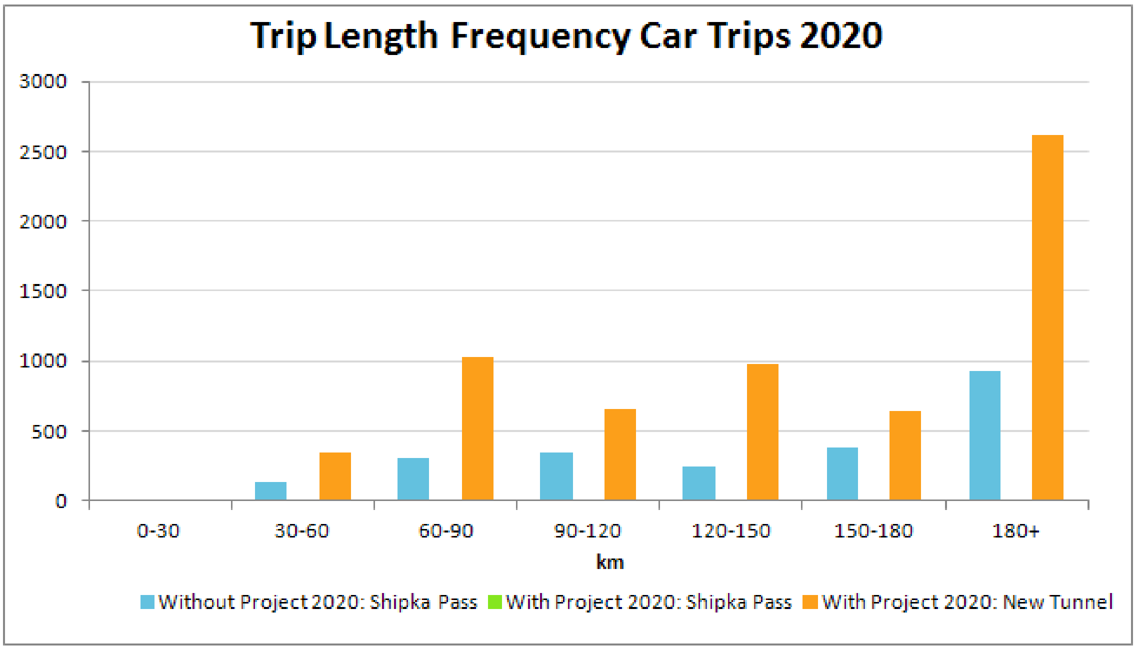


Figure 5.4 Trip Length Frequency Distribution for Car Trips in 2030

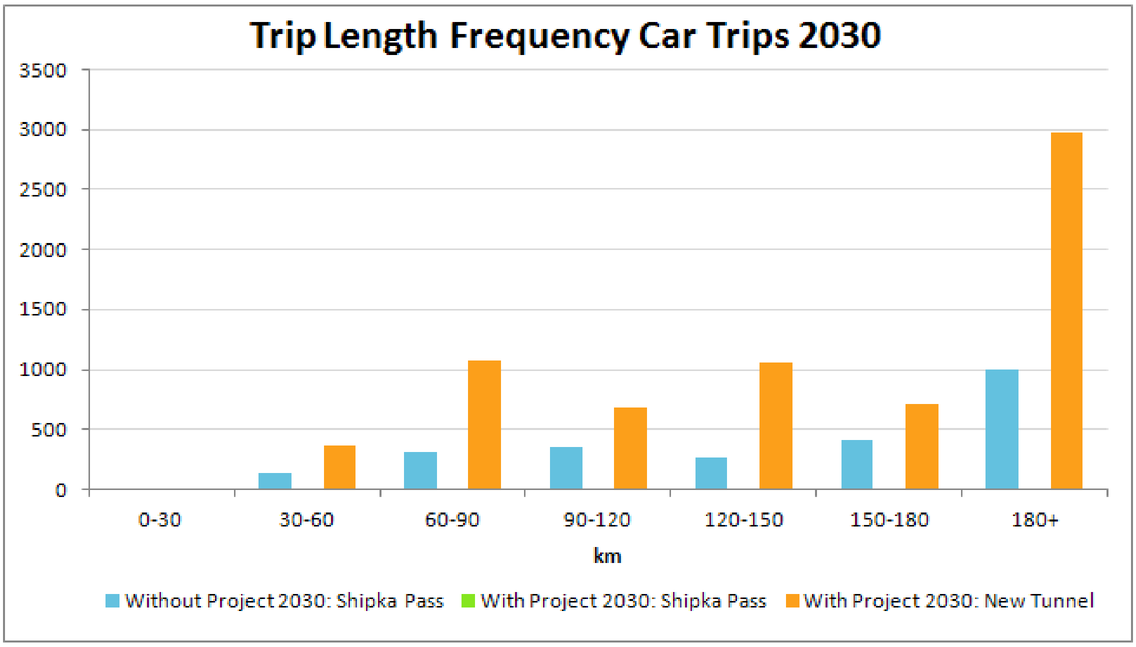
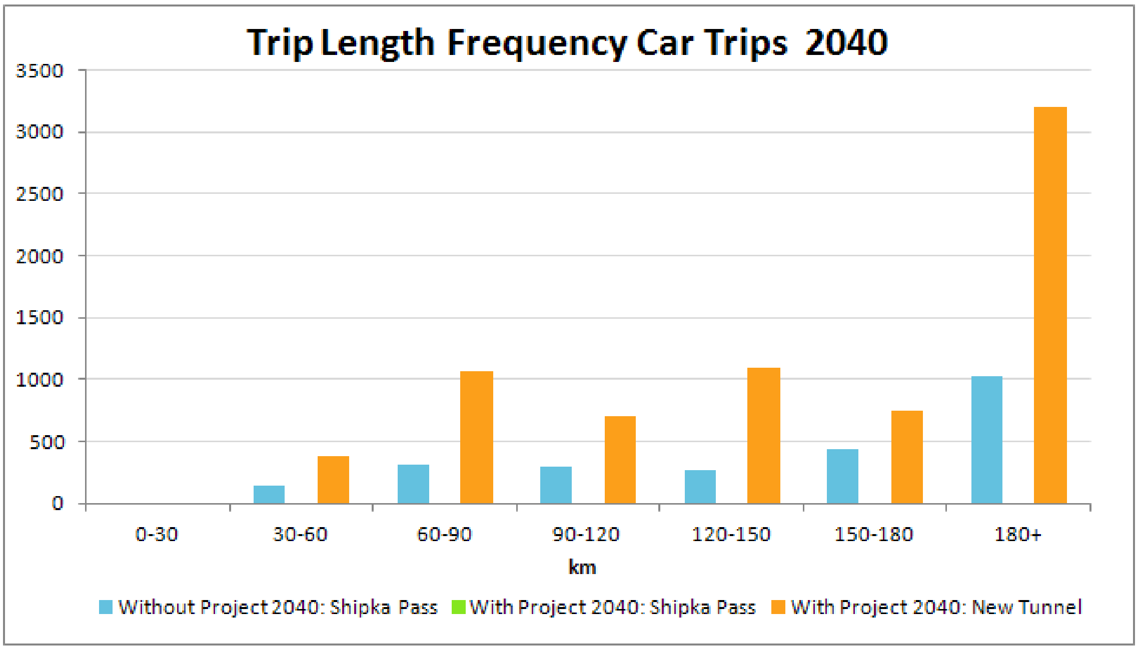


Figure 5.5 Trip Length Frequency Distribution for Car Trips in 2040



A similar analysis for HGV trips in 2020, 2030 and 2040 is presented in **Figures 5.6** to **5.8**. A similar situation is observed for HGV trips in the corridor, firstly, a shift from the existing road to the new section and secondly, a significant increase in longer distance trips using the corridor.

Figure 5.6 Trip Length Frequency Distribution for HGV Trips in 2020

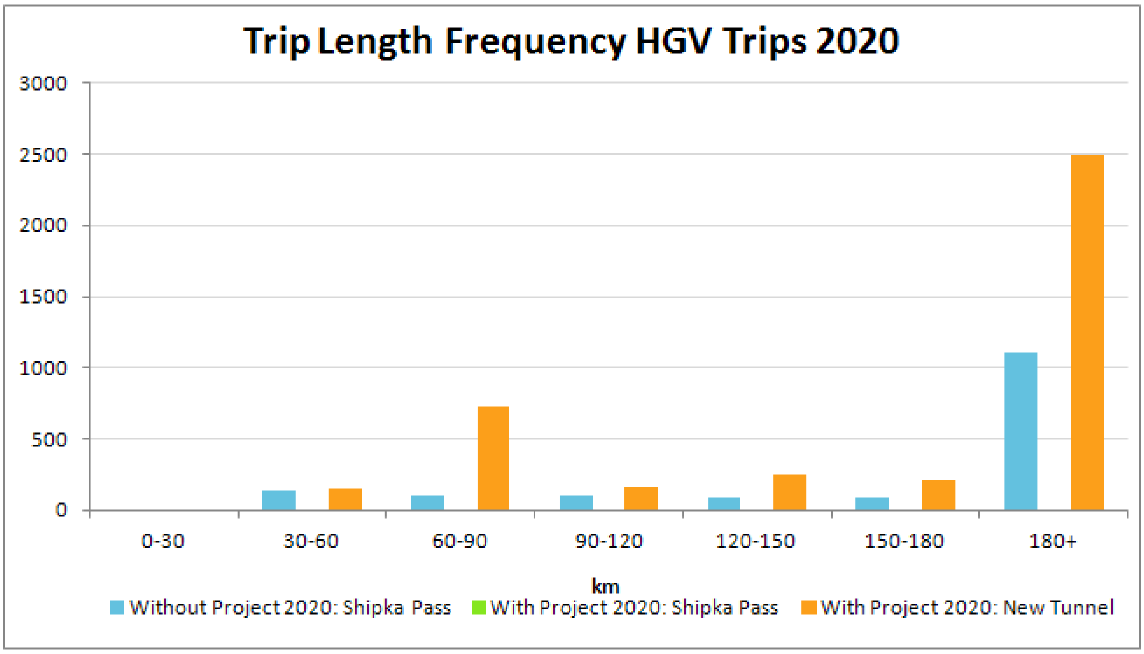


Figure 5.7 Trip Length Frequency Distribution for HGV Trips in 2030

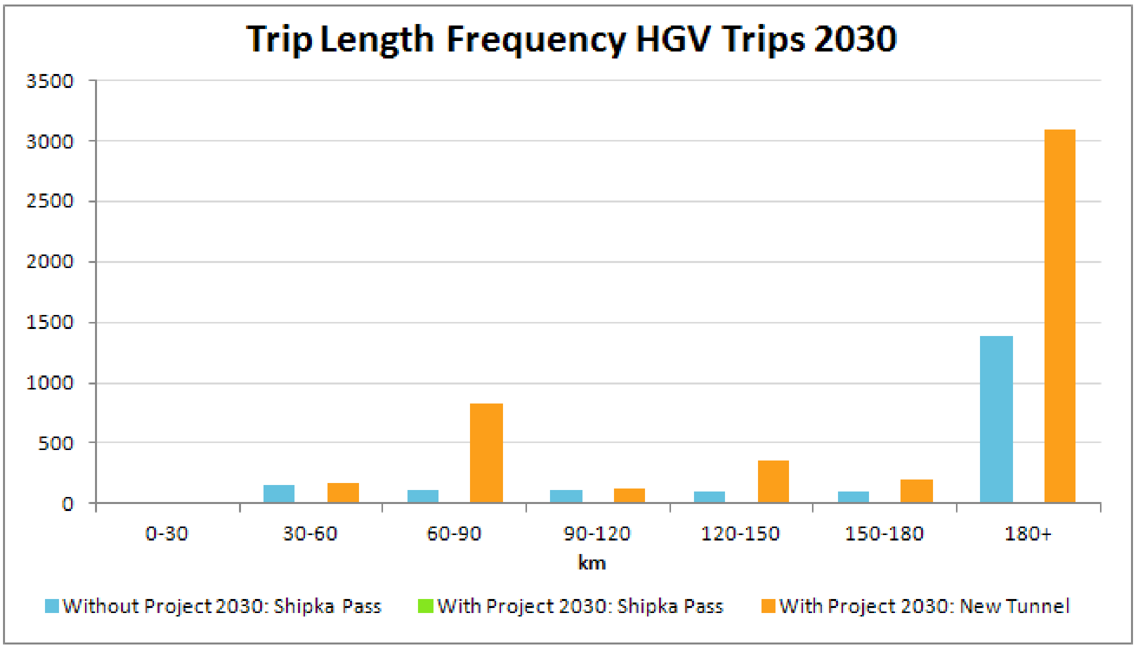
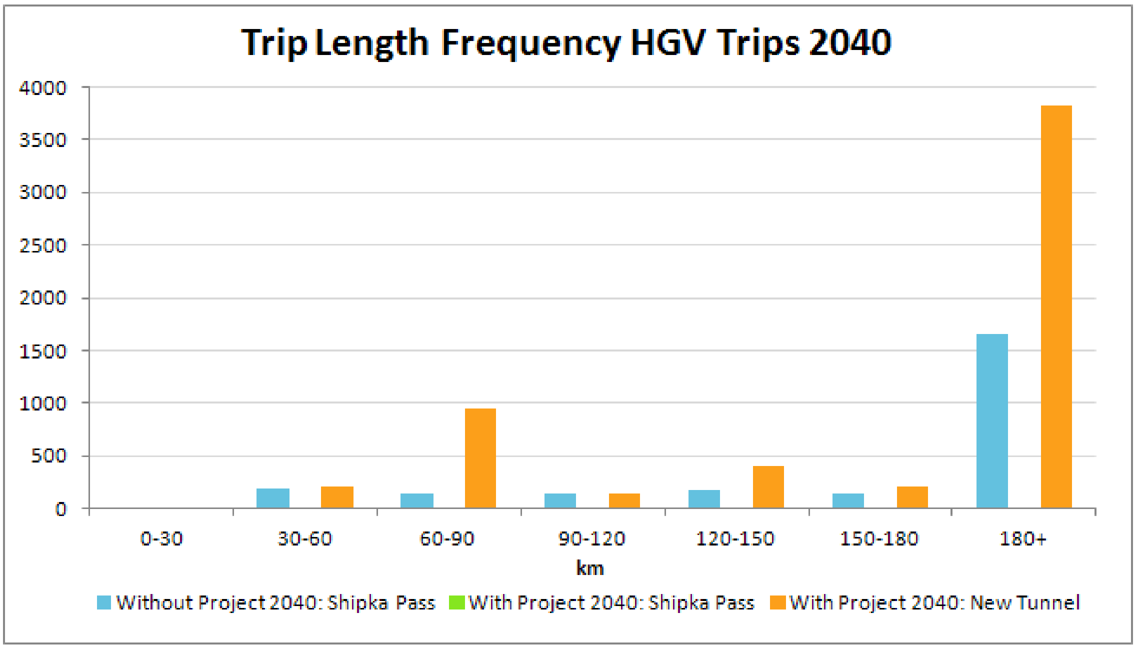


Figure 5.8 Trip Length Frequency Distribution for HGV Trips in 2040



5.3.2 Bypass Only Preferred Option J

A select link analysis for the bypass only Option J was not appropriate because representative links within the Gabrovo Corridor for both the 'with' and 'without' project scenarios for three of the four forecast years (2020, 2030 and 2040) could not be assessed in isolation. The trip length distributions would not highlight any significant changes or impact as a result of the new bypass sections. The results would show that some cars do shift onto the bypass to avoid the centre of Gabrovo but that HGVs remain on the existing network (alternative route to the east). This is because of the perceived operating costs of HGVs, that distance is perceived as a more important cost that time savings. Therefore, HGV traffic remains on the existing network because it is shorter, with similar journey times.

5.3.3 Tunnel Only Preferred Option N

A select link analysis was undertaken for representative links within the Gabrovo Corridor for both the 'with' and 'without' project scenarios for three of the four forecast years (2020, 2030 and 2040), (2015 is not shown as the project is not expected to be complete until 2020). The representative links chosen were along the I-5 on the Shipka Pass and the new Stage 5 section (link 10644-17005 and 17003-17004 respectively). The results in terms of trip length frequency distribution are presented in **Figures 5.9** to **5.11** for car trip lengths. Examination of **Figures 5.9** to **5.11**, shows that the provision of the tunnel section is sufficient for traffic to switch into the corridor from parallel routes. Similar to when the bypass and tunnel are in place, the switch in traffic is largely from the adjacent II-55 route. Analysis of the trip length distribution for Option N is very similar to Option E, with the exception for traffic around Gabrovo, which still uses the Class IV road to the east of Gabrovo because the bypass to the west is not complete.

