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Research Paper

Simulation of Route Direction Reconfiguration for Traffic Management in Medium-Sized Cities (Case Study: Central District of Yazd)

Hamid Dehghan Banadaki[1], Mahmoud Saffarzadeh[2]*, Hassan Zoghi[3], Masoud Shahsavari[4]

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Abstract

One way to change the allocation of road resources to traffic demand is to convert two-way roads into one-way streets. This conversion can be done for a variety of reasons such as insufficient street width for two-way traffic, reducing delay at intersections, increasing safety and reducing congestion. In the city of Yazd, the urban road network has very few one-way thoroughfares and its traffic flow directions have not been optimally configured to solve the traffic problems of this city. Converting two-way streets into one-way routes may therefore serve as a means of better traffic management in the central district of this city. In this research, after a review of the literature, the physical and traffic characteristics of main roads in the central district of Yazd were investigated through a field study in order to identify the two-way roads that are technically and practically eligible for conversion into one-way. The results of the field study, which were obtained from 78 data collection stations, were then used to build a simulation model in the Aimsun software. The network was then calibrated and prepared for the execution of the scenarios. The results indicated that as long as the number of trips ending in or passing through the area remains the same, these streets cannot be made one-way and all scenarios have worse results than the current situation.

Finally, the proposed scenarios were re-simulated with the assumption of a 30% decrease in travel demand in the area. It was found that scenario 6 offers better outcomes than other options and it is practically impossible to make the streets one-way without reducing the demand for private transport.

Keywords: traffic allocation, traffic direction management, simulation, network, Aimsun

* Corresponding author: E-Mail: saffar_m@modares.ac.ir

[1] Ph.D. candidate, Department of Civil Engineering, faculty of civil and earth resources engineering, Centeral Tehran Branch, Islamic Azad University, Tehran, Iran.

[2] Full Professor, Dept. of Civil & Environmental Engineering, Tarbiat Modares University, Tehran, Iran.

[3] Associate Professor, Dept. of Technical and Engineering, Karaj Branch, Islamic Azad University, Alborz, Iran.

[4] Ph.D. candidate, School of Civil Engineering, Iran University of Science and Technology, Narmak, Tehran, Iran.

1. Introduction

Traffic congestion is one of the major problems of urban life with wide-ranging effects in terms of wasting commuters' time, producing emissions, wasting non-renewable energy sources, lowering environmental quality, reducing the quality of life, etc [Irena Ištoka Otković et al, 2020].

While this problem can be alleviated through the expansion of road networks, this solution is not only difficult to implement due to financial constraints and land acquisition problems but also tends to ultimately exacerbate the traffic's environmental effects. Therefore, it is preferred to instead focus on making better use of existing networks [Cenk Ozan, 2017].

One of the methods most widely used to solve traffic problems is traffic management, which itself consists of transport demand management (TDM) and transport supply management (TSM). Traffic management can be described as a strategy to improve the efficiency of the urban transportation system or the traffic situation in certain areas of a city by reducing unnecessary use of private vehicles, improving the road network efficiency,or through other environment -friendly solutions [Broaddus, A , 2009].

According to Litman, complementary TDM strategies can be classified into five major categories of improved transport options, incentives to use alternative modes and reduce driving, parking and land-use management, policy and institutional reforms, and TDM programs and program support.

One way to reduce traffic in certain parts of an urban road network is to turn some of its streets into one-way routes. From the traffic engineering perspective, this strategy offers advantages such as increasing capacity by 10 to 20% (compared to two-way routes), reducing the variety of maneuvers at intersections and reducing the delays they cause, reducing roadside activities (e.g. taxis picking up and dropping off passengers), reducing travel time, preventing vehicles from entering certain areas or directing traffic to other areas, and reducing fuel consumption and resulting emission. However, this strategy also has some drawbacks such as increasing travel distance (wear) and increasing the demand for turning at certain intersections. From the perspective of users (drivers, pedestrians, users of public transport vehicles), making streets one-way has drawbacks such as misleading drivers and passengers who are unfamiliar with the network layout and reducing the safety of pedestrians (because of the higher speed of vehicles). Also, residents and businesses tend to dislike living and working in one-way streets because of the high speed of vehicles and the difficulty of reaching close destinations on the upstream side.

In this study, the goal is to choose a set of urban roads for conversion into one-way in order to reduce traffic in certain areas of the city of Yazd and then examine the impact of this conversion on traffic parameters. The roads are chosen such that fewer travels pass through the areas of interest and especially the center of the city, leading to reduced traffic in these areas.

In the remainder of this article, section 2 reviews the previous studies on the use of one-way streets as a means of traffic management and section 3 describes the research method. Section 4 explains the process of identifying roads that technically and practically eligible for conversion into one-way, collecting data from 78 survey stations, importing data into the Aimsun software environment, calibrating the network model with real-world data, and preparing the model for simulating the considered scenarios. In the end, the software outputs are used to analyze and compare the network performance in different scenarios and assess the extent of improvement in different network parameters in each case.

2. Review of Literature

In a study by Drezner, he formulated the problem of configuring one-way streets in a road network to minimize the total travel time of users. This researcher used three methods to solve this problem. The first method was an exact method based on the branch and bound algorithm, which was able to solve small-scale problems, the second method was a heuristic algorithm, and the third method was a meta-heuristic algorithm based on simulated annealing. After solving small, medium, and large-scale instances of the problem with the proposed algorithms, this study reported that the exact algorithm has a reasonable solution time for smaller problems but not for larger ones such as networks with 40 nodes and 99 arcs. Thus, these problems can only be solved by the heuristic algorithm [Drezner and Wesolowsky, 1997].

Drezner and Salhi formulated the problem of finding the near-optimal configuration of one-way and two-way routes with the same objective function as Drezner and Wesolowsky. Basically, the goal of this study was to minimize travel time between each origin-destination pair through the proper selection of a combination of one-way and two-way arcs. These researchers developed a Tabu search algorithm for solving this problem, and after applying their method on two random networks, they reported that the method had a significant impact on the solution quality [Drezner and Salhi, 2000].

Drenzer and Wesolowsky introduced the problem of designing a network with a number of potential arcs that can be built at a certain cost and if built, can be used as one-way or two-way routes. In this problem, the objective was to minimize the total cost of construction and transportation in the network. These researchers reported that all states of this problem can be reduced to four basic formulations, which they solved by the gradient descent algorithm, simulated annealing, Tabu search, and genetic algorithm. Among these algorithms, the genetic algorithm showed the best performance in solving this problem [Drezner and Wesolowsky, 2003].

In a study by Colman and Steven, they examined the advantages and disadvantages of one-way streets and introduced a number of criteria for assessing their condition. To identify the one-way streets in Auckland that could be good candidates for conversion into two-way, they rated these one-way streets on a scale of -5 to +5 based on these criteria and aggregated the ratings. The evaluation criteria introduced by these researchers were: traffic volume during peak hours, highway connection, land use consistency, access to parallel high-capacity streets, public transportation facilities, street width, network access, and consistency of traffic signs. These researchers stated that converting the direction of streets is not cheap and should only be done with strict conditions [Colman and Steven, 2004].

