Urban Street Network Upgrade for the New Intercity Bus Terminal in the City of Athens

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ABSTRACT

The proper and effective design of the urban road network encourages the safe and efficient coexistence of different transportation modes and users including private vehicles, taxis, public transportation passengers and vulnerable users (pedestrians, cyclists, etc), thus promoting multimodality. The complexity of the road network design depends on various factors such as land uses, available space, local characteristics, traffic volumes, inclinations, etc. The paper conceptualizes a large transportation project in the city of Athens, the construction of the new intercity bus terminal, bringing about the adaptation and upgrade of the existing urban road network of the near and greater area around the station. Designing of new local streets, and upgrade of urban arterials by addition of lanes and alignment improvements were urgent in order to serve the new demand emerging from the operation of the new terminal and the safe and efficient access to the terminal by various transportation modes (intercity buses, trucks, cars, taxis). Additionally, the road network inside the terminal area was designed so that vehicles and pedestrians can move safely in the new terminal's platforms, parking lots and commercial facilities. Finally, an underpass connecting the terminal with the metro railway station located opposite the bus terminal was incorporated in the design, thus serving a large part of the additional traffic demand generated by the new bus terminal by efficient exploitation of existing infrastructure without interaction with the local urban traffic around the terminal.

Keywords: road design, urban network, road design, multimodality

INTRODUCTION

Transportation systems are one of the most important aspects of the everyday life of the cities and their citizens. Urban regeneration transportation projects focusing on transport multimodality can lead to an overall upgrade of an area and its surroundings, enabling easy transfer and connection between different modes of transportation and thus improving in the long-term traffic characteristics. Previous research indicates that such projects can have a significant social, economic and environmental impact on the areas or cities they are implemented *(1-3).* Various transportation projects achieving urban regeneration or renewal have been reported worldwide, such as the restoration of the Cheonggyecheon River in Seoul, Korea *(4)* or the development of the Camden Walking Plan in London, UK *(5)* and the replacement of the Embarcadero freeway in San Francisco by a trolley line-supported boulevard *(6).* Pedestrianization projects are also a case of transportation projects aiming at urban regeneration such as the pedestrianization of Bucharest's historic center *(5)* and the pedestrianization of a major arterial, in the downtown area of the city of Athens *(7).* 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 *(8-12).* The impacts of urban transportation projects on urban development, redevelopment and regeneration were also investigated by *(13)* who analyzed projects conducted in 12 European cities. Peripheral new centers, urban reconstruction potentials or upgrade of deteriorated areas are among the advantages of such projects.

In this paper, the design of a major transportation project combined with urban regeneration and mainly with urban street network upgrade is presented and investigated: the new Athens intercity bus terminal. Greek cities are connected with each other mainly with intercity buses, since the railway network is not appreciated as in most European cities. In Athens there are two intercity bus terminals serving all domestic destinations: "Kifisos" and "Liosion" bus terminals (they may be referred in the text as Terminal 1 and Terminal 2). Terminal 1, serving the highest passenger demand, 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, serving much lower demand, is located near the same motorway with no direct access to it, but it is 700 m from a train station and the percentage of the people arriving by train is way higher. Also, stations for buses towards international destinations (mainly capitals of neighboring countries) are scattered in several locations.

The aim of this project is to present the design of a new terminal, serving all trips (domestic, substituting the existing two terminals and international). The operation of the new terminal is expected to relieve the road network around the existing old terminals as none of the two terminals currently 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, 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 city bus terminal will be constructed serving 5 new public transportation lines connecting the city center and districts with the new terminal.

The greater area around the new terminal concentrates different land uses such as 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, 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 a large area around it, as besides the new terminal, a hotel, cafes and other commercial facilities will be constructed and various commercial and leisure activities will take place. Despite the fact, that the highest share of passengers is expected to shift to public transportation, still, the terminal and its facilities will create high additional traffic demand, including passengers cars, taxis, trucks and the intercity buses. The prevailing as well as the future traffic demand generated by the project realization will bring about significant traffic related issues and will increased the accident probability occurrence. The existing road network around the new terminal and its geometric characteristics cannot serve the additional demand and many road segments as missing for enabling the access to the terminal. Figure 1 illustrates a 3D drawing of the new project as well as the ground plan of the construction.

