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Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

Impacts of Large Urban Regeneration Projects: The case of the New Athens Intercity Bus Terminal

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Abstract

Urban regeneration projects are constituted and realized worldwide in large cities positively influencing specific degraded areas and their surroundings. Such projects can alter the traffic conditions, as well as the transportation systems of these areas by introducing multimodality and new modes of transportation in these areas. Assessing the impacts of large scale transportation projects under the urban regeneration concept is complex and demand a multimodal multiparameter analysis of both the existing and the anticipated conditions. The present work attempts a multifaceted approach for quantifying the impacts of the construction and operation of a large intercity bus terminal in the city of Athens, as a substitute of two existing terminals. The findings showed that the new project will significantly improve the traffic conditions in the areas around the old terminals. As far as the road network in the near and greater area of the new terminal, the additional traffic will slightly degrade traffic conditions, a problem which can be tackled by applying specific traffic management measures.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: urban regeneration; intercity bus terminal; multimodal analysis

1. Introduction

Transportation systems are one of the most important aspects of the everyday life of the cities and their citizens. Urban regeneration transportation projects can lead to an upgrade of an area and its surroundings where they are constructed, to a multimodal transport which enables easy transfer and connection between different modes of transportation and maybe a long-term traffic dissipation. It has been revealed that these projects can have a social, economic and environmental impact on the areas or cities they are applied (May and Crass, 2007; May, 2013; ECTM, 2000). Various transportation projects achieving urban regeneration or renewal have been reported worldwide such as

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the restoration of the Cheonggyecheon River in Seoul, Korea (Preservation Institute 2007a) or the development of the Camden Walking Plan in London, UK (EPOMM 2011) and the replacement of the Embarcadero freeway in San Francisco by a trolley line-supported boulevard (Preservation Institute 2007b). Pedestrianization projects are also a case of transportation projects aiming at urban regeneration such as the pedestrianization of Bucharest's historic center (EPOMM 2011) and the pedestrianization of a major arterial, in the downtown area of the city of Athens (Kepaptsoglou et al, 2015). Many studies have analyzed and presented the connection between the concept of urban regeneration and transportation projects and how these actions can influence and affect land uses, area accessibility and connection with other areas or the center, improve or worsen traffic conditions and improve or introduce public transportation services (Gospondini, 2005; Popa et al., 2006; Wilson, 2008; Tzakris, 2008; Babalik - Sutcliffe, 2013).

In this paper a transportation project combined with urban regeneration is introduced and investigated. Greek cities are connected with each other with intercity buses on a daily basis and also during the weekends and on (public) holidays. In Athens there are two terminals, where the intercity buses depart from with different destinations around the country, "Kifisos" and "Liosion" bus terminals (they may be referred in the text as Terminal 1 and Terminal 2). Terminal 1 is located directly on the A1 motorway (Kifisou Ave) connecting Athens with Thessaloniki, the second largest city in Greece and it serves daily most of the trips, around 400 trips and more than 15.600 passengers on a typical day. It is not accessible with public transportation and thus most of the passengers are arriving by car or taxi, creating high congestion levels and long queues on the road network around it. Terminal 2 is located near the same motorway with no direct access to it and the serving passenger demand is much lower, approximately 220 trips and around 9000 passengers on a daily basis on a typical day. It is located 700 m from a train station and the percentage of the people arriving by train is way higher; an indicator that shows the significance of the location of the new terminal as it will be revealed in the next sections. The aim of this project is to construct a new terminal, serving all the trips (substituting the existing two terminals) and which will be located also near the A1, but southern, and near other main road axis of the city with high capacity and high traffic volumes especially during the peak hours. The importance of this project focuses on the fact that the operation of the new terminal will relieve the road network around the existing old terminals as (a) none of the two terminals provide any space exclusively used for parking (park&ride, kiss&ride facilities) and as a result illegal parking and stops is a very frequent phenomenon; which deteriorates the already congested road segments due to heavy traffic and high demand. Furthermore , (b) the existing road infrastructure around the terminals cannot serve the high demand during morning and evening peak hours, consisting of the users of the intercity buses, the passing through traffic and the intercity buses which arrive and depart from the terminal driving on road segments with very low capacity and insufficient geometric characteristics The basic advantage of this area is that except of the 17 public transportation lines, the metro station right opposite the location of the new terminal, will be directly connected via underpass with the new intercity bus terminal. Additionally, above the existing metro station a new bus terminal will be constructed serving 5 new public transportation lines connecting the city center and districts with the new terminal. Therefore, it is expected that most of the future passengers will shift to public transportation in order to reach and depart from the terminal, resulting in a possible non - significant additional traffic.