O'Toole studied the air pollution and safety implications of using one-way streets in a road network. According to this researcher, since vehicles produce more pollution at low speeds than at high speeds, two-way streets tend to be more polluting because of the more frequent shifts from stopping to motion and vice versa. He estimated that the difference between one-way and two-way streets in this respect is about 10-13%. After comparing the safety of one-way and two-way streets by examining the outcomes of conversion of two-way streets into one-way in some American cities, this researcher reported that more pedestrian accidents happen on two-way streets and thus it is wrong to consider them safer than one-way streets because of lower speeds [O'Toole, 2005].

In a study by Jing and Li, they proposed three scenarios for converting some streets of the city of Kunming in China into one-way routes to alleviate their traffic congestion problem. To measure the effect of this conversion, they investigated the road network saturation and travel delay before and after the medication. These researchers reported that in all scenarios, the conversion decreased the saturation rate as well as travel delay. In the end, they compared the results of three scenarios to identify the best option [Jing and Li, 2009].

Miandoabchi and Farahani studied the subject of designing street directions and adding lanes to existing urban road networks based on the concept of reserve capacity. In this study, the goal was to find the optimum configuration of street directions and lane allocation to streets so that the reserve capacity of the road network is maximized. These researchers considered the problem in two states: 1- when lane allocations in two-way streets should be symmetric and 2- when lane allocations need not be symmetric.Then they solved the problem by a genetic algorithm and an evolutionary simulated annealing algorithm [Miandoabchi and Farahani, 2011].

Citing the great potential of intelligent optimization systems in improving the existing urban infrastructure, Salcedo-Sanz et al. tried to use this approach in the reconfiguration of one-way streets to give citizens alternative routes after the occurrence of major problems such as prolonged blockage. These researchers developed a bi-objective solution method based on the Harmony Search for this problem [Salcedo-Sanz et al, 2013].

In Iran, Mirjalalieh designed a network of one-way streets for the city of Shiraz using the SA algorithm. In this study, expert opinions were used to define various constraints for the network design. In the end, it was claimed that the algorithm can offer significantly better results than the conventional candidate selection method [Mirjalalieh, 2001].

In another study conducted in Iran, Hosseinlou et al. examined the traffic situation of Dastgheib Street in Tehran in the segment between Moin Street and Saeedi Highway. These researchers first analyzed the traffic data collected through a field survey and the physical information of roads in this area, and then used the Corsim simulation software to come up with solutions for reducing traffic in this segment based on engineering judgment [Hosseinlou et al, 2010].

Motlagh et al. studied the effects of converting Valiasr Street in Tehran into a one-way route. In this study, the social impact of this project was examined by surveying and interviewing stakeholders in four groups of residents, businesses, drivers, and pedestrians about different dimensions of the project [Motlagh et al, 2010].

In a study by Karimi et al., they investigated the effect of converting streets into one-way roads on traffic in an area. These researchers considered three conditions for choosing which streets to convert: 1- causing the minimum increase in the total travel time of the network, 2- reducing the travel time on the streets of the target area as much as possible, and 3- not having extensive social consequences for the city. They then created a series of scenarios by placing different combinations of streets in the conversion list and estimated the total travel time of the network and the target area in each case. Because of the presence of two objective functions in the problem, they ultimately used a multi-objective decision tool to identify the superior scenario.

As the above literature review suggests, most studies on the subject of making streets one-way have been focused on reducing the traffic and increasing the capacity of thoroughfares. This article examines whether this solution can be used to reduce traffic in the central parts of the city of Yazd, Iran. Since the traffic flow of any urban area also includes the traffic that simply passes through that area, converting a set of urban streets into one-way can be utilized as a measure to reduce traffic by reducing the number of travels through the area.

Table 1 summarizes the studies in the field as well as following data like (a) author(s), (b) year, (c) software, and (d) main results and major outlines. Analysis of the previous research indicated the extensive use of a variety of micro-simulation models in the studies.

1- Software capability
2- Simplified application
3- User-interface or user-graphics,
4- Software costs,
5- Software/hardware requirements
6- Emulation ability of specific properties of the operations,
7- Earlier software running
8- Precision in the estimation of diverse indices of transport network performance (i.e., travel time & speed, vehicle flow & delay)
9- Users' requirements
10- Goals of the project, etc.

Therefore, researchers addressed the evaluation of the models SimTraffic micro-simulation and AIMSUN for those sections of street with various practical classifications with regard to several performance indices like travel speed and time, fuel consumption, total distance of travel, and vehicle flow.

Table1. Literature review summary

Author(s)	year	Software used	Key findings and important notes
Bloomberg and dale	2000	CORSIN;VISSIM	The differences among the considered micro simulation models were minimal, and the selection of the appropriate micro simulation model was primarily affected by the user needs
Shaw and nam	2002	CORSIM; PARAMICS; VISSIM	PARAMICS was found to be the most appropriate model for the southeast Wisconsin freeway system based on the model capabilities, ease of use, and application requirements.
Tian et al	2002	CORSIM; sim traffic VISSIM	CORSIM produced the lowest variations in both vehicle delays and throughput flow rates, while simtraffic retimed the highest variations.
Jones et al	2004	AIMSUN; CORSIM; sim traffic	sim traffic was reported to have the most user-friendly graphical interface, while CORSIM was found to be more efficient for modeling complex transportation networks.
Fang and elefteriadou	2005	AIMSUN; CORSIM; VISSIM	Identified the most critical factors that should be considered in the selection of the appropriate micro simulation model. Familiarity with the facility was found to be one of the main factors that could improve the modeling accuracy
Xiao el al	2005	AIMSUN; VISSIM	The models were evaluated based on the functional capabilities, service quality, and ease of use. Presences to use a specific model were primarily determined by the type of user.
Shariat and babaie	2006	AIMSUN; VISSIM	The Whiteman-Ritter car-following model (used in VISSIM) was found to be more logical and typically yielded more accurate
Shariat	2011	AIMSUN; sim traffic; VISSIM	AIMSUN was superior to VISSIM and sim traffic in terms of knowledge management, user-friendliness, software cost, and popularity amongorganizations
Pourreza et al	2011	AIMSUN; CORSIM; INTERATION; PARAMICS; VISSIM	CORSIM was found to be most advantageous micro simulation model based on the considered performance indicators (i.e., model capabilities, previous, previous software implementation, software support, software costs, user-friendliness, graphics, and interface).
Da Rocha et al	2015	N/V	The Gipps and Newell car-flowing models were studied. The Gipps car car-flowing models demonstrated higher accuracy in terms of the simulated vehicle trajectories. The selection of the non-optimal parameters substantially increased the variance of the model outputs.
Ibrahim and far	2015	AIMSUN	The numerical experiments demonstrated that the AIMSUN micro simulation model was able to reduce the time by ~5 30%,while the congestion duration was decreased by~8-41%
Pratico et al	2015	VISSIM	Aimed to estimate vehicle travel speeds on roundabouts. The accurate Travel speed estimates could be provided when the model parameters were carefully calibrated.
Shaaban and Kim	2015	SimTeaffic.VISSIM	For the high traffic flow scenarios, VISSIM provided higher delay values as compared to SimTeaffic.