There is an increase in the number of trips in each distance band, with a significant increase in the 60 – 90km band and longer distance trips, over 180 km. Similar to Option E, there is an increase in demand between Pleven and Plovdiv, as the tunnel provides improved access for north-south movements. However, unlike Option E, where the demand uses the bypass around Gabrovo, traffic in this option traffic travels directly through the centre of Gabrovo on the II-44 / I-5 before accessing the new tunnel section.

Figure 5.9 Trip Length Frequency Distribution for Car Trips in 2020

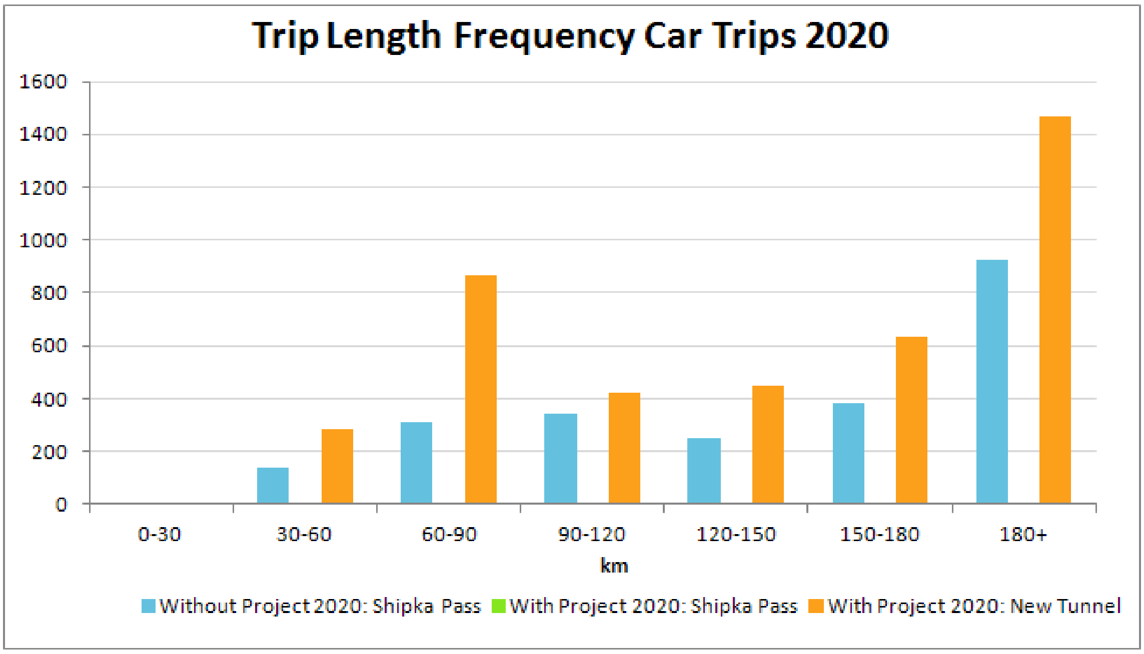


Figure 5.10 Trip Length Frequency Distribution for Car Trips in 2030

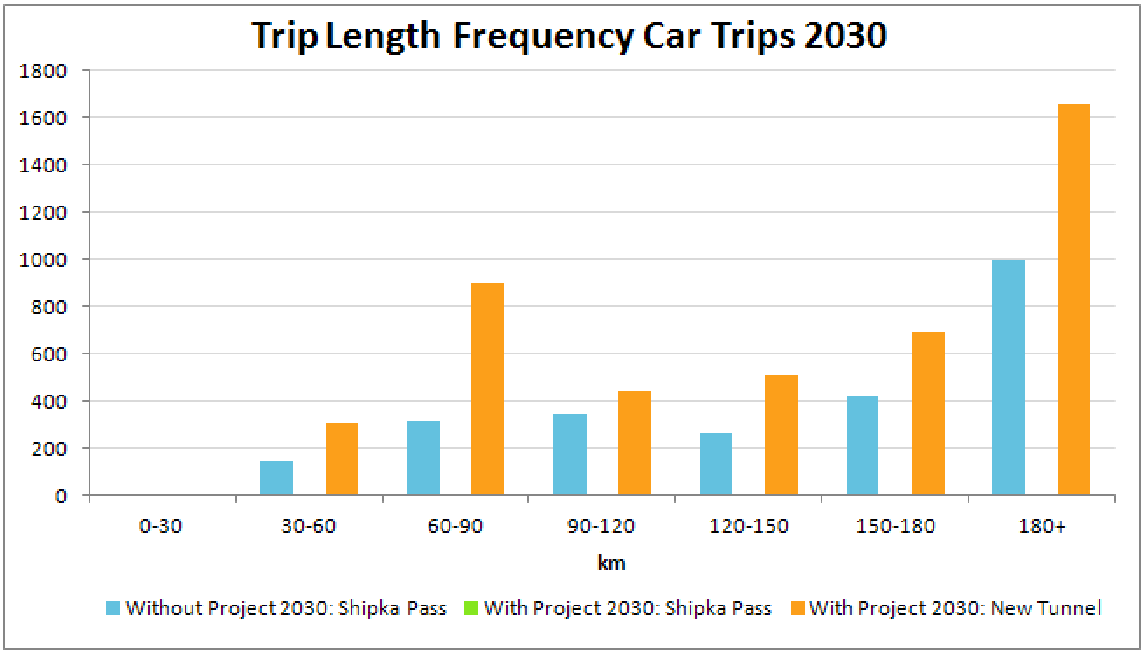
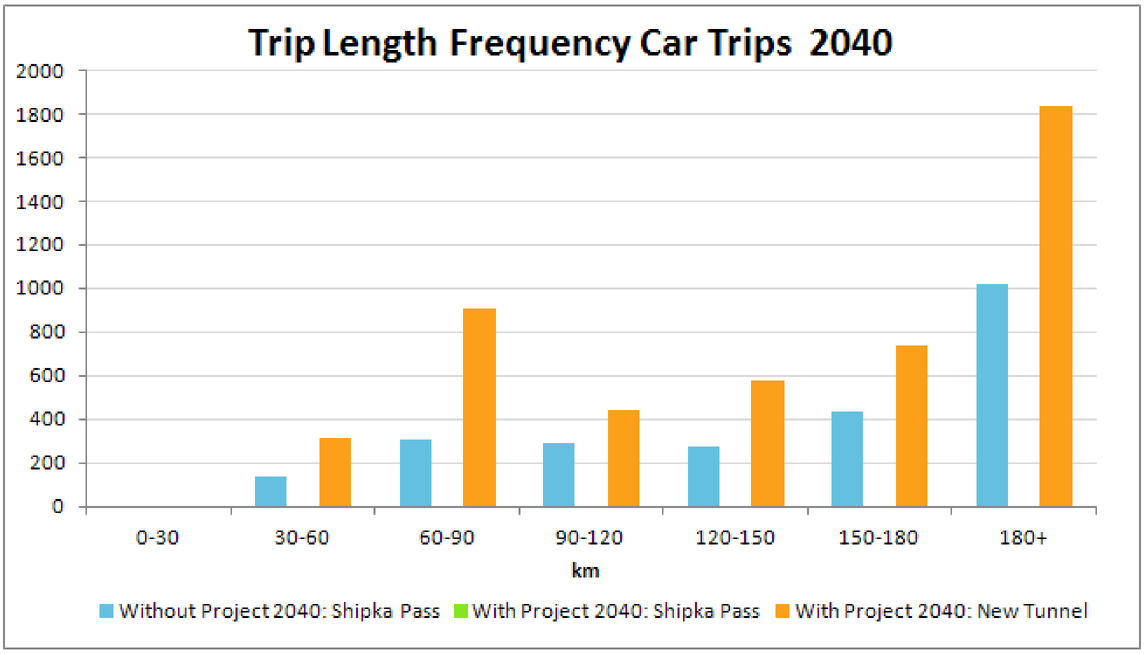


Figure 5.11 Trip Length Frequency Distribution for Car Trips in 2040



A similar analysis for HGV trips in 2020, 2030 and 2040 is presented in **Figures 5.12** to **5.14**. A similar situation is observed for HGV trips in the corridor, firstly, a shift from the existing road to the new section and secondly, a significant increase trips in the 60 – 90 km band and longer distance trips using the corridor.

Figure 5.12 Trip Length Frequency Distribution for HGV Trips in 2020

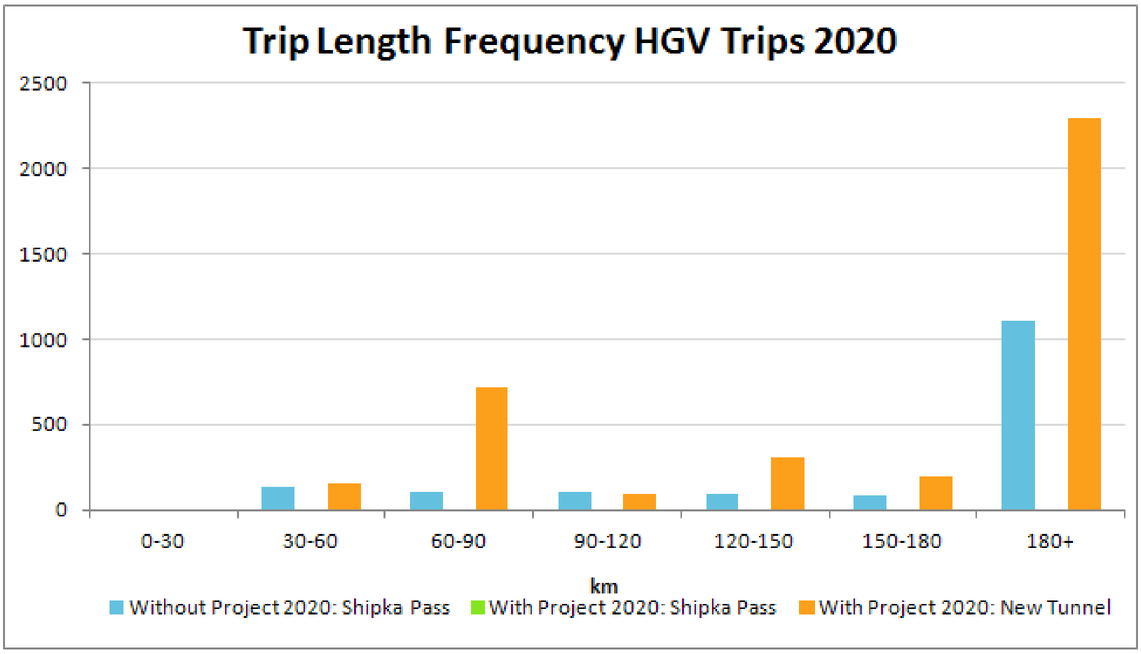


Figure 5.13 Trip Length Frequency Distribution for HGV Trips in 2030

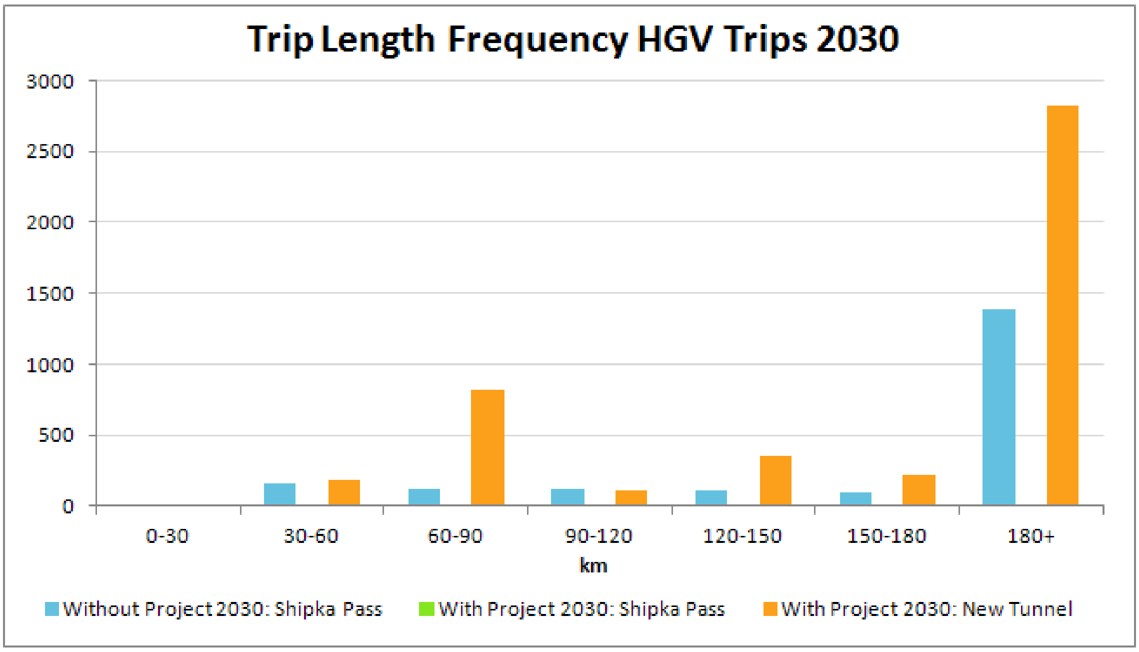
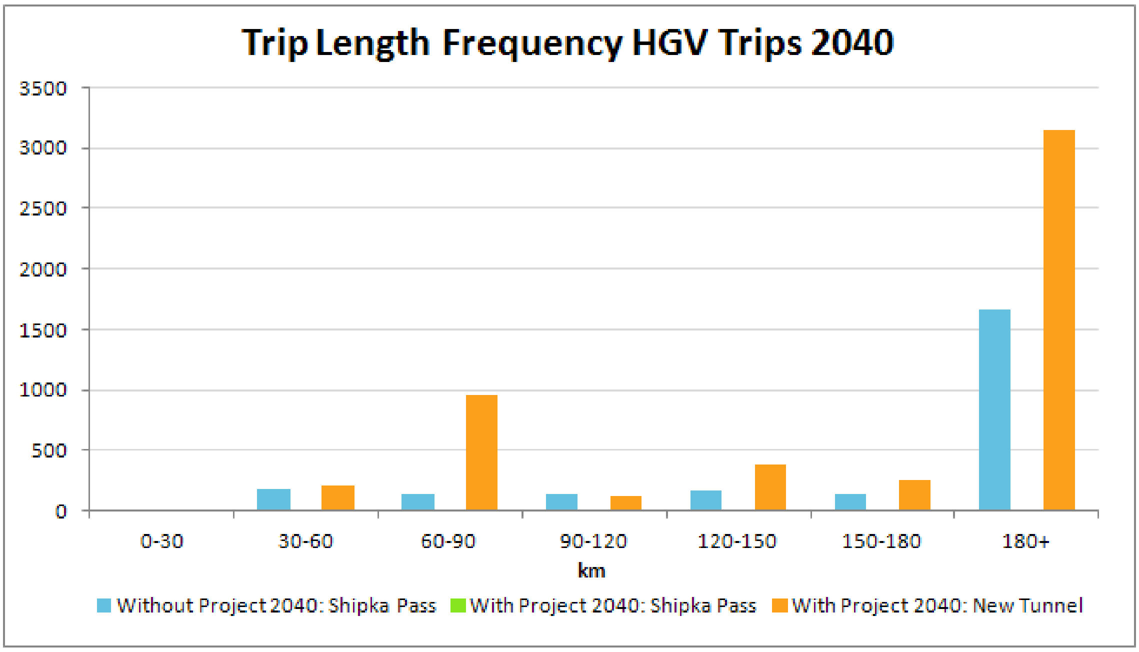


Figure 5.14 Trip Length Frequency Distribution for HGV Trips in 2040



5.4 Transit Traffic

Transit traffic is defined as traffic with an origin and/or destination outside of Bulgaria. Thus, only traffic starting and ending a journey within Bulgaria is termed local traffic.

5.4.1 Bypass and Tunnel Preferred Option E

An analysis of transit traffic has been undertaken using a select link analysis for the section of the Gabrovo corridor between Gabrovo and Shipka, highlighting traffic on the Shipka Pass. Again, the analysis has considered both the 'with' and 'without' project scenarios for three of the four forecast years (2015 is not shown as the project is not expected to be complete until 2020) and the results are presented in **Table 5.13**.

Table 5.13 Proportion of Transit Traffic along the Gabrovo Corridor on the Shipka Pass

Year	Without Project		With Project			
	Existing Road		Existing Road		New Road	
	Car	HGV	Car	HGV	Car	HGV
2020	1%	31%	0%	0%	1%	20%
2030	1%	35%	0%	0%	1%	23%
2040	1%	40%	0%	0%	1%	27%

The data in **Table 5.13** shows that there is little transit car traffic in the corridor whilst HGV transit traffic ranges from 30% to 40% across the forecast years. In the 'with' project scenario, there is little change in the car transit but a reduction in HGV transit. Although there is a reduction in the proportion of HGV transit using the corridor, there is an increase in the absolute number of HGV transit traffic but this increase is offset by a higher proportion of national trip movements along the corridor. The data indicates that the route is still used for HGV transit traffic, with one in five trips being transit in 2020, rising to one in four by 2040.

