

FORECAST OF FREIGHT TRAFFIC WITH THE PTV VISION VISUM SOFTWARE TOOL OF A SMALL TOWN

PREVISÃO DO TRÁFEGO DE MERCADORIAS COM A FERRAMENTA DE SOFTWARE PTV VISION VISUM DE UMA PEQUENA CIDADE

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Abstract

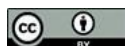
The dynamic development of transport in recent years has been an important factor in the economic development of the world, solving many important social issues, economic problems, unemployment and poverty, but on the other hand, urban transport (transport), for many reasons, is becoming a bigger and bigger problem today. Through the street network of the city of Bitola, various flows of goods, materials and cargo intertwine every day: trade goods, finished products, semi-finished products, raw materials, building materials, consignments, secondary raw materials, waste and the like. The transport of goods is an integral part of the city's economy and is a prerequisite for sustainable urban life, but it causes a number of negative effects on the environment followed by air pollution and increased noise. The problems arising from road freight transport are constantly overlooked. In this article, we will analyze the road freight transport in the city of Bitola. The analysis will be done on three entry-exit routes, i.e. cordon research points. With the help of the PTV VISION VISUM software tool, a model will be created and a forecast of transport demand will be made.

Keywords: Analysisism. Odeling. Loading. Transportation. Software Tooling.

Resumo

O desenvolvimento dinâmico dos transportes nos últimos anos tem sido um fator importante no desenvolvimento económico do mundo, resolvendo muitas questões sociais importantes, problemas económicos, desemprego e pobreza, mas, por outro lado, os transportes urbanos (transportes), por muitas razões, estão a tornar-se um problema cada vez maior nos dias de hoje. Através da rede de ruas da cidade de Bitola, vários fluxos de mercadorias, materiais e cargas se entrelaçam todos os dias: mercadorias comerciais, produtos acabados, produtos semi-acabados, matérias-primas, materiais de construção, consignações, matérias-primas secundárias, resíduos e afins. O transporte de mercadorias é parte integrante da economia da cidade e um pré-requisito para uma vida urbana sustentável, mas provoca uma série de efeitos negativos no ambiente, seguidos da poluição atmosférica e do aumento do ruído. Os problemas decorrentes do transporte rodoviário de mercadorias são constantemente ignorados. Neste artigo, vamos analisar o transporte rodoviário de cargas na cidade de Bitola. A análise será feita em três rotas de entrada/saída, ou seja, pontos de pesquisa de cordão. Com a ajuda da ferramenta de software PTV VISION VISUM, será criado um modelo e será feita uma previsão da procura de transportes.

Palavras-chave: Análise. Odeling. Carregamento. Transporte. Ferramentas de Software.



1 INTRODUCTION

Freight road transport is considered one of the key drivers of trade and logistics. This sector encompasses companies engaged in transporting goods and materials through road infrastructure, providing essential services for various industries, from manufacturing to trade.

Efficient freight transport provides a range of economic benefits that enrich living standards through multiple effects, such as better market access, employment, and additional investment.

The role that transports plays in the economy has contributed in recent years, continuously investing in the development of this activity to improve the quality of services, as well as to introduce innovations to better respond to the demands of customers that are equally present both in the manufacturing sector and among consumers. Under such conditions, quality transport, especially road freight transport, has established itself as an indispensable part of modern living. And the main prerequisite for developed freight transport is road infrastructure, which is not infrequently compared to the bloodstream of a modern society. Compared to rail, water, or air, road freight transport offers greater flexibility in terms of planning the time and speed of delivery.

It provides a door-to-door service and can be easily adapted to customer requirements. It is more convenient for short-distance transport, and it is easy to keep track of where the goods are at the moment. There are conditions for continuous communication with the driver. It is also best suited for transporting goods to rural areas. In fact, this is the greatest advantage because without the development of road freight transport, no other transport can be realized.

In Europe, freight transport is expected to increase by 80% in 2050 where this data shows that everywhere we will see growth in kilometers travelled under load, with quality and reliable transport companies. We are witnessing that our country is gradually approaching and improving communication with firms and companies from abroad with which it cooperates.

This leads to a smoother exchange of goods, which means easy, fast and high-quality distribution of goods from the manufacturer to the consumer. It imposes other additional activities in improving road infrastructure, building new roads, widening lanes, bypasses for better transport and a better standard of living.

Monastir is a city through which a large number of traffic flows transit daily, primarily because of its good road connection with the cities of Ohrid, Kičevo, via Prilep with Skopje, but most importantly with neighbouring Greece.

On the territory of the city of Bitola, data collection was carried out, i.e. cordon counting.

The purpose of the survey is to give an estimate of the number and structure of vehicles transiting through the territory of the city of Bitola. A cordon supported an imaginary border line around the city of Bitola, and the counting of vehicles was carried out on all vehicles crossing the cordon line, which were:

1. A road with access to - from Prilep
2. A road with access to – from Greece
3. Road access to – from Ohrid

These checkpoints are set up in such a way as to cut off all traffic entering the city of Bitola, in order to avoid the problem of turning vehicles, which makes it unclear whether they enter the defined area or not. The data collection was carried out on 15.05.2025 on Thursday, within one hourly count, i.e. from 14:00 – 15:00.

A software tool was used to create a model and forecast future transport demand.

The subject of this research is the collection of data on the size and structure of road freight transport at three locations in the city of Bitola. The data collection will look at the size of freight flows transiting through the city of Bitola at peak hours and those vehicles that remain within the city. Creation of a model and application of the software tool PTV VISION VISUM for calculation and forecasting of transport demand, with an emphasis on freight transport.

With the counting carried out, it can help achieve a number of goals such as:

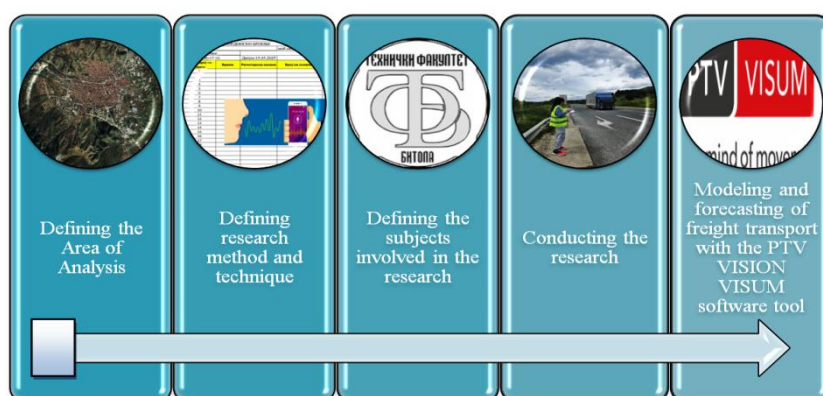
- Analysis of the size and structure of road freight transport while taking three entry-exit points;
- Comparative data analysis;
- Application of GEH analysis;
- Creating a model using the PTV VISION VISUM software tool.

2 RESEARCH METHODOLOGY

To conduct this study, the following methodology was applied, shown in Figure 1.

Figure 1

Research Methodology



Source: Produced by the authors.

2.1 DEFINING THE AREA OF ANALYSIS

The area of analysis in this paper is the city of Bitola.

Bitola is the largest city center in the fertile and largest Macedonian valley of Pelagonia and the second largest city in the Republic of North Macedonia. The city of Bitola is located in the extreme southwestern part of the Republic of North Macedonia, at the foot of Baba Mountain with Pelister Peak (2601 m) next to the Greek border which is 13 km away. Bitola in the north is surrounded by four connected hills, with a height of 640 to 890 m, called Bair, which are part of the Oblakovsko-Snegovska mountain (1430 m). From the south, the town is surrounded by the 744-metre-high Tumbe Kafe hill, which is a branch of the higher mountain locality of Neolica, which in turn is part of the vast Baba Planina. To the east, Bitola is wide open to the valley bottom of Pelagonia, and to the west, to the fluvioglacial sediments of the Dragor River, the wide Đavati Pregraben valley and the high Pelister. The terrain on which Bitola lies is tilted from 715 to 585 meters, from west to east, i.e. from Pelister and Baba Planina to the Pelagonia valley, and from 710 to 590 meters, giving the city an average altitude of 650 meters above sea level. These differences in elevation significantly affect the appearance of the city and the

structure of the cityscape. To the north of Bitola is the capital of Macedonia, Skopje (169 km), to the northeast is the city of Prilep (43 km), to the south are the city of Lerin (Greece) (33 km) and to the northwest are Resen (29 km) and Demir Hisar (29 km).