Figure 1 3D drawing of the new transportation project and ground plan of the construction

Scope of this paper is to present the urban street network upgrade around the new terminal which includes increase of number of lanes, as well as the design and construction of a new road segments facilitating the arrival and departure to and from the terminal preventing the overload of the existing and already loaded street segments. This upgrade will result in an optimized road network ready to fulfil the need for unobtrusive and safe transport of the intercity buses as well as the passengers and the other users of the terminal facilities. Additional, the traffic model developed within the framework of this project taking into consideration the new traffic demand, the mode choice distribution, as well as the changes implemented in the street network will be presented in order to assess the impact of the new project on traffic conditions. 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.

METHODS

Study Area

The traffic 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. **Figure 2** shows the locations of the existing terminals and the new terminal while Figure 3 presents a detailed overview of the near and greater area around the new terminal.

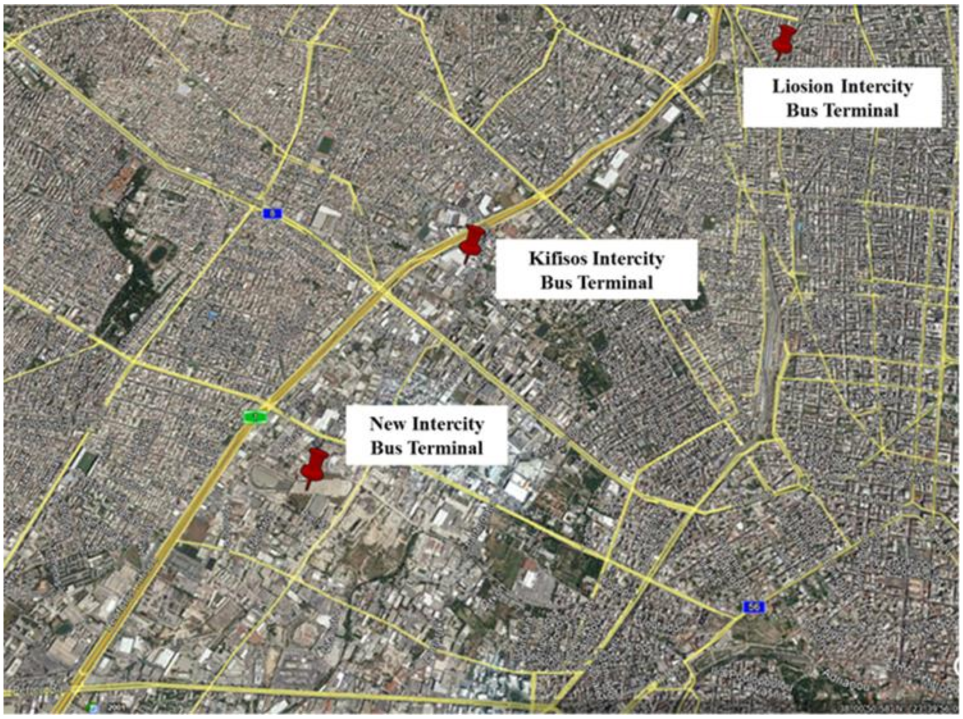

Figure 2 Old and new terminal locations

The near and greater area around the new terminal includes several major road axes with high capacity and demand (**Figure 3**). According to traffic data from the Traffic management Center of Athens, Kifisou Ave can serve more than 6000 veh/h 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 veh/h during peak hours per direction. On the other hand, Petrou Ralli Ave - direction east serves daily more than 23000 vehicles and around 1400 **-** 1500 veh/h during peak hours while the other direction serves more than 25000 vehicle and around 1800 veh/h respectively. Last but not least, Athinon Ave can serve around 34000 vehicles daily and 2350 veh/h during peak hour on the direction to east while 39000 and 2800 veh/h are driving along the direction to west on a daily basis and during peak hours respectively.

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 traffic related to the terminals operation, i.e. vehicles entering, exiting and parking/ stopping over in order to drop off or pick up passengers. These counts enabled the distinction of traffic exclusively generated by the operation of the terminals from 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, i.e. 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; 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 axes 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 8:00-10:00 while the evening peak hour during 15:00 -18:00. Figure 3 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.