5.4.2 Bypass Only Preferred Option J

An analysis of transit traffic has been undertaken using a select link analysis for the section of the Gabrovo corridor in Gabrovo centre and on the bypass Stage 2. As before, the analysis has considered both the 'with' and 'without' project scenarios for three of the four forecast years (2015 is not shown as the project is not expected to be complete until 2020) and the results are presented in **Table 5.14**.

The data in **Table 5.14** shows that there is little transit car traffic on the corridor whilst HGV transit traffic ranges from 15% to 50% across the forecast years, on the two existing routes. In the 'with' project scenario, there is little change in the car transit but a decrease in HGV transit in Gabrovo centre. The decrease in HGV transit in the centre is a direct result of the new bypass (Stage 2), as approximately 40% of the HGV traffic on the new bypass is transit, highlighting the shift in traffic flow onto the new bypass.

Table 5.14 Proportion of Transit Traffic along the Gabrovo Corridor on the Shipka Pass

Year	Without Project				With Project					
	I-5 Gabrovo Centre		IV-5522 Boriki Road		I-5 Gabrovo Centre		IV-5522 Boriki Road		Stage 2	
	Car	HGV	Car	HGV	Car	HGV	Car	HGV	Car	HGV
2020	0.2%	15.5%	1.2%	36.8%	0.1%	5.2%	1.2%	36.9%	0.6%	36.1%
2030	0.2%	18.1%	1.2%	40.8%	0.1%	6.7%	1.1%	41.1%	0.6%	38.6%
2040	0.2%	20.8%	1.2%	52.3%	0.1%	8.9%	1.2%	52.6%	0.6%	40.7%

5.4.3 Tunnel Only Preferred Option N

An analysis of transit traffic has been undertaken using a select link analysis for the section of the Gabrovo corridor between Gabrovo and Shipka, highlighting traffic on the Shipka Pass. Again, the analysis has considered both the 'with' and 'without' project scenarios for three of the four forecast years and the results are presented in **Table 5.15**.

Table 5.15 Proportion of Transit Traffic along the Gabrovo Corridor on the Shipka Pass

Year	Without Project		With Project			
	Existing Road		Existing Road		New Road	
	Car	HGV	Car	HGV	Car	HGV
2020	1%	31%	0%	0%	0.4%	21%
2030	1%	35%	0%	0%	0.5%	24%
2040	1%	40%	0%	0%	0.5%	24%

The data in **Table 5.15** shows that there is little transit car traffic on the corridor whilst HGV transit traffic ranges from 30% to 40% across the forecast years. In the 'with' project scenario, there is little change in the car transit but a reduction in HGV transit. Although there is a reduction in the proportion of HGV transit using the corridor, there is an increase in the absolute number of HGV transit traffic but this increase is offset by a higher proportion of national trip movements along the corridor. The data shows that the route is still a route used for HGV transit traffic, with one in five trips being transit in 2020, rising to one in four by 2040.

5.5 Generated Traffic

An analysis has been undertaken to identify generated traffic within the Gabrovo corridor once the scheme is completed. Generated traffic is assumed to comprise genuinely new traffic generated (induced) within the corridor as a result of the reduced journey costs that the new road affords, and also traffic that has switched mode onto the new road network. Generated traffic also relates to that which has redistributed to take advantage of the reduced travel costs in the corridor once the new road network is opened.

5.5.1 Bypass and Tunnel Preferred Option E

Generated traffic has been examined on representative links (17003-17004) for the tunnel section of the corridor for three of the four forecast years (2015 is not shown as the project is not expected to be complete until 2020). The results are presented for the without project scenario and with project scenario in **Table 5.16**.

In order to fully understand the proportion of generated trips as a result of the project, the 'without' project (Do Minimum) demand matrices were assigned to the 'with' project (Do Something) network. This represents a traditional fixed trip matrix approach where any change in the flows along the corridor is entirely due to trips re-routeing to the new road network because of the travel time savings. For the section of the Shipka Tunnel, the proportion of trips re-routing in 2020 is 51% (4,864 trips). This is the flow in the corridor in the 'with' project scenario (9,587) minus the flow in the corridor in the without project scenario (4,723). In 2030 the proportion of trips that re-route is very similar, at around 52% and 53% in 2040, indicating that congestion has reached a point sufficient in the surrounding network for increased numbers of trips to re-route to the corridor.

An assignment of the 'with' project (Do-Something) demand matrices to the 'with' project (Do-Something) network will produce a variable trip matrix response where any further increases in trips in the corridor is due to generated (induced, mode shifted or redistributed) traffic. **Table 5.16** shows that, for the section of the Shipka Tunnel, the percentage of generated trips is 19% in each forecast year.

This generated traffic through the Shipka Tunnel is largely a combination of traffic re-routeing from the adjacent II-55 and induced traffic for north-south movements between Pleven and Plovdiv / Kazanlak / Stara Zagora, as a result of the improved access provided by the Tunnel through the mountains.

Table 5.16 Re-routed and Generated Traffic on the Gabrovo Corridor

Year	I-5 – Existing Road			Tunnel Section			In Gabrovo Corridor			
	Without Project	With Project		Without Project	With Project					
	DM Demand	DM Demand	DS Demand	DM Demand	DM Demand	DS Demand	Re-routed Traffic	% Re-routed	Generated Traffic	% Generated
2020	4,723	0	0	-	9,587	11,863	4,864	51%	2,275	19%
2030	5,101	0	0	-	10,643	13,109	5,542	52%	2,465	19%
2040	5,323	0	0	-	11,443	14,093	6,120	53%	2,650	19%

Table 5.17 shows the fixed trip assignment demand for each of the assessment links in the corridor.

Table 5.17 Traffic Flow in the Gabrovo Corridor in Forecast Years, with project / DM Demand (Fixed Trip)

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)			
			2015	2020	2030	2040
I-5	10656	10657	-	5,065	6,848	7,456
I-5	10657	10658	-	2,215	2,378	2,494
I-5	10658	10659	-	2,215	2,378	2,494
I-5	10659	10611	-	2,215	2,378	2,494
I-5	10611	10612	-	9,368	9,890	9,762
I-5	10612	10640	-	2,526	2,690	2,441
I-5	10640	10641	-	674	693	694
I-5	10641	10642	-	1,227	98	97
I-5	10642	10643	-	1,227	98	97
I-5	10643	10644	-	1,227	98	97
I-5	10644	17005	-	0	0	0
I-5	17005	10645	-	9,587	10,643	11,443
IV-5522	10656	12104	-	1,131	0	0

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)			
			2015	2020	2030	2040
IV-5522	12104	12103	-	1,131	0	0
IV-5522	12103	12102	-	1,131	0	0
IV-5522	12102	12101	-	1,131	0	0
III-552	12101	12505	-	1,901	790	792
III-552	12505	10641	-	1,901	790	792
IV-5006	10640	12031	-	1,852	1,998	1,747
II-44	10611	10610	-	7,153	7,511	7,268
II-44	10610	10609	-	4,718	4,883	4,889
II-44	10609	10608	-	4,718	4,883	4,889
Minor Rd	11987	11988	-	3,227	3,480	4,010
Stage 1	13045	11987	-	2,849	4,469	4,962
Stage 1	11987	13057	-	4,237	5,964	6,887
Stage 1	13057	13058	-	4,237	5,964	6,887
Stage 1	13058	10608	-	4,237	5,964	6,887
Stage 2	10608	17000	-	6,508	8,548	9,598
Stage 2	17000	13093	-	6,508	8,548	9,598
Stage 3	13093	12031	-	6,508	8,548	9,598
Stage 4	12031	17001	-	8,361	10,546	11,345
Stage 4	17001	17002	-	8,361	10,546	11,345
Connector	10644	17002	-	1,227	98	97
Stage 5	17002	17003	-	9,587	10,643	11,443
Stage 5	17003	17004	-	9,587	10,643	11,443
Stage 5	17004	17005	-	9,587	10,643	11,443

5.5.2 Bypass Only Preferred Option J

Generated traffic has been examined on representative links (10611-10612 and 17000-13093) for the I-5 and Stage 2 section of the corridor for three of the four forecast years (2015 is not shown as the project is not expected to be complete until 2020). The results are presented for the without project scenario and with project scenario in **Table 5.18**.

In order to fully understand the proportion of generated trips as a result of the project, the 'without' project (Do Minimum) demand matrices were assigned to the 'with' project (Do Something) network. This represents a traditional fixed trip matrix approach where any change in the flows along the corridor is entirely due to trips re-routeing to the new road network because of the travel time savings. For the Stage 2 section of bypass, the proportion of trips re-routing in 2020 is 2% (65 trips). This is the flow in the corridor in the 'with' project scenario (11,979) minus the flow in the corridor in the without project scenario (11,914). In 2030 the proportion of trips that re-route is very similar, at around 9% and 12% in 2040, indicating that congestion has reached a point sufficient in the surrounding network for increased numbers of trips to re-route to the corridor in later years. The majority of re-routeing traffic has switched from the I-3 / II-55 via Veliko Tarnovo to the II-35 / I-5 via Gabrovo for movements between Pleven and Stara Zagora.

An assignment of the 'with' project (Do-Something) demand matrices to the 'with' project (Do-Something) network will produce a variable trip matrix response where any further increases in trips in the corridor is due to generated (induced, mode shifted or redistributed) traffic. **Table 5.18** shows that, for the section of the new bypass, the percentage of generated trips is only 1% in each forecast year. The option only generates a marginal number of new trips because the alignment of the Shipka Pass is still difficult to traverse, so any increase is limited to new traffic accessing Gabrovo.

Table 5.18 Re-routed and Generated Traffic on the Gabrovo Corridor

Year	I5 – Existing Road			Stage 2			In Gabrovo Corridor			
	Without Project	With Project		Without Project	With Project					
	DM Demand	DM Demand	DS Demand	DM Demand	DM Demand	DS Demand	Re-routed Traffic	% Re-routed	Generated Traffic	% Generated
2020	11,914	9,369	9,358	0	2,610	2,761	65	2%	140	1%
2030	12,433	9,891	9,881	0	2,805	2,985	263	9%	170	1%
2040	12,693	10,133	10,121	0	2,916	3,103	355	12%	175	1%

Table 5.19 shows the fixed trip assignment demand for each of the assessment links in the corridor.

Table 5.19 Traffic Flow in the Gabrovo Corridor in Forecast Years, with project / DM Demand (Fixed Trip)

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)			
			2015	2020	2030	2040
I-5	10656	10657	-	3,304	3,556	3,742
I-5	10657	10658	-	2,215	2,378	2,494
I-5	10658	10659	-	2,215	2,378	2,494
I-5	10659	10611	-	2,215	2,378	2,494
I-5	10611	10612	-	9,369	9,891	10,133
I-5	10612	10640	-	2,526	2,691	2,810
I-5	10640	10641	-	2,526	2,691	2,810
I-5	10641	10642	-	2,315	2,534	2,615

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)			
			2015	2020	2030	2040
I-5	10642	10643	-	2,315	2,534	2,615
I-5	10643	10644	-	2,315	2,534	2,615
I-5	10644	17005	-	4,925	5,338	5,531
I-5	17005	10645	-	4,925	5,338	5,531
IV-5522	10656	12104	-	1,312	1,469	1,486
IV-5522	12104	12103	-	1,312	1,469	1,486
IV-5522	12103	12102	-	1,312	1,469	1,486
IV-5522	12102	12101	-	1,312	1,469	1,486
III-552	12101	12505	-	3,016	3,279	3,351
III-552	12505	10641	-	3,016	3,279	3,351
IV-5006	10640	12031	-	0	0	0
IV-4404	10612	13092	-	0	0	0
IV-4404	13092	13093	-	0	0	0
II-44	10611	10610	-	7,153	7,513	7,639
II-44	10610	10609	-	4,719	4,885	4,890
II-44	10609	10608	-	4,719	4,885	4,890
Minor Rd	11987	11988	-	3,227	3,480	3,640
Stage 1	13045	11987	-	1,089	1,178	1,248
Stage 1	11987	13057	-	2,064	2,252	2,357
Stage 1	13057	13058	-	2,064	2,252	2,357
Stage 1	13058	10608	-	2,064	2,252	2,357
Stage 2	10608	17000	-	2,610	2,805	2,916
Stage 2	17000	13093	-	2,610	2,805	2,916
Stage 3	13093	12031	-	2,610	2,805	2,916
Stage 4	12031	17001	-	2,610	2,805	2,916
Stage 4	17001	17002	-	2,610	2,805	2,916
Connector	10644	17002	-	2,610	2,805	2,916

5.5.3 Tunnel Only Preferred Option N

Generated traffic has been examined on representative links (17003-17004) for the tunnel section of the corridor for three of the four forecast years (2015 is not shown as the project is not expected to be complete until 2020). The results are presented for the without project scenario and with project scenario in **Table 5.20**.

In order to fully understand the proportion of generated trips as a result of the project, the 'without' project (Do Minimum) demand matrices were assigned to the 'with' project (Do Something) network. This represents a traditional fixed trip matrix approach where any change in the flows along the corridor is entirely due to trips re-routeing to the new road network because of the travel time savings. For the section of the Shipka Tunnel, the proportion of trips re-routing in 2020 is approximately 38% (3,493 trips). This is the flow in the corridor in the 'with' project scenario (8,216) minus the flow in the corridor in the without project scenario (4,723). In 2030 and 2040, the proportion of trips that re-route is similar, at 35% and 39% respectively, indicating that congestion increases to a point sufficient in the surrounding network for increased numbers of trips to re-route to the corridor.

An assignment of the 'with' project (Do-Something) demand matrices to the 'with' project (Do-Something) network will produce a variable trip matrix response where any further increases in trips in the corridor is due to generated (induced, mode shifted or redistributed) traffic. **Table 5.20** shows that, for the section of the Shipka Tunnel, the percentage of generated trips is between 11% and 14% in each forecast year.

The percentage of re-routed traffic and generated traffic in Option N occurs for similar reasons as Option E. There is a considerable shift in traffic from the II-55 onto the I-5 because of the improved access provided by the new Tunnel section, as well as an increase in demand between Pleven and towns and cities south of Gabrovo (Plovdiv / Kazanlak / Stara Zagora). The magnitude of the re-routed and generated traffic in Option N, is marginally smaller than Option E because the bypass around Gabrovo is not complete in Option N, therefore traffic still has to use the Class IV road to the west of Gabrovo before accessing the tunnel section, so full continuity along the route has not been provided, unlike Option E.

Table 5.20 Re-routed and Generated Traffic on the Gabrovo Corridor

Year	Existing Road			New Road			In Gabrovo Corridor			
	Without Project	With Project		Without Project	With Project					
	DM Demand	DM Demand	DS Demand	DM Demand	DM Demand	DS Demand	Re-routed Traffic	% Re-routed	Generated Traffic	% Generated
2020	4,723	0	0	-	8,216	9,253	3,493	38%	1,037	11%
2030	5,101	0	0	-	8,649	10,048	3,548	35%	1,399	14%
2040	5,323	0	0	-	9,489	10,789	4,166	39%	1,300	12%

Table 5.21 shows the fixed trip assignment demand for each of the assessment links in the corridor.

