A COMPUTERIZED MODEL TO ASSESS THE TRANSPORT DEMAND IN A COUNTY PUBLIC TRANSPORTATION SYSTEM

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Abstract: *This paperwork presents the travel demand model that utilizes a traditional four-step model process consisting of trip generation, trip distribution, mode choice and trip assignment for Olt county, accomplished with a software specialized in transportation planning, travel demand modeling and network data management. At each step in the model development process, the model components are subjected to a series of aggregated and disaggregated validation tests following estimation of model parameters. Model validation is strictly an aggregated set of comparisons and represents the final test of the model's ability to accurately simulate existing travel behaviors. The land use, demographic and economic data are the key inputs for the model. The main data source for the elaboration of the travel demand model was obtained from the local public authorities and the National Institute of Statistics. Model calibration uses the travel time survey for different pairs origin / destination zones located in the studied area and actual transit boarding for each route for an entire weekday obtained from on-board rider surveys.*

Keywords: computerized model, travel demand, public transport system, four-step model

1. INTRODUCTION

In general, simulation is defined as dynamic representation of some part of the real world achieved by building a computer model and moving it through time. Computer models are widely used in traffic and transportation system analysis. The use of computer simulation started when D.L. Gerlough published his dissertation: *"Simulation of freeway traffic on a general-purpose discrete variable computer"* at the University of California, Los Angeles, in 1955. From those times, computer simulation has become a widely used tool in transportation engineering with a variety of applications from scientific research to planning, training and demonstration [6]. The movement of people or goods over medium distances is known as regional transport and usually this is between separate but nearby urban areas, or between urban area and areas with low population density [9]. For passengers, regional transport caters for a wide range of trip types, from longer-distance commuting and regional business travel to leisure trips, normally by car or motorcycle, medium-distance bus and coach services, or regional train services. The county public transport service is a social utility domain, having a direct influence on life quality, by ensuring the basic right of mobility for every citizen. Transport demand modeling involves a series of mathematical models that attempt to simulate human travel behavior. The travel simulation process follows trips as they begin at a trip generating zone, move through a network of links and end at a trip attracting zone. The simulation process is known as the four step process for each of the four basic models used in the overall process.

2. THE GENERAL STRUCTURE OF THE FOUR-STEPS MODEL FOR ASSESSING THE TRANSPORT DEMAND

The classical travel demand modeling approach consists of four major steps (figure 1): *trip generation*, *trip distribution*, *mode choice* and *trip assignment*. The four-step model shows how many people travel, what are the travel patterns for the considered area, what travel modes are used and what trip itinerary will be followed through the transportation network [13].

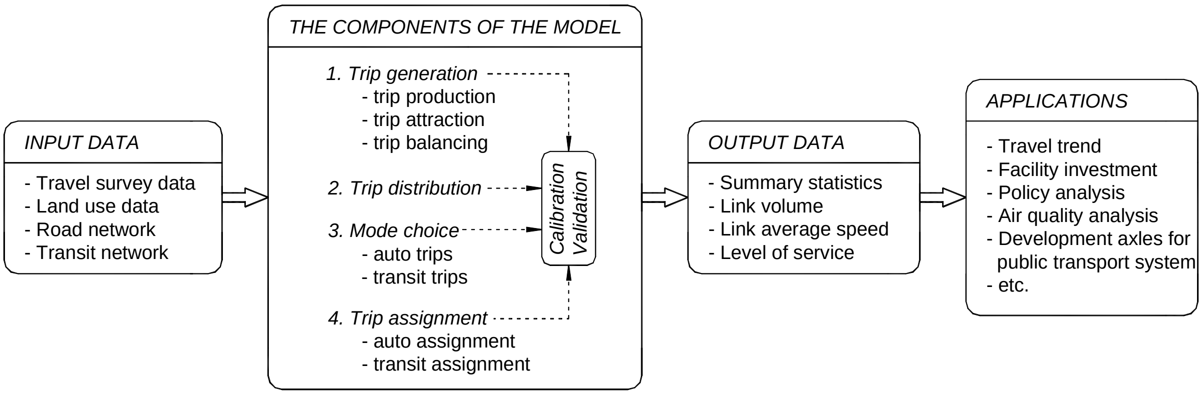


Fig. 1. The conceptual framework of four-step travel modeling system.