In the results published by the State Statistical Office for the census held in September 2021, the Municipality of Bitola has a population of 85,164 inhabitants or 10,221 inhabitants less compared to the previous census conducted in 2002, when in the city of Bitola and 65 villages there were 95,385 inhabitants.

As in the previous census, the Municipality of Bitola is again the third largest municipality in Macedonia – again in second place is Kumanovo with 98,104 inhabitants, after Skopje. In terms of gender structure, there are 43,319 women and 41,845 men in the Municipality and according to these figures, women by 1,474 in the Municipality are more numerous than men. Based on the results obtained from the 2021 census, the municipality had 85,164 inhabitants, 30,154 households, and 43,724 dwellings.

Bitola is a city with a road and railway network, and the municipality includes 64 villages.

Most cities in North Macedonia are chronically burdened with time and space congestion in traffic, noise, pollution, conflicts with pedestrians, cyclists and other motor vehicles. Such a city is Bitola, which does not lag behind other cities in the growth of the degree of motorization, spatial expansion of the city, low level of transport service with public city transports, increasing concentration of activities, unformed network of vehicles, increased flow of freight vehicles through narrow and legacy infrastructure areas, all this leads to the degradation of the urban space, endangering the safety of road users, etc.

The transport network of the city of Bitola has bus, collection (collection), and local (service, residential, etc.). Main streets are the thoroughfares that allow entry and exit flows to and from the narrower area of the city.

In addition to the overall territorial area of the city of Bitola, special emphasis is paid to the entry-exit routes from the city, which are the subject of analysis in this seminar paper.

The following sections were analyzed:

- A3 highway, Prilep – Bitola – R.Greece,
- E 65 from Bitola to Ohrid, at the Lukoil gas station,

- The ring road on Vasko Karangelevski Street - Partizanska - Krushevo Republic.
This is shown in Fig. 2

Figure 2

Defining the Area of Analysis.



Source: Produced by the authors.

2.2 DEFINING RESEARCH METHOD AND TECHNIQUE

The methods used in this study are a counting sheet, a mobile phone with a voice recording app, and a survey.

→ Counter Sheet – Vehicle Counting Form

The counting sheet was made into an excel document. It was composed of three parts:

- The first part consists of general data: first and last name of the observer/student, index number, phone number, location/direction, day, date, time, temperature, conditions/condition, note.
- The second part consists of a table intended to record the number of vehicles, registration marking and number of axles.
- The third part consists of a single column in which the classification of vehicles is made, whether light, medium or heavy goods vehicles.

The counting was carried out in the time interval from 14:00 to 15:00.

Mobile phone and voice recording app

The observers used their smartphone mobile phone with a corresponding audio recording program installed. A voice recorder is a sound recording device commonly used for recording. The easiest and fastest way to spot trucks is by reading their license plates while recording their voice. Later, the same data was entered into the excel document.

Figure 3 shows the voice recording app.

Figure 3

Voice recording app.



Source: Produced by the authors.

2.3 ANALYSIS PERIOD

The cordon counting of freight vehicles was made on Thursday, May 15, 2025 between 2:00 pm - 3:00 pm. The temperature at the time of analysis was 20° Celsius. The weather was partly cloudy with sunny periods.

2.4 DEFINING ALL SUBJECTS INVOLVED IN THE RESEARCH

Subjects involved in conducting the research were students from the Faculty of Technical Sciences of Bitola. They were students in the second year (summer semester) who were taking the course Collection and Analysis of Transport Data.

3 CONDUCTING THE RESEARCH

A group of six counters went out into the field in order to collect data on the number and structure of freight vehicles transiting through the territory of the city of Bitola, i.e. cordon counting. A cordon supported an imaginary border line around the city of Bitola, and the counting of vehicles was carried out on all vehicles crossing the cordon line, which were:

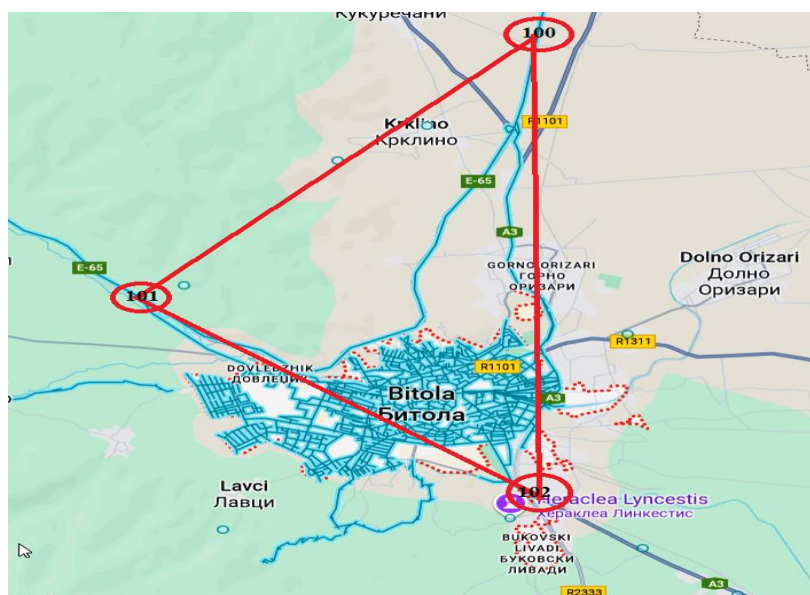
1. Traffic with access to – from Prilep
2. Traffic with access to – from the Greek Road
3. Road access to – from Ohrid

These checkpoints are set up in such a way as to cut off all traffic entering the city of Bitola, in order to avoid the problem of turning vehicles, which makes it unclear whether they enter the defined area or not.

The students were assigned to three locations, two per location. Figure 4 shows the locations where the counters were set.

Figure 4

Locations where data collection was performed.



Source: Produced by the authors.

To collect the data, they needed a smartphone/phone and a voice recording app. After the student notices the vehicle approaching, they verbally pronounce the license

plate and the corresponding category, and then enter the results of the voice recording into an excel document.

Freight vehicles were divided into three categories: light trucks, medium freight vehicles, and heavy duty vehicles. According to the number of axles, the classification of vehicles was made.

Figure 5 shows photographs of the data collection site.

Figure 5

Shows photographs of the data collection site.



Source: Produced by the authors.

4 PROCESSING OF RESEARCH DATA

→ Cordon counting

Based on the one-hour counting of freight vehicles, i.e. the cordon counting carried out at three locations, we have the following output results by structure and direction of movement.

Table 1

Tabular presentation of the output results of the one-hour count by structure and direction of movement.

	Greece Bitola	Bitola Greece	Ohrid Bitola	Bitola Ohrid	Prilep Bitola	Bitola Prilep
Light trucks	23	23	17	12	9	36
Medium trucks	0	0	2	0	0	2
Heavy trucks	11	11	8	9	10	17
Total	34	34	27	21	19	55

Source: Produced by the author.

From the results obtained we can conclude that the most intense flows of light freight vehicles are on the route from Bitola to Prilep, where 36 vehicles are registered, while the second most intensive is the road route from Greece to Bitola and the same number from Bitola to Greece. The flow of medium-sized freight vehicles occurs at two points: from Ohrid to Bitola and from Bitola to Prilep. The largest flow of heavy goods vehicles appears on the road route from Bitola to Prilep.

100 - Prilep

101- Ohrid

102 - Greece

Table 2 shows the results of transit freight vehicles by structure and direction of movement. These are vehicles that transit through the territory of the city of Bitola.

Table 2

Results of transit trucks by structure and direction of movement.

Transit light trucks			
External zone	100	101	102
100	0	0	1
101	3	0	0
102	3	1	0
Transit medium trucks			
External zone	100	101	102
100	0	0	0
101	0	0	0
102	0	0	0
Transit heavy trucks			
External zone	100	101	102
100	0	5	4
101	5	0	1
102	6	0	0

Source: Produced by the author.

5 MODELING AND FORECASTING OF FREIGHT TRANSPORT WITH SOFTWARE TOOL PTV VISION VISUM

Man has a number of rights, one of the fundamental ones being the right to mobility. All human mobility takes place on fully or partially landscaped traffic surfaces. Traffic planning is the coordination between transportation enforcement, land use, economic development, and social planning.

The continuous increase in traffic demand leads to an increase in traffic flows resulting in traffic congestion, increased environmental pollution and an increased risk of traffic accidents.

In developed European and world countries, traffic forecasts are made using modern software tools without which traffic engineering cannot be imagined. Thus, in addition to facilitating the work of traffic engineers, there are outputs, i.e. benefits and losses, if a new type of traffic control is introduced, without conducting trial tests directly in the field.

PTV Visum is the world's leading traffic analysis, forecast and data management software, which reliably models all traffic participants and their interactions. It can model transport demand and forecast transport demand for urban areas, cities, regions, and even countries.