The greater area around the new terminal concentrates different land uses such as industry - craft industries, transport agencies, wholesalers, car service garages and car dealerships, training units, services, military facilities, and residential areas. The near area around the location of the new terminal is degraded and risky enough, as there are abandoned construction sites and factories within privately restricted areas. It is obvious that this project will not only give an asset on an economic and social level but it will also upgrade an area as besides the new terminal, a hotel, cafes and other commercial facilities will be constructed and various commercial and leisure activities will take place.

The construction of parking garages, offering Park&Ride facilities and Kiss&Ride areas will alleviate phenomena of illegal parking, parking maneuvers and illegal temporary stops which create traffic disturbances in the network. It is clear that this project will create an area redevelopment and a multimodal transportation center where different modes of transportation can be easily and safely combined. Such projects have far reaching implications to traffic and transportation operations in the near and greater area and the dynamics of traffic are expected to change.

A 3D drawing of the new project which includes the new terminal and the supplementary facilities is illustrated in Fig. 1, while Fig. 2 presents the ground plan of the construction.

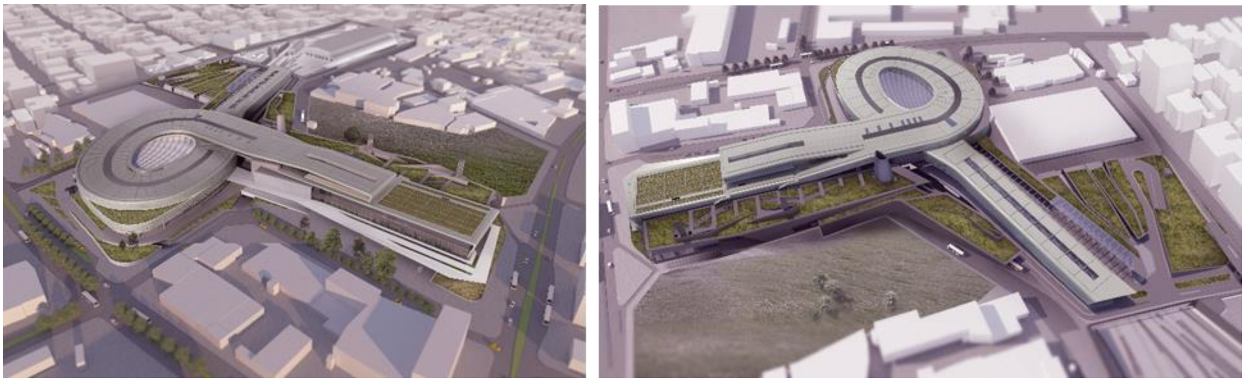


Fig. 1: 3D drawing of the new transportation project

Fig. 2: Ground plan of the construction

The scope of this paper is to analyze and assess the impact of this project on the traffic conditions around the existing terminals as well as the near and greater area of the new intercity bus terminal. Changes in passenger demand, mode choice distribution, changes in traffic volumes as well as the additional demand caused by the various facilities of the new terminal will be incorporated and a traffic model including all these factors will be developed.

2. Methodology

2.1. Study Area

The analysis was conducted in three different study areas: the areas around the existing terminals and the near and greater area around the new bus terminal (Fig. 3).