Author(s)	year	Software used	Key findings and important notes
Essa and sayed	2016	PARAMICS; VISSIM	Default model parameters gave poor correlation with field-measured data. Both micro simulation models could not estimate conflicts accurately without proper calibration
Astarita et al	2019	AIMSUN; Tritone ; VISSIM	The experiments showed some variations in the simulation outputs. How ever , the roundabout interaction generally has the largest number of conflicts.
Kan et al	2019	AIMSUN; MOTUS	Studied freeway corridors that had dedicated lanes and experienced congestion. The experiments provided some insights into driver behavior on freeways.
Shaaban et al	2019	VISSIM	It was found that the replacement of roundabouts whit traffic signals could reduce emissions by 37%-43% at one of the urban arterial corridors in Qatar.
Grana et al	2020	AIMSUN	The results showed that the operational performance of roundabouts could be significantly affected by the percentage of heavy vehicles.
Kim et al	2020	VISSIM	The study proposed a systematic guideline that could be used for calibrating reliable micro scale estimates of vehicle emissions.
Song et al	2020	Trans Modeler; VISSIM	The experiments showed that, even after calibration, both micro simulation models had significant errors in some performance indicators when comparing o the actual values.
Van Beinum et al	2020	MOTUS;VISSIM	The considered models were not able to accurately emulate turbulent traffic flows in terms of the headway distribution and lane-changing locations.
Pell et al	2017	Survey study	Conducted a detailed analysis of 17simulation packages. It was found that many software of drawbacks in modeling capabilities.
Azlan and Rohani	2018	Survey study	Provided a comprehensive overview of microscopic, macroscopic,and macroscopic traffic simulation models. The study highlighted that the project needs mostly affect the final selection of the appropriate traffic simulation model
Gora et al	2020	Survey study	Studied the existing literature on the applications of the microscopic traffic simulation for modeling connected and autonomous vehicles. It was highlighted that new algorithms should be developed to better capture the travel behavior of vehicles.

3. Methodogy

Traffic engineering studies on urban thoroughfares are typically done either by conducting pre-post analyses or by running simulations. The first method involves monitoring the effect of the medications made in a system or how it is managed. The simulation approach allows the impact of medications to be assessed almost instantly at much lower costs. In this method, the routes are simulated as realistically as possible and the resulting models are updated on a time basis (at regular intervals) or an event basis (after any change in the system). The vehicles are then placed in the network with specific distributions to initiate their traffic behaviors. Ultimately, the computer produces the simulation outputs based on its view of the modeled network [Bernice Liu, 2019].

In this study, traffic simulation is performed macroscopically using the event-based approach in the Aimsun software. Developed by TTS Spain, Aimsun allows users to simulate a transport network and the links between its components with various transportation modes, roads, intersections, etc., and produce outputs at various levels in the form of data or 2D and 3D representations.

3.1. Step 1: Selecting the Zone and Candidate Streets

As stated earlier, the goal of this study is to examine whether a set of streets in an urban road network can be chosen for conversion into one-way routes in order to reduce traffic in certain areas of that network and examine the impact on traffic parameters.

Traffic in any given area comes from four sources:

1- Travels from origins inside the area to destinations outside the area

2- Travels from origins inside the area to destinations inside the same area

3- Travels from origins outside the area to destinations inside the area

4- Travels from origins outside the area to destinations outside the area

To reduce traffic in the central part of a city, the streets to be converted should be chosen in such a way as to reduce the number of travels that just go through the target areas. In other words, it is necessary to reduce the number of travels from origins outside the region to destinations outside the region by making these drivers choose alternative routes.

3.1.1. Candidate streets for conversion into one-way

1. Two parallel streets with a distance of one or a few blocks.
2. Places where there are a sufficient number of intersecting streets with enough distance for optimal traffic flow.
3. Streets with very high trip generation and attraction during peak hours due to the presence of certain land uses (e.g. residential, commercial, educational, health and medical).
4. Narrow streets that cannot be widened because of being located in historical neighborhoods of Yazd, which have been registered in the UNESCO World Heritage list.
5. Streets where daily parking demand is more than parking capacity.
6. Streets that according to Yazd transportation master plan should become one-way within the plan’s timespan.

The criteria used in this study for choosing which candidate streets should be converted are as follows:

1. Minimum increase in the total travel time of the entire road network
2. Maximum decrease in the travel time on the streets of the target area
3. Needing to convert as few streets as possible to limit the social impact on the city

Ultimately, candidate streets are selected with attention to convergence and importance of streets as well as the above criteria.

3.2. Step 2: Modeling the Geometry of Roads and Intersections

To create the geometry of roads and intersections in Aimsun, after adding, scaling, and matching map layers from Google Map, aerial photos, etc., the road sections are drawn and connected and the relevant infrastructure information and features such as road type, maximum speed, view distances, lane capacity, and the presence or absence of dedicated left-turn lanes are introduced to the software.

3.3. Step 3: Introducing Information

Traffic information can be given to the software in the form of either traffic flow distribution or origin-destination matrix. In the matrix method, it is necessary to specify the points of origin and destinations to form travels and also specify the amount of traffic between each origin and destination with the help of the distribution matrix. However, the traffic flow distribution method, which is the method used in this study, is based on giving a number of inputs with known distribution to the network. In this method, the traffic flow distribution in the software is an exact copy of the one in the real network and can be used only when distribution in all branches of the network is available.

3.4. Step 4: Categorizing the Roads and Running the Base State Simulation

In this stage, the type of road control measures, the schedule of traffic signals, the presence of stop or right of way signals, and other relevant information about the traffic flow are introduced to the software. Then, the network in its current condition (base state) is simulated and the outcome is compared with real-world data to detect potential errors in modeling or inputs.

3.5. Step 5: Creating Feasible Scenarios and Determining the Number of Simulations

After making sure that the software model conforms to the real network, the feasible scenarios for converting streets into one-way routes are constructed.

Given the criteria considered for converting streets, it is likely that optimal traffic conditions can be achieved by converting a large number of streets. But since this will result in public dissatisfaction, we try to convert as few streets as possible.

3.6. Step 6: Solving the Traffic Allocation Problem for Each Scenario and Interpreting Software Outputs

After determining the feasible scenarios, the traffic allocation problem is solved separately for each scenario, and the equilibrium flow obtained in each case is assessed.

The statistical outputs of the software describe the system performance quantitatively in terms of measures such as delay per unit distance traveled (kilometer), total travel distance, total travel time, stop time per unit distance traveled (kilometer), vehicle density, and average vehicle speed. The graphical outputs of the software provide a better understanding of how the network works by displaying traffic flow and phenomena such as queuing, congestion, and blockage.

3.7. Step 7: Comparing the Scenarios and Identifying the Best Option

Finally, different scenarios are compared with each other and with the base model (current situation) in terms of defined criteria to determine which one results in the best reduction in travel demand, travel time throughout the network, and travel time in the target area.