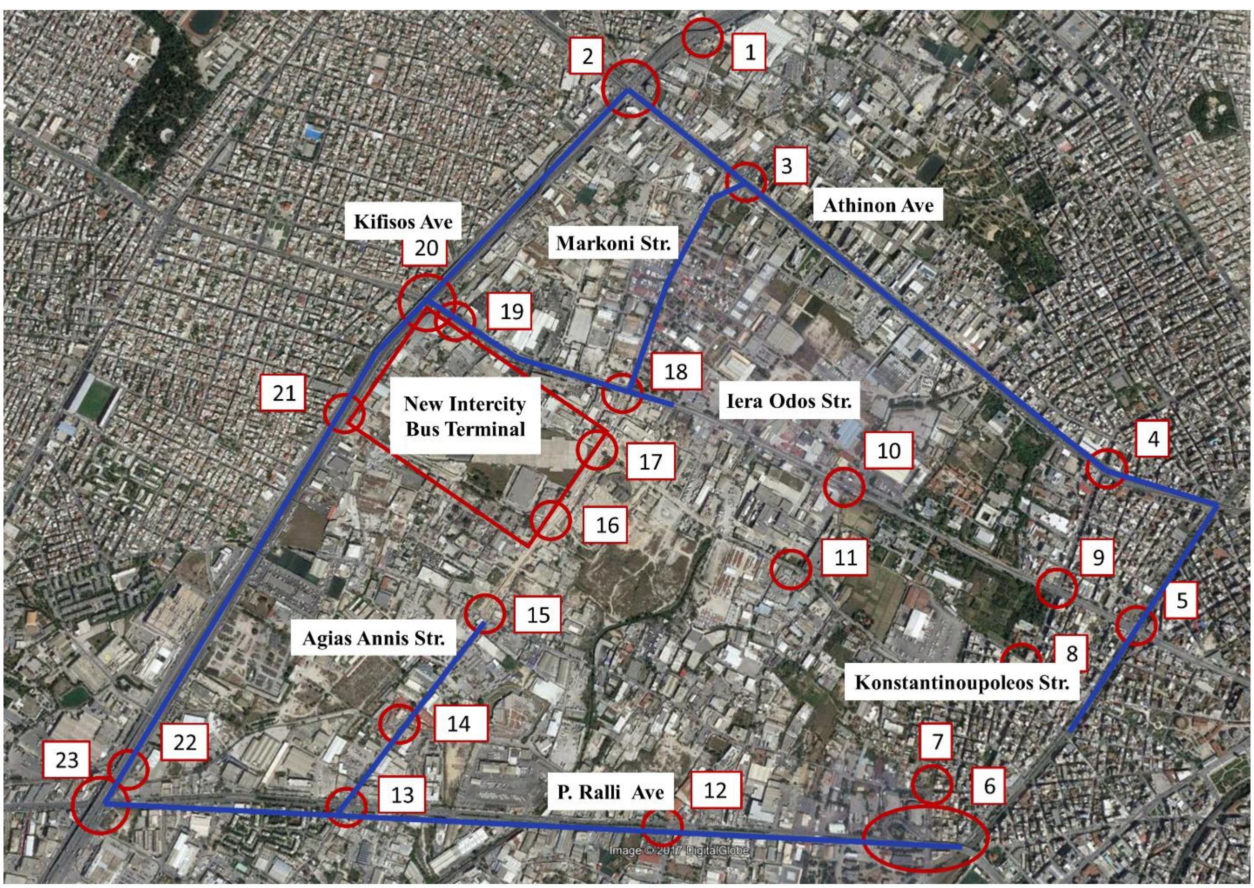

Figure 3 Intersections in the near and greater area of the new intercity bus terminal.

The prediction of the passenger demand expected to be served by the new terminal in the future is also an important design consideration. 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 *(15-16).* 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 *(17)* for evaluating sustainable development action plans. Regarding historic values for the GDP per capita in Greece, World Bank figures *(18)* were used, 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 *(19-20)*. 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 *(21-22)*. 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%. 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.

Concerning the street network update, apart from the data regarding the traffic and passenger demand that the network will serve, various studies were collected and analyzed. Environmental and geotechnical studies, transportation project studies, study for rainwater drainage network, traffic study for the relocation and installation of traffic lights and traffic signs, detailed road geometric design studies, the Greek guidelines of road geometric designs, the guidelines of road geometric design, topological background, urban planning studies, land uses, laws and directives. Additionally, the type and locations of buildings locating on the road sides affecting the road horizontal design and the need for intersection construction and formulation was recorded through on site visits.