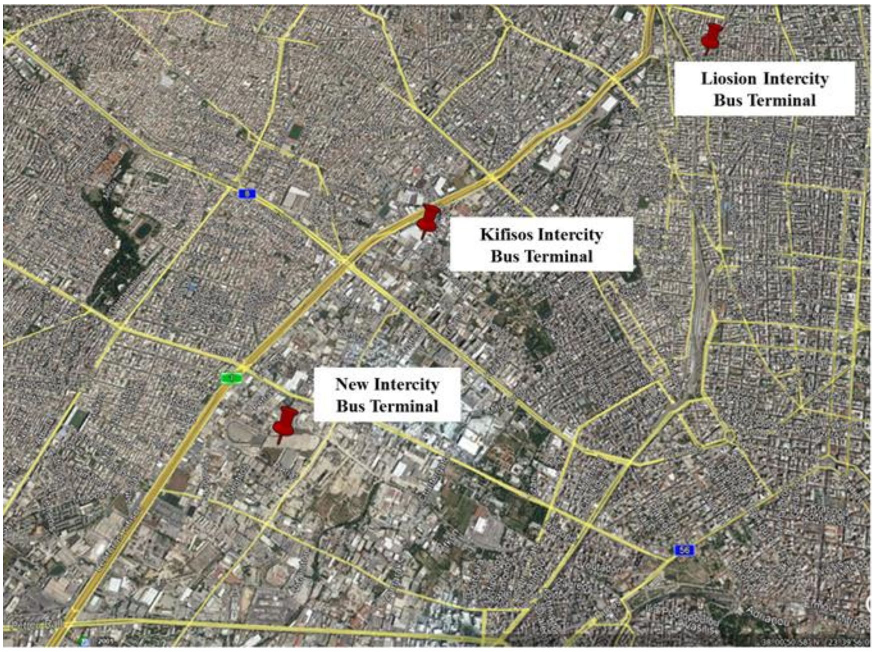


Fig.3: The three study areas of the project

Fig. 4a and 4b show the areas around the exiting bus terminals as well as their entrances and exits and the road segments being more affected by the terminal operation, the passenger demand it serves and the flow of intercity buses when they arrive or depart from the terminal.