Table 5.21 Traffic Flow in the Gabrovo Corridor in Forecast Years, with project / DM Demand (Fixed Trip)

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)			
			2015	2020	2030	2040
I-5	10656	10657	-	3,164	3,405	3,581
I-5	10657	10658	-	2,215	2,378	2,494
I-5	10658	10659	-	2,215	2,378	2,494

Road	i Node	j Node	Total 2 Way Flow – 24 hour AADT (Vehicles)			
			2015	2020	2030	2040
I-5	10659	10611	-	2,215	2,378	2,494
I-5	10611	10612	-	12,804	13,677	14,223
I-5	10612	10640	-	5,962	6,478	6,902
I-5	10640	10641	-	5,962	6,478	6,902
I-5	10641	10642	-	8,216	8,649	9,489
I-5	10642	10643	-	8,216	8,649	9,489
I-5	10643	10644	-	8,216	8,649	9,489
I-5	10644	17005	-	0	0	0
I-5	17005	10645	-	8,216	8,649	9,489
IV-5522	10656	12104	-	2,832	2,766	3,184
IV-5522	12104	12103	-	2,832	2,766	3,184
IV-5522	12103	12102	-	2,832	2,766	3,184
IV-5522	12102	12101	-	2,832	2,766	3,184
III-552	12101	12505	-	3,602	3,557	3,976
III-552	12505	10641	-	3,602	3,557	3,976
IV-5006	10640	12031	-	0	0	0
IV-4404	10612	13092	-	0	0	0
IV-4404	13092	13093	-	0	0	0
II-44	10611	10610	-	10,589	11,299	11,729
II-44	10610	10609	-	7,786	8,274	8,565
II-44	10609	10608	-	7,786	8,274	8,565
Minor Rd	11987	11988	-	1,835	1,978	2,074
Stage 1	13045	11987	-	2,803	3,025	3,164
Stage 1	11987	13057	-	949	1,026	1,087
Stage 1	13057	13058	-	949	1,026	1,087
Stage 1	13058	10608	-	1,835	1,978	2,074
Connector	10644	17002	-	8,216	8,649	9,489
Stage 5	17002	17003	-	8,216	8,649	9,489
Stage 5	17003	17004	-	8,216	8,649	9,489
Stage 5	17004	17005	-	8,216	8,649	9,489

6 Project Costs

6.1 Introduction

This section describes how the preliminary capital costs and operation and maintenance costs have been determined for the Gabrovo-Shipka Highway Project Cost Benefit Analysis. These costs are based on the following sources of information:

- Bill of Quantities contained within "*Road III-5004 Gabrovo Bypass From km 0+000 to km 31+000"* - Intermediate Report (PATPROJECT ltd, 2008); and
- "*Cost Estimate Note 110623*" produced by Arup, who were appointed by JASPERS to review the option analyses and preparatory documents for the Struma Motorway Scheme CBA.

6.2 Calculation of Capital Costs for the Preferred Option

6.2.1 Construction Cost Estimates

AECOM has used the principles described in the Arup Cost Estimate Note to price the options for the Gabrovo to Shipka Highway Project. These principles were agreed by Arup and JASPERS to assist with the costs of highway projects.

For Stage 1 (rehabilitation) and 2 (reconstruction) of the Gabrovo Bypass, the cost from the Bill of Quantities has been used. For Stages 3, 4 and 5 the major items of work were extracted from the Bill of Quantities and priced using the rates derived from the Arup Note.

The main items measured and quantified are listed in **Table 6.1**

Table 6.1 Main Bill of Quantities Items

Item	Unit
Cut to spoil	m^3
Cut to fill	m^3
Imported fill	m^3
Placing of fill	m^3
Roadworks	km
Bridges	m^2
Short tunnel (less than 1 km)	km
Medium tunnel (1 to 3km)	km
Long tunnel (longer than 3 km)	km

The rates from the Arup note were for a dual carriageway motorway and have therefore been adjusted to suit the single carriageway construction for the Gabrovo-Shipka scheme. The exchange rate used to convert BGN to EUR was 1 BGN = 0.51 EUR.

The rate for cut and fill has been taken from the Arup note and is shown in **Table 6.2**

Table 6.2 Rates for Cut and Fill (2011 prices)

Cut and Fill	Unit	€
Excavation in earth material (unsuitable for fill, for depot). Cut to spoil	m^3	4.60
Excavation of suitable material for fill. Cut to fill	m^3	1.57
Placing of fill	m^3	1.30
Imported material*	m^3	10.20

* As no rate for imported fill was provided in Struma Cost Estimate Note, the rate from the Bill of Quantities was used.

The rate for roadworks has been taken from the Arup note for a motorway and converted into a rate for a single carriageway road, **Table 6.3**. The motorway rate was multiplied by 12/28 to convert it to a single carriageway road. This assumes the cross-section of the single carriageway road is similar to a class I road shown in **Figure 6.1**.

Figure 6.1 - Cross-Section of Single Carriageway Road

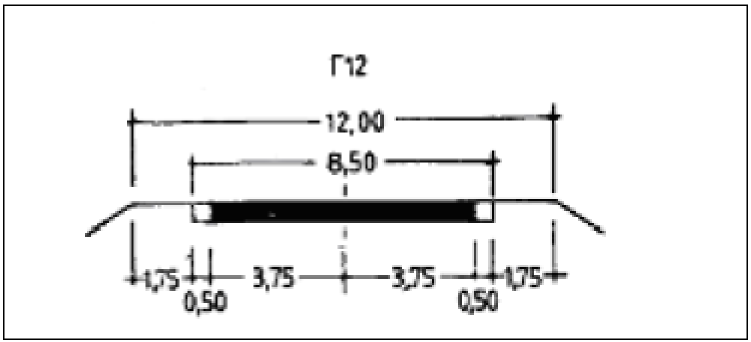


Table 6.3 Rates for Roadworks (2011 prices)

Roadworks	Unit	€ / km
Motorway design	km	1,348,611.87
Single carriageway design (12/28) of a motorway road	km	577,976.52

The rate for structures has been taken from the Arup note and converted into Euros, shown in Table **6.4**

Table 6.4 Rate for Bridges (2011 prices)

Bridges	Unit	€ / m^2
Bridges	m^2	492.15

For some sections of the scheme, the bill of quantities contained high costs associated with retaining walls and reinforced earth and drainage structures. These costs have been added to AECOM's cost estimate for the relevant sections of the scheme as a lump sum value.

The tunnel rates have been taken from the Arup note and adjusted for a single bore tunnel, as shown in **Table 6.5**.

Table 6.5 Rates for Tunnels (2011 prices)

Tunnel Length	Unit	Million Euro/km for twin bore	Million Euro/km for single bore
Short tunnel with lengths less than 1km	km	29.70	14.85
Medium tunnel with length greater than and equal to 1km and less than or equal to 3km	km	38.00	19.00
Long tunnels with a length greater than 3km	km	46.30	23.15

6.2.2 Planning and Design Costs

AECOM has made an allowance of 20% for unmeasured items as the main items account for 80% of the cost.

An allowance of 10% has been made for Preliminary and General Items and an allowance of 1.5% has been made Environmental Mitigation (taken from the Arup note).

The Planning and Design costs have been taken from the Arup note and adjusted for a single carriageway road, as shown in **Table 6.6**.

Table 6.6 Rates for Planning and Design Costs (2011 prices)

Planning and Design Costs	Unit	€ / km
Rehabilitation of motorway	km	3,141.60
Rehabilitation of single carriageway road (12/28 of motorway)	km	1,346.40
New motorway	km	12,240.00
New single carriageway road (12/28 of motorway)	km	5,245.71
Twin bore tunnel	km	24,480.00
Single bore tunnel	km	12,240.00

6.2.3 Expropriation Costs

The cost of land required for the Gabrovo-Shipka scheme has been taken from the Arup note and adjusted to suit a single carriageway road, as shown in **Table 6.7**.

Table 6.7 Rates for Expropriation (2011 prices)

Land costs	Unit	€ / km
For a new motorway	km	568,650.00
For a single carriageway road (12/28 of new motorway)	km	243,707.14

With the exception of Stage 1 and 2, AECOM has assumed that the land is required to be purchased for all new sections of road, including tunnel sections.

6.2.4 Contingency

A contingency for 10% of the construction costs has been allowed for unforeseen construction needs, as per the Arup note.

6.2.5 Technical Assistance

A project management fee for 2% of the construction costs has been allowed, as per the Arup note.

6.2.6 Publicity

A fee for 0.1% of the construction costs for publicity of the scheme has been assumed, as per the Arup note.

6.2.7 Site Supervision

A site supervision fee for 3% of the construction costs has been assumed, as per the Arup note. VAT has been added to all costs except the land cost, as it is not eligible for VAT.

6.2.8 Detailed Costs

The detailed capital costs of the preferred options for each scenario are discussed in this section and presented in **Table 6.9**. The costs presented are in nominal prices (2017). These prices have been calculated using the principles discussed in this section but uplifted in line with inflation, as forecast by the International Monetary Fund (IMF), from 2011 prices, **Table 6.8**.

Table 6.8 IMF World Economic Outlook Database, April 2012 (estimates start after 2011)

Year	Inflation, Average Consumer Prices (Index)
2007	115.55
2008	129.36
2009	132.56
2010	136.58
2011	141.21
2012	144.11
2013	147.47
2014	151.56
2015	156.11
2016	160.79
2017	165.61
2018	171.32
2019	177.04

Table 6.9 Detailed Capital Costs for the Preferred Options

Activity	Cost (€) Option E Bypass and Tunnel	Cost (€) Option J Bypass Only	Cost (€) Option N Tunnel Only
Construction	226,882,314	45,243,246	188,955,084
Planning and Design	206,380	102,586	122,002
Expropriation	6,972,521	3,822,010	4,008,953
Contingencies	22,688,231	4,524,325	18,895,508
Project Management	4,537,646	904,865	3,779,102
Publicity	226,882	45,243	188,955
Site Supervision	6,806,469	1,357,297	5,668,653
Sub - Total	268,320,445	55,999,842	221,618,256
VAT	52,269,585	10,435,566	43,521,861
Total	**320,590,029**	**66,435,408**	**265,140,117**

6.3 Operational and Maintenance Costs

AECOM has used the values from CBA Guidelines for Transport Sector Bulgaria, 2008 which has the costs for Operation and Maintenance (O&M) calculated by Bulgarian and Dutch experts under the Partners for Roads programme in the period 2005 – 2007. This is presented in **Table 6.10**.

Table 6.10 Operation and Maintenance Costs

Maintenance Activity			Motorway	I Class	II Class	III Class
Routine	Routine maintenance	€/km	9,487	872	718	385
	Winter maintenance	€/km	16,154	1,487	1,231	641
Periodical	Rehabilitation	€/km	205,128	64,103	51,262	30,769
	Structural	€/km	871,795	307,692	256,410	153,846

In accordance with usual practice for Bulgaria, it was assumed that for periodical maintenance activity, road rehabilitation would be carried out every 7 years and that structural rehabilitation would be carried out every 14th year. This practice is described in the Bulgarian "Methodology for justifying road repair projects" (1993). In the document the term "rehabilitation" refers to placing a new wearing course layer and, if needed, levelling course. The term "structural maintenance" refers to placing more than one asphalt layer with the purpose of increasing the wearing capacity of the road construction.

When the new road is built, the structural maintenance of the existing road occurs at the beginning of the project and then at 14 year intervals and that rehabilitation occurs every 7 years, in accordance with existing practice. The reason for this is the new road network will provide some relief, but not total relief to the existing road once completed and hence the traffic loading on the existing road will only be partially reduced. AECOM feels that the cost and interval of periodic maintenance will be the same to maintain a consistent road network into and around Gabrovo.

Rehabilitation of the new road, once completed, will be carried out every 7th year and structural rehabilitation every 14th year, in accordance with usual practice for Bulgaria. Routine and winter maintenance is assumed to occur annually for all roads, regardless of type.

The operation and maintenance costs for a tunnel were benchmarked against European tunnels. Based on this benchmarking, an operation and maintenance rate per kilometre cost for different twin and single bore tunnel lengths was derived, **Table 6.11**. The tunnel operation and maintenance cost over the life of the appraisal period was weighted based on the rate per km for different lengths of tunnel. This weighted average cost was applied as routine maintenance, annually.

Table 6.11 Operation and Maintenance Costs

Tunnel annual O&M costs	€ / km twin bore tunnel	€ / km single bore tunnel
Short Tunnel (less than 1km)	208,407.00	104,203.50
Medium Tunnel (between 1km and 3km)	292,995.00	146,497.50
Long Tunnel (greater than 3km)	396,619.00	198,309.50

7 Economic Cost Benefit Analysis

7.1 Introduction

Both Economic Cost Benefit Analyses and Financial Analyses aim to assess the value for money of projects; however, they examine the project from different viewpoints and contain differing costs and benefits. This chapter discusses the economic cost benefit analysis which assesses the value of the project from the viewpoint of society as a whole, regardless of to whom the benefits and costs fall. An economic cost benefit analysis assigns a value to certain goods, such as travellers' time, accidents and vehicle emissions, for which there is no direct market.

Economic cost benefit analyses and financial analyses may place a different value on the same entity. An economic cost benefit analysis is concerned with the resource value of goods, and it therefore excludes "transfer" payments, (such as VAT and social payments) which are money payments transferred from one group in society to another, and as such do not represent the real consumption of resources.

A summary of the main costs and benefits of the Gabrovo-Shipka highway project, and the treatment of these in the economic cost benefit analysis, is included in **Table 7.1**.

Table 7.1 Economic Costs Benefit Analysis

Source of Cost / Benefit	Economic Cost Benefit Analysis	Comment
Capital Cost	Valued net of VAT on materials, and social cost on labour	Capital Cost for economic cost-benefit analysis is therefore significantly lower than in financial analysis.
Financing Costs	Excluded	
Residual Value of the Project	Standard Capital Costs Major Infrastructure Capital Costs (Bridges) Land Value	
Operating and Maintenance Costs	Valued net of VAT on materials, and social costs on labour.	Cost for economic cost-benefit analysis is therefore significantly lower than in financial analysis
Travellers Time Savings	Valued according to economic cost, by either savings to economy for business journeys, or value assigned by individuals for non business journeys	Bulgarian values used in the economic cost-benefit analysis
Vehicle Operating Cost Savings	Valued according to economic cost, excluding items such as VAT and fuel taxes.	Bulgarian values used in the economic cost-benefit analysis
Accident Savings	Valued according to economic cost, i.e. direct cost of emergency services, loss of the economic value of the lost working time in the case of death or serious injury. An allowance for pain and suffering can also be included	Bulgarian values used in the economic cost-benefit analysis
Benefits From Reduced Emissions	Economic value assigned to these	Bulgarian estimates used in the economic cost-benefit analysis

There are a number of guidance documents specific to the EU, two of which are focused solely on the requirements of the transport sector in Bulgaria. These documents have contributed towards the detailed approach to generating the financial and economic cost benefit analysis, including placing monetary values on air pollution, climate change and time savings as well as the processes for calculating costs.

The documents reviewed and utilised in the GTMP process include:

- **Guide to Cost Benefit Analysis of Investment Projects** – Structural Funds, Cohesion Fund and Instrument for Pre Accession – Final Report/ 16th June 2008 (European Commission Directorate General Regional Policy);
- **Guidance on the Methodology for Carrying Out Cost Benefit Analysis Working Document No 4** – August 2006 (European Commission Directorate General Regional Policy);
- **HEATCO Developing Harmonised European Approaches for Transport Costing and Project Assessment –** February 2006; and
- **Requirements for Preparation of CBA in transport sector** – December 2008 (Produced by the Ministry of Finance, Ministry of Transport, National Company Railway Infrastructure, Metropolitan EAD, National Road Infrastructure Fund).

The financial and economic analysis was prepared by the incremental method, which calculates the difference in the value of the financial and economic parameters of the 'without project' and 'with project' alternatives.

In the case of the evaluation of the Gabrovo-Shipka highway schemes, the 'without project' scenario comprises the existing highway network and committed future road projects, including completion of the Trakia motorway and recent transport schemes under the OPT 2007 – 2013 period (the Maritsa motorway, Struma highway, Kardzhali-Podkova highway and Hemus motorway). Under this alternative, the road maintenance expenses will continue to be made as they are at present. The 'with project' is identical to the 'without project' option in all respects, except that it includes a completed Gabrovo-Shipka highway scheme by providing a parallel alternative to the I-5, around Gabrovo to Shipka. This enables the effect of the Gabrovo-Shipka highway schemes to be isolated from all other projects.

To conduct the analysis and evaluation of the project, an integrated dynamic financial model has been developed, data models created, and processes for investment and operational activities included for the project analysis.

7.2 Assumptions

The economic cost benefit analysis sums costs and benefits over a 30 year horizon period, with all data presented in years. The stages of implementation are:

- Investment period (3 years): 2017 – 2019; and
- Operational period (30 years): 2020 – 2049.

It uses a discounted cash flow to take account of the fact that benefits and costs that occur in the future are valued less highly than those that occur in the shorter term. In the calculation, the discount value used is 5.5%, in accordance with Working Document No. 4 – Guidance on the Methodology for Carrying out a Cost Benefit Analysis.

7.2.1 Investment Costs

As part of the economic analysis, identifiable fiscal transfer payments should be eliminated from the project cash flow. For the project, the main sources of cash flow are capital expenditure and operational costs, discussed in ***Chapter 6***. Basic transfers include VAT, as well as payments involving salaries and other taxes (e.g. fuel tax) and the net financial flows for each year of analysis are adjusted by removing VAT and applying coefficients. Furthermore, the construction cost is divided into components based on the type of infrastructure for past construction contracts. The construction costs coefficients are listed in **Table 7.2**.