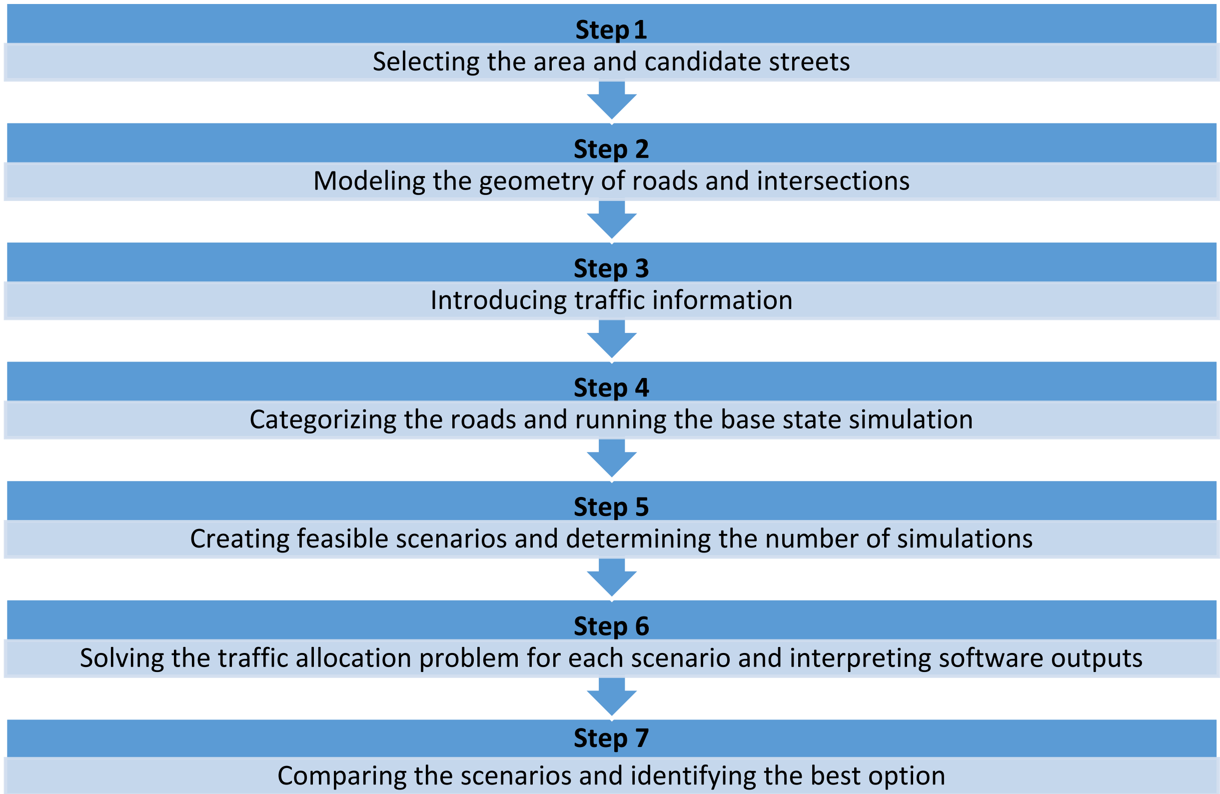


Figure 1. Research process

4. Case Study

The study area is located in the historical district of the city of Yazd, which is one of five municipal districts of this city. While the historical district is 1285 hectares in total, this study is focused on a 465-hectare area of this district (equivalent to 36% of its total area). The length of the main thoroughfares in the study area is 15 km. This area is enclosed by Golsorkh Street and Imamzadeh Boulevard in the north, Asizadeh, Basij and Montazer Ghaem Boulevards in the south, Fahadan and Mahdi Streets in the east and Motahari Street and Taleghani Boulevard in the west. A map of the study area is shown in Figure 1.

The main thoroughfares in the study area are all two-way roads. Large traffic flows pass through these thoroughfares, causing significant conflict at intersections. Out of 13 main intersections in this area, 8 have been signalized, 3 have been converted into a square (Golsorkh, Beheshti, Azadi), 1 has been made into a grade-separated intersection (Mahdieh), and 1 has been turned into a signalized three-way (Khomeini-Fahadan).

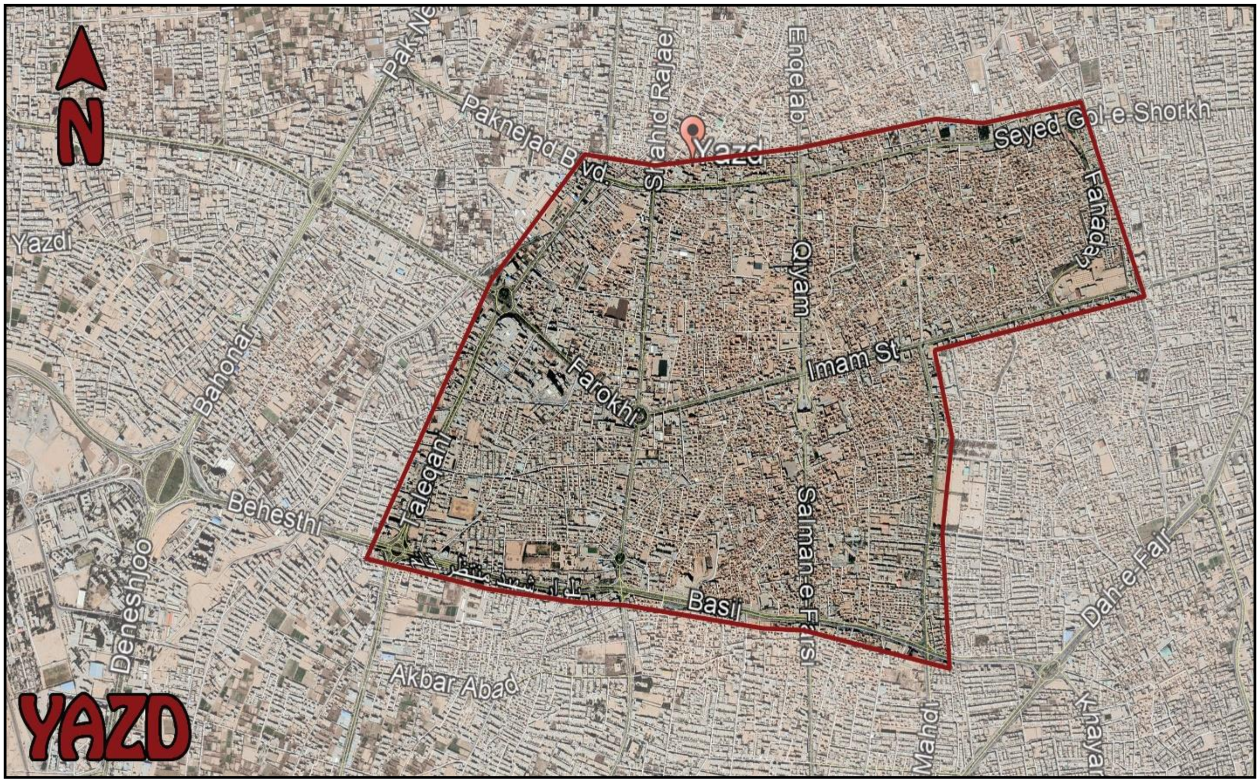


Figure 2. Study area

The major problems of the road network in this area include the narrowness of the roads and the high volume of incoming traffic. Also, because of the variety of land-uses in this area (residential, commercial, educational, health, and medical) which produce and attract a large number of travels especially during peak hours, this area has a significant roadside parking problem, which further reduces the capacity of roads and their service level. Furthermore, it is common to have heavy traffic in the approaches of the eight intersections that have been signalized. The traffic problem of this area is exacerbated by the fact it is located in the historical district of Yazd, which is a registered UNESCO world heritage site. This not only increases the demand for travel to the area but also makes it impossible to widen the roads or reform the land-uses.