A few savvy researchers from the Karlsruhe Institute of Technology founded the PTV group 40 years ago. Over the years, the PTV Group team has created amazing software tools and technology that are used today by transport planners around the world. The PTV software portfolio is presented in this directory, but each piece of software has its own story to tell.

The role of transportation modeling software is to enable planners to develop digital copies of the transportation system to use as a tool for analysis and decision-making. Having such software available "on the shelf" offers many benefits, including lower costs and faster model development, transparency and consistency in sharing results, portability of skills in user communities, support from a professional maintenance and training team, continuous future development, and much more.

This PTV philosophy provides all the benefits of specialized off-the-shelf transportation modeling software and maximizes flexibility with advanced interfaces with other software and programming tools. Each PTV software includes a wide range of tools

and features built into its code, created by transportation planners and software developers from the PTV Group with feedback from software users between the public and private sectors.

Each piece of code has its own purpose and collectively provides a comprehensive tool for transportation planners. The main motivation of the founders and everyone at PTV Group is to empower transport professionals with the right tools to create a cleaner, smarter and better future for everyone.

PTV Planung Transport Verkehr AG is a company whose foundations were laid in 1979 by Michael Saling and Dr. Hans Hubschneider based in Karlsruhe, Germany. It is a company specializing in software solutions and consulting services for transport, transport, mobility and logistics. One of them is the world's leading software suite for traffic analysis and transport demand forecasting, PTV Vision VISUM.

The PTV Vision software includes the following software packages:

- PTV Visum (Macroscopic Modelling of Travel Demand),
- PTV Vissim (Microscopic Traffic Simulation),
- PTV Viswalk (microscopic simulation of pedestrians),
- PTV Vistro (Traffic Engineering),
- PTV Optima (real-time traffic management),
- PTV Visum Publisher,
- PTV Model2Go,
- PTV Flows,
- PTV Lines,
- PTV Access

PTV Vision VISUM is the world's leading software for planning and analysis of traffic in cities, regions and countries, forecasting and data management based on GIS. It is a complex, comprehensive and flexible macroscopic software system because it is designed for multimodal analysis containing all modes of transport (automobile, truck, bus, pedestrian and bicycle).

VISUM software is one of the market leaders, offering a wide range of functions, analysis and development of variant solutions compared to other software packages in the field of traffic planning:

- Constant updates;

- Planning and development of the road network;
- Planning and optimization of routes;
- Display the traffic load of nodes, connectors of the traffic zone;
- Planning using the JGP timetable and route model;
- Simulation of YGP passengers and car drivers, with rewriting trips;

national planning. Given that it has a wide reach of users, the group does not stop and constantly updates and improves the software tool. PTV VISION VISUM 2023 allows users to develop a hybrid macro-meso solution and view the entire model while drastically reducing modeling efforts. With Visum 2023, the simulation-based assignment Simulation-Based Assignment (SBA) examines the settings for permissible transportation systems – permanently, as well as limited to certain periods. The expansion opens the stage for new SBA applications, i.e., it is possible to explore changes at the tape level. Examples include: the introduction of special bands, e.g. for high-occupancy vehicles (HOV) on highways, for electric, autonomous vehicles, taxis or buses, use of temporary lanes, etc. PTV Vision VISUM was used for the first time in the Republic of Macedonia, in the traffic study for the city of Bitola, for forecasting the transport demand for the city of Bitola (2010). This software tool has been used for a number of projects, analysis, and research in the following cities: Munich, Singapore, Colombia, Hamilton County, Ohio, Bogotá, Mashhad-Iran, Madrid-Spain, Mumbai, China, Stockholm, Beijing. Optimization of the road network in Łódź, Poland. Poland used VISUM to model traffic on the main route to the S14 motorway, simulating road widening scenarios and new connections to deal with congestion. The software was used to model the Lao Kai-Hanoi-Hai Phong-Quang Ninh economic corridor in Vietnam, assessing the impact of different development scenarios and evaluating the effectiveness of key projects.

To implement this software, you need to have a wide range of data available. You need to have:

- Quality of the area under consideration,
- precise measurement data for a particular traffic lane or other facility, for setting scale,
- data on the type of intersection control, number of traffic lanes, capacity, permitted transportation systems, speeds,

- data on attributes of zones (number of inhabitants per zone, employees by zone and in sectors education, administration, health, industry, hospitality, shopping, recreation, tourism, forestry, animal husbandry and agriculture, by zone, by zone),
- real data on the highest demand for travel, between zones and the transport network,
- cordon counting data for transit freight and individual journeys,
- matrices for travel between zones for different purposes (home-work, home-school, etc.),
- factors of attraction and production of travel, for generation and distribution,
- Route of movement of freight vehicles.

The creation of macroscopic models is based on a pre-established methodology for creating a model for public and private transport, which is based on the four-step standard model (generation, distribution, species distribution, and travel prescribing). The prescribing of journeys, i.e. the allocation of traffic, the purpose of which is to stimulate the choice of route through a defined transport network. The rewrite of traffic is discussed in two parts. First, it is necessary to define the transport network and determine the criteria for choosing a route through the network. Second, using the interzonal travel matrix as input, trips are assigned to this network. When assigning levels to future journeys, it is possible to assess deficiencies in the existing transport network and thus determine a list of priorities for construction. Based on the collected and processed data, with the "feeding" of the software and the application of the model, we will perform a calculation and forecast of transport demand, especially the emphasis will be placed on freight transport in the city of Bitola.

5.1 Setting up a background in VISUM

Once we have turned on the program, we choose a background to work on. The setup is as follows:

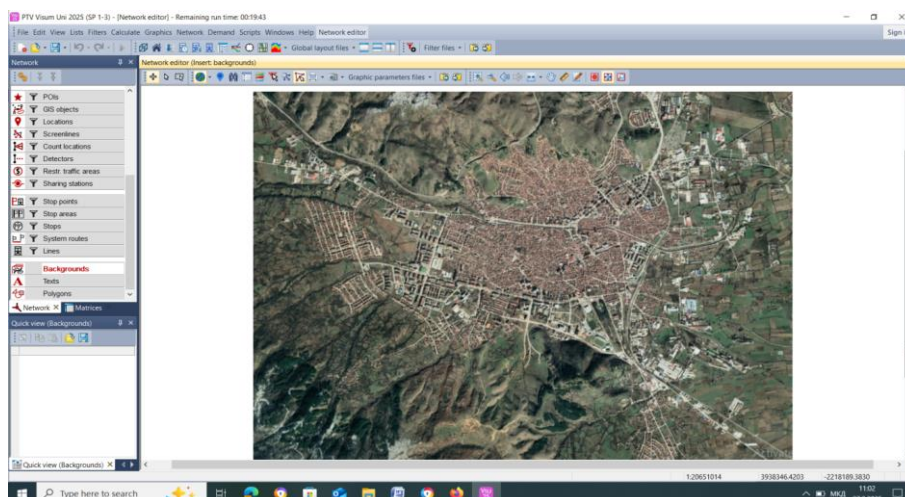
Step 1: Preparing the background

We prepare the background by mapping the city of Bitola from Google Earth using the Print Screen function, and then rearrange it in the Paint tool. Once we have edited the background, it is necessary to save it in the appropriate format. After getting the desktop or user interface, there is a web toolbar on the left side, from which we select

the Backgrounds tool and the Insert Mode function. By dragging the cursor and clicking on the desktop, we set the background in Figure 6.

Figure 6

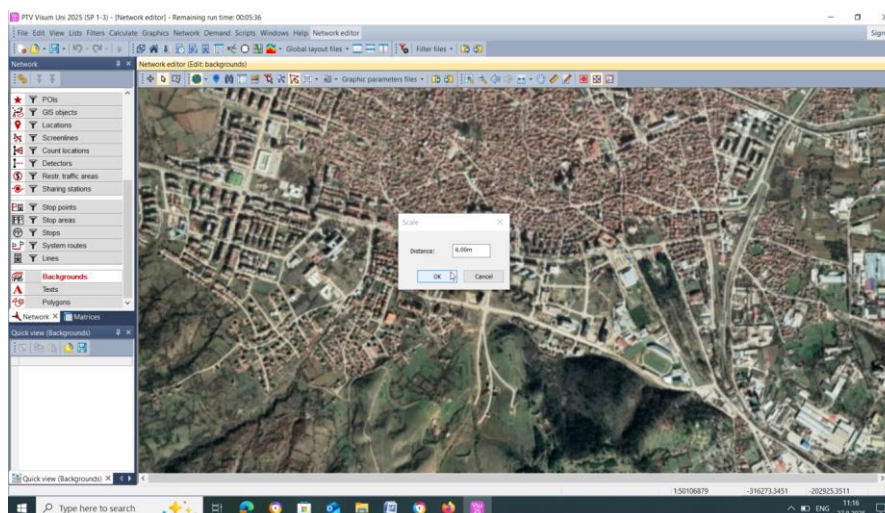
Background set in the software



Source: Produced by the authors.