2.1. TRIP GENERATION

In the first stage of the four-step model, generating trips, socio economic and demographic structure of areas of traffic constitutes inputs to the applied regression model used to estimate the number of trips generated by each area.

The number of generated trips for each zone N_{gen} is given by the formula:

$$N_{gen} = \sum_i a_i \cdot x_i \; [\text{trips}] \tag{1}$$

where:

- x_i are socio - economic variables;
- a_i are calibration coefficients of the regression model.

2.2. TRIP DISTRIBUTION

The trips beginnings and ends in each zone are linked together to form an origin – destination pattern of trips through the process of trip distribution. The most commonly used procedure for trip distribution is the gravity model. The gravity model is of the form:

$$T_{ij} = g_i \cdot a_j \cdot f(d_{ij}) \; [\text{trips}] \tag{2}$$

where:

- T_{ij} are the flows estimated to be produced between the “ i ” and “ j ” traffic zones;
- g_i is the generation and application from “ i ” area;
- a_j is attract demand in the “ j ” area;
- $f(d_{ij})$ is the difficulties function in making travel between zones“ i ” and “ j ”.

2.3. MODE CHOICE

Ownership of private cars, the timetable of public transport, the cost and the duration of trip are parameters of the utility function which is associated with each mode of transportation. This function is used for choosing the transportation mode. The mathematical model that estimates the probability of choosing a particular transport mode is *Logit* model:

$$P_k = \frac{e^{-\beta C_{ij}^k}}{\sum_m e^{-\beta C_{ij}^m}} \; [\%] \tag{3}$$

$$C_{ij}^k = \sum_p \varphi_{kp} \cdot x_{kp} \; [\text{m.u.}] \tag{4}$$

where:

- C_{ij}^{k} is total cost to make the journey using " k " transportation mode;
- φ_{kp} is the equivalence parameter for the variables of time, cost monetary movement;
- x_{kp} are components of the generalized travel cost;
- k represents private car, public transportation;
- β is the calibration model coefficient.

2.4. TRIP ASSIGNMENT

The aim of the trip assignment process is to develop the loadings, or user's volume, on each segment of a transportation network, as well as the turning movements at intersections of the network. For assignment matrixes O/D it was used incremental procedure. Using this procedure, the matrix O/D is divided by percentage in several sub-matrixes, which are affected the network. Search algorithm to find routes takes into consideration links impedance resulting from traffic volumes assignment on previous iteration.

3. APPLYING THE TRAVEL DEMAND MODEL FOR ASSESS THE PUBLIC TRANSPORT SYSTEM OF OLT COUNTY

The steps followed to build the computerized model, using Visum software, in case of Olt County are listed below.

- *Network graph construction* (figure 2).

Each link of the network, representing the road segment between two intersections, has associated parameters like class, capacity, number of lanes, traffic speed at free flow, modes that can use the segment. The road network calibration was done using recorded travel times between different points of the network.

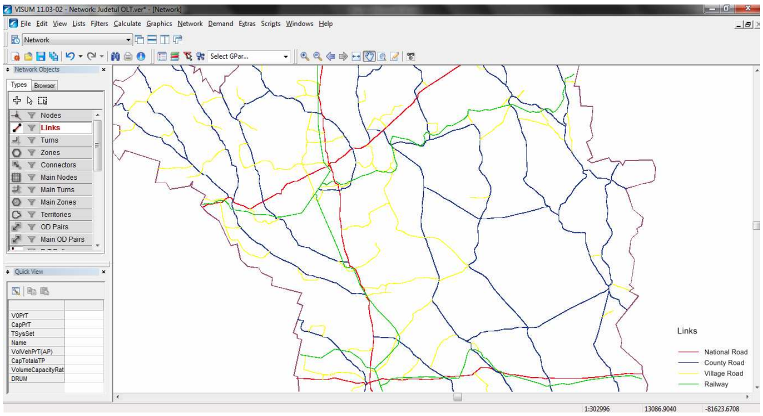


Fig. 2. The graph network.

- *Zoning territory* (figure 3).

The *transportation analysis zones* provide the spatial unit (or geographical area) within which travel behavior and traffic generation are estimated. Simulation was done by analyzing travel trips aggregated at locality level. The model is based on 378 internal separated areas on administrative territorial limits of the county villages and 6 external zones corresponding to the county points limit those include cities served in relation to county Olt by national roads.