Therefore, the only way to reduce traffic and increase road capacity in this area is to adopt transport supply and demand management strategies such as converting two-way roads into one-way, banning roadside parking, implementing traffic reduction schemes, etc.

5. Data Collection

After an initial field survey of the study area, it was decided to conduct the data collection over three evening peak hours of three weekdays (9 hours in total). The data collection process involved traffic counting and license plate reading and was performed by 207 people from 17:30 to 20:30 on normal weekdays. More details about the location of traffic counting and license plate reading station are given in Table 2 and Figure 3. It should be noted that according to the statistics, the peak traffic hour in the study area was 19:00-20:00.

Table 2. Type and number of data collection stations

Type of station	Number of stations
Traffic counting	51
License plate reading	27

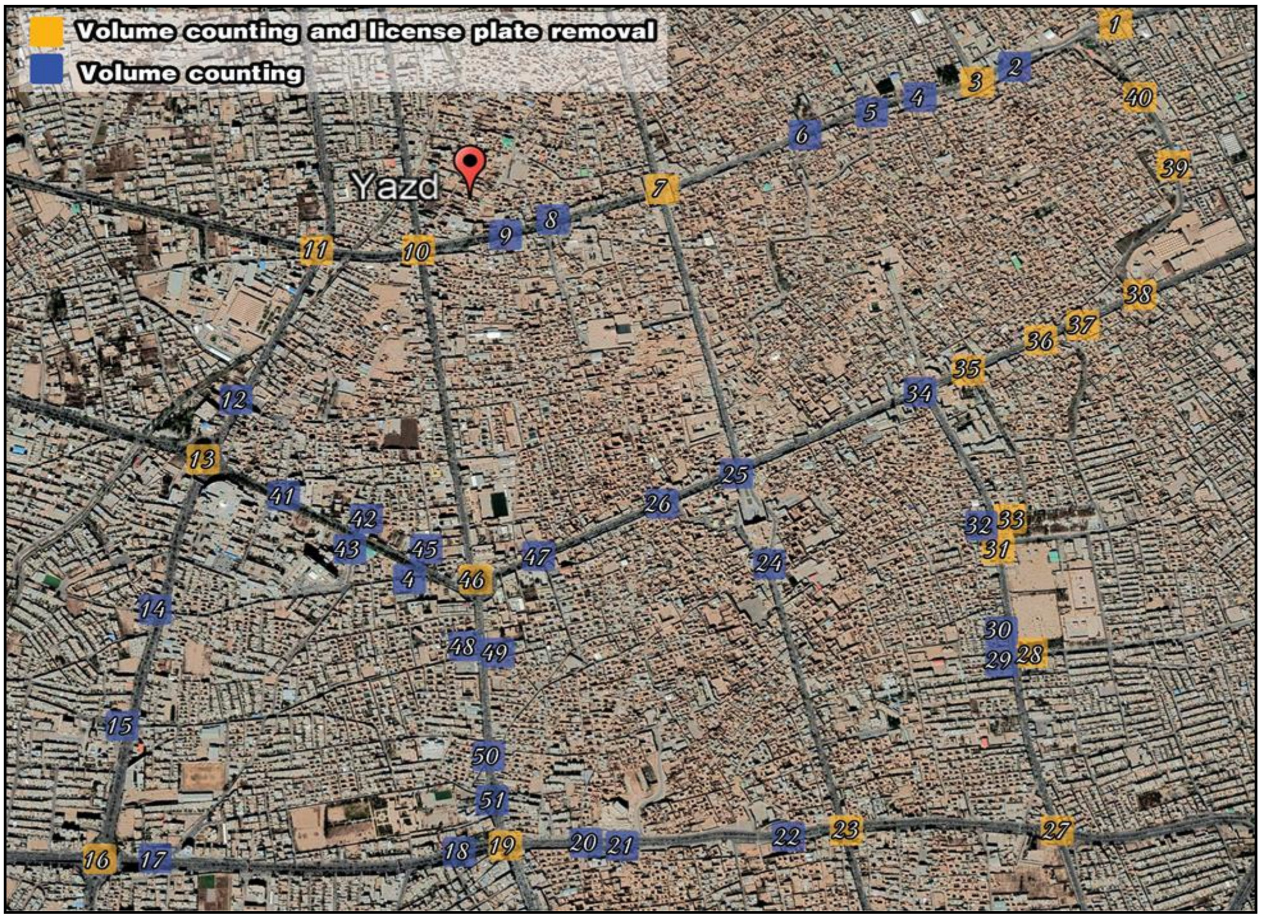


Figure 3. Location of data collection stations (Traffic counting And License plate reading)

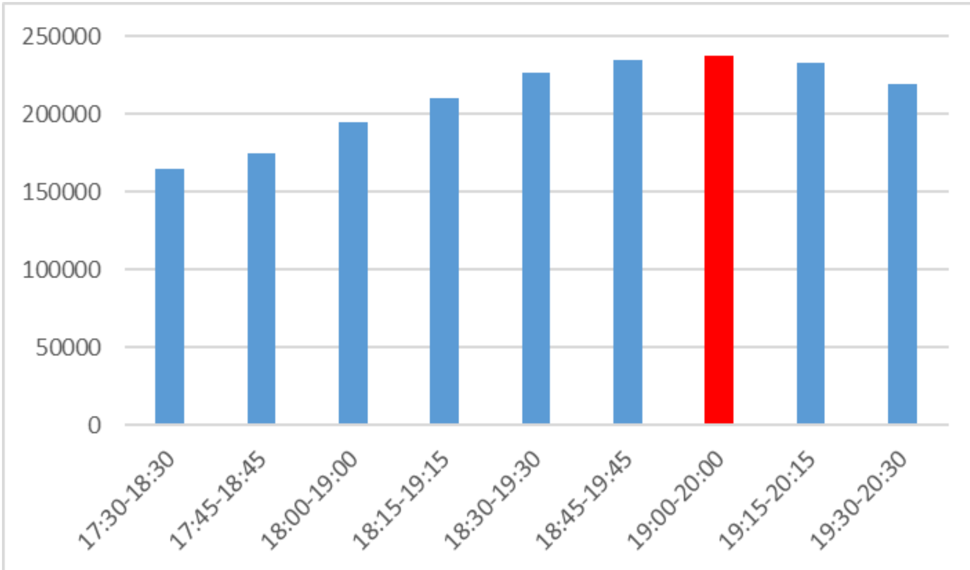


Figure 4. Peak traffic hours according to the data collected by 27 traffic counting stations