RESULTS

Street Network Update

Upgrade of streets in the near area of the terminal

The first street segments that were upgraded in the near area around the new terminal is Agias Annas St. and Agiou Polukarpou Str. (**Figure 4**). More specifically, the upgrade included the opening - widening of the Agias Annas road segment between Iera Odos and Orfeos Str. and the street segment of Agiou Polukarpou Str. between Agias Annas and Profiti Daniil. Both road segments are belonging to category C and more specifically CIII (urban street) with max. allowed speed 60km/h, separated with intersections for connections between the different segments and design speed 50 km/h. All type of vehicles can use and drive on this type of streets. The upper asphalt layer is 0,05m thick, type A265. The road segment evaluation will be conducted based on Safety Criteria III taking into consideration that the percentage of the vertical friction factor is equal to 70%, both for the maximum and minimum invocation.

The curve success of Agias Annas street segment is PM=1.000m., K2=1.100m and K3=800m., the alignment inclination of the street is 0.67% and the superelevation Is -2.5% (in the curving sections). The Safety Criteria III was applied for the curve with radius K3=800m and the results revealed Good Design Quality. The segment will consisted of two traffic lanes per direction, their width is 3.50m, with a dividing island of 4,00m width and pedestrian zones on either road side of 2.50m. The total width of the street is equal to 23m. As far as the road segment of Agiou Polykarpou Str., the alignment inclination is 0.5% for the initial part and 0.98% for the last part. The superelevation is -2.5%. 3 signalized intersections will be constructed or reformulated: Agias Annas – Iera Odos, Agiou Polukarpou – Agias Annas and Agias Annas – Orfeos Str. Similarly to above described section, there are two lanes per direction with width equal to 3.50m. The width of the dividing island, separating the two directions, and the pedestrian zones located at either road side is equal to 2.00m. The total length of the segment is 20m. **Figure 4** shows typical cross sections for both Agias Annis Str and Agiou Polykarpou Str.