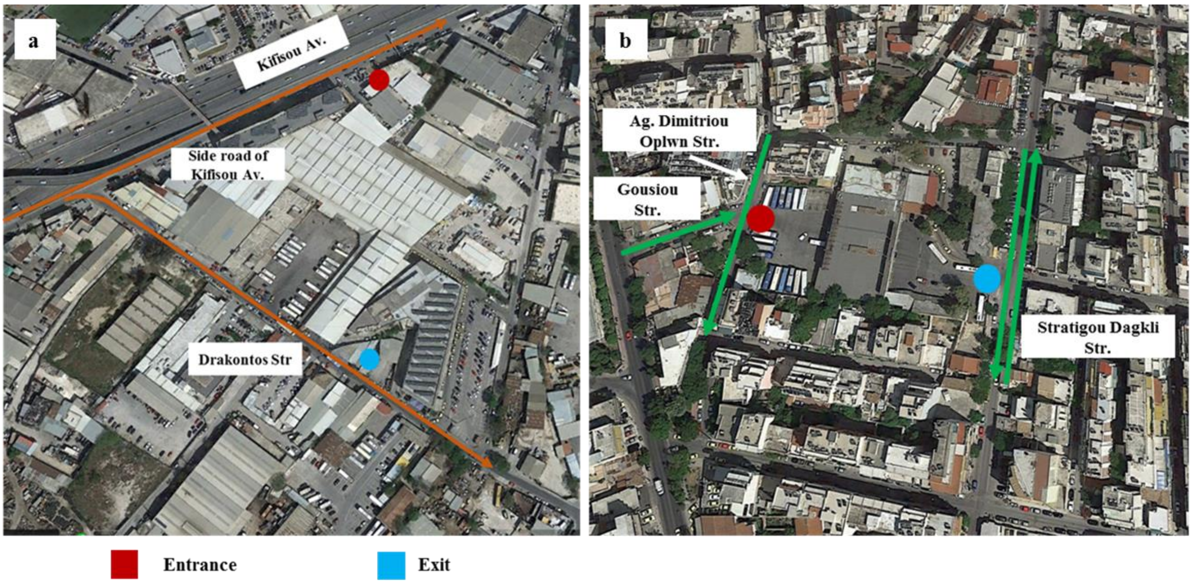


Fig. 4: (a) Kifisos bus terminal (b) Liosion bus terminal

As seen in Fig. 5, the near and greater area around the new terminal consists of major road axis with high capacity and demand. According to traffic data from the Traffic management Center of Athens, Kifisou Ave can serve more than 6000 vehicle during peak hours and more than 95000 vehicles per direction on a daily basis, while for Iera Odos Str. traffic volumes are around 15500 vehicles on a daily basis and approximately 1100-1400 vehicles during peak hours per direction. On the other hand, Petrou Ralli Ave - direction east serves daily more than 23000 vehicles and around 1400 - 1500 vehicles during peak hours while the other direction serves more than 25000 vehicle and around 1800 vehicles respectively. Last but not least, Athinon Ave another major road axis of the city of Athens can serves around 34000 vehicles daily and 2350 vehicles on the direction to east while 39000 and 2800 vehicles are driving along the direction to west on a daily basis and during peak hours respectively.

Fig. 5: The near and greater area of the new terminal

2.2. Data collection

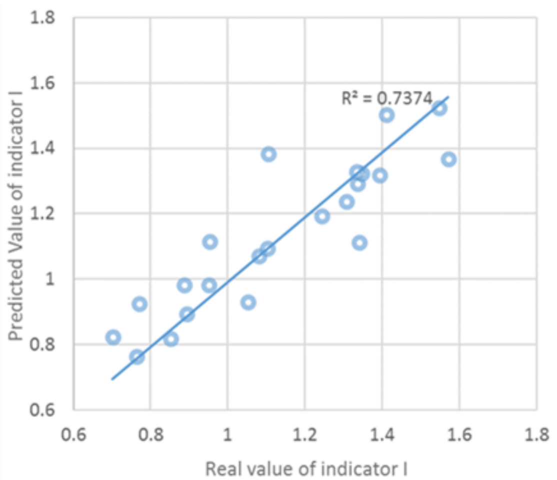
Within the present study, data related to passenger demand of the intercity buses and traffic data around the existing terminals and the road network around the new one was collected. The passenger demand data was collected in both terminals, Terminals 1 and 2 on two different days: a weekday (typical day) and a public holiday (day with higher demand) during morning and evening peak hours. Number of buses departing and arriving at the terminal was also collected. Additionally, traffic counts took place at the entrance and exit of the terminals in order to analyze the traffic that passes by the terminals and the number of vehicles entering, exiting and parking/stopping over in order to drop or pick up passengers. These counts were significant in order to distinguish the traffic exclusively generated by the operation of the terminals and the normal prevailing traffic. The traffic counts were conducted for 4 different vehicle categories: passenger cars, taxis, trucks, and motorcycles. An important factor that should be taken into consideration is the mode choice of the intercity buses passengers; that means the mode they choose to arrive and depart from the terminals. For this purpose, interviews were conducted with the users and 2.977 questionnaires were collected: 1.244 in Terminal 1 and 1.733 in terminal 2. Questions related to gender, age, are of origin and destination of the user/participant were also included in the survey. The second step was collecting traffic data for the greater area around the new terminal in order to analyze the prevailing traffic conditions before the construction and operation of the terminal. For this purpose, traffic volumes, speed and density from 74 loop detectors located on main road axis were provided by the Traffic Management Center (TMC) for typical weekdays and Sunday of May and August 2016. For updating and complete the data collected, especially concerning the turning movements where loop detectors could not give sufficient data, manual traffic counts took place in 23 intersections (signalized and unsignalized ones) of the greater area on a typical weekday during both morning and evening peak hour. Observing the traffic data given by the TMC, the morning peak hour occurs between 8-10 a.m. while the evening peak hour during 15:00 -18:00. Fig. 6 shows the greater area and the analyzed intersections where the traffic counts were conducted. Three different vehicle classes were applied: passenger cars (including taxis), heavy vehicles and motorcycles.