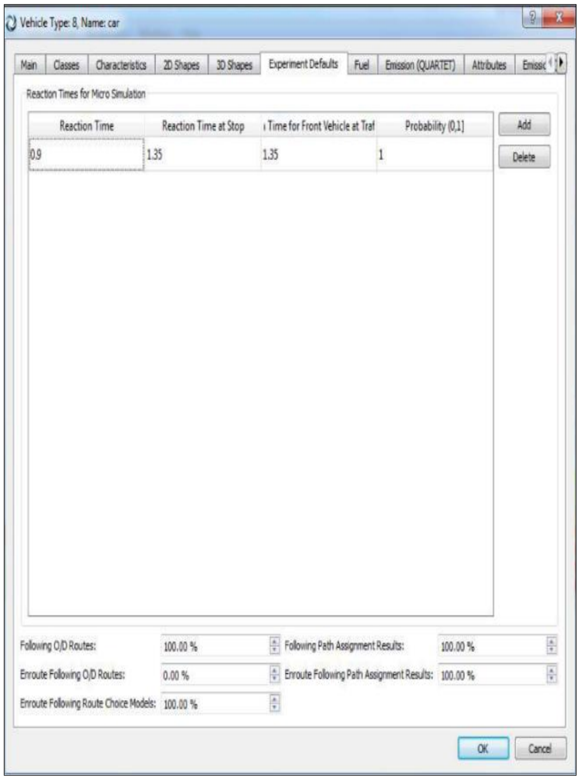
6. Simulation of Proposed Scenarios

The simulations necessary to assess the road network in its current situation based on its physical and traffic characteristics and after the proposed modifications were conducted in Aimsun v.8.

However, before creating modification scenarios, it was necessary to introduce the collected data to the simulation software to reproduce the current network in the software environment. This was necessary to calibrate the model through comparison with real-world data and make sure that it can properly simulate the network under the defined scenarios. Further, the software outputs for the base model offer a baseline for comparing the results of the proposed scenarios and estimating the extent of improvement in different parameters in each case.

It should be noted that the characteristics of vehicles and road network arcs, including vehicle dimensions and headings and the parameters of lane changing and gap acceptance sub-models were set according to the instructions of the Traffic & Transportation Department of Tehran Municipality for model calibration and simulation in Aimsun.

Considering the problems of the studied network and the data collected from the area, the authors developed nine solutions, which are described below in detail. It should be noted that in all of the scenarios, it was assumed all of the modified roads will have an exclusive bus lane.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2D Shapes
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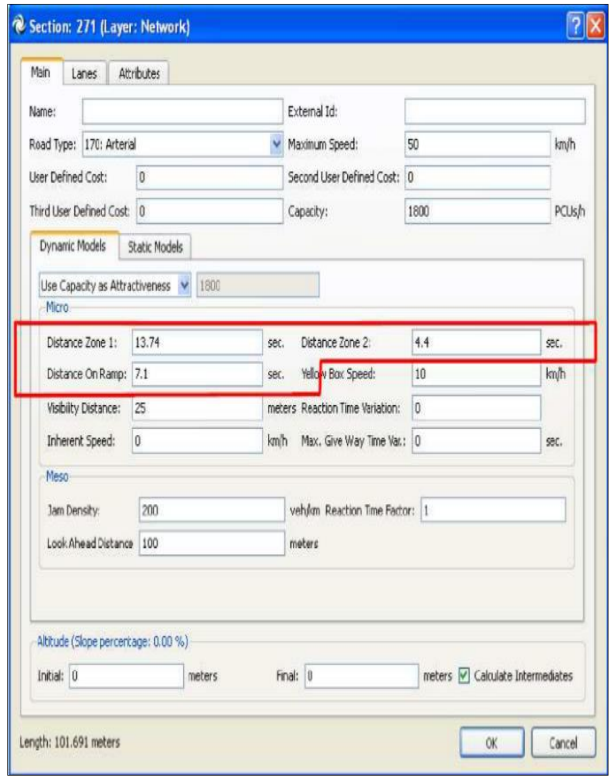
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PCUs/h
Dynamic Models
Static Models
Use Capacity as Attractiveness
1800
Micro
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13.74
sec.
Distance Zone 2:
4.4
sec.
Distance On Ramp:
7.1
sec.
Yellow Box Speed:
10
km/h
Visibility Distance:
25
meters
Reaction Time Variation:
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Inherent Speed:
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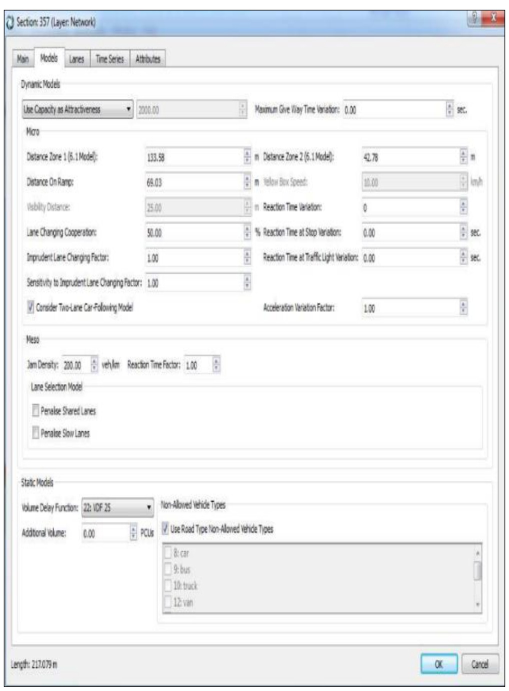
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Use Capacity as Attractiveness
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Lane Selection Model
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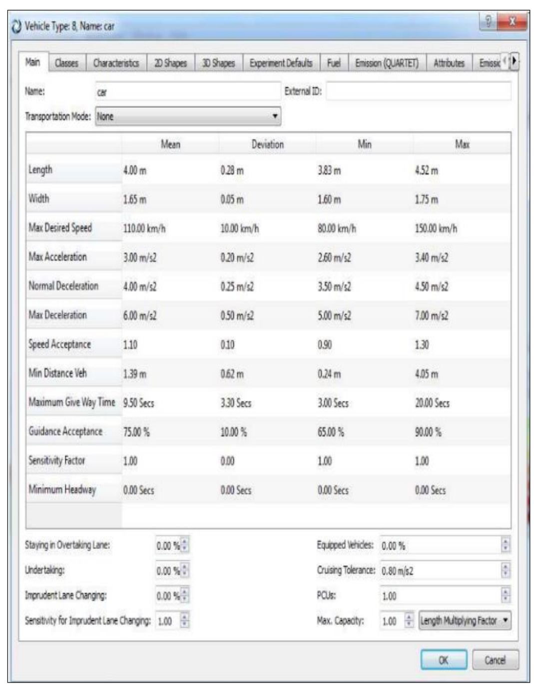
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Max Desired Speed
Max Acceleration
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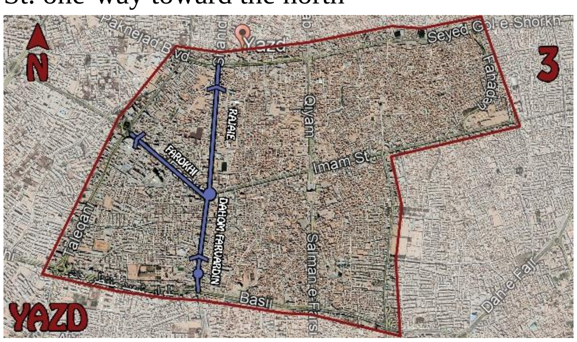
Min Distance Veh
Maximum Give Way Time
Guidance Acceptance
Sensitivity Factor
Minimum Headway
OK
Cancel