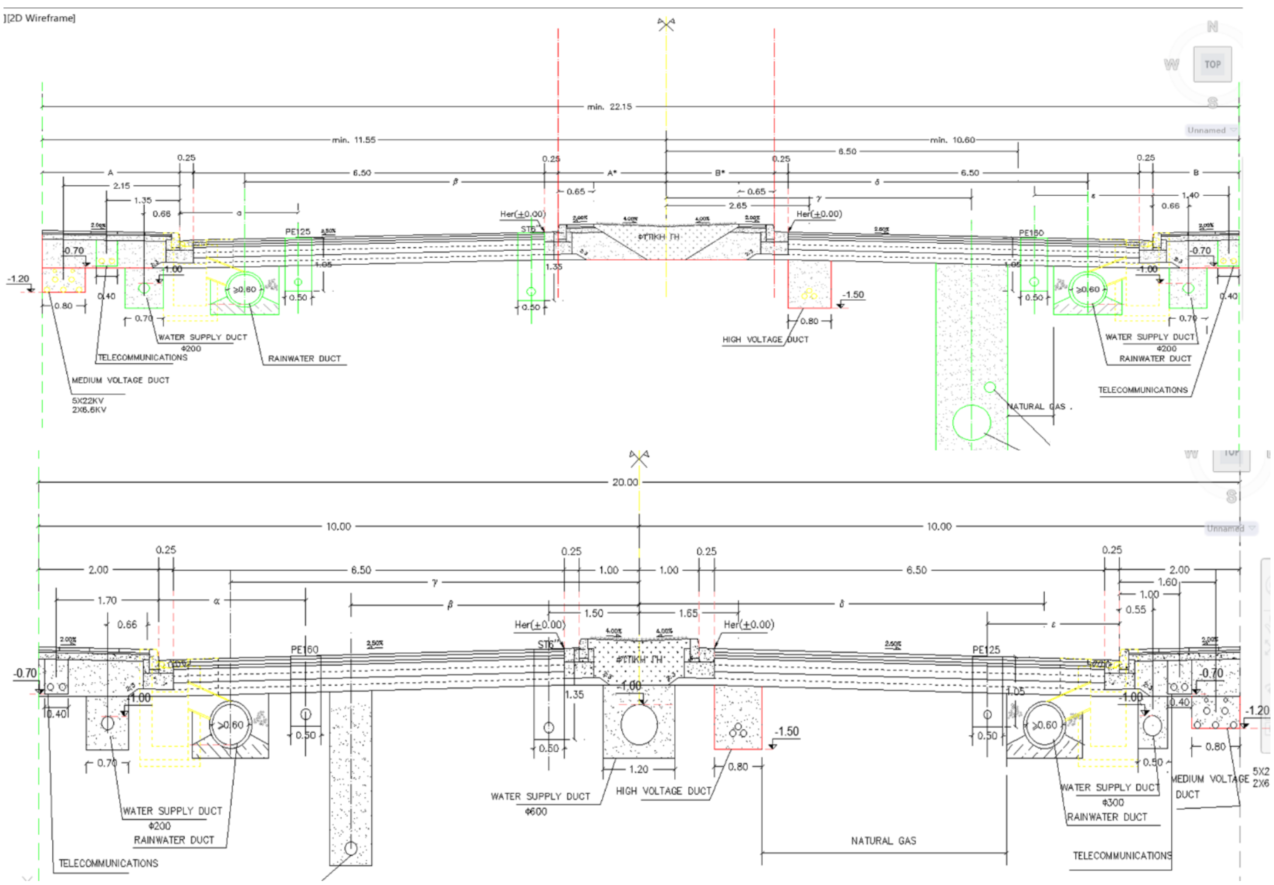

Figure 4: Typical Cross Section of Agias Annis Str. and Agiou Polykarpou Str. (Scale 1:50)

Upgrade of the streets around the terminal

Apart from the streets in the near area of the new terminal, it was of vital importance to reconstruct or reformulate the network used for accessing the terminal, either by passengers cars, taxis and trucks or by intercity buses. The demand generated by the terminal operation will be caused by the terminal function, Kiss&Ride or Park &Ride areas, the hotels, cafes and other commercial facilities located in the terminal area. Additionally, the network should be appropriately designed for facilitating the intercity buses arriving to and departing from the terminal safely without experiencing congestion, delays and simultaneously without causing other traffic issues in the prevailing traffic. The streets of this group belong to category D, i.e . they are urban streets serving accessibility purposes, and more specifically they are DV type of roads (urban streets) with max. allowed speed 50km/h and the connection with the other streets is achieved through intersections. The upper asphalt layer is 0,05m thick, with asphalt mixture hot prepared in a permanent installation with crushed aggregates quarry type PM 12.5 or PM 20 according to the approved composition study and EIB 05-03-11-04 "Coated asphalt asphalt layers concrete ". The network upgrade includes the following road segments **(Figure 5)**:

1. Pierias Str. (Street 1)
2. Petras Str. (Street 2)
3. Ag. Panteleimonos Str. (Street 3)
4. Ploutonos Str. (Street 4)
5. Kastorias Str. (Street 5)