Table 7.2 Construction Costs Coefficients

Cost Component	Road Project
Equipment	8%
Materials	64%
Labour	18%
Other costs	10%

The costs in the economic analysis are converted from financial to economic using standard conversion coefficients for the separate cost components as follows:

- Land expropriation; CF = 1.00;
- Equipment; CF = 0.95;
- Materials; CF = 0.83;
- Labour; CF = 0.56; and
- Other (Risks, overheads etc); CF = 0.83.

7.2.2 User Time benefits

Time savings and changes in vehicle operating costs are the main benefits in most transport scheme appraisals. There are three market segments that need to be considered:

- Existing users who travel the same distance benefit from improved travel times and changes in distance;
- Existing users who travel further due to the increased opportunities the scheme provides; and

- Modal transfer journeys that are created because of the improved attractiveness that the scheme provides.

The calculation of transport user benefits is based on a conventional consumer surplus theory. In simple terms, 'consumer surplus' is defined as the benefit which a consumer enjoys, in excess of the costs which he or she perceives. Across all travellers, the change in consumer surplus is the difference between the change in the total benefit enjoyed and the change in the costs perceived.

The method used to calculate the user time benefits and operating cost benefits uses the principle of a "rule of a half". This takes into account the fact that, in usual conditions, demand changes in response to the increase or decrease in costs; and there is therefore a lesser impact on new or lost travellers. With relatively small changes in costs, the convention is to attribute half of the change in costs to the trip lost or gained. Due to the re-distribution effect, users may change their destinations as a result of improved journey opportunities. These trips will be treated as new trips for the new destination. Therefore the rule of a half principle will be applied to calculate the user time and vehicle operating cost benefits for these trips. This is shown as Equation 1.

Equation 1 User Time Benefits Calculation

$$B_{UserTime} = \sum_i \sum_j (D_0 + D_1) * (C_0 - C_1) / 2$$

Where:

$B_{UserTime}$ – Total user time savings in minutes;

D_0 – Trip matrix in the Do-Minimum (reference case) scenario;

D_1 – Trip matrix in the Test scenario (post-demand model calculations);

C_0 – Travel time matrix in minutes in the Do-Minimum (reference case) scenario; and

C_1 – Travel time matrix in minutes in the Test scenario.

The strategic transport model outputs form the basis for the benefit calculations. The model is based on a 12-hour day simulation period; 07:00hrs-19:00hrs for a typical weekday. In order to assess the benefits of each scheme over the full appraisal period, these 12-hour benefits are annualised. Manual classified count data, for June 2005 from the Bulgarian Central Road Laboratory Bureau (CRLB) has been used to calculate the annualisation factor. The 12-hour average vehicle flow across all sites was summed and averaged. This value was divided by an annual 24 hour average (calculated from an expanded average 24-hour flow) to obtain an annualisation factor of 480.

The user time benefits are calculated at a matrix level. The time benefits of an option are a combination of time savings to existing highway users, and the benefit of any new trips on the highway, as a result of improved infrastructure.

7.2.3 Vehicle Operating Cost (VOC) benefits

The VOC benefits are calculated to assess the cost or benefit of a highway scheme on vehicle operating costs. Generally this will be a disbenefit because a successful scheme should attract more journeys. This will cause a rise in overall vehicle kilometres and therefore vehicle operating costs. However, in some cases, where new infrastructure creates a shorter route, VOCs will decrease overall. The switching of trips from a long existing route to a new shorter highway can offset the increase in vehicle kilometres from induced trips. The VOC calculation is similar to the user time benefits calculation. It is calculated on a matrix level and also uses the 'rule of a half' principle. The VOC user benefits are split by trip purpose because different trip purposes have different occupancy factors in the model. The occupancy factors must be applied to convert from passenger trips to vehicles, see Equation 2.

Equation 2 VOC Benefits Calculation

$$B_{userVOC} = \sum_i \sum_j ((S_1 - S_0) * (K_f + K_n)) * (D_0 + D_1) / (2 * F_o)$$

$$B_{CarVOC} = B_{BusinessVOC} + B_{CommutingVOC} + B_{LesiureVOC}$$

$$B_{TotalVOC} = B_{CarVOC} + B_{hgvVOC}$$

Where:

$B_{UserVOC}$ – User VOC benefits in EUROs;

$B_{BusinessVOC}$ – Business User VOC benefits in EUROs;

$B_{CommutingVOC}$ – Commuting User VOC benefits in EUROs;

$B_{LesiureVOC}$ – Leisure User VOC benefits in EUROs;

B_{CarVOC} – Car User VOC benefits in EUROs;

B_{hgvVOC} – HGV User VOC benefits in EUROs;

$B_{TotalVOC}$ – Total User VOC benefits in EUROs;

D_0 – Trip matrix in the Do-Minimum (reference case) scenario;

D_1 – Trip matrix in the Test scenario (post-demand model calculations);

S_0 – Distance matrix in kilometres in the Do-Minimum (reference case) scenario;

S_1 – Distance matrix in kilometres in the Test scenario;

S_1 – Distance matrix in kilometres in the Test scenario;

F_o - Occupancy factor (by trip purpose) in the Test scenario;

K_n – Vehicle operating cost (non-fuel costs) per kilometre in EUROs; and

K_f – Vehicle operating cost (fuel costs) per kilometre in EUROs

The benefits are initially calculated over the 12-hour modelling period and then annualised. The benefits from the different trip purposes and from both vehicle types are then summed together.

7.2.4 Accidents

Accident benefits or disbenefits to society arise as a result of a change in vehicle kilometres, and a change in accident rates for different types of road. For example, accident rates are generally lower for sections of dual carriageway, as opposed to single carriageway, undivided roads. An economic cost to society can be calculated for each road accident depending on its level of severity. Accident rates according to different road types are provided by Jaspers “Requirements for preparation of CBA in Transport Sector” appraisal guidance document. The equation from which these impacts are calculated is shown by Equation 3. These benefits have been calculated over a 12 hour period and then annualised.

Equation 3 Accident Impact Calculation

Accident Impact = Accident rate per vehicle kilometre x Change in vehicle kilometres x Cost per accident.

7.2.5 Environmental Costs

Air pollution and noise result in external costs which can be measured as a financial burden to society. Air pollutants from vehicles are a complex mix of chemicals that change after they leave the emission source and include particulate matter, sulphur oxide, nitrogen oxides, carbon monoxide and CO_2. These pollutants impose a financial burden on society by increasing health costs and damage to buildings, crops, flora and fauna.

The impact of air pollution can be quantified and is related to travel speed and vehicle type. The General Road Administration, 1999 defines “Instructions for the estimation of the exhaust gasses emitted by vehicles”.

Equation 4 Emissions of Harmful Substances Calculation

Light Vehicle

CO: $e = 123.89 . V^{-0.5383}$

NO_2: $e = -1E . V^3 + 0.0006V^2 – 0.0373V + 2.0389$

SO_2: $e = 0.3293.V^{-0.3776}$

$PM_{2.5}$: $e = 1.6369.V^{-0.93}$

Heavy Vehicle

CO: $e = 257.77 . V^{-1.0217}$

NO_2: $e = 54.386.V^{-0.3871}$

SO_2: $e = 10.37.V^{-0.5569}$

$PM_{2.5}$: $e = 4.2296V^{-0.7508}$

Where

e is emission in g/km

V is travel speed in km/h

7.2.6 Car Occupancy

As prosperity increases over time there is a resultant increase in car ownership. This is something which has been reflected in the forecasting model, however, in converting person benefits to car benefits one needs to take account of the reduction in car occupancy. The car occupancy factors for future years are listed in **Table 7.3**.

Table 7.3 2015, 2020, 2030 and 2040 Car Occupancy Factors

Trip Purpose	Occupancy Factor			
	2015	2020	2030	2040
Business	1.759	1.737	1.694	1.651
Commuting	1.779	1.762	1.729	1.696
Leisure	2.274	2.247	2.193	2.139

In the valuation of future benefits, the future values of operating costs have been included so as to represent the real rise in fuel and non fuel costs by 2015 and 2030 – see **Table 7.4**.

Table 7.4 2015, 2020, 2030, and 2040 Operating Costs by Vehicle Type

Trip Purpose	Car (€/vkm)				HGV (€/vkm)			
	2015	2020	2030	2040	2015	2020	2030	2040
Fuel	0.065	0.078	0.110	0.155	0.210	0.250	0.356	0.505
Non-Fuel	0.064	0.077	0.109	0.155	0.273	0.326	0.463	0.657

7.3 Cost Benefit Analysis Parameter Assumptions

The assumptions and parameters to be used in the analysis of the economic and financial performance of the Gabrovo-Shipka Project are discussed in **Table 7.5**.

Table 7.5 CBA Parameters

Input	Source	Application in the Cost Benefit Analysis
Capital Costs	Capital costs are calculated by the applying specified unit cost rates for measured quantities, as specified from the bills of quantities	Construction Costs Unit rates: • Cut to spoil – €4.6 / m^3 • Cut to fill – €1.57 / m^3 • Imported fill – €10.20 / m^3 • Placing of fill – €1.3 / m^3 • Roadworks – €577,977 / km • Bridges – €492.15 / m^2 • Short tunnel (< 1km) – €14,850,000 / km • Medium tunnel (1 – 3km) – €19,000,000 / km • Long Tunnel (> 3km) – €23,150,000 / km Additional construction contingencies, as a percentage of construction costs include: • Unmeasured items 20% • Preliminary and general items 10% • Environmental mitigation 1.5% Planning and Design Costs unit rates: • Rehabilitation of single carriageway road – €1,346 / km • New single carriageway road – €5,246 / km • Single bore tunnel – €12,240 / km Expropriation Costs unit rate: • Single carriageway road – €243,707 / km Additional costs calculated as a percentage of construction costs: • Contingency 10% • Project Management 2% • Site Supervision 3% • Publicity 0.1%

Input	Source	Application in the Cost Benefit Analysis
		VAT at 20% is added on all costs, except Expropriation costs. Capital costs are adjusted for the economic and financial appraisal by applying the adjustment factors for the fiscal effects for socio-economic analysis and standard conversion coefficients (SCC) (Bulgarian CBA guidance section 3.5, page 11). Capital cost spend profile is specified across a 3 year implementation period.
Operating Cost (Scheme and DM)	Bulgarian CBA Guidelines 2008, Section 4.3 Maintenance and Operating Costs	Operational cost rates are applied to the road lengths by road classification and infrastructure type within each of the "With Project" (WP) and "Without Project" (WOP) scenarios. Consultant assumptions are applied for operational rates for tunnels. Operational costs are profiled for the appraisal period and discounted to base year prices. The incremental difference between the WOP & WP scenarios represents the additional operational cost/saving for the scheme. WOP: *Existing Road* • Routine and Winter Maintenance – annually • Rehabilitation – every 7th year • Structural – every 14th year (starting at new road opening year) WP: *Existing Road* • Routine and Winter Maintenance – annually • Rehabilitation – every 7th year • Structural – every 14th year (starting at new road opening year) *New Road* • Routine and Winter Maintenance – annually • Rehabilitation – every 7th year after opening year • Structural – every 14th year after opening year Based on CBA guidance operation costs often increase in the "With Project" scenario due to the increase in road classification.

Input	Source	Application in the Cost Benefit Analysis
Maintenance Cost (Scheme and DM)	Bulgarian CBA Guidelines 2008, Section 4.3 Maintenance and Operating Costs	Maintenance cost rates are applied in a similar manner to operational costs, including consultant assumptions for tunnels. Example Class I and Class III operational and maintenance cost rates and their application are: Class I Routine Activity (euro/km) • Annual cost for routine maintenance 872 • Annual cost for winter maintenance 1,487 Periodical Activity (euro/km) • Cost for rehabilitation (every 7 years) 64,103 • Cost for structural improvement (every 14 years) 307,692 Class III Routine Activity (euro/km) • Annual cost for routine maintenance 385 • Annual cost for winter maintenance 641 Periodical Activity (euro/km) • Cost for rehabilitation (every 7 years) 30,769 • Cost for structural improvement (every 14 years) 153,846
Residual value	Bulgarian CBA Guidelines 2008, Section 4.6 Project Residual Value, page 18.	30% Standard highway infrastructure, 50% Major highway Infrastructure and 100% for land
Accident rate (Scheme and DM)	Accident rates for Class I and Class III calculated from 2004-8 observed data, Ministry of Interior, General Directorate “Security Police” HEATCO factors source: Deliverable 5, Annex C: Unreported Accidents, Page 10, Table 2. Unreported accident correction factors.)	Accident rates for Fatal, Serious and Slight Injuries are included within CBA assessment and applied to each modelled year by road classification. Accident rates are assumed to decline at a rate of 1% per annum throughout the 30 year appraisal period. Accident rates as presented as 10^{-6}/v/km, for Class I and Class III roads are: Class I • 2009: 0.278 • 2015: 0.262 • 2020: 0.249 • 2030: 0.225 Class III • 2009: 0.626 • 2015: 0.589 • 2020: 0.560 • 2030: 0.507

Input	Source	Application in the Cost Benefit Analysis
		• 2040: 0.204 • 2040: 0.458 The following severity splits are applied and remain constant throughout the appraisal period. • Fatal (F): 9.43% • Serious Injury (SI): 20.75% • Slight Injury (SLI): 69.81% European HEATCO correction factors for unreported accidents applied to accident rates. • Fatal (F): 1.02 • Serious Injury (SI): 1.50 • Slight Injury (SLI): 3.00
Value of Time (by traffic class)	Bulgarian CBA Guidelines 2008, Section 5.4.2 Value of Time Costs, page 26 (Road & Rail Modes). Vehicle occupancy UK Department for Transport WebTAG.	Value of passenger time is multiplied by average vehicle occupancy for each car user class modelled. Bus and rail VOT remains as per guidance and HGV VOT is calculated by multiplying the VOT tonnage value by average tonnage (14) (Calculated using the Eurostat Data) All VOT values are adjusted over the appraisal period on the basis of elasticity to growth of GDP/capita of 0.7, as specified in CBA guidance section 5.6.1.1. Average car vehicle occupancy factors are included in the transport model and decline throughout the appraisal period based on indicative reductions within UK's Department for Transport's guidance in WebTAG, as follows; • 2015: Car Business (CB) 1.759, Car Commuter (CC) 1.779, Car Leisure (CL) 2.274 • 2020: CB 1.737, CC 1.762,CL 2.247 • 2030: CB 1.694, CC 1.729 ,CL 2.193 • 2040: CB 1.651, CC 1.696,CL 2.139
Values of accidents	Bulgarian CBA Guidelines 2008, Section 5.6.1.1 Estimating the unit value	Accident severity cost values are adjusted over the appraisal period on the basis of elasticity to growth of GDP/capita of 0.7, as specified in CBA guidance section 5.6.1.1.

Input	Source	Application in the Cost Benefit Analysis
	of accidents, page 31.	
Values of vehicle operating costs	VOC forecast values based on "Consultant Assumptions". Fuel price set at 128 euro/litre at base year to fall by 11.5% (2009-2015) and increase by 14% (2015-2040). Fuel efficiency in 2008 is assumed to be the same as UK in 2002. For 2015 assumed at UK 2009 level and by 2030 Bulgaria is considered to be identical to the UK. Fuel efficiency increases from base 2008 are; 2015 8.3%, 2030 23.3% & 2040 33.3%.	Vehicle operating costs are calculated at a matrix level for the DM & DS scenarios within the transport model setup, including Fuel and Non Fuel costs. CBA spreadsheet contains the incremental difference between the two scenarios. VOC values are presented as (€/vkm) for each assessment year. • 2015: Car 0.130, HGV 0.483 • 2020: Car 0.155, HGV 0.576 • 2030: Car 0.219, HGV 0.818 • 2040: Car 0.310, HGV 1.162
Values of environmental impacts: air pollution	Environmental impacts: air pollution/air quality factors/equations extracted for Light and Heavy Vehicles. (General Road Administration 1999. Cost rates extracted from Requirements to the justification of Projects Under the Operational Program on Transport, V 1.2, May 2008, MF, MT, NRIC, Metropolitan., NRIF	Air quality impact is calculated within the CBA assessment by applying the following equations based on the traffic volumes and average modelled speed. Light Vehicle CO: e = 123.89 . V-0.5383 NO_2:e = -1E . V3 + 0.0006V2 – 0.0373V + 2.0389 SO_2:e = 0.3293.V-0.3776 $PM_{2.5}$: e = 1.6369.V-0.93 Heavy Vehicle CO: e = 257.77 . V-1.0217 NO_2:e = 54.386.V-0.3871 SO_2:e = 10.37.V-0.5569 $PM_{2.5}$: e = 4.2296V-0.7508 Where: e is emission in g/km; V is travel speed in km/h
Values of environmental impacts:	Bulgarian CBA Guidelines 2008, Section 5.8 Climate Change Costs, Table 12,	The climate change cost calculation is based on the volume of CO2 generated in tonnes in the WP and WOP scenarios, multiplied by the financial cost of each CO2 tonne in the given

<table>
<tr><th>Input</th><th>Source</th><th>Application in the Cost Benefit Analysis</th></tr>
<tr><td>climate change</td><td>page 34. Average tonne of CO2 generate in each scenario multiplied by the Table 12, Expected prices per ton of C02 (Euroct/v/km) (2010, 2020, 2030 ,2040 & 2050)</td><td>year, as expressed in the Bulgarian CBA Guidance. The values between modelled scenarios are calculated through the interpolation. The incremental value is the difference between the two financial values.</td></tr>
<tr><td>Values of benefits “others”</td><td>Bulgarian CBA Guidelines 2008, Section 5.10 Noise Costs, Table 13, page 36-37. Costs rates assumed on a link basis for different vehicle types in different conditions at 2007 costs. (Euroct/v/km)</td><td>“Other” costs represent noise within the current CBA assessment. Noise costs are calculated by applying a fixed cost rate to the vehicle kilometres travelled in the complete Bulgarian National Transport Model for the WP and WOP scenarios throughout the appraisal period.