Scenario 1: Making Farrokhi St. one-way toward the east + Making 10-Farvardin St. one-way toward the south

Scenario 2: Making Farrokhi St. one-way toward the west + Making 10-Farvardin St. one-way toward the north

Scenario 3: Scenario 2 + Making Shahid Rajaei St. one-way toward the north



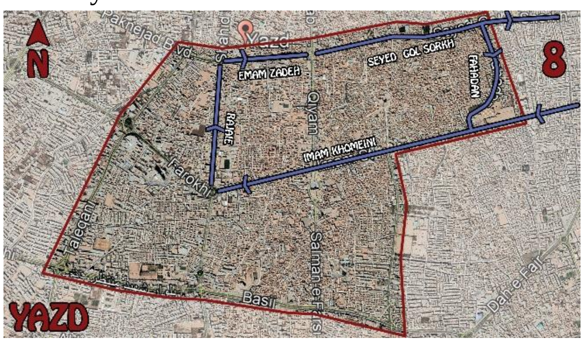
Scenario 4: Scenario 1 + Making Shahid Rajaei St. one-way toward the north

Scenario 5: Scenario 1 + Making Shahid Rajaei St. one-way toward the south

Scenario 6: Making Shahid Rajaei St. and 10-Farvardin St. one-way toward the south + Making Salman Farsi St., Qayam St. and Enghelab St. one-way toward the north

Scenario 7: Making Imam Khomeini St. one-way toward the west + Making Imamzadeh Jafar St. and Golsorkh St. one-way toward the east + Making Shahid Rajaei St. one-way toward the north

Scenario 8: Scenario 1 + Making Fahadan St. one-way toward the south



Scenario 9: Making Shahid Rajaei St. and 10-Farvardin St. one-way toward the south + Making Salman Farsi St., Qayam St., and Enghelab St. one-way toward the north + Making Farokhi St. and Imam Khomeini St. one-way toward the east + Making Golsorkh St. and Imamzadeh St.to one-way toward the west + Making Fahadan St. one-way toward the north

Figure 5. Medications made to the network in the nine defined scenarios

Table 3. Comparison of traffic indexes of the network in its current configuration and after applying the considered modifications

Scenario / Index	Current configuration	1	2	3	4	5	6	7	8	9
Total delay (s/km)	122.1	156.1	248.9	263	236	168.7	144.7	151.8	166.6	197.3
Traffic flow (vehicle/hour)	22426	9823	14676	13105	12669	9607	15640	14787	15652	11203
Average network speed (km/h)	31.6	28.5	22.5	21.2	22.2	27.3	28.9	29.8	29.3	24.7
Number of vehicles passing through	22426	9823	14676	13105	12669	9607	15640	14787	15652	11203
Number of vehicles let in	2146	6648	5558	6201	6184	7153	5196	6161	6207	7372
Number of vehicles left out	2813	10297	7127	8037	8489	10613	6436	6156	5147	8767

As shown in Table 3, in all scenarios, the number of vehicles left out of the area (i.e. vehicles that could not enter the area from their origin and therefore did not reach the destination) is higher than the corresponding number in the current network. This indicates that the modeled network has not been successful in letting traffic flow pass through, because increased delay at intersections and queue formation in their approaches have led to the blockage of a part of the network. Given the network's failure to transfer traffic flow, it is pointless to examine other traffic indexes and impossible to compare the scenarios (even with multi-objective or multivariate evaluation methods). Therefore, none of these scenarios can be considered practical.

The 9 defined scenarios produced better results than other studied options, including the 6 scenarios introduced in Yazd transportation master plan(which aren't included in this article). Next, the proposed scenarios were re-simulated with the assumption of a 30% decrease in travel demand in the study area. The results of these simulations are presented in Table 4. Please note that this table only compares the results of five scenarios (out of nine) that had the least number of left-out vehicles.

It was found that applying scenario 6 (while implementing the traffic restriction scheme and reducing demand by 30%) will deliver better results than other alternatives.

The low number of vehicles left out in these scenarios indicates that these networks will not have any major congestion source and delays and queues at their intersections will not be significant enough to undermine their performance.

Table 4. Comparison of traffic indexes of the network in its current configuration and after applying the considered modifications (with the assumption of a 30% decrease in travel demand)

Scenario / Index	Current configuration	1	4	6	7	8
Total delay (s/km)	32.61	95.54	115.41	32.14	34.35	36.2
Traffic flow (vehicle/hour)	18983	16107	15234	17755	16976	17262
Average network speed (km/h)	40.43	32.29	30.66	39.66	39.42	38.24
Number of vehicles passing through	18983	16107	15234	17755	16976	17262
Number of vehicles let in	1442	2344	2938	1213	1308	1530
Number of vehicles left out	368	868	1159	303	898	324

7. Conclusions and Suggestions

The results of field examinations, cross-section profiling, statistical survey, road network modeling, and scenario-based simulations of this study showed that considering the capacity and other constraints of the central (historical) district of Yazd, it would be counterproductive to convert the thoroughfares of this district into one-way routes without somehow reducing demand for private transportation.

In the end, the defined scenarios were re-simulated with the assumption of a 30% decrease in demand in the central district. The results of this simulation showed that scenario 6 offers better results than other options. The small number of vehicles remained outside the network indicates that the network does not have any major traffic node and delays and queuing at intersections are not large enough to cause network disruption.Thus, it is recommended to take the following actions before implementing such solutions in this district:

- Planning traffic reduction schemes for the central district of Yazd to shift traffic flow out of this area.
- Banning roadside parking in the central district of the city.
- Applying geometric modifications to intersections,limiting access near inter-sections and reconfiguring traffic lights.
- Adopting culture-oriented strategies or other solutions to reduce travel demand.
- Building a BRT line in Imam Khomeini and Farrokhi streets to shift a portion of demand from private transport to public transport.

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9. References

- Broaddus, A., Litman, T. and Menon, G.(2009), “Transportation demand management”, Water, energy and transport, Vol. 44.

- Colman, A. and Steven, B. (2004) “Re-thinking the one-way grid”, ITE Transportation Planning Council Newsletter, Vol., pp. 3-9.

- Das, I. (1999) “On characterizing the knee of the Pareto curve based on normal-boundary intersection”, Structural Optimization ,Vol. 18, pp. 107-115.

- Deb, K. (2001) “Multi-objective optimization using evolutionary algorithms”, John Wiley & Sons.

- Drezner, Z. W.G. (1997) “Selecting an optimum configuration of one-way and two-way routes”, Transport Science, Vol. 33, pp. 386-394.