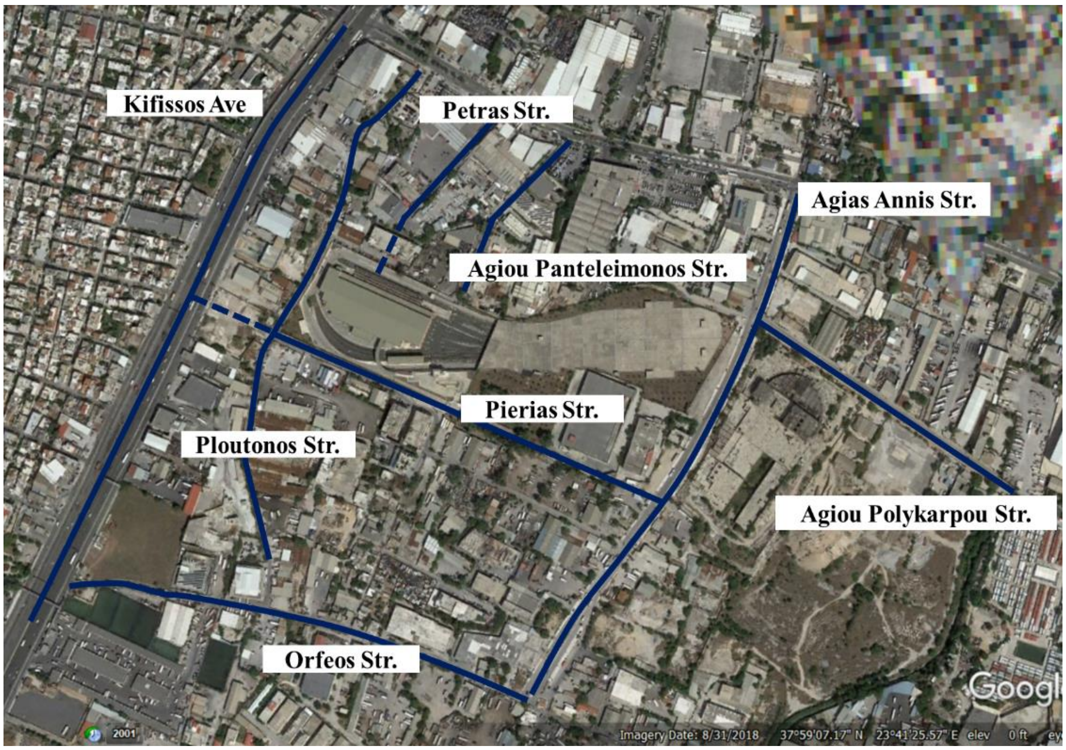

Figure 5 Street network upgrade around the new terminal

Street 1 has a total width of 10,50m., one traffic lane on the direction towards Agias Annis and two traffic lanes on the opposite direction (towards Kifissos Ave.) The width of all lanes is 3.50m while the pedestrian zone on either road side is 2,25m wide. Street 2 is a one direction street with total width of 7,00m and two traffic lanes (each 3,55m wide). The pedestrian zone on either side has a width fluctuating from 1,70 – 2,25m. One direction street is also Street 3 but with one traffic lane, 4,00 – 5,50m wide, on street parking places, 2,00m wide and pedestrian zones on either road side with width equal to 3,00m. Ploutonos Str. (Street 4) is 9,00m wide and is divided into two parts, both one direction with two traffic lanes (3,50m wide each) and on street parking area on one road side (2,00m). The only differentiating characteristics is the width of the pedestrian zone, i.e 2,75m width on either road side for section 4a and 2,75m on one road side and 2,50m width on the other for section 4b. Finally, the last analyzed street is used for various purposes and is divided in 9 segments with different geometric characteristics (**Figure 6**). The horizontal alignment of some of the upgraded segments is shown in **Figure 7.**

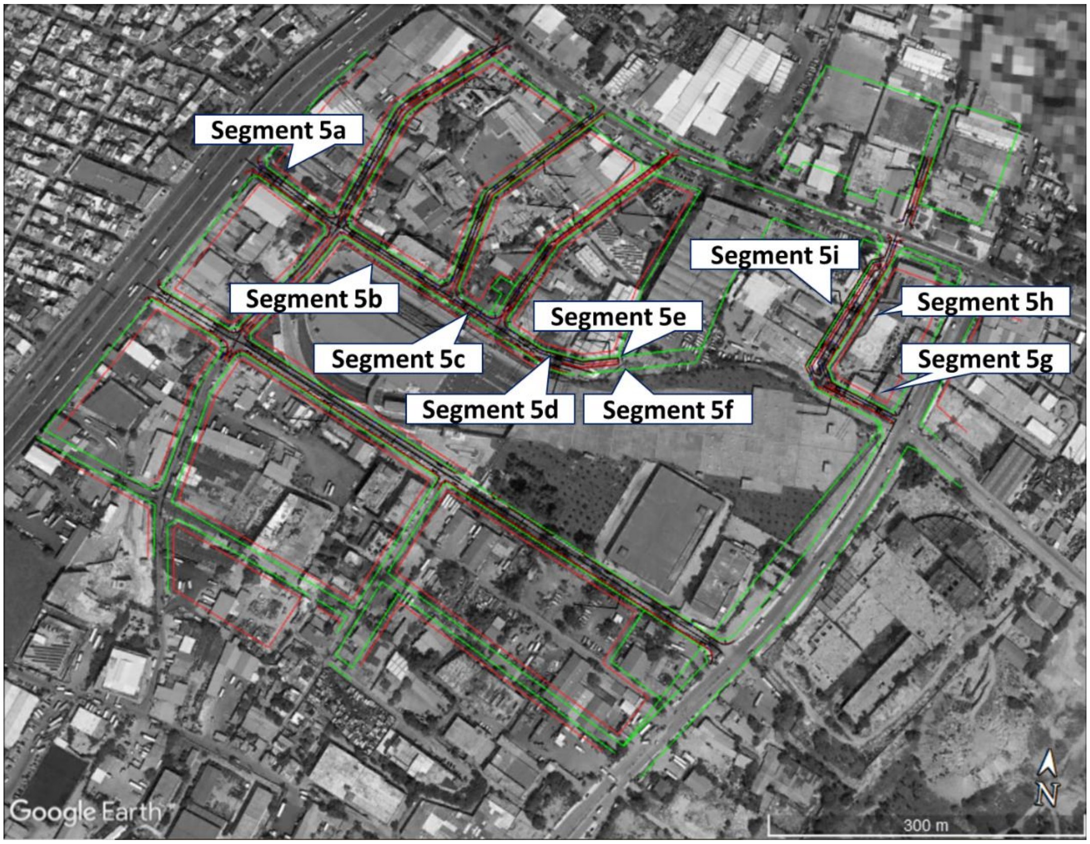

Figure 6 The 9 segments of Kastorias Str. (Street 5)