Noise per trip (euro/vehicle.km) rates applied are:
<table>
<tr><th></th><th>City Conditions</th><th>Out of City Conditions</th><th>Rural Areas</th></tr>
<tr><td>Cars</td><td>0.3</td><td>0.05</td><td>0</td></tr>
<tr><td>Buses</td><td>1.52</td><td>0.24</td><td>0.03</td></tr>
<tr><td>Light vehicles – freight</td><td>1.52</td><td>0.24</td><td>0.03</td></tr>
<tr><td>Heavy vehicles - freight</td><td>2.8</td><td>0.44</td><td>0.05</td></tr>
</table></td></tr>
<tr><td>Road lengths (scheme and existing road)</td><td>Road lengths calculated from supplied 1:25000 scale mapping using AutoCAD.</td><td>Road length data is used to calculate link level vehicle kilometres (10-^{6}/v/km) for “With” and “Without Project” scenarios by multiply the road length by the total traffic volume. Vehicle kilometres values are used as inputs to Air Quality and Accident calculations.</td></tr>
<tr><td>Road Surface quality: base year</td><td>Unknown</td><td>N/A</td></tr>
<tr><td>Road Surface quality: base year</td><td>Unknown</td><td>N/A</td></tr>
<tr><td>Traffic forecasts</td><td>Traffic forecast based on the GDP and population growth assumptions as sourced from the Economist Intelligence Unit (EIU).

International trade makes</td><td>GDP growth forecasts are applied to create the forecast matrices for the transport model assessment. Within the CBA analysis GDP growth per head is applied to calculate forecast rates and costs for value of time, accident costs etc.

Applied GDP growth factors are shown in Table 5.10.</td></tr>
</table>

Input	Source	Application in the Cost Benefit Analysis
	up a considerable proportion of freight traffic in Bulgaria, growth in exports and transit demand is linked to the GDP of Bulgaria's trading partners. GDP figures for all major trading nations have been updating using World Economic Outlook Database figures up to 2015.	
Conversion factors from market to economic prices	Bulgarian CBA Guidelines 2008, Section 3.2 Discount Rate for Economic Analysis, page 10.	Discount rate 5.5% applied to convert market prices to economic price base year.

7.4 Fixed Trip Assignment

To assess the performance of the model and the parameters used, the without project (do minimum) demand was assigned on the 'with project' (do something) network. This demand was fixed so that changes that occur are as a direct result of the network improvements only. The impact of this on the economic performance, compared to the 'with project' (variable demand) assignment for the 2020, 2030 and 2040 forecast years, is shown for the two preferred options that yield positive benefits in **Tables 7.6 to 7.9**. The Bypass Only Option did not yield value for money in the variable demand situation and this is unchanged in the fixed trip assignment, thus is not shown.

The conclusions are that first, the re-distribution, induced traffic and mode shares do not influence the project excessively, and secondly that the benefits to re-distributed, mode share change and induced traffic produced by the consumer surplus methodology are not excessive. Indeed, the Bypass and Tunnel Option and Tunnel Only Options projects are still very good value for money with the fixed trip assumption.

The "fixed trip" test assumes demand to be fixed, that is that the project would lead to no change in mode split, no re-distribution of traffic due to changes in accessibility, and no induced traffic. The difference between the fixed trip assessment and the mainstream evaluation is a measure of the contribution these changes in traffic patterns make to the economic benefits.

Table 7.6 Bypass and Tunnel Preferred Option E Fixed Trip Assignment Comparison – Time Benefits

Time benefits (minutes)		2020			2030			2040		
		Fixed	Variable	%	Fixed	Variable	%	Fixed	Variable	%
Car	Business	64,056	76,827	-17%	65,794	79,754	-18%	70,611	86,362	-18%
	Commuting	12,736	15,825	-20%	13,414	17,058	-21%	14,885	19,315	-23%
	Leisure	91,010	105,013	-13%	102,566	118,467	-13%	114,033	132,267	-14%
	Total	**167,802**	**197,665**	**-15%**	**181,773**	**215,279**	**-16%**	**199,529**	**237,943**	**-16%**
Bus	Business	8,190	9,281	-12%	7,550	8,560	-12%	6,846	7,764	-12%
	Commuting	1,522	1,748	-13%	1,425	1,642	-13%	1,316	1,522	-14%
	Leisure	39,929	45,225	-12%	37,431	42,429	-12%	34,470	39,098	-12%
	Total	**49,642**	**56,254**	**-12%**	**46,407**	**52,631**	**-12%**	**42,632**	**48,385**	**-12%**

Table 7.7 Bypass and Tunnel Preferred Option E Fixed Trips Assignment Comparison – VOC Benefits

VOC benefits (euro)		2020			2030			2040		
		Fixed	Variable	%	Fixed	Variable	%	Fixed	Variable	%
Car	Business +LGV	5,803	7,211	-20%	8,573	10,675	-20%	12,314	15,390	-20%
	Commuting	809	1,145	-29%	1,357	1,894	-28%	2,021	2,849	-29%
	Leisure	8,746	10,436	-16%	13,702	16,333	-16%	20,651	24,313	-15%
	Total	**15,358**	**18,792**	**-18%**	**23,632**	**28,902**	**-18%**	**34,985**	**42,551**	**-18%**

For the Bypass and Tunnel preferred option, the analysis shows that (a) the differences are as expected: about 15% of time benefits for car come from changes in mode choice, distribution, and generated traffic in 2020; and (b) the contribution of these elements increases over time (but not excessively) to 16% by 2040. We conclude from these results that the model mechanisms which generate mode choice, re-distribution and induced traffic are not distorting the economic evaluation, **Table 7.6** and **7.7**.

Table 7.8 Tunnel Only Preferred Option N Fixed Trip Assignment Comparison – Time Benefits

Time benefits (minutes)		2020			2030			2040		
		Fixed	Variable	%	Fixed	Variable	%	Fixed	Variable	%
Car	Business	35,978	39,878	-10	38,212	43,322	-12	43,797	48,247	-9
	Commuting	7,517	8,506	-12	7,996	9,401	-15	8,843	10,264	-14
	Leisure	47,523	51,548	-8	54,838	60,719	-10	66,263	70,827	-6
	Total	**91,018**	**99,932**	**-9**	**101,045**	**113,443**	**-11**	**118,903**	**129,337**	**-8**
Bus	Business	5,471	6,187	-12	5,050	5,711	-12	4,586	5,185	-12
	Commuting	743	895	-17	705	851	-17	663	800	-17
	Leisure	26,618	30,228	-12	25,041	28,416	-12	23,140	26,240	-12
	Total	**32,832**	**37,310**	**-12**	**30,797**	**34,978**	**-12**	**28,389**	**32,224**	**-12**

Table 7.9 Tunnel Only Preferred Option N Fixed Trips Assignment Comparison – VOC Benefits

VOC benefits (euro)		2020			2030			2040		
		Fixed	Variable	%	Fixed	Variable	%	Fixed	Variable	%
Car	Business +LGV	4,713	5,224	-10	6,816	7,754	-12	9,832	11,172	-12
	Commuting	599	721	-17	1,016	1,240	-18	1,543	1,890	-18
	Leisure	5,605	6,197	-10	8,782	9,764	-10	13,143	14,505	-9
	Total	**10,917**	**12,142**	**-10**	**16,614**	**18,758**	**-11**	**24,519**	**27,567**	**-11**

For the Tunnel only preferred option, the analysis shows that (a) the differences are as expected: about 9% of time benefits for car come from changes in mode choice, distribution, and generated traffic in 2020; and (b) the contribution of these elements are maintained over time to at 8% by 2040. We conclude from these results that the model mechanisms which generate mode choice, re-distribution and induced traffic are not distorting the economic evaluation, **Table 7.8** and **7.9**.

8 Financial Cost Benefit Analysis

8.1 Introduction

As discussed in ***Chapter 7***, both an economic cost benefit analysis and a financial analysis aim to assess the value for money of projects, however they examine the project from different viewpoints, and contain differing costs and benefits. This chapter pertains to the financial analysis and the means by which it considers the financial impacts of transactions that affect the financial flows for the project owner. Financial analysis values all quantities according to their financial cost, or revenue, as they accrue to the project's owner.

In the case of the Gabrovo-Shipka Highway schemes, a summary of the main costs and benefits, and their treatment in the financial analysis, is shown in **Table 8.1**.

Table 8.1 Financial Analysis Costs and Benefits

Source of Cost / Benefit	Financial Analysis	Comment
Capital Cost	Full cost	Capital Cost for financial analysis is significantly higher than in economic CBA
Financing Costs	Included	
Residual Value of the Project	Valued at 30% of the standard capital cost, 50% of the major infrastructure cost with 100% of the land cost recoverable	
Operating and Maintenance Costs	Full cost	Cost for financial analysis is therefore significantly higher than in economic analysis
Travellers Time Savings	Not included, as there is no direct income to the project owner from this source	Bulgarian values used in the economic cost-benefit analysis
Vehicle Operating Cost Savings	Not included, as there is no direct income to the project owner from this source	Bulgarian values used in the economic cost-benefit analysis
Accident Savings	Not included, as there is no direct income to the project owner from this source	Bulgarian values used in the economic cost-benefit analysis
Benefits From Reduced Emissions	Not included, as there is no direct income to the project owner from this source	Bulgarian estimates used in the economic cost-benefit analysis

8.2 Assumptions, Values and Methodology

Financial projections are calculated in real prices on a base of 2008, in Euro, with and without inflation. In accordance with Working Document No. 4 – Guidance on the Methodology for Carrying Out Cost Benefit Analysis, a discount value of 5.5% is used for the financial analysis. The 'with' and 'without' project scenarios and horizon period are the same as described in ***Chapter 7***.

8.2.1 Investment Costs

The investment costs for the project are discussed in ***Chapter 6***.

8.2.2 Operational Income

The Gabrovo-Shipka project will not generate any revenues because it will operate without tolls.

8.2.3 Residual Value

The residual value of the asset is determined at the end of the forecast period as the difference between the initial investment value and the depreciation accumulated up until that moment in time. The standard transport infrastructure of the carriageway has a 30% residual asset value, whereas major infrastructure (bridges, overpasses, underpasses) has a 50% residual asset value. Where the assets can be recovered over the period of the project, they are incorporated with the total investment value. 100% of the land value has been included in the residual value.

For the financial rate of return calculations, the residual value of the project was assumed to be a revenue to the project.

9 Economic and Financial Cost Benefit Analysis Results

9.1 Financial Analysis

The financial projections are made on conditions and assumptions explained in the previous chapters. The financial sustainability and affordability are verified in nominal terms. The financial viability of the project is verified in real terms.

Table 9.1 Financial Cost Breakdown

	Item	Bypass and Tunnel Option E Total Project Costs €	Bypass Only Option J Total Project Costs €	Tunnel Only Option N Total Project Costs €
1.	Planning/design fees	206,380	102,856	122,002
2.	Land purchase	6,972,521	3,822,010	4,008,953
3.	Building and construction	226,882,314	45,243,246	188,955,084
4.	Plant and machinery	0	0	0
5.	Contingencies	22,688,231	4,524,325	18,895,508
6.	Price adjustment	0	0	0
7.	Technical assistance	4,537,646	904,865	3,779,102
8.	Publicity	226,882	45,243	188,955
9.	Supervision during construction implementation	6,806,469	1,357,297	5,668,653
10.	**Sub-TOTAL**	268,320,445	55,999,842	221,618,256
11.	(VAT)	52,269,585	10,435,566	43,521,861
12.	**TOTAL**	**320,590,029**	**66,435,408**	**265,140,117**

Land costs included above are post 2007 and therefore eligible. However, land is zero-rated for VAT, and land VAT has therefore been excluded.

The data on investment costs and operating costs is used to evaluate the financial return on the investment. The indicators needed for testing the project's financial performance are:

- Financial Net Present Value of the project (FNPV);
- Financial Internal Rate of Return (FIRR); and
- Financial Payback Period (FPBP).

The financial analysis for the investment, without EU funding, is presented in **Table 9.2**. Since there are no sources of income to the project other than possible maintenance savings, the rates of return and NPV are inevitably negative. With EU assistance the financial indicators of the project would significantly improve.

Table 9.2 Financial Indicators of the Investment Scenarios - Without EU Funding

Indicator	Measure	Bypass and Tunnel Option E	Bypass Only Option J	Tunnel Only Option N
FNPV/C	**€**	-134.1	-29.1	-109.6
FRR/C	**%**	-5.9%	-7.1%	-5.6%
FPBP/C	**Years**	-	-	-

Note: The financial rate of return was calculated assuming that the residual value is a revenue to the project.

9.2 Economic Cost Benefit Analysis

The project brings economic benefits such as reducing travel time and improving traffic safety. The Economic Cost Benefit uses discounted cash flow techniques to take account of the fact that benefits and costs that occur further into the future are valued less highly than those that occur in the short term. The positive impact of the project is measured by the economic indicators of the Net Present Value (NPV) of the project (which is the sum of the net benefits of the project discounted using the given rate to base year 2008 values), and in terms of the Economic Rate of Return (EIRR), which is the discount rate which gives a Net Present Value of zero. National Governments and international bodies such as the European Union set certain standards for the EIRR of transport infrastructure projects: typically the EIRR for a road project should be at around 5 to 10%. A summary of the economic results of the Preferred Options for the Gabrovo-Shipka Highway Project is presented in **Tables 9.3 to Table 9.5**.

Table 9.3 Bypass and Tunnel Preferred Option E Economic Appraisal Table

		EUR (millions) Discounted			
No	**Economic Impact**	**"Without Project"**	**"With Project"**	**Incremental Cost or Benefit**	**Share in Total Costs/ Benefits**
A	To Infrastructure Manager/Government				
1	Capital / Investment Costs		79.28	79.28	89.53%
2	Maintenance and Operation Costs	29.26	38.53	9.27	10.47%
B	To Users & Providers				
3	Value of Time	-97,601	-97,370	231.47	47.14%
4	Vehicle Operating Costs	-157,189	-157,002	190.91	38.88%
C	External Impacts				
5	On Safety (Accidents)	-275.01	-195.23	79.79	16.25%
6	Air Pollution	-81.36	-83.60	-2.24	-0.46%
7	Climate Change	-1271.70	-1279.03	-7.33	-1.49%
8	Noise	-1.98	-3.55	-1.57	-0.32%
9	Total Costs			88.55	
10	Total Benefits			491.02	
11	Net Present Value (NPV)	402.47			
12	EIRR	25.68%			
13	Benefit/Cost Ratio	5.54			

The analysis shows that, under the assumptions made for the project, the key indicators for the Gabrovo-Shipka Highway Project are positive. With a discount rate of 5.5%, there is a positive NPV of €402.47m, at 2008 prices, and a benefit cost ratio of 5.54. The corresponding EIRR is 25.68%.