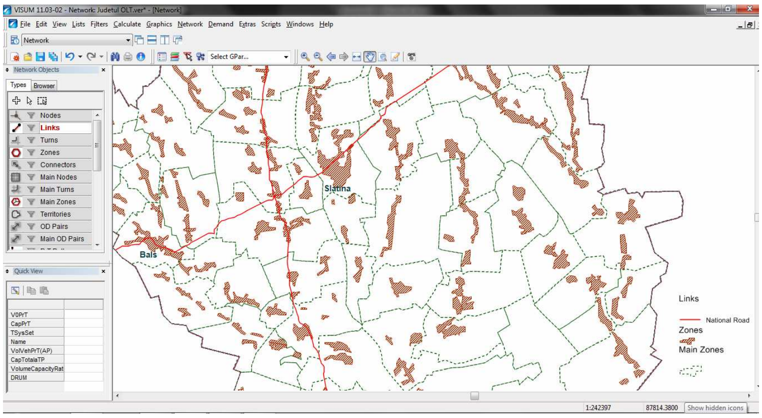


Fig. 3. Transportation analysis zones.

The internal zones are aggregated into 112 main zones representing areas of influence of towns and villages. The zones of the model are represented as geometric shapes.

- *Connecting the zone centroids to the network graph* (figure 4).

Each transport zone is associated with a point called zone centroid where is concentrated the whole activity of represented area. Zone centroid can be identified as the center of gravity of the associated area and includes the following features:

• *the zone parameters are located in zone centroid;*

• *the distance between the two zones is the distance between the centroids of those zones;*

• *for connecting a zone to a graph network, the zone is represented by the centroid.*

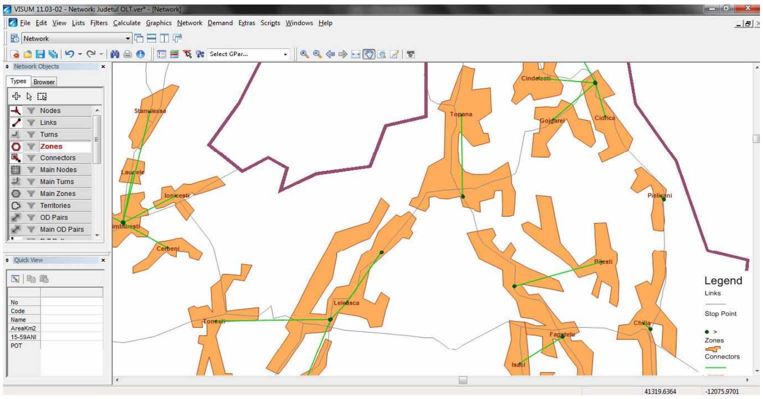
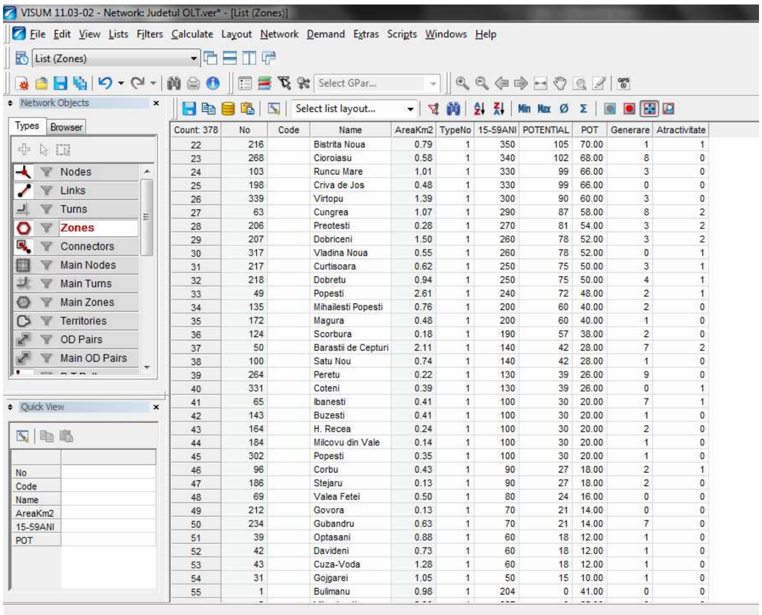


Fig. 4. Transport zone connectors.