Setting the Background Scale

Setting the background scale is done as follows: Select the Edit mode command to be active, then a drop-down menu appears on the background. We select Scale and measure using the ruler that appears on our desktop, from one point to another, for which distance we previously knew or measured using Google Earth Measure. Write down the distance and press OK (Fig. 7), thus setting the background to scale.

Figure 7*Setting the scale.*

Source: Produced by the authors.

5.2 Setting up nodes and plotting links

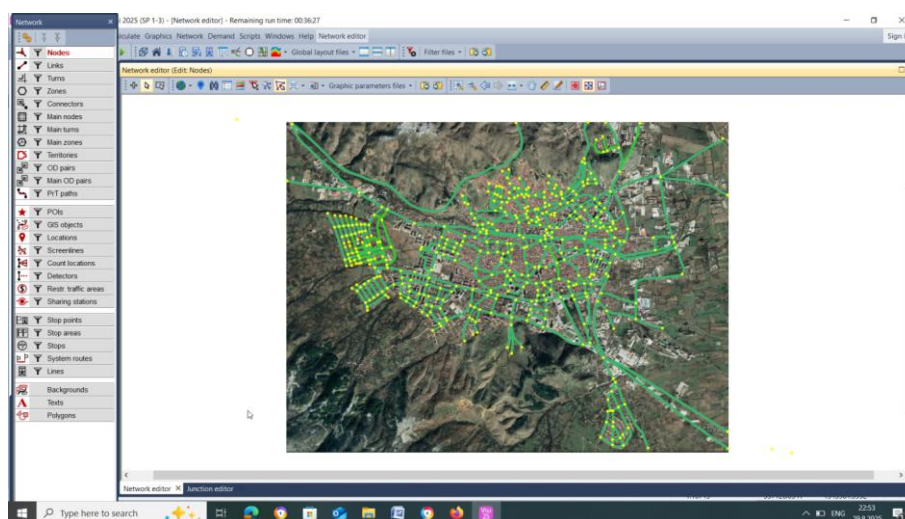
After placing a map of the city of Bitola in the software, the next step will be to draw the traffic network. It can be defined as a set of nodes and links on which transport activities take place.

The delineation of the transport network is the placement of nodes and connection to links, and nodes can be stops, intersections, entire cities, airports, railway stations, ports, goods terminals, etc. To get started, you need to have the Nodes tool and the Insert mode command active. To enter a link, you need to use the Links tool and the Insert mode command. The start and end nodes are selected, and a link is created. We continue in the same way until we have delineated the entire traffic network.

Figure 8 shows the road network of the city of Bitola in green.

Figure 8

The road network of the city of Bitola.

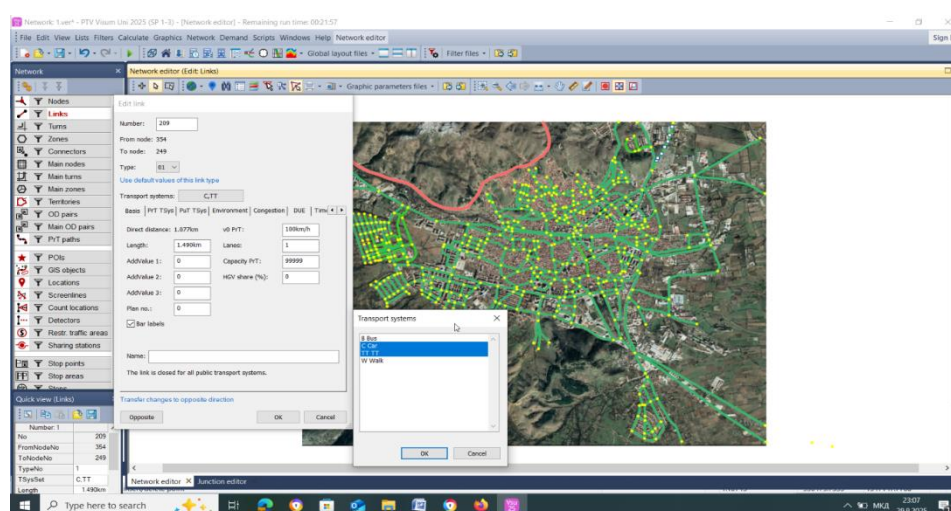


Source: Produced by the authors.

For each link, we define the speed of movement, which transport systems are allowed to move along the link itself, i.e. traffic, and we also define whether the street itself is one-way or two-way. This is shown in Figure No. 9.

Figure 9

Display the definition parameters of the link.



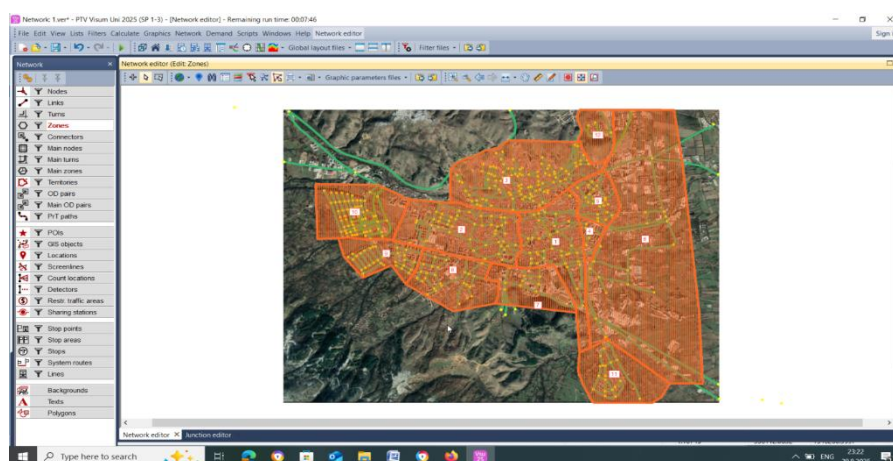
Source: Produced by the authors.

5.3 Zoning and attribute creation

Zoning is the very procedure of determining and delineating the zoning of a city. Zones are objects that describe a special purpose area of land and its location in the grid. The purpose can be in the form of settlements, commercial zones, shopping centers, schools, industrial centers, recreational areas, etc. They are the source and purpose of travel in the transport network. They are the source and purpose of a journey in the transport network. The urban area of the municipality of Bitola is divided into 12 traffic zones, which are functionally compact units that are delimited by separate city transport lines.

Figure 10

Zoning.



Source: Produced by the authors.

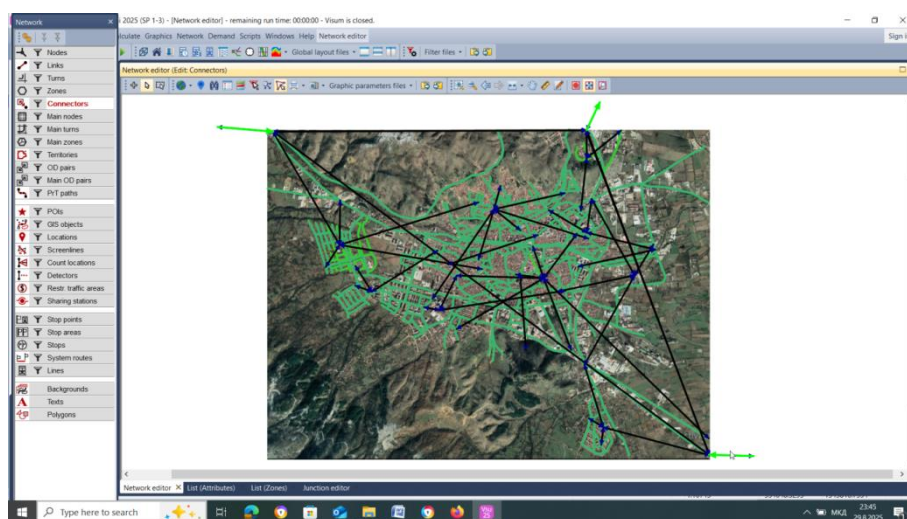
One of the most important procedures for zones is the entry of attribute data. Figure 11 shows the sixteen (sixteen) attributes already created: In the zone, Zone, All jobs, RM Agriculture (Jobs Agriculture), RMINindustry (jobs industry), RMAadministration (workplace administration), Shopping, Catering, Tourism, RMEeducation (jobs, education), Recreation, Residents, Employees and so one. Once we have created the attributes, the next step is to enter the data, i.e. feed the software. Input can be done manually or by copying an excel spreadsheet and pasting it into the software itself.