- Segment 5a: total width 9,00m, one traffic lane per direction (3,50m each), on street parking area on one side (2,00m width), pedestrian zone 2,45m wide on the road side where parking is allowed and 2,05m on the other side of the road.
- Segment 5b: total width 7,00m, one traffic lane per direction (3,50m each), pedestrian zone on either road side with width fluctuating from 2,45m – 3,20m
- Segment 5c: total width 7,00m, one traffic lane per direction (3,50m each), pedestrian zone on either road side 3.50m wide.
- Segment 5d: total width 9,90m, two lanes on one direction (width 3,00m and 3,90m), one traffic lane on the opposite direction (width 3,00m) and 2,05m pedestrian zone on both road sides.
- Segment 5e: total width 6,00m, one traffic lane per direction (width 3,00m) and 2,05m pedestrian zone on both sides of the road.
- Segment 5f: this segment is the entrance to the terminal with 2,05m pedestrian zone
- Segment 5g: total width 6,00m, one direction, two traffic lanes (3,00m wide) and 2,25m pedestrian zones.
- Segment 5h: total width 9,50m, one direction, two traffic lanes (3,00m each), Kiss&Ride lane (2,50m width) and pedestrian zone that varies in width on the road side next to the terminal and 2,05m on the other side.
- Segment 5i: total width 6,00m, one direction , one traffic lane (3,00m width), 2,50m lane for TAXI (resting area, embarking/disembarking purposes).