The zone centroid must be connected with the transport network through a link called connector.

- *Trip generation* (figure 5).

An important parameter as the basis for generating travel is the household car ownership. For the application that will be presented in this paperwork, the motorization level dynamics for entire Romania and for the studied county is presented in figure 6 [1]. It can be noticed that for Olt county this parameter is below country average.



Count: 378	No	Code	Name	AreaKm2	TypeNo	15-59ANI	POTENTIAL	POT	Generare	Atractivitate
22	216		Bistrita Noua	0.79	1	350	105	70.00	1	1
23	268		Cioroiasu	0.58	1	340	102	68.00	8	0
24	103		Runcu Mare	1.01	1	330	99	66.00	3	0
25	198		Criva de Jos	0.48	1	330	99	66.00	0	0
26	339		Virtopu	1.39	1	300	90	60.00	3	0
27	63		Cungrea	1.07	1	290	87	58.00	8	2
28	206		Preotesti	0.28	1	270	81	54.00	3	2
29	207		Dobriceni	1.50	1	260	78	52.00	3	2
30	317		Vladina Noua	0.55	1	260	78	52.00	0	1
31	217		Curtisoara	0.62	1	250	75	50.00	3	1
32	218		Dobretu	0.94	1	250	75	50.00	4	1
33	49		Popesti	2.61	1	240	72	48.00	2	1
34	135		Mihailesti Popesti	0.76	1	200	60	40.00	2	0
35	172		Magura	0.48	1	200	60	40.00	1	0
36	124		Scorbura	0.18	1	190	57	38.00	2	0
37	50		Barastii de Cepturi	2.11	1	140	42	28.00	7	2
38	100		Satu Nou	0.74	1	140	42	28.00	1	0
39	264		Peretu	0.22	1	130	39	26.00	9	0
40	331		Coteni	0.39	1	130	39	26.00	0	1
41	65		Ibanesti	0.41	1	100	30	20.00	7	1
42	143		Buzesti	0.41	1	100	30	20.00	1	0
43	164		H. Recea	0.24	1	100	30	20.00	2	0
44	184		Milcovu din Vale	0.14	1	100	30	20.00	1	0
45	302		Popesti	0.35	1	100	30	20.00	1	0
46	96		Corbu	0.43	1	90	27	18.00	2	1
47	186		Stejaru	0.13	1	90	27	18.00	2	0
48	69		Valea Fetei	0.50	1	80	24	16.00	0	0
49	212		Govora	0.13	1	70	21	14.00	0	0
50	234		Gubandru	0.63	1	70	21	14.00	7	0
51	39		Optasani	0.88	1	60	18	12.00	1	0
52	42		Davideni	0.73	1	60	18	12.00	1	0
53	43		Cuza-Voda	1.28	1	60	18	12.00	1	0
54	31		Gojgarei	1.05	1	50	15	10.00	1	0
55	1		Bulimanu	0.98	1	204	0	41.00	0	0

Fig. 5. Generated / attracted trips.

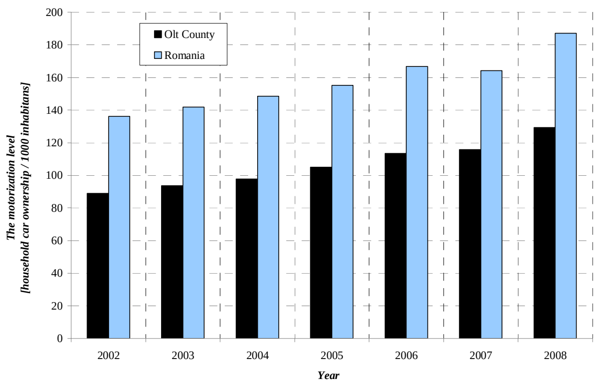


Fig. 6. The motorization level dynamics for Romania and Olt county.

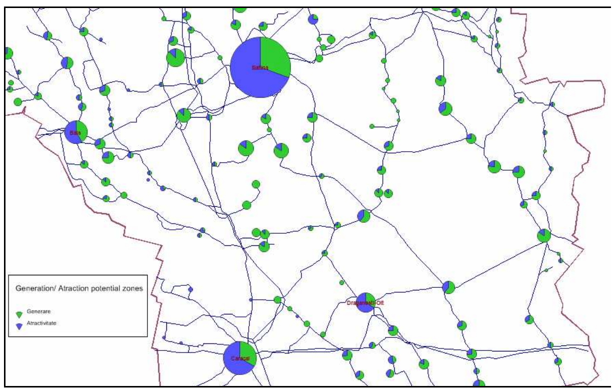


Fig. 7. Generation / attraction potential zones.