Fig. 6: Intersections in the near and greater area of the new intercity bus terminal.

2.3. Passenger demand prediction

The prediction of the passenger demand expected to be served by the new terminal is necessary to be estimated as the construction of the terminal is scheduled to be finished by 2020. For this purpose, historic data was collected and factors influencing the demand evolution in the future were identified. A study conducted by Attiko Metro S.A. in 1998 revealed that on a typical day the number of passengers arriving and leaving the two terminals in total was approximately 17.106 while few years later, in 2006 the demand was increased by 28,6% (2,55% increase per year) reaching the 22.000 passengers (OASA, 2006). During the counts that took place within the current study and were described in the previous chapter the demand in 2017 was only 12,1% higher than the 2006 data (1,04% increase per year) reaching the 26.650 passengers on a typical day and 44.196 on holidays. Factors like the economic crisis, the continuously increased unemployment rate as well as the reduction of the GDP led to a reduction of the yearly demand change (Hellenic Statistical Authority 2017a, b). Since the GDP evolution seems to influence the passenger demand, an indicator I was set expressing the ratio of passenger demand to GDP per capita, an indicator that has been also applied by the European Commission (EUROSTAT 2017) for evaluating sustainable development action plans. The historic values for the GDP per capita for the case of Greece are provided by the WORLD BANK (https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=GR) while the predicted values for the period

(2017-2040) are based on estimations made by the Directorate‑General for Economic and Financial Affairs of European Commission (EC, 2015). The data showed that the average change rate of the GDP per capita is expected to increase by almost 1,58% per year. The prediction of passenger demand for the period 2017-2040 was estimated by using the ARIMA model. The ARIMA model, an autoregressive integrated moving average model, is fitted to time series in order to predict future values. Due to the stochasticity that the passenger demand presents, non - seasonal ARIMA (p,d,q) models were applied, where p, d, and q are non-negative integers, p is the order (number of time lags) of the autoregressive model, d is the degree of differencing (the number of times the data have had past values subtracted), and q is the order of the moving-average model. ARIMA models have been widely used in many transport studies (Vlahogianni et al. 2004, Karlaftis and Vlahogianni 2009). The analysis revealed that the best model describing the evolution of the indicator I is the ARFIMA (1, 0.14, 0) with a MAPE of around 3,9% (Fig. 7). Based on the model results, the demand in 2030 will be up to 28.461 (typical day) and 51.028 (holidays) while in 2040 the number of passengers will be increased reaching 31.790 and 56.995 respectively for the two periods.



	Coef.	Std. Err.	z	P>|z|
constant	1.193	0.161	7.420	0.000
AR (1)	0.875	0.086	10.140	0.000

Fig. 7: Correlation between real and predicted value of indicator I

3. Results

3.1. Traffic impacts on the area around Bus Terminal 1 (Kifisos Bus Terminal)

In this section the traffic conditions in the area around the Kifisos bus terminal are analyzed and the traffic impacts from the construction of the new terminal are investigated and presented. More specifically, the side road of Kifisos Ave and Drakontos Str. which are the two road axis along the entrance and exit of the terminal are deeply analyzed.

Fig. 8: Traffic distribution for the morning and evening peak hour in Kifisos bus terminal (a) on a typical day (b) on a non-typical day (holidays).

Fig. 8a and b present the distribution of traffic in passing through traffic and the traffic being generated by the operation of the terminal for the morning and evening peak hour of a typical day and non-typical day respectively. As it shown, at the entrance of the terminal, the percentage of traffic related to the terminal (cars entering/exiting/parking/stopping over for drop off) is around 8% of the total traffic during morning and evening peak hour and can be up to 16% during morning peak hour of a non-typical day. The traffic conditions are different around the exit of the terminal as the traffic related to its operation is significantly higher reaching 39% and 43%, during morning and evening peak hour of a typical day respectively. This share can be increased by 20% during morning peak hour of a non - typical day. Such an increase could not be observed during evening peak hours of a non-typical day as traffic management applied by police was prohibiting temporary parking maneuvers along Drakontos St.
Table 1 shows the traffic composition for the total traffic, the normal traffic and the traffic related to the terminal existence and operation, separately for the entrance and exit of the terminal. The data presented refer to morning and evening peak hours both for a typical and non- typical day.