Creating attributes and entering data.

Source: Produced by the authors.

5.4 Creating connectors

Connectors represent connections between zones and the transportation network. They are the stewards of traffic flows from the zone to traffic flows in and out of the zone. Connectors can be internal and external, internal are in the zone itself, and external connectors are those that are placed at the outer boundaries or border traffic. These are connectors that show the direction of traffic to and from the entrance and exit corridors of the city, i.e. the direction of traffic from the outer zones to the entrance and exit corridors of the city. They are shown in green in Fig. 12. First, we create the outer zones, and then we create the connectors. The outer zones are named by the numbers 100, 101 and 102.

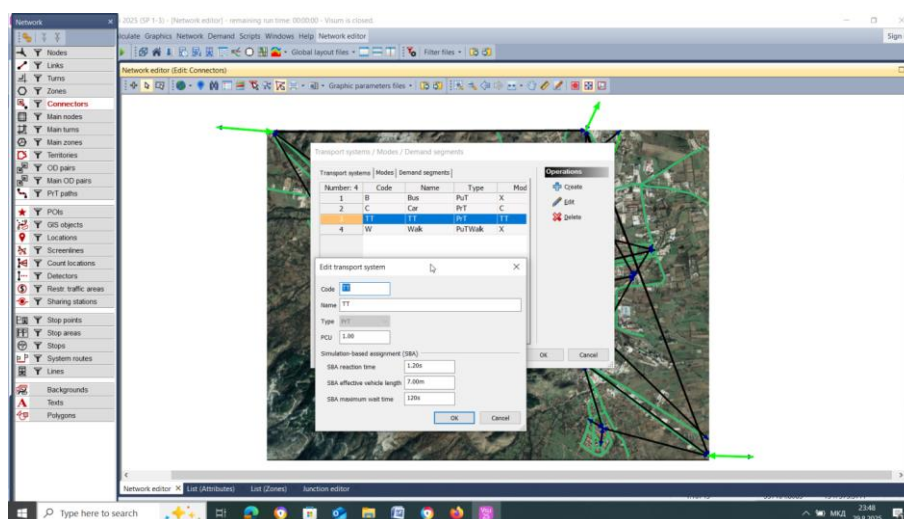
Figure 12*Creating connectors.*

Source: Produced by the authors.

5.5 Creating a demand model

The next step to be taken is to forecast the transport demand for the city of Bitola by defining the transport demand.

We start by setting up the transportation systems. From the toolbar, select the Demand tool – Tsys/Modes/DSegs. Here appears a drop-down menu (Fig. 13) in which the Car, Bus, and Walk transport systems already exist. We need a freight transport system, so we go to Create and in the newly opened drop-down menu we enter a name and code and a mandatory type of transport system, whether public or private transport.

Figure 13*Creating the transportation systems.*

Source: Produced by the authors.

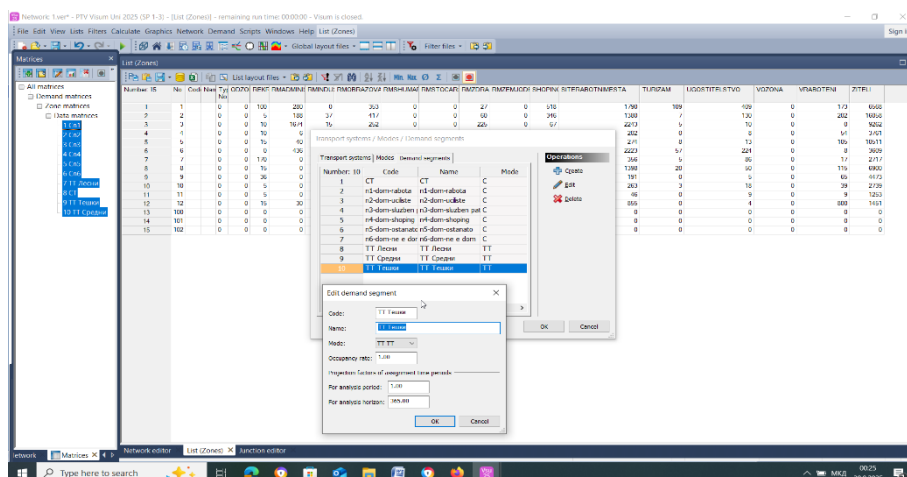
In the Demand Segments section of the Sys/Modes/DSEgs drop-down menu (Fig.14). We are entering the zones, without residents. In our example, we have six purposes that we will designate as follows:

- n1 – house – work,
- n2 – home – school,
- n3 – house – official road,
- n4 – house – shopping,
- n5 – home – rest,
- n6 is not a home.

Because the six uses do not include transit traffic, we add four plus demand segments for transit traffic. For freight transit vehicles, we write TT, Light, Medium, Heavy, and for transit individual transportation, we write CT.

Figure 14

Definition of purpose, specific purpose display for transit freight traffic.

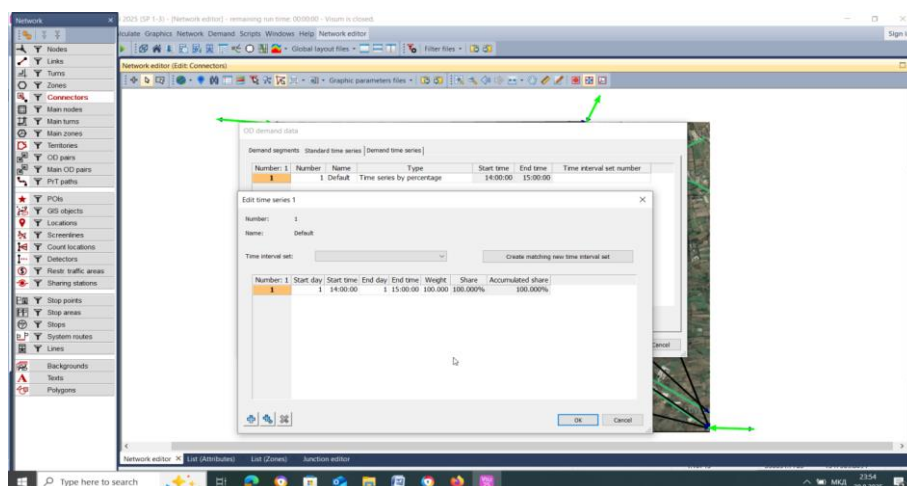


Source: Produced by the authors.

From the toolbar, select Demand – Demand Data. In the Standard time series, select Create and a row appears in which we need to enter the peak period for the peak hour from 14:00 – 15:00 h. The entry is done by clicking on the column and selecting Edit, and a drop-down menu appears again. Here again we select Create and in from time we write 14:00:00, and in To time we write 15:00:00 and go to Ok.

Figure 15

Defining the time of analysis.

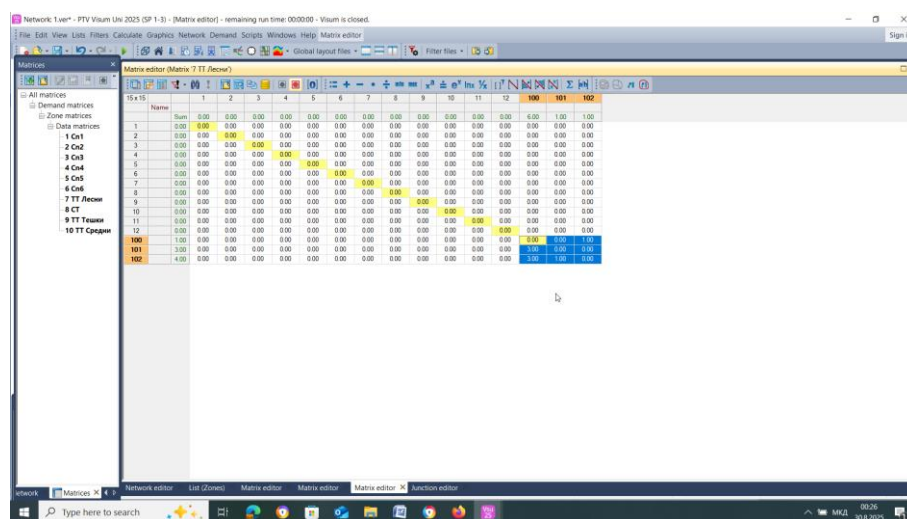


Source: Produced by the authors.