The number of trips attracted to each traffic zone is determined according to points of interest located in that area (jobs, administrative centers, health centers, schools, commercial areas) (figure 7).

By applying these procedure, in which the used data were obtained by count trips made at the level of some zones from studied area [3], there were estimated 38133 trips in a usually working day in all Olt county.

- *Trip distribution*

The result of this model's step is is the global matrix origin – destination (O/D) (figure 8).

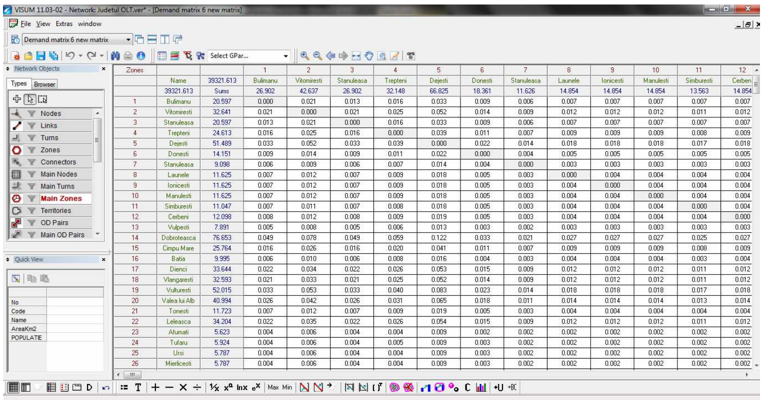


Fig. 8. O/D matrix.

- *Mode choice*

Applying the *Logit* model, it results that in Olt county 70 % from all travels are made with public road transportation system, which is managed by the County Council. Also, in the morning peak hour, between 7:00 and 8:00 a.m., the rail transportation system supply for passengers does not fulfill the estimated travel demand.

In Olt county, the road network is more dense that the railway one, which crosses the county along the national roads. In the rush hour interval, the train schedule does provide only in a small extend the link between the rural and urban areas, which are the main interest economic and social points to achieve trips.

- *Trip assignment*

Knowing the number of trips that enter and leave each zone, as well as the transportation modes used by the travelers, it can be identified precisely the roadways or routes that will be selected for each trip. Trip assignment involves assigning traffic to a transportation network. Traffic is assigned to available transit routes using a mathematical algorithm that determines the amount of traffic as a function of time, volume, capacity, or impedance factor (figure 9).

- *Model calibration*

To calibrate the developed transport model, it was chosen for data collection the counter system, recording the number of passengers on each route, in every sense, in a certain section.

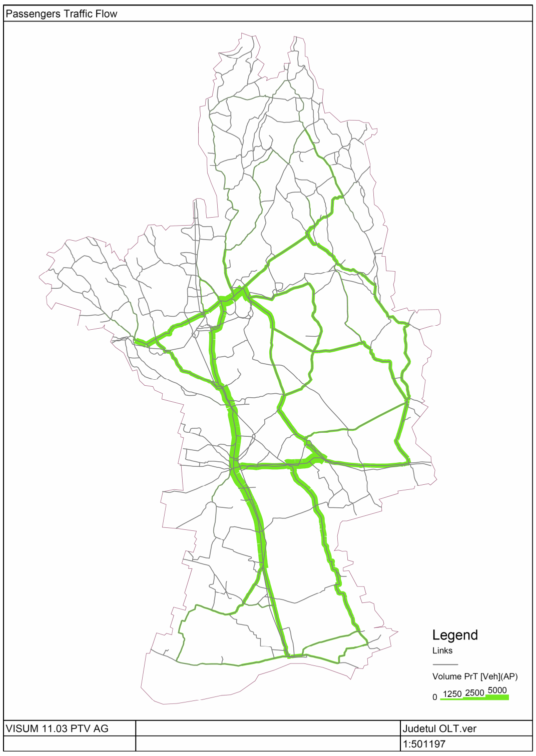


Fig. 9. The passenger's volumes.