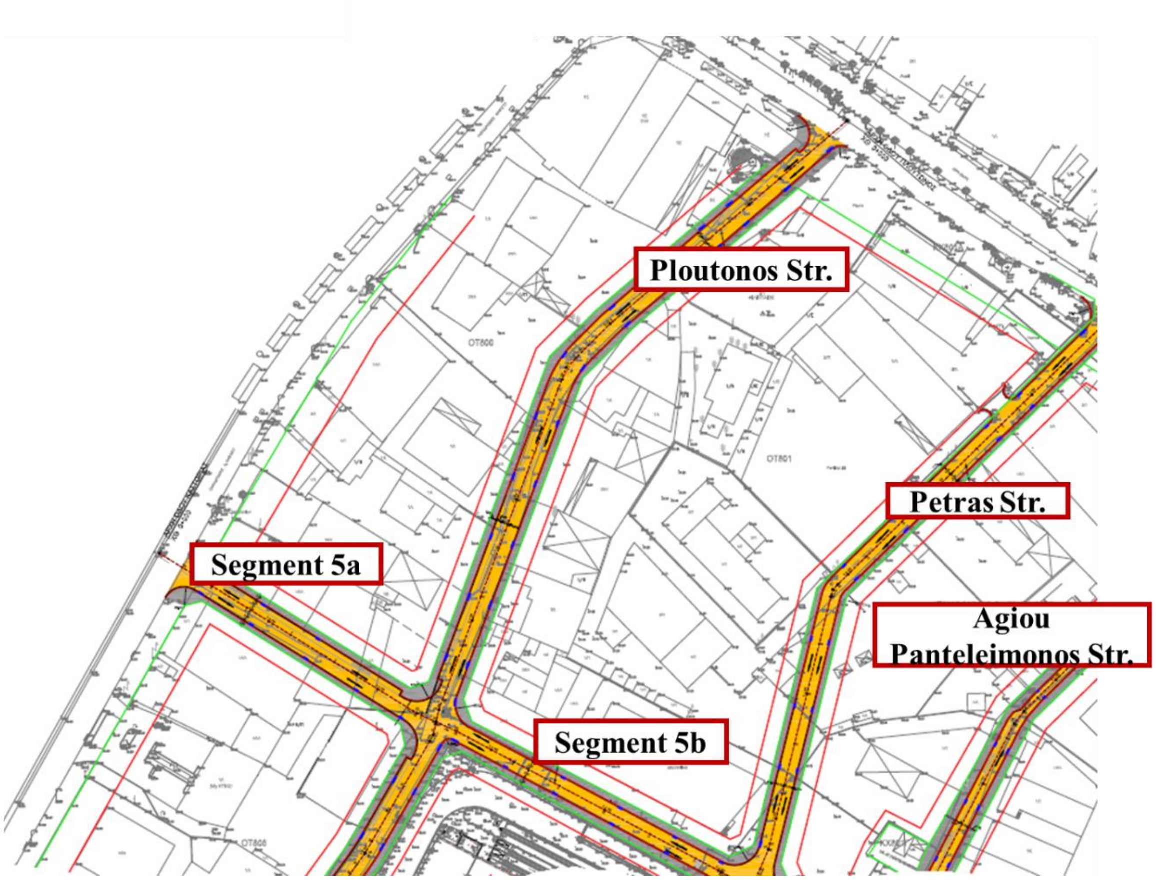

Figure 7 Horizontal alignment of Ploutonos Str, Petras Str, Agiou Panteleimonos Str. and Kastorias Str. (Segments 5a and 5b).

Traffic Model Development

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 analyzed 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

Figure 8 Volume map of the best scenario

Figure 8 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 1** 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 scenarios 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 1 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 LOS	40.6 D	49 D	21% -
18	Delay LOS	50.0 D	61 E	22% ▼
3	Delay LOS	177.9 F	217 F	22% -
17	Delay LOS	- -	17 B	- -

** Intersection id refers to Fig. 7*

DISCUSSION

Transportation projects are life projects and are directly related to core points of strategic planning in local, regional and national level, significantly affecting the quality of life of most city residents. They are used for urban regeneration and area (re)development, they can change the area physiognomy and the prevailing land uses or make an area attractive to tourists and visitors. These changes may lead to migration especially when these projects are implemented in the suburbs (decentralization). Transportation projects connect areas, increase and improve accessibility, can significantly reduce travel times and improve environmental conditions. Street upgrade can alleviate congestion phenomena and improve traffic conditions while simultaneously it contributes to air pollution and noise reduce. Construction of cycling paths or tram lines has also a positive environmental impact and upgrade the area and projects related to pedestrianization can also ensure the preservation of the historical city centers.

Scope of this paper was the description, analysis and assessment of such a transportation project, namely the new intercity bus terminal in the city of Athens. This terminal will substitute the two existing ones and will transfer the traffic generated by their operation in another part of the city. The network around the old terminals could not efficiently serve the passenger demand leading to congestion and serious traffic issues especially during peak hours and holidays. The road network around the terminal includes major road axes with high capacity able to absorb the additional demand. Apart from these type of streets, the network used for enabling the direct access to the new terminal is not sufficient in terms of road design quality and geometric characteristics while there are street segments that need to be constructed for facilitating the arrival and departure from the terminal. Therefore, the need for street upgrade was of vital importance for enabling the safe and efficient transport of the passengers and the other users of the terminal and its facilities. 7 streets near the terminal were upgraded by adding more traffic lanes, convert streets of two directions to one directions roads, adding pedestrian areas on either road sides, adding streets dedicated for taxis of Kiss&Ride areas, preventing from illegal parking or mixing use of the areas around the terminal, deteriorating the serving of the generated demand. The paper showed the geometric characteristics of the street segments that were specified based on various studies as well as data collection and demand prediction.

The traffic model developed incorporated all the changes implemented in the street network in the area around the new terminal taking into consideration mode choice distribution and future demand to observe whether the upgrade and the preserved road network could efficiently serve the additional existing traffic using the network increased by the additional traffic generated due to the terminal operation. Various scenarios were developed and simulated and the analysis revealed also the best route the intercity buses should follow for arriving and departing from the terminal resulting in the least delays. The analysis showed that the upgraded and the preserved network in the near and greater can serve the increased demand but traffic management strategies are necessary to be applied (e.g. optimization of signal plans in certain and critical intersections) in order to improve LOS. It should be mentioned that the operation of new terminal will have traffic impacts on a greater area than the one analyzed within the framework of this project due to land use changes land value increase. Therefore, it would be necessary to conduct an extensive traffic study and additional transportation projects and traffic management strategies and measures may potentially need to be adopted.

CONCLUSIONS

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. It is important to mention that such transportation projects can be a very good example for cities aiming at urban and suburban planning development.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: road design study and drawings: A. Dragomanovits and T. Mavrogieorgis; data collection for the road design: T. Mavrogieorgis; data collection for traffic analysis: F. Orfanou, E. Vlahogianni, G. Yannis; traffic model development: F. Orfanou, E. Vlahogianni, G. Yannis; analysis and interpretation of results: F. Orfanou, E. Vlahogianni; draft manuscript preparation: F. Orfanou. All authors reviewed the results and approved the final version of the manuscript.

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