Table 1: Traffic composition at the entrance and exit of Kifisos bus terminal.

Mode of transport	**Entrance of the terminal**			**Exit of the terminal**		
	Total	**Passing through traffic**	**Traffic generated by terminal operation**	**Total**	**Passing through traffic**	**Traffic generated by terminal operation**
			Morning Peak Hour – Typical Day			
PC	75%	77%	58%	51%	49%	55%
Taxi	5%	4%	15%	32%	33%	28%
Motorcycles	12%	11%	22%	9%	8%	10%
HV	8%	8%	5%	9%	10%	7%
			Evening Peak Hour – Typical Day			
PC	80%	83%	55%	51%	50%	51%
Taxi	3%	3%	7%	365%	36%	34%
Motorcycles	13%	11%	31%	9%	7%	12%
HV	3%	3%	7%	5%	7%	3%
			Morning Peak Hour – Holiday			
PC	72%	74%	59%	50%	48%	53%
Taxi	8%	6%	26%	35%	39%	30%
Motorcycles	15%	16%	15%	10%	8%	13%
HV	4%	5%	0%	4%	5%	4%
			Evening Peak Hour – Holiday			
PC	85%	86%	78%	37%	46%	20%
Taxi	10%	9%	17%	59%	52%	71%
Motorcycles	5%	5%	4%	2%	2%	3%
HV	1%	1%	1%	2%	0%	5%

** PC: passenger cars, HV: heavy vehicles*

Interestingly, the taxi share is up to 30% and can be above 50% during the evening peak hours on a non-typical day

where the passenger demand is the extremely high. The adverse traffic conditions can be also proved by the bad level of service (E) on Drakontos St. (where the exit of the terminal is located).
It can be concluded that, the construction of the new terminal will significantly improve the traffic conditions in the area around Terminal 1 due to the following factors:

- Demand reduction up to 8% - 16% on Kifisou Ave and 32% - 43% on Drakontos St. (the street where the exit of the terminal is located).
- Alleviation of all the parking maneuvers at the entrance and exit points of the terminal which take place due to lack of space dedicated to parking and stop over processes (kiss&ride).
- Significant improvement will occur in traffic flow conditions and safety levels on Kifisou Ave (near the entrance of the terminal) as the number of lane changes applied by the drivers of passenger cars, taxi and intercity buses will be eliminated.

3.2. Traffic impacts on the area around Terminal 2 ("Liosion" Terminal)

The same process was applied for Liosion Terminal and the traffic was distinguished in traffic related to the terminal operation and normal traffic. Fig. 9a and b show the traffic distribution for morning and evening peak hours on a typical day and non- typical day (public holidays, holiday period). At the exit of the terminal, on a typical day, 31% and 41% of the total traffic is terminal related traffic during morning and evening peak hours respectively. Slight difference is observed on a non-typical as these percentages are around 31% and 37%.