The sectioning points were taken at the entrances into the Slatina municipality, allowing this way tole capture all the line routes in the south-east of the county, related to main transport pole (figure 10), making records during working days, between the hours 06:00 to 18:00 (figure 11).

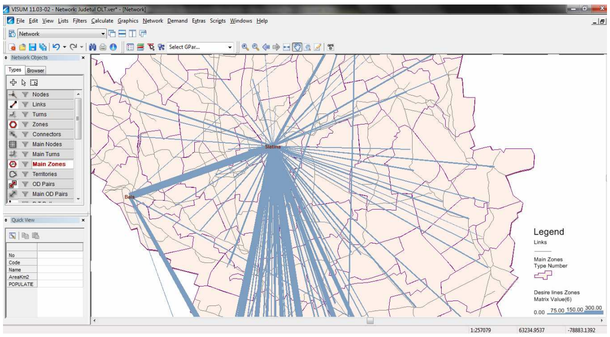


Fig. 10. Spider diagram.

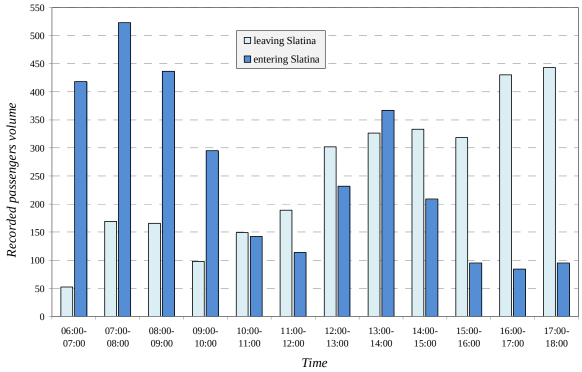


Fig. 11. Recorded passengers' volumes in the exemplified counting section.

4. CONCLUSIONS

Building this model, it was obtained a detailed view of the passenger traffic at the county level. Having the supply transport system, as well as the estimated travel demand by realizing the four steps model, it was noticed that there is not equilibrium between the two ones at the level of the entire county public transport system. It results the optimizing necessity, in order to assure a well functioning, in the frame of the land use and integrated development of the territory.

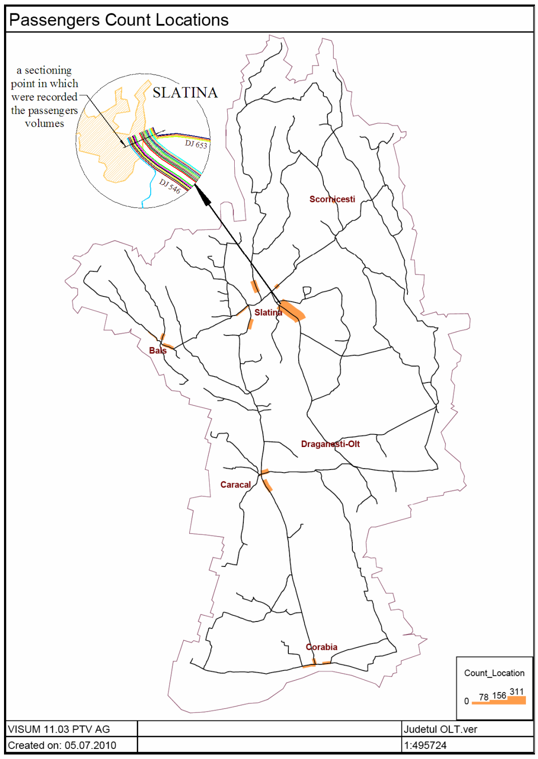


Fig. 12. Passengers' volume in count locations.

Also, such a computerized model has the following advantages:

- *it allows to estimate the future travel demand at different time horizons and different scenarios of transport systems development;*
- *the model can be developed to include other public transport modes present in the analyzed area (e.g. rail transport), the software used – Visum – allowing modal integration of transport modes;*
- *the model allows to determine the level of service offered by public transport, for different characteristics of public transport systems (e.g. the loading of vehicles, on – time performance, service coverage, accessibility);*
- *it allows to identify the problems in public transport;*
- *it permits the identification of the solutions to optimize the functioning of the public transport system;*
- *it permits the evaluating of the alternatives for improving public transport system.*

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