Table 9.4 Bypass Only Preferred Option J Economic Appraisal Table

		EUR (millions) Discounted			
No	**Economic Impact**	**"Without Project"**	**"With Project"**	**Incremental Cost or Benefit**	**Share in Total Costs/ Benefits**
A	To Infrastructure Manager/Government				
1	Capital / Investment Costs		16.55	16.55	83.63%
2	Maintenance and Operation Costs	29.26	32.50	3.24	16.37%
B	To Users & Providers				
3	Value of Time	-97,601	-97,587	14.94	74.46%
4	Vehicle Operating Costs	-157,189	-157,191	-6.19	-30.87%
C	External Impacts				
5	On Safety (Accidents)	-275.01	-263.80	11.21	55.90%
6	Air Pollution	-81.36	-81.56	-0.20	-1.01%
7	Climate Change	-1271.70	-1271.52	0.18	0.90%
8	Noise	-1.98	-1.86	0.13	0.63%
9	Total Costs			19.78	
10	Total Benefits			20.06	
11	Net Present Value (NPV)	0.28			
12	EIRR	5.12%			
13	Benefit/Cost Ratio	1.01			

The analysis shows that, under the assumptions made for the project, the key indicators for the Gabrovo-Shipka Highway Project are negative. With a discount rate of 5.5%, there is a positive NPV of €0.28m, at 2008 prices, and a benefit cost ratio of 1.01. The corresponding EIRR is 5.12%.

Table 9.5 Tunnel Only Preferred Option N Economic Appraisal Table

			EUR (millions) Discounted		
No	**Economic Impact**	**"Without Project"**	**"With Project"**	**Incremental Cost or Benefit**	**Share in Total Costs/ Benefits**
A	To Infrastructure Manager/Government				
1	Capital / Investment Costs		65.50	65.50	91.09%
2	Maintenance and Operation Costs	29.26	35.67	6.41	8.91%
B	To Users & Providers				
3	Value of Time	-97,601	-97,478	123.49	42.10%
4	Vehicle Operating Costs	-157,189	-157,051	135.75	46.28%
C	External Impacts				
5	On Safety (Accidents)	-275.01	-236.33	38.68	13.19%
6	Air Pollution	-81.36	-82.01	-0.65	-0.22%
7	Climate Change	-1271.70	-1274.45	-2.75	-0.94%
8	Noise	-1.98	-3.18	-1.20	-0.41%
9	Total Costs			71.91	
10	Total Benefits			293.33	
11	Net Present Value (NPV)	221.42			
12	EIRR	19.88%			
13	Benefit/Cost Ratio	4.08			

The analysis shows that, under the assumptions made for the project, the key indicators for the Gabrovo-Shipka Highway Project are positive. With a discount rate of 5.5%, there is a positive NPV of €221.42m, at 2008 prices, and a benefit cost ratio of 4.08. The corresponding EIRR is 19.88%.

10 Risk Analysis on the Preferred Options

10.1 Introduction

The sensitivity tests and risk assessment have been undertaken on both the economic and financial analyses. As the roads comprising the scheme are un-tolled, there is no income for the financial analysis. It is expected that some of the costs will be contributed by the EU. Hence, there are two financial NPV's, depending on whether or not this contribution is included.

These tests are designed to do two things:

1. Indicate the stability in the assessment of ENPV and EIRR in the event of changes to costs and benefits; and
2. Identify which factors make the most difference to the economic assessment.

There may be changes in the amount and timing of investment costs; ongoing costs including operation and maintenance; the amount of benefit produced; and the monetary value of that benefit. For most of the roads, congestion is not a major issue. Hence, the benefits of the improvements are approximately proportional to the traffic flows. It is therefore reasonable to undertake sensitivity tests in the economic assessment spreadsheet without re-running the traffic model.

10.2 Sensitivity Tests

There will be six different sensitivity tests performed on the preferred options CBA that affect the costs and benefits which include:

1. Increase Investment Costs;
2. Change of Investment Profile;
3. Change of Operation and Maintenance Costs;
4. Reduce Traffic Volume;
5. Reduce Value of Time Savings; and
6. Reduce GDP Growth.

10.2.1 Sensitivity Test 1 - Increase Investment Costs by 30%

Investment costs have been developed using unit rates per kilometre. For most projects, the construction costs will be the highest by a considerable margin. There will be a small number of cases where the land costs will be more significant. Hence, this sensitivity test is really concentrating on the impact if construction is more expensive than expected. The investment costs for the project include:

- Land;
- Construction (equipment, materials, labour);
- Expropriation;
- Project Management; and
- Publicity.

The results of this test, compared with the base case, are shown in **Table 10.1**. The base case is the preferred option result. The impact of the change is a 6% and 9% decrease in the economic Net Present Value of the bypass and tunnel project, and tunnel only project respectively.

Table 10.1 Results of Sensitivity Test 1

Scenario		EIRR	ENPV
Bypass and Tunnel	Base Case	25.68%	402.47
	Increase of Investment Cost by 30%	21.09%	377.36
	Percentage Change	**-17.9%**	**-6.2%**
	Impact of 1% change in sensitivity variable	-0.60%	-0.21%
	Is the variable critical	Not Critical	Not Critical
Bypass Only	Base Case	5.12%	0.28
	Increase of Investment Cost by 30%	3.18%	-5.02
	Percentage Change	**-37.6%**	**-1903.8%**
	Impact of 1% change in sensitivity variable	-1.26%	-63.46%
	Is the variable critical	Critical	Critical
Tunnel Only	Base Case	19.88%	221.42
	Increase of Investment Cost by 30%	16.28%	200.72
	Percentage Change	**-18.1%**	**-9.3%**
	Impact of 1% change in sensitivity variable	-0.60%	-0.31%
	Is the variable critical	Not Critical	Not Critical

10.2.2 Sensitivity Test 2 - Change of Investment Cost Profile

The Base Case assumes that the expenditure is spread evenly throughout the construction period and that the new road opens upon completion. This sensitivity test brings forward the cost, so that all of the spend occurs in the first year, but leaves the opening date unchanged. This sensitivity test represents two effects. Firstly, that expenditure occurs earlier, and secondly, that there is a delay to scheme opening after costs have been incurred.

Table 10.2 Results of Sensitivity Test 2

Scenario		EIRR	ENPV
Bypass and Tunnel	Base Case	25.68%	402.47
	100% Construction Costs Occur in First Year	21.09%	393.36
	Percentage Change	**-17.9%**	**-2.3%**
Bypass Only	Base Case	5.12%	0.28
	100% Construction Costs Occur in First Year	4.39%	-1.72
	Percentage Change	**-14.2%**	**-716.5%**
Tunnel Only	Base Case	19.88%	221.42
	100% Construction Costs Occur in First Year	16.81%	213.63
	Percentage Change	**-15.5%**	**-3.5%**

10.2.3 Sensitivity Test 3 - Increase Operation and Maintenance Cost by 30%

The cost of maintenance for the project is determined by the length of the scheme. Activities for maintenance undertaken annually include:

- Routine maintenance; and
- Winter maintenance.

Other activities occur periodically over time:

- Rehabilitation every 7 years; and
- Structural improvement every 14 years.

For the Gabrovo-Shipka Highway Project it has been assumed that rehabilitation of the existing road will occur after 7 years and structural improvement after 14 years, in accordance with current best practice. This is because of the new road will not provide full relief to the existing road network, and access to Gabrovo will need to be maintained.

The results for changing the costs of operation and maintenance show the change in ENPV for the bypass and tunnel option and tunnel only option is negligible, as illustrated in **Table 10.3**.

Table 10.3 Results of Sensitivity Test 3

Scenario		EIRR	ENPV
Bypass and Tunnel	Base Case	25.68%	402.47
	Increase of Operation and Maintenance Costs by 30%	25.58%	399.68
	Percentage Change	**-0.4%**	**-0.7%**
	Impact of 1% change in sensitivity variable	-0.01%	0.02%
	Is the variable critical	Not Critical	Not Critical
Bypass Only	Base Case	5.12%	0.28
	Increase of Operation and Maintenance Costs by 30%	4.64%	-0.69
	Percentage Change	**-9.3%**	**349.2%**
	Impact of 1% change in sensitivity variable	0.31%	-11.64%
	Is the variable critical	Not Critical	Critical
Tunnel Only	Base Case	19.88%	221.42
	Increase of Operation and Maintenance Costs by 30%	19.77%	219.50
	Percentage Change	**-0.6%**	**-0.9%**
	Impact of 1% change in sensitivity variable	0.02%	0.03%
	Is the variable critical	Not Critical	Not Critical

Sensitivity Test 4 - Reduce Traffic Volume by 30%

This test can represent two possible situations. Firstly, a situation in which the scheme capture is reduced because more traffic remains on the existing road. In this case, fewer vehicles will obtain the potential benefit and the remaining vehicles do not gain any reduction in cost. Secondly, it can represent a reduction in demand, but the same capture rate, so the same numbers of vehicles gain the benefit. The results show that the impact of this change is significant for the bypass and tunnel with a 37% decrease in the schemes economic value, as shown in

Table 10.4 Results of Sensitivity Test 4

Scenario		EIRR	ENPV
Bypass and Tunnel	Base Case	25.68%	402.47
	Reduce Traffic Volume by 30%	19.51%	255.16
	Percentage Change	**-24.0%**	**-36.6%**
	Impact of 1% change in sensitivity variable	0.80%	1.22%
	Is the variable critical	Not Critical	Critical
Bypass Only	Base Case	5.12%	0.28
	Reduce Traffic Volume by 30%	1.87%	-5.74
	Percentage Change	**-63.5%**	**-2163.2%**
	Impact of 1% change in sensitivity variable	2.12%	72.11%
	Is the variable critical	Critical	Critical
Tunnel Only	Base Case	19.88%	221.42
	Reduce Traffic Volume by 30%	15.00%	113.42
	Percentage Change	**-24.5%**	**-39.7%**
	Impact of 1% change in sensitivity variable	0.82%	1.32%
	Is the variable critical	Not Critical	Critical

Sensitivity Test 5 - Reduce Value of Time Savings by 40%

For the construction of a road along a new route, the main economic benefits would be generated by the savings of costs, related to the value of time. This test can represent a number of situations. Firstly, where the number of minutes saved does not change, but their valuation does change. However, the resulting benefits will be the same, given the same proportional change in the number of minutes saved, but with an unchanged valuation.

The results in **Table 10.5** show a significant decrease in the benefits for the bypass and tunnel option, with the ENPV reduced by 23%.

Table 10.5 Results of Sensitivity Test 5

Scenario		EIRR	ENPV
Bypass and Tunnel	Base Case	22.68%	402.47
	Reduce Value of Time Savings by 40%	21.81%	309.88
	Percentage Change	**-15.1%**	**-23.0%**
	Impact of 1% change in sensitivity variable	0.38%	0.58%
	Is the variable critical	Not Critical	Not Critical
Bypass Only	Base Case	5.12%	0.28
	Reduce Value of Time Savings by 40%	1.83%	-5.70
	Percentage Change	**-64.3%**	**-2147.6%**
	Impact of 1% change in sensitivity variable	1.61%	53.69%
	Is the variable critical	Critical	Critical
Tunnel Only	Base Case	19.88%	221.42
	Reduce Value of Time Savings by 40%	17.18%	172.02
	Percentage Change	**-13.6%**	**-22.3%**
	Impact of 1% change in sensitivity variable	0.434%	0.56%
	Is the variable critical	Not Critical	Not Critical

10.2.4 Sensitivity Test 6 - Reduce GDP Growth by 10%

GDP has an impact upon the level of traffic flow, affecting all types of benefits. It also has an effect on the valuation of benefits, particularly value of time. This test does not affect the base year, but does affect growth beyond the base. It has a progressively greater impact on the level of benefits as the assessment period progresses. The bypass and tunnel option results indicate a 15% reduction in the ENPV as a result of the change, **Table 10.6**.

Table 10.6 Results of Sensitivity Test 6

Scenario		EIRR	ENPV
Bypass and Tunnel	Base Case	25.68%	402.47
	Reduce GDP Growth by 10%	24.04%	343.03
	Percentage Change	**-6.4%**	**-14.8%**
	Impact of 1% change in sensitivity variable	0.64%	1.48%
	Is the variable critical	Not Critical	Critical
Bypass Only	Base Case	5.12%	0.28
	Reduce GDP Growth by 10%	3.53%	-2.74
	Percentage Change	**-31.1%**	**-1085.1%**
	Impact of 1% change in sensitivity variable	3.11%	108.51%
	Is the variable critical	Critical	Critical
Tunnel Only	Base Case	19.88%	221.42
	Reduce GDP Growth by 10%	18.52%	187.06
	Percentage Change	**-6.8%**	**-15.5%**
	Impact of 1% change in sensitivity variable	0.68%	1.55%
	Is the variable critical	Not Critical	Critical

10.2.5 Switching Value Parameters

These are the changes required in each of the variables to reduce the NPV to zero, and are shown in **Table 10.7**.

Table 10.7 Switching Values

Scenario	Variable	Percentage Change Required
Bypass and Tunnel	Investment Cost	508%
	Operation and Maintenance Cost	4341%
	Traffic Volume	-82%
	Value of Time	-1474%
	GDP Growth	N/A
Bypass Only	Investment Cost	2%
	Operation and Maintenance Cost	9%
	Traffic Volume	-1%
	Value of Time	-2%
	GDP Growth	N/A
Tunnel Only	Investment Cost	338%
	Operation and Maintenance Cost	3455%
	Traffic Volume	-75%
	Value of Time	-179%
	GDP Growth	N/A

10.2.6 Scenario Analysis

The sensitivity tests have each concentrated on one variable. There is no reason to believe that most of these variables are correlated. However, it is possible for several of them to be on the downside, or upside, at the same time. The following sections present a downside scenario and an upside scenario using combinations of some of these variables.

10.2.6.1 Downside Scenario

The assumptions for the downside scenario are listed in **Table 10.8**, with the results presented in **Table 10.9**. The impact of the downside scenario is a 20% reduction in the economic net present value of the bypass and tunnel project.

Table 10.8 Assumptions for the Downside Scenario

Variable	Percentage Change
Investment Cost	+10%
Operation and Maintenance Cost	+10%
Traffic Volume	-10%
Value of Time	-10%

Table 10.9 Results of the Downside Scenario

Scenario		EIRR	ENPV
Bypass and Tunnel	Base Case	25.68%	402.47
	Downside Scenario	21.20%	323.23
	Percentage Change	**-17.4%**	**-19.7%**
Bypass Only	Base Case	5.12%	0.28
	Downside Scenario	2.57%	-5.16
	Percentage Change	**-49.8%**	**-1955.3%**
Tunnel Only	Base Case	19.88%	221.42
	Downside Scenario	16.42%	173.43
	Percentage Change	**-17.4%**	**-21.7%**

10.2.6.2 Upside Scenario

The assumptions for the upside scenario are listed in **Table 10.10**, with the results shown in **Table 10.11**.

Table 10.10 Assumptions for the Upside Scenario

Variable	Percentage Change
Investment Cost	-10%
Operation and Maintenance Cost	-10%
Traffic Volume	+10%
Value of Time	+10%

The impact of the upside scenario is almost identical to that of the downside scenario, with an increase in the bypass and tunnel project's ENPV by 21%

The results show that the project has a positive NPV, and an EIRR which is well above 5.5% in all the scenarios tested.

Table 10.11 Results of the Upside Scenario

Scenario		EIRR	ENPV
Bypass and Tunnel	Base Case	25.68%	402.47
	Upside Scenario	30.95%	486.33
	Percentage Change	**20.5%**	**20.8%**
Bypass Only	Base Case	5.12%	0.28
	Upside Scenario	7.75%	6.02
	Percentage Change	**51.5%**	**-2062.7%**
Tunnel Only	Base Case	19.88%	221.42
	Upside Scenario	23.92%	271.88
	Percentage Change	**20.3%**	**22.8%**

10.3 Risk Analysis

There are two problems with the scenario analysis approach. Firstly, there is no reliable way of assigning probabilities to the outcomes; secondly, the combination of variables takes no account of whether they are positively or negatively correlated, or not correlated at all. It is true that some variables are correlated, such as values of time and economic growth. Combining low economic growth and low value of time growth is a legitimate method and these are linked in the economic analysis spreadsheet. However, there is no reason to believe that a change in investment costs should influence traffic volumes. There is also the possibility that some variables will diverge from forecasts in a favourable direction, whilst other changes are unfavourable. For this reason, we have conducted a risk analysis using @Risk which uses a Monte Carlo simulation approach.

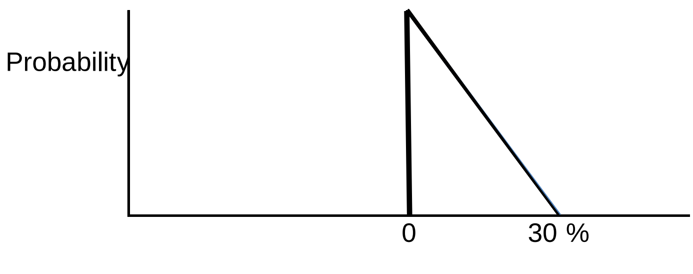
Risk Analysis addresses several of the weaknesses of the scenario approach:

- It does produce probabilities of certain outcomes, and it does so with complete flexibility – any outcome can be assigned a probability; and
- Variables which are correlated (or not) can be specified as such (indeed more complex dependency structures can also be specified).