Create six matrices for their respective purposes, plus four for transit traffic. That is, we create three matrices for transit light, medium and heavy freight traffic and one matrix for individual traffic. Once we have created them, we proceed by entering the cordon-counting data into the matrices themselves.

Figure 16

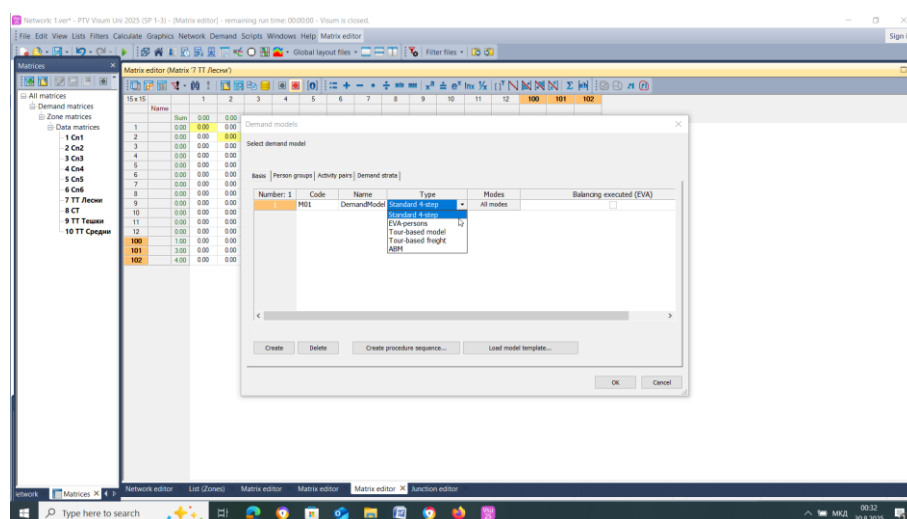
Create six matrices and proceed by entering the cordon counting data into the matrices.



Source: Produced by the authors.

We associate the matrices with the respective purposes of travel.

Creating a demand model. Select the Demand tool and the Demand models command. In Basis – Type (Fig.17) we choose the standard four-stage model (production – distribution – distribution – rewriting of journeys).

Figure 17*Creating a demand model.*

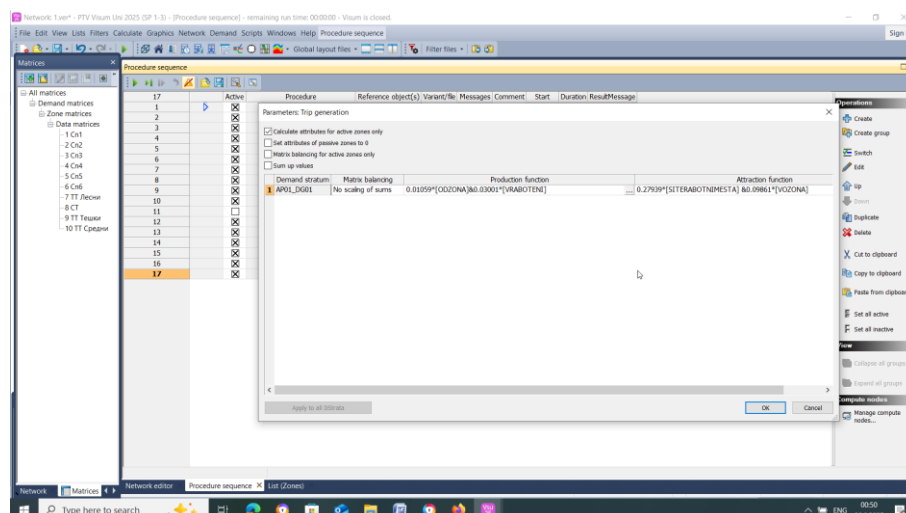
Source: Produced by the authors.

In Person groups we select Create, a queue appears in which we enter private traffic with double click.

In Activity Pairs we enter all activities – trips created in 6 groups. In our example, we have: home – work, home – school, home – business trip, home – shopping, home – rest and not home.

5.6 Procedures for calculating modal sizes

Computational procedures are the most important part of the model. This is where we do the generation, distribution, and rewriting of the trip. To make the generation from the right we select Create group and a new drop-down menu opens for us, in the Demand model select Trip generation and click Ok as in Fig.18. In Reference objects a new drop-down menu opens, in Demad Stratum we select the first group and go to OK. In the same way, we enter six generations of trips for all six groups of activities.

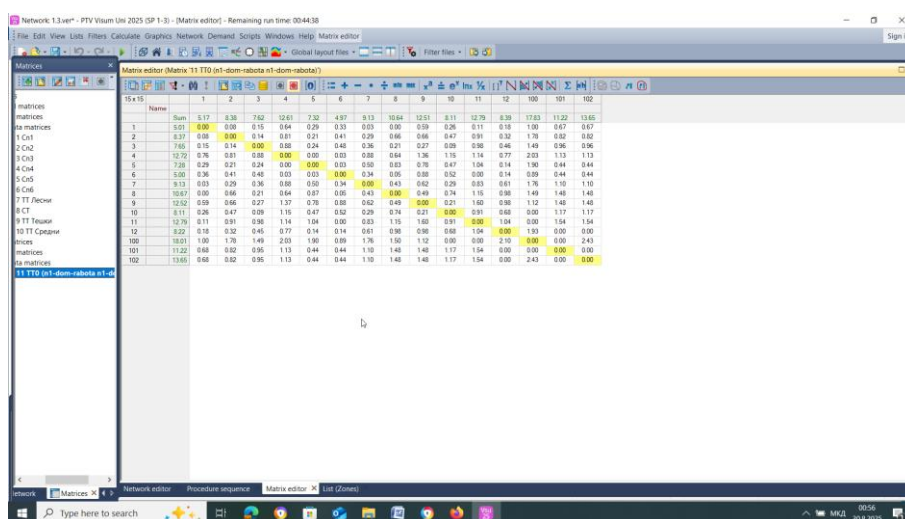
Figure 18*Creating Trip generation.*

Source: Produced by the authors.

We create a Skim matrix. We create this matrix, which is a matrix of travel resistance, as follows:

- From the toolbar, select Calculate – Procedure sequence – Create;
- In the drop-down menu, select Matrices – Calculate – PrT skim matrix;
- After creating the Skim matricata, the parameters are defined;
- In the Path search criterion, select t0. That means there are no obstacles, no obstacles on the road, so vehicles are free to move around the entire network.

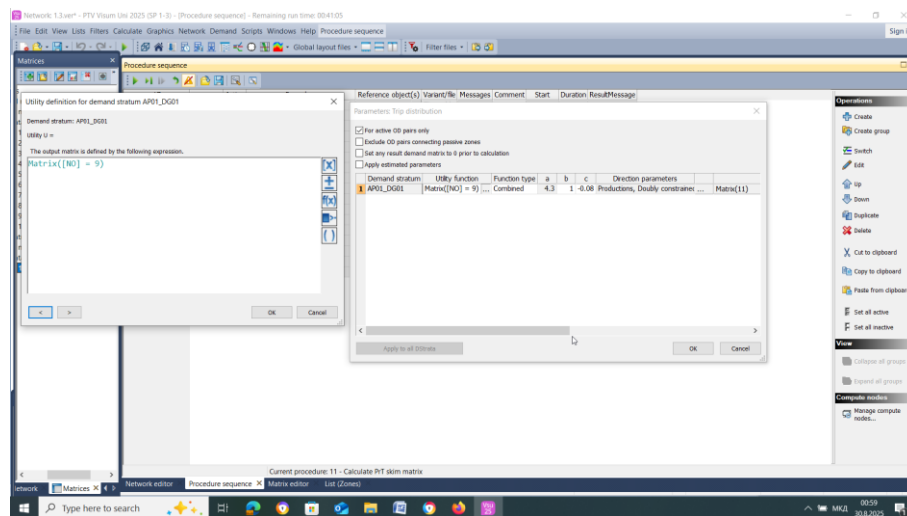
In Sum up paths from we only select Links, because we are working on a small model. For Skims at t0, select all, i.e., Calculate, Save to file, Open.

Figure 19*Create skim matrix.*

Source: Produced by the authors.

From the drop-down menu, go to Create group and click on the new group. A drop-down menu appears, here we select Demand model, select Trip distribution, and click Ok. In Reference objects we go to Selection DStrata, and then in Demand Stratum we select the first group and go to Ok.

Next, a drop-down menu appears in Parameters. We go to Create and in Matrix/Attribute/Constant select the previously created Skim matrix (Fig.20). In the Distribution model, a new drop-down menu opens, which shows what should be active. In Function type, we select Combined, in Direction of the distribution, we select Production distribution, we select Active Doubly constrained: Balancing by multi-procedure, and here we select a sum for data that we are confident to be approximately correct, in the example we select sum of productions (Production total). Once we've made all the changes, click OK. In the same way, we introduce distribution for all six purposes.