- Drezner, Z. and Salhi, S. (2000) “Selecting a good configuration of one-way and two-way routes using tabu search”, Control and Cybernetics, Vol. 29, pp 725-740.

- Drezner, Z. and Wesolowsky, G. O. (2003) , “Network design: selection and design of links and facility location”, Transportation Research Part A: Policy and Practice, Vol. 37, pp.241-256.

- Leblanc, L. J. (1975) “ An algorithm for discrete network design problem”, Transportation Science, Vol. 9, pp. 183-199.

- Litman, T. (2013) “ Online TDM encyclopedia”, Victoria Transport Policy Institute, Website : http:\\ www.vtpi.org.

- Litman, T. (2012) “ Online TDM encyclopedia”, Available at : http:\\ www.vtpi.org.

- Lu, J., Zhang, G. and Ruan, D. (2007) “Multi objective group decision making: methods, software and applications with fuzzy set techniques”, Imperial College Press.

- Miandoabchi, E. and Farahani, R. Z. (2011) "Optimizing reserve capacity of urban road networks in a discrete network design problem", Advances in Engineering Software, Vol. 42, pp. 1041-1050.

- O'Toole, R. (2005) "Should cities convert oneway streets to two-way?", The Center for the American Dream Independence Institute.

- Salcedo-Sanz, S., Manjarres, D., Pastor-Sánchez, Á., Del Ser, J ,.Portilla-Figueras, J.A. and Gil-Lopez, S. (2013) "One-way urban traffic reconfiguration using a multi-objective harmony search approach", Expert Systems with Applications", Vol. 40, pp. 3341-3350.

- Shi Jing, B.W., TAO Li. (2009) "Quantitative Analysis of One-Way Street Effects in Urban Central District", International Conference on Management and Service Science, pp. 1-4.

- Tian, Z., Jia, L., Dong, H., Su, F. & Zhang, Z. (2016), "Analysis of Urban Road Traffic Network Based on Complex Network". Procedia Engineering, 137, pp.537-546.

- Jon D. Fricker1 and Yunchang Zhang. (2019), "The Effects of a Change from One-Way to Two-Way Street Operation". TRR journal of the Transportation Research Board, pp.1-14.

- Shariat, A. Calibration Of Traffic Engineering Software Based On Tehran's Traffic Condition; A report prepared for the Tehran's municipality; Tehran, Iran, 2011.

- Pell, A.; Meingast, A.; Schauer, O. Trends in real-time traffic simulation. Transp. Res. Procedia 2017, 25, 1477–1484.

- Azlan, N.N.N.; Rohani, M.M. Overview of application of traffic simulation model. In Proceedings of the MATEC Web of Conferences, Penang, Malaysia, 6–7 December 2017; EDP Sciences: Paris, France; Volume 150, p. 03006.

- Gora, P.; Katrakazas, C.; Drabicki, A.; Islam, F.; Ostaszewski, P. Microscopic traffic simulation models for connected and automated vehicles (CAVs)—State-of-the-art. Procedia Comput. Sci. 2020, 170, 474–481.

- Bloomberg, L.; Dale, J. Comparison of VISSIM and CORSIM simulation models on a congested network. Transp. Res. Rec. 2000, 1727, 52–60.

- Shaw, J.W.; Nam, D.H. Microsimulation, freeway system operational assessment, and project selection in southeastern Wisconsin: Expanding the vision. In Proceedings of the 81st Annual Meeting of the Transportation Research Board, Washington, DC, USA, 13–17 January 2002.

- Tian, Z.; Urbanik, T.; Engelbrecht, R.; Balke, K. Variations in capacity and delay estimates from microscopic traffic simulation models. Transp. Res. Rec. 2002, 1802, 23–31.

- Jones, S.L.; Sullivan, A.J.; Cheekoti, N.; Anderson, M.D.; Malave, D. Traffic Simulation Software Comparison Study; A Report Prepared by the University Transportation Center of Alabama; Huntsville, AL, USA, 2004.

- Fang, F.C.; Elefteriadou, L. Some guidelines for selecting microsimulation models for interchange
- Xiao, H.; Ambadipudi, R.; Hourdakis, J.; Michalopoulos, P. Methodology for Selecting Microscopic Simulators: Comparative Evaluation of AIMSUN and VISSIM; Report no. CTS 05-05; University of Minnesota: Minneapolis, MN, USA, 2005.

- Shariat, A.; Babaie, M. An evaluation of car following models in microsimulations. In Proceedings of the 7th International Civil Engineering Congress, Tehran, Iran, 8–10 May 2006.

- Pourreza, M.; Mirza Broujerdian, A.; Dindar, M. An evaluation of transport simulation models and choosing best microsimulation for traffic study. In Proceedings of the 9th International Conference on Traffic and Transportation Engineering, Tehran, Iran, 25 February 2011.

- Da Rocha, T.V.; Leclercq, L.; Montanino, M.; Parzani, C.; Punzo, V.; Ciuffo, B.; Villegas, D. Does traffic-related calibration of car-following models provide accurate estimations of vehicle emissions? Transp. Res. Part D Transp. Environ. 2015, 34, 267-280.

- Ibrahim, H.; Far, B.H. Simulation-based benefit analysis of pattern recognition application in intelligent transportation systems. In Proceedings of the IEEE 28th Canadian Conference on Electrical and Computer Engineering (CCECE), Halifax, NS, Canada, 3–6 May 2015.
- Praticò, F.G.; Vaiana, R.; Gallelli, V. Micro-simulation effectiveness in predicting operating speed profiles in a roundabout. Adv. Transp. Stud. 2015, 37, 5–14.

traffic operational analysis. J. Transp. Eng. 2005, 131, 535–543.

- Shaaban, K.; Kim, I. Comparison of SimTraffic and VISSIM microscopic traffic simulation tools in modeling roundabouts. Procedia Comput. Sci. 2015, 52, 43–50.

- Essa, M.; Sayed, T. A comparison between PARAMICS and VISSIM in estimating automated field-measured traffic conflicts at signalized intersections. J. Adv. Transp. 2016, 50, 897–917.

- Astarita, V.; Festa, D.C.; Giofrè, V.P.; Guido, G. Surrogate safety measures from traffic simulation models a comparison of different models for intersection safety evaluation. Transp. Res. Procedia 2019, 37, 219–226.

- Kan, X.D.; Xiao, L.; Liu, H.; Wang, M.; Schakel, W.J.; Lu, X.Y.; van Arem, B.; Shladover, S.E.; Ferlis, R.A. Cross-comparison and calibration of two microscopic traffic simulation models for complex freeway corridors with dedicated lanes. J. Adv. Transp. 2019, 1–15.

- Bernice Liu. (2019), “Evaluating Urban Downtown One-Way to Two-Way Street Conversion Using Microscopic Traffic Simulation”.Master Dissertation, California Polytechnic State University.

- Cenk Ozan (2017), “Determining optimum configuration of one-way and two-way streets using shortest path travel costs based on results of traffic assignment ”. Pamukkale University Journal of Engineering Sciences.

- Irena Ištoka Otković et al. (2020). “Validation of the calibration methodology of the microsimulation traffic model ”. Transportation Research Procedia 45 . pp. 684–691.