10.3.1 Risk Distributions for Costs

Changes in the spend profile only have a small impact compared to changes in the total investment cost. Hence, it is the investment cost which is incorporated into the risk analysis. The maximum extent of the difference modelled is 30%. It is assumed that the tender price is a minimum, and therefore can only increase by up to 30%. It is most likely that the actual cost will be close to the estimate, taking account of compensating errors. Hence, we are using a triangular distribution as shown in **Figure 10.1**.

Figure 10.1 Investment Cost Risk Distribution



We have assumed that the operation and maintenance costs will be symmetrically distributed by +/- 30% with a triangular distribution. This is assumed not to be correlated with construction costs.

10.3.2 Risk Distributions for Benefits

There are normally two types of uncertainties in the assessment of benefits for road projects: traffic capture and growth. Capture is nearly always the most significant effect in the early years (a base year issue) with growth becoming progressively more significant (a forecasting years' issue).

Base year risks are those that are due to our imperfect understanding of the present situation. These risks may be due to statistical uncertainty in the surveys or variations in the speed of roads in the traffic model. These risks are static risks as they will not change over time, and apply to the opening year (although their effects will persist into the future).

The second major class of risk is forecast risk. This represents uncertainty in growth parameters. This type of risk includes factors such as GDP; we have greater confidence about the level of GDP next year than we have in 20 years time.

The risk in the early years of the road project is dominated by the base year risk. The later years are dominated by the forecast risks.

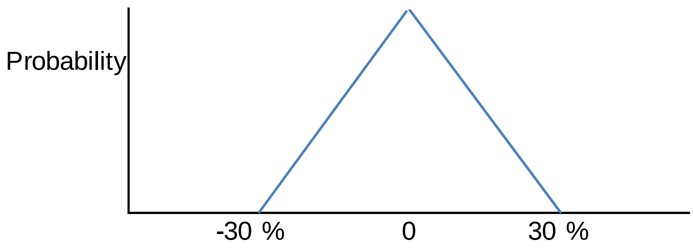
10.3.3 Base Year Risks

The base year risk can best be understood as the uncertainty there would be if the road were in operation at this point in time. This removes any growth issues but does include:

- Existing levels of traffic flow (counts). Any error in this estimate will have a proportional impact on the benefits as there will be less traffic to benefit from the improvements;
- Pattern of origins and destinations (roadside interview surveys). This can affect the assessment of the number of drivers who will transfer to a new route, and hence the number who will gain the benefit from it;
- Network speeds and capacities. The benefit achieved is partly determined from the saving in journey time. Hence, we must model the speeds on the project road and on the alternative road network. Any errors in the model will affect the assessment of the amount of time saved; and
- Value of Time. As these are not toll roads, it is a reasonable assumption that people will use the fastest route. Hence, this will not affect assignment, but only the value put on the savings.

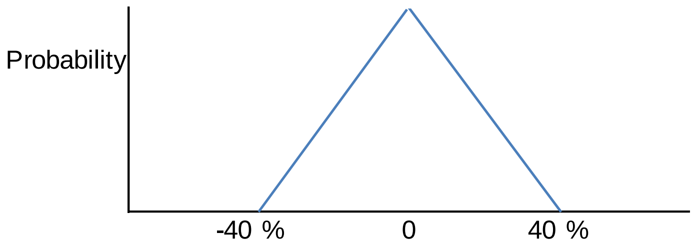
The first two of these risks affect the amount of traffic gaining the benefit. This is modelled as a triangular distribution with the apex in the middle. The maximum deviation is ±30%.

Figure 10.2 Base Year Risk Distribution



The third and the fourth risk relate to the time saving benefit. One of them relates to the amount of time saved, while the other relates to the valuation of it. It is the product of these two variables which gives the overall benefit. Hence, a proportional change in one of them has exactly the same effect on the benefits as the same proportional change in the other. This is modelled as a triangular distribution with the apex in the middle. The maximum deviation is ±40%.

Figure 10.3 Time Saving Benefit Risk Distribution



10.3.4 Overall Base Risks

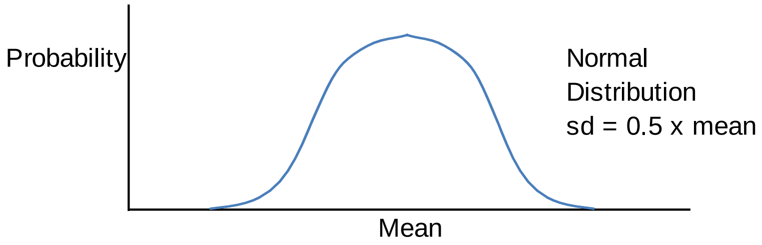
The potential errors described above do not necessarily imply a wide risk distribution in the base year. Lack of correlation in the variables will result in compensating errors. Even if the base year origin destination pattern is incorrect, much of the flow will be in scope as it is using a closely parallel highway.

10.3.5 Forecasting Year Risks

The key driver of growth is GDP. If GDP differs from its forecast levels then demand growth will also be different. GDP growth may be higher than forecast in some years but lower in others. There is considerable variation in the short term to GDP growth but long term average growth levels tend to hold.

To represent this uncertainty in the GDP growth, we use a normally distributed random variable for GDP growth with a mean value equal to the most recent growth factor and a standard deviation of half of the forecast growth. There is no correlation between years. The effect of this is that the absolute variability in the growth increases each year, but the relative variability (compared to the total growth) reduces over time.

Figure 10.4 Forecasting Years Risk Distribution



Value of time is closely tied with GDP growth. The overall value of time growth of the driving population will be lower than the growth in value of time of individuals as most of the growth in the driving population will be in lower income groups. The GDP and value of time effects are already linked in the economic appraisal spreadsheet and no further adjustment is required.

10.3.6 Risk Analysis Results

All of these factors are then combined to produce an alternative NPV and EIRR for each option scenario. This process is undertaken 100,000 times to provide a distribution of results, which are presented in **Tables 10.12** to **10.14**.

Table 10.12 Bypass and Tunnel Preferred Option E Risk Analysis Results @RISK Software

	Economic Variables		
	ENPV	EIRR	BCR
Base Case	**402.5**	**25.7%**	**5.54**
Minimum	151.8	13.8%	2.44
Maximum	799.0	38.7%	9.75
Mean	395.8	23.9%	5.10
Std Deviation	96.9	3.6%	1.05
5% Percentile	**249.7**	**18.3%**	**3.53**
10% Percentile	277.7	19.4%	3.82
15% Percentile	297.1	20.2%	4.04
20% Percentile	312.3	20.8%	4.21
25% Percentile	326.4	21.4%	4.36
30% Percentile	339.1	21.9%	4.49
35% Percentile	351.2	22.4%	4.62
40% Percentile	363.7	22.9%	4.75
45% Percentile	376.3	23.3%	4.88
50% Percentile	**388.1**	**23.8%**	**5.01**
55% Percentile	401.7	24.2%	5.14
60% Percentile	414.0	24.7%	5.28
65% Percentile	426.5	25.2%	5.43
70% Percentile	440.5	25.7%	5.58
75% Percentile	455.9	26.2%	5.75
80% Percentile	474.1	26.9%	5.95
85% Percentile	495.9	27.6%	6.18
90% Percentile	522.5	28.6%	6.50
95% Percentile	**568.5**	**30.1%**	**6.98**

The mean value of the distribution for both the ENPV and EIRR is marginally lower than the model value. Similarly, the median (50^{th} percentile) is marginally lower. The percentiles for the ENPV distribution demonstrate that less than 5% of the distribution is below zero. There is less than a 5% chance that the ENPV will be negative. Similarly, there is less than a 5% chance that the EIRR will fall below 5.5%, which is the discount rate used in the ENPV calculation.

Table 10.13 Bypass Only Preferred Option J Risk Analysis Results @RISK Software

	Economic Variables		
	ENPV	EIRR	BCR
Base Case	**0.3**	**5.1%**	**1.01**
Minimum	-15.1	-1.5%	0.38
Maximum	23.2	131982.5%	2.09
Mean	-1.4	20.1%	0.94
Std Deviation	5.1	1355.1%	0.23
5% Percentile	**-8.8**	**0.8%**	**0.60**
10% Percentile	-7.5	1.5%	0.66
15% Percentile	-6.5	2.0%	0.70
20% Percentile	-5.7	2.4%	0.74
25% Percentile	-5.0	2.8%	0.77
30% Percentile	-4.3	3.2%	0.80
35% Percentile	-3.6	3.5%	0.83
40% Percentile	-3.0	3.8%	0.86
45% Percentile	-2.4	4.0%	0.89
50% Percentile	**-1.8**	**4.3%**	**0.92**
55% Percentile	-1.2	4.6%	0.95
60% Percentile	-0.5	4.9%	0.98
65% Percentile	0.2	5.2%	1.01
70% Percentile	0.9	5.5%	1.04
75% Percentile	1.7	5.8%	1.08
80% Percentile	2.7	6.2%	1.13
85% Percentile	3.8	6.6%	1.18
90% Percentile	5.4	7.2%	1.26
95% Percentile	**7.7**	**8.0%**	**1.37**

The mean value of the distribution for both the ENPV and EIRR is lower than the model value. Similarly, the median (50^{th} percentile) is lower. The percentiles for the ENPV distribution demonstrate that 60% of the distribution is below zero. There is a 35% chance that the ENPV will be positive. Similarly, there is less than a 30% chance that the EIRR will be above 5.5%, which is the discount rate used in the ENPV calculation.

Table 10.14 Tunnel Only Preferred Option N Risk Analysis Results @RISK Software

	Economic Variables		
	ENPV	**EIRR**	**BCR**
Base Case	**221.4**	**19.9%**	**4.08**
Minimum	66.7	10.3%	1.82
Maximum	460.3	29.3%	6.98
Mean	215.3	18.5%	3.75
Std Deviation	55.8	2.7%	0.74
5% Percentile	**132.2**	**14.2%**	**2.64**
10% Percentile	146.5	15.0%	2.84
15% Percentile	157.2	15.6%	2.98
20% Percentile	166.8	16.1%	3.10
25% Percentile	175.2	16.6%	3.21
30% Percentile	183.1	17.0%	3.32
35% Percentile	190.6	17.3%	3.41
40% Percentile	197.6	17.7%	3.51
45% Percentile	204.9	18.1%	3.61
50% Percentile	**211.7**	**18.4%**	**3.69**
55% Percentile	218.2	18.8%	3.79
60% Percentile	225.2	19.1%	3.88
65% Percentile	232.7	19.4%	3.98
70% Percentile	240.9	19.8%	4.08
75% Percentile	249.6	20.3%	4.20
80% Percentile	259.9	20.7%	4.34
85% Percentile	273.0	21.3%	4.50
90% Percentile	289.3	22.0%	4.73
95% Percentile	**314.5**	**23.1%**	**5.06**

The mean value of the distribution for both the ENPV and EIRR is marginally lower than the model value. Similarly, the median (50^{th} percentile) is marginally lower. The percentiles for the ENPV distribution demonstrate that less than 5% of the distribution is below zero. There is less than a 5% chance that the ENPV will be negative. Similarly, there is less than a 5% chance that the EIRR will fall below 5.5%, which is the discount rate used in the ENPV calculation.

11 Summary and Conclusions

11.1 Gabrovo Conclusions

11.1.1 Policy Context

Gabrovo is located on PETC-IX, which runs north to south through Bulgaria, connecting Greece to Northern Europe, demonstrating that the corridor is of economic significance to the European Union. The Gabrovo – Shipka corridor also forms a key component of the TEN-T road network, providing one of only two north-south connections of the network within the country.

The Gabrovo-Shipka Highway project is a national priority for Bulgaria's Transport Sector. It meets national objectives as set out in the National Strategic Reference Framework 2007-2013, and falls under Priority 2 of the Transport Sector's Roads and Motorways priorities, detailed in the National Strategy for the Integrated Development of the Infrastructure of Bulgaria and Action Plan for the Period 2006-2015.

11.1.2 Feasibility Studies & Preferred Option Selection

The detail of the Gabrovo – Shipka Highway Project are set out in a 2008 Feasibility Study, which examined detailed design variants for the bypass and tunnel components of the scheme. These variants form the Project Options which have been grouped into the three scenarios for the CBA; the Gabrovo-Shipka bypass and tunnel, the Bypass only and the Tunnel only. The Project Options are listed in **Table 11.1**.

A multi criteria analysis was not feasible on the identified options, therefore the choice of the preferred option for each scenario has been assessed on the grounds of the CBA results alone. The CBA results are presented in **Table 11.1** and show that the Preferred Option for each scenario are as follows:

- Bypass and Tunnel – Option E;
- Bypass Only – Option J; and
- Tunnel Only – Option N.

The alignment of Option E is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2 and the Red variant of Stage 3 (as described in Option D). Option E then includes the Red variant of Stage 4 and the Red variant of Stage 5 (as described in Option B). The total length of Option E is 31.861km.

The analysis shows that, under the assumptions made for the project, the key indicators for the Gabrovo-Shipka Highway Project are positive. With a discount rate of 5.5%, there is a positive NPV of €402.47m, at 2008 prices, and a benefit cost ratio of 5.54. The corresponding EIRR is 25.68%. This Preferred Option is illustrated in **Figure 3.6**.

For the Bypass Only, Option J is the Preferred Option. The alignment of Option J is made up of the rehabilitation of Stage 1, the reconstruction of Stage 2, the Red variant of Stage 3 and the Blue variant of Stage 4 (as described in Option D). The stage connector then forms the final part of the bypass alignment, linking into the I-5 south of Gabrovo. The total length of Option J is 21.328km.

The analysis shows that, under the assumptions made for the project, the key indicators for the Gabrovo-Shipka Highway Project are just positive. With a discount rate of 5.5%, there is a positive NPV of €0.28m, at 2008 prices, and a benefit cost ratio of 1.01. The corresponding EIRR is 5.12%. The Preferred Option is illustrated in **Figure 3.11**.

For the Tunnel Only, Option N is the Preferred Option. The alignment comprises the stage connector and the Red variant of Stage 5 (as described in Options B and E which joins the I-5 north of Shipka. The total length of Option N is 10.273km.

The analysis shows that, under the assumptions made for the project, the key indicators for the Gabrovo-Shipka Highway Project are positive. With a discount rate of 5.5%, there is a positive NPV of €221.42m, at 2008 prices, and a benefit cost ratio of 4.08. The corresponding EIRR is 19.88%. The Preferred Option is illustrated in **Figure 3.15.**

Table 11.1 Gabrovo – Shipka Bypass Options

Scenario	Option	Total Length excluding Stage Connection (km)	Economic Indicator		
			NPV	EIRR	BCR
Bypass and Tunnel	A	31.644	398.14	24.43%	5.27
	B	31.414	408.84	25.06%	5.42
	C	31.339	371.50	19.31%	3.86
	D	32.091	392.09	24.97%	5.39
	E	**31.861**	**402.47**	**25.68%**	**5.54**
	F	31.786	390.43	20.47%	4.09
Bypass Only	G	20.881	-1.86	4.24%	0.92
	H	21.141	-2.03	4.22%	0.91
	I	21.181	-3.54	3.66%	0.86
	J	**21.328**	**0.28**	**5.12%**	**1.01**
	K	21.588	-1.28	4.34%	0.94
	L	21.628	-2.31	3.88%	0.89
Tunnel Only	M	10.763	219.52	19.61%	4.02
	N	**10.273**	**221.42**	**19.88%**	**4.08**
	O	10.158	183.92	14.32%	2.69

11.1.3 Traffic Modelling and Forecasts

The Gabrovo Highway Project has been evaluated using a multi-modal transportation model that was originally developed to provide the evidence base to be used in the production of the Bulgarian General Transport Master Plan.

The Bulgaria Transport Model (BTM) is a large-scale inter-urban model comprising both elements of people movement and also the movement of freight. It is required to be able to test the impact of relatively large-scale improvements to the infrastructure available for inter-urban travel between Bulgarian cities and between Bulgaria and the rest of Europe.

It includes all the main mechanised modes of transport, and produces forecasts of travel demand up to the year 2040. The outputs, as far as highways are concerned, are forecasts of the demand on each road by vehicle type, costs (journey time and vehicle operating costs) of travel between origins and destinations, and the routes used between origins and destinations. The outputs are used in three ways:

- For the operational performance of interventions –the demand for new infrastructure or services, and identification of capacity issues;
- To assess the economic and financial performance using the demand for new infrastructure or services, whether such demand is existing, diverted, generated, transit or national traffic; and travel); and
- For environmental performance using particular vehicle kilometres from the network outputs.