Figure 20*Creating Trip distribution.*

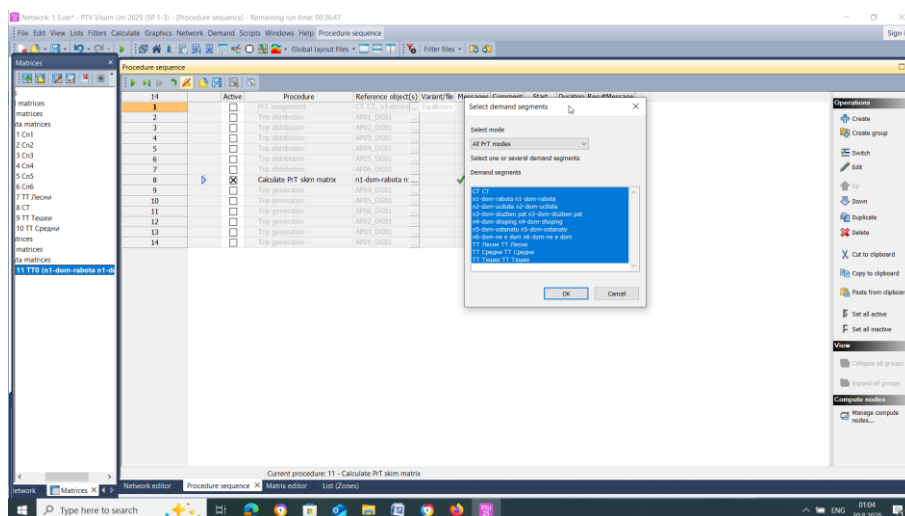
Source: Produced by the authors.

The next thing we need to do is enter the PrT Assignment.

- Select Calculate – Procedures – Create;
- In the drop-down menu, select Assignment – PrT Assignment – OK;
- Go to Selection DSeg, select all the demand segments and click Ok.
- For Procedure, we choose Equilibrium assignment.
- Click Parameters, in the OD demand share per iteration step we take an iteration in three steps: in the first step we write 34, in the second 33 and in the third 33. We don't change anything.

Figure 21

Selecting all transportation systems to perform a prescription of the trip.

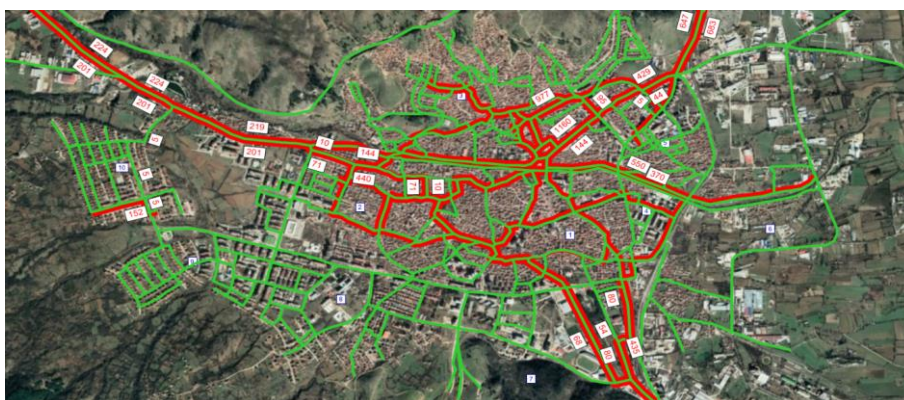


Source: Produced by the authors.

The next step is to calculate the modal sizes. To calculate the software these sizes, we include all active generations and distributions, as well as rewrite. We exclude the Skim matrix because the calculations for it are already strained. Click Execute and get the sizes. Modal sizes are actually the rewrites of the trips of particular traffic, the distribution of trips by traffic.

Figure 22

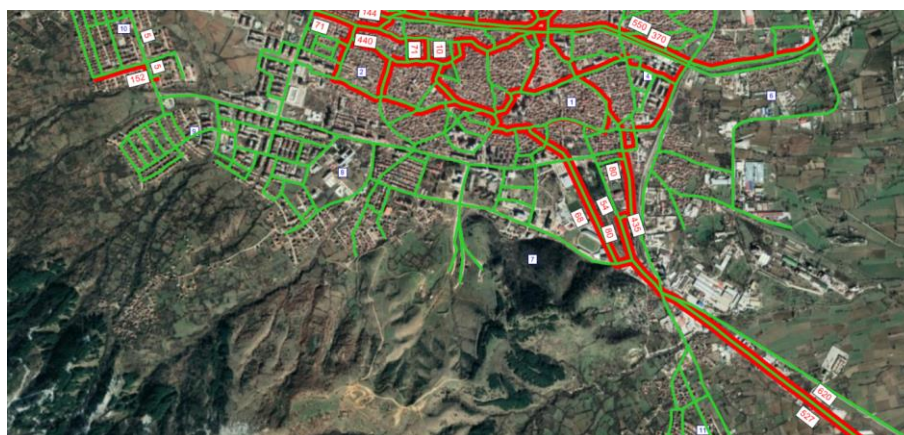
Calculated modal sizes of the road route Bitola - Prilep, Bitola - Ohrid and vice versa.



Source: Produced by the authors.

Figure 23

Calculated modal sizes of the road route Bitola – Greece and vice versa.

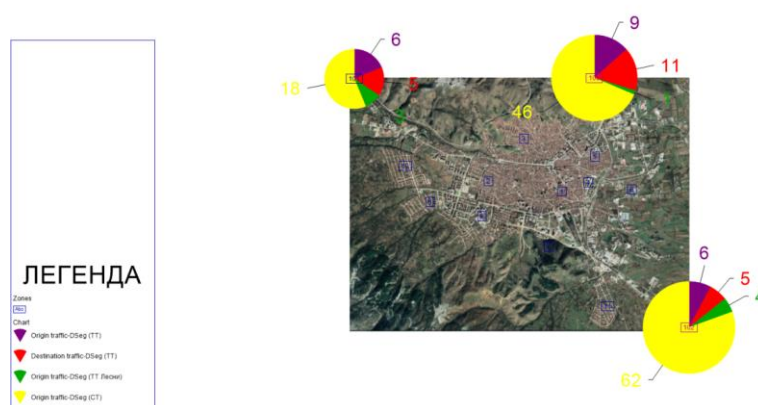


Source: Produced by the authors.

The calculated modal sizes also include freight traffic sizes, since the one-hour count values were small, individually as a value shown in the following figure.

Figure 24

Display of entered data for transit freight and individual traffic in the VISUM software.



Source: Produced by the authors.

The LEGEND, which is attached to the lower left corner of the image, explains what we have chosen to display on the surface itself: interior and exterior zones, uses (heavy goods vehicles (TTs), light trucks (TT Lights), and individual traffic (CT)). Since the data collection was done at the three locations, the output results can be seen in a different color.

5.7 Transport demand forecast

There are a number of ways to do this, but in this example, we will use the following method.

- From the menu, select Matrices – All Matrices – Zone Matrices – 1Cn1. The First Purpose Tag appears and select the Projection tool.
- A drop-down menu appears. For General parameters, we select the command Multiply with factor to be active. We select Projection is execute – For the entire matrix – which means to compute for the entire matrix.
- Activate Parameters for reference type "entire matrix" factor where we write 2, meaning that for the whole matrix we define an increment factor 2.

We took the growth factor 2 because, based on the existing state and comparative analysis of the outputs from previous surveys, it was not determined that the demand for freight traffic would decrease over the coming years.

Figure 25

Transport demand forecast for Bitola – Prilep, Bitola – Ohrid and vice versa.



Source: Produced by the authors.

Figure 26

Transport demand forecast for Bitola – Greece and Greece – Bitola.



Source: Produced by the authors.

With the forecast, i.e. with the application of growth factor 2 for the city of Bitola in the coming years, an increase in the demand for transport is determined, as a comparison we can take into account the trips to and from the city, i.e. zones 100, 101, 102.

6 COMPARATIVE ANALYSIS OF OUTPUTS

As explained at the beginning of this research, for the needs of the PTV VISION VISUM software tool, we needed to have a wide range of data from different traffic-related areas.

In addition to data on the number of traffic lanes, how traffic is regulated at intersections, city zoning rules, data on zone attributes, attraction factors, production and distribution of trips, it is necessary to feed the software with traffic flow sizes.