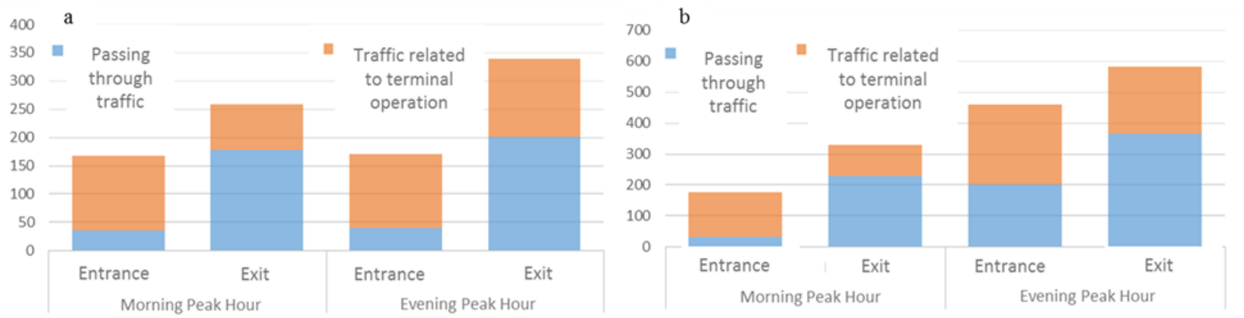


Fig. 9: Traffic distribution for the morning and evening peak hour in Liosion bus terminal (a) on a typical day (b) on a non-typical day (holidays).

Table 2 shows the traffic composition in Liosion terminal at the entrance and exit of the terminal for the morning and evening peak period of a typical and non-typical day. Similar to the analysis conducted for Kifisos terminal, the data is presented separately for the total traffic, the traffic related to the terminal operation and the normal traffic passing through the road segments running in front of the entrance and exit of the terminal.
The new terminal will contribute in improving the traffic conditions around Liosion Terminal as the average delay per vehicle will be significantly reduced due to demand reduction that has as origin and destination this terminal as well as the intercity buses arriving and departing from the terminal through streets with very low capacity. Additionally, traffic disturbances within peak hours, due to deficiency of space where cars can stop over for dropping off and picking up the intercity buses passengers, will be eradicated while parking maneuvers will be eliminated.

Table 2. Traffic composition at the entrance and exit of Liosion bus terminal.

Mode of transport	Entrance of the terminal			Exit of the terminal		
	Total	Passing through traffic	Traffic generated by terminal operation	Total	Passing through traffic	Traffic generated by terminal operation
Morning Peak Hour – Typical Day						
PC	45%	57%	41%	54%	63%	33%
Taxi	20%	6%	24%	15%	10%	28%
Motorcycles	33%	31%	34%	22%	19%	28%
HV	2%	6%	1%	8%	8%	10%
Evening Peak Hour – Typical Day						
PC	48%	52%	45%	54%	58%	49%
Taxi	20%	15%	23%	16%	13%	20%
Motorcycles	30%	30%	30%	27%	24%	30%
HV	2%	3%	1%	3%	5%	0%
Morning Peak Hour – Holiday						
PC	45%	49%	44%	52%	62%	29%
Taxi	21%	3%	25%	18%	11%	36%
Motorcycles	34%	48%	31%	23%	21%	29%
HV	0%	0%	0%	7%	7%	7%
Evening Peak Hour – Holiday						
PC	73%	76%	71%	48%	55%	37%
Taxi	19%	18%	19%	32%	28%	37%
Motorcycles	6%	4%	7%	17%	16%	18%
HV	2%	2%	2%	3%	1%	7%

** PC: passenger cars, HV: heavy vehicles*

3.3. Traffic impacts on the near and greater area around the new terminal

The collection of the traffic data and the prediction of the passenger demand were followed by the design and simulation of the greater area around the new terminal using the simulation software AIMSUN (developed by TSS) in order to investigate if the construction will deteriorate the level of service of the intersections, will cause additional traffic problems and to which extent and generally if the road network can absorb the additional traffic that will be added and generated due to the operation of the new terminals and the other facilities (hotel, commercial centers, etc.). Beside the collected traffic data (provided by the TMC and the traffic counts on site) for the morning and evening peak and for each vehicle category (passenger cars and trucks), the public bus routes and schedules passing by/having as a terminal the area of the new terminal were also imported in the traffic model. The model was calibrated based on the data collected and the process was terminated according to the values GEH indicator. GEH formula was developed by Geoffrey E. Havers (1970), and it is an empirical formula used to compare two traffic volume datasets. A model is acceptably calibrated and it resembles the real traffic conditions when for at least 85% of the detector data GEH is lower than 5. In the current study, for the prevailing traffic conditions during morning peak hour GEH indicator was below 5 for the 97% of the detectors and below 10 for 100% of the dataset while during evening peak the percentages were 98% and 100% respectively. For investigating in detail the traffic impact the construction of the new terminal would have on the overall traffic, 17 scenarios were developed, simulated, tested and analyzed. The differences among these scenarios were:

- the horizon of analysis (2017, 2020 and 2030),
- the period within the day (morning/evening peak/holidays),
- changes in road segments geometry and infrastructure (more lanes per direction, new road segments) and
- the routes the intercity busses should follow in order to reach and leave the new terminal. Three different routes for approaching the terminal were developed and tested. For leaving the terminal, only one route was tested.

Beside the traffic data imported into the traffic model, it was necessary to transform the passenger demand (existing and predicted) into numbers of cars and taxis as they are the modes of transportation that will be added to the prevailing traffic. For this purpose, the data from the personal interviews with the passengers at the two existing terminals, data collected from the Athens international airport and port of Piraeus were analysed and combined and the mode choice distribution for the new terminal was estimated. Based on the analysis, the metro terminal located near the new terminal will serve the major part of the passenger demand (around 60%), 14% will reach and depart from the intercity bus terminal by car, 15% by taxi and the rest by other means of transportation (PT, motorcycles, etc.). This distribution was applied to all the three horizons (2017, 2020, and 2030).

Summarizing, the traffic model developed und used for the traffic simulation included:

- Strategic plan of the Athens Bus Transport Organization
- Passenger demand prediction of the intercity buses and mode choice distribution
- A demand model which predicts the future demand of the network incorporating not only traffic data but also other projects which can generate traffic (like parking stations, etc.)
- Interconnected transport facilities
  - Metro stations
  - Park&Ride facilities for commuters, visitors, employers, etc.)
  - New terminal bus for serving the 5 new public transport lines

Fig. 10: Volume map of the best scenario

Fig. 10 shows the volume map for the best scenario having the lowest impact on the traffic conditions of the road network of the near and greater area of the new terminal. Table 3 shows the delay per vehicle for the most important and critical intersections and the level of service for the current situation, and for the best scenarios. Both scenario refer to morning peak hours for the horizons 2017 and 2020 (first year of new bus terminal operation) respectively. In order to improve traffic conditions after the realization of the new project, changes in the signal plans of critical approaches where traffic volumes exceed capacity (LOS F) were also implemented and tested.

Table 3: Delay per vehicle and LOS for the current scenario, the best scenario and the best scenario with traffic management measures.

Intersection id		**Current situation**	**Best Scenario**	**Difference (%)**
20	delay	40.6	49	21%
	LOS	D	D	-
18	delay	50.0	61	22%
	LOS	D	E	▼
3	delay	177.9	217	22%
	LOS	F	F	-
17	delay		17	-
	LOS		B	-

* *Intersection id refers to Fig. 6*

4. Conclusion

Transportation projects and urban regeneration and redevelopment actions can be combined in order to upgrade areas, their accessibility levels and also the traffic and environmental conditions of the affected parts of the city. Such a project is the construction of the new intercity bus terminal in the city of Athens, which will substitute the two existing stations where the high traffic and high demand result in congested phenomena and frequent traffic disturbances of the road network in the area around them. This project will transfer the passenger demand in another part of the city where main road axis with higher capacity and better geometric characteristics can absorb the additional traffic and thus traffic dissipation will be achieved around the old terminals. The direct connection of the new terminal with a metro station as well as the new public transportation lines will lead to a shift of the passenger demand towards public transportation while the construction of parking garages and kiss&ride areas will diminish illegal parking and stops as well parking maneuvers which cause traffic disturbances and delays. Additionally, implementation of changes in signal plans in critical interception will improve traffic conditions in the near and greater are of the new terminal after its construction and during its operation.

However, the increasing passenger demand, as well as the additional demand generated by other commercial and leisure facilities that will be provided within the terminal, should be served in a way that higher percentages of users will shift to public transportation and not to an increased private car or taxi use resulting in further traffic evaporation and positive impacts on an environmental level.

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