For this purpose, a study of the incoming exit routes, i.e. cordon counting at three locations on the territory of the city of Bitola, was carried out. From the same data, we obtained an idea of the structure and direction of movement of vehicles, as well as data on vehicles transiting through the territory of the city of Bitola.

The data collection was done on Thursday 15.05.2025 in the period from 14:00-15:00. Given that in this data collection the emphasis was placed only on freight traffic, which we divided into light, medium and heavy freight vehicles, data on transit individual traffic, as well as data on passenger and bus traffic were taken from the previous field

research for the purposes of the master's thesis: "Planning of public city transports in Small Towns using PTV Vision VISUM software".

Table 3 shows the output data from the cordon count made on 20.05.2022.

Table 3

Shows the output data from the cordon count made on 20.05.2022.

	Greece Bitola	Bitola Greece	Ohrid Bitola	Bitola Ohrid	Prilep Bitola	Bitola Prilep
Car	534	491	141	143	613	586
Bus	47	13	1	1	16	27
Heavy trucks	31	23	49	22	36	69

Source: Produced by the author.

Within the analysis of collected data, various statistical tests are often used in the practice of traffic engineering. Commonly used tests are as follows:

- Testing the reliability of the sample,
- Comparative or "before and after" tests,
- Nonparametric tests Comparative analysis has been done to make it easier to see the difference between modal and projected sizes of traffic journeys.

The following table shows the difference between the modal sizes and the projected sizes obtained through the development of a macroscopic model of the city-level transport demand for 2022 and 2025.

Table 4

Comparative Analysis 2022/2025

	Modal size 2022	Forecast size 2022	Modal size 2025	Forecast size 2025
Bitola - Prilep	682	1321	683	1413
Prilep - Bitola	649	1239	647	1239
Bitola - Ohrid	219	379	224	472
Ohrid - Biola	200	357	201	359
Bitola - Greece	527	1054	527	1130
Greece - Bitola	612	1224	620	1240

Source: Produced by the author.

From the comparative analysis carried out, it can be concluded that we have at certain directions of movement a slight increase in vehicle flows, both in modal and

forecasted sizes. The Bitola-Greece flow in the 2022 survey was 527 the same as in the survey conducted in 2025, i.e. there is no change in size.

7 APPLICATION OF GEH ANALYSIS

Verification of developed models is based on an assessment of the similarity between the real system and the model system. Transport system models are homomorphic models, meaning that not all elements of a real system are described using a model system. GEH statistics is a formula used in traffic engineering, traffic forecasting, and traffic modeling to compare two sets of traffic volumes. The GEH formula takes its name from Jeffrey E. Havers, who invented it in the 1970s while working as a transportation planner in London, England. Although its mathematical form is similar to the chi-square test, it is not a true statistical test. On the contrary, it is an empirical formula that has proven useful for various purposes of traffic analysis. The formula for "GEH statistics" is:

$$GEH = \sqrt{\frac{2*(M-C)^2}{M+C}} \quad (1)$$

Where they are:

- peak time of the current model (or new counts),
- Peak time of the current count (or previous counts).

A presentation of the comparison of these results according to traffic counting and modelling by PTV Visum using the GEH formula test is shown in the following table.

Table 5

Application of GEH Analysis

	Traffic counting 2022	Modal size	Difference	GEH test %	Previous counts 2022	Modal size	Difference	GEH test %
Bitola-Prilep	682	682	0	0 %	682	683	1	0 %
Prilep - Bitola	665	649	16	0,62 %	665	647	18	0,7 %
Bitola - Ohrid	166	219	-53	3,81 %	166	224	-58	4,15%
Ohrid - Bitola	191	200	-9	0,64 %	191	201	-10	0,71 %

Bitola-Greece	527	527	0	0 %	527	527	0	0 %
Greece – Bitola	612	612	0	0 %	612	620	-8	0,32 %

Source: Produced by the author.

The boundaries that determine the correspondence between real and model flows are:

- If $GEH < 5$, then the modeled and measured clock flows fit perfectly. Lower GEH values mean better fit flows than the actual counting model. - If $5 < GEH < 10$, further research can be carried out; - If $GEH > 10$, then it is very likely that there is a problem with the model, either for traffic demand or for the data.

The comparison shows that for all locations the results are met under the condition $< 5\%$, and by comparing the results obtained by counting traffic with the results modelling using PTV Visum we can conclude that they are below an acceptable level.

8 CONCLUSION

Freight transport plays a key role in today's economy because it allows production and consumption to take place in locations hundreds of thousands of kilometers apart. As a result, markets are broader, which stimulates direct competition between manufacturers from different countries and encourages companies to take advantage of economies of scale.

In this paper, the subject of analysis is freight transport in the city of Bitola. With the use of the software tool PTV VISION VISUM, which is the world's leading software, we made a calculation and forecast of the transport demand on the territory of the city of Bitola.

Macroscopic traffic models for transport demand creation are widely used in transport engineering to analyze and evaluate the projected transport system, traffic operations, the choice of alternative solutions, forecasts of transport demand, etc. They are simpler to apply, cheaper, more efficient, faster, as opposed to analysis and testing performed directly in the field.

To that end, it was necessary to do a collection of data, such as: the surface we were working on, the scale, the number of traffic lanes, the speed of movement, the control of intersections, the factors of attraction, the production and distribution of the

trip, the division of the city into zones, and the collection of data to feed those zones, such as the number of residents, employees, shopping, etc. Data on transit freight and individual traffic was set up for this purpose at three points on Thursday. The points were carefully selected to preserve all flows.

The data collection was done by mobile phone, and a voice recording program. Later, the data was entered into an excel spreadsheet. Freight vehicles were divided into three groups: light, medium, and heavy according to the number of axles. From the data we can say that the largest flow of light and heavy goods vehicles occurs on the road Bitola - Prilep - 36 light and 17 heavy freight vehicles.

Comparative analysis was also applied to the study itself where we compared the data obtained from the 2022 traffic count, the modal sizes in 2022, as well as the current data in 2025. We can conclude that we have an increase in the current transport demand, and there is a factor of growth in freight transport in the future.

The high and accurate accuracy of the data entered and obtained by the model is demonstrated by the GEH test.

Cities are striving to introduce sustainable transportation systems, systems that will be safe, noise-free, pollution-free, and this trend will be seen more and more in freight transport.

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ABOUT THE AUTHORS

Vaska Atanasova

Dr. Vaska Atanasova She completed her studies at the Department of Transport and Transport at the Technical Faculty in Bitola, and by defending his thesis with a grade of 10 (ten), he acquired the title of Bachelor of Transport Engineer. In 2000, she passed all postgraduate exams in "Transport Planning and Engineering" with an average grade point average of 9.42. In December 2002, by defending his master's thesis, titled "Application of Flexible Road Transport in Macedonia: Exploring an Optimal Service Model for the Example of the City of Bitola", he was awarded the title of Master of Transport Sciences. In November 2005, she successfully defended her doctoral dissertation, titled "Supplement to the Research of a System with Points for Coordinated Passenger Accommodation", which earned her the title of Doctor of Sciences in the field of transport and transport. Since 27.06.2011, Dr. Atanasova has been elected to the title of Associate Professor, and since 28.12.2015 she has been elected as a full professor. Prof. Atanasova teaches the subjects of the first, second and third cycle of studies.

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Prof. Atanasova has published more than 150 papers in journals, conferences, and symposia, and more than 130 expertises and projects She is member of professional bodies, she has specific experience in the country and in the region, licences and international certificates.

Marija Stojanoska

PhD student Marija Stojanoska was born on 31.12.1998 in Prilep, Republic of Macedonia. On 09.07.2021, he was awarded the title of Graduate Transport Engineer with an average grade of 9.67 and was declared the best graduate student. He is the recipient of the Recognition ENGINEERING RING 2022, for the best graduate engineer of the Technical Faculty of Bitola, University "St. Kliment Ohridski", awarded by the Association of Associations of Engineers Engineering Institution of Macedonia and the Chamber of Chartered Architects and Chartered Engineers, Skopje, 23.06.2022. On 11.04.2023 he received the title of Master of Transport Engineering, Department of

Transport and Transport, University of St. Constantine. Technical Faculty – Bitola with average grade 10.00. She is currently enrolled in the third cycle of doctoral studies at the Technical Faculty of Bitola. He served as a demonstrator from 2021 to 2023. She will begin working as an assistant on 06/21/2023. Since her employment, she has been actively involved in the overall activities of the traffic department, as well as in research and application activities. He actively participates in a number of scientific meetings, conferences, symposia. In the field of research, she focuses on research related to traffic planning, with a special emphasis on sustainable urban transport systems and public urban transport, with the help of modern software tools, among them the PTV VISION VISUM tool.

Authors' Contribution

Both authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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