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Land Use Change and Traffic Impact Study of Al-Shaab Residential Complex as a Case Study

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Abstract

Due to rapid urbanization, building new developments leads to increased attraction activities that negatively affect traffic on the existing road network. The influence of land use has increased impacts from the generation of additional traffic, which causes increased congestion with a negative effect on the environment. In this study, we analyze the effects of the construction of the Al Shaab Complex on the traffic volume of a major arterial road located in the north entrance area of Baghdad, which represents one of the main entrances to Baghdad city. Traffic volume data were collected for each day before the opening of the complex and in the four years following the opening. This study's goal is to determine the impact of the new developments on the surrounding roads and manage future traffic operations to facilitate future trips that would be generated by the development activity. Impact assessment was analyzed using PTV Vissim software and the authors found that the control measures could manage the traffic conditions at the road entrance, but they do not solve the problem for long-term planning. A necessary traffic management plan must be created following the impact assessment to lessen the detrimental effects of land use change on the road network.

Keywords

intersection, Al-Shaab area, vissim, land use, traffic impact

1 Introduction

The rapid increase in building patterns, household size, and population led to land use changes that revealed impacts on the generation of vehicle trips that increased the existing demand (Kazaura and Burra, 2017). Sharma et al. (2024) refer to one promising urban planning strategy to deal with the issues of urbanization, traffic, and sustainability, namely transit-oriented development (TOD). To promote TOD, land-use policies, regulatory frameworks, and transportation infrastructure must be in place. Lodhi et al. (2024) stated planning a sustainable transportation system requires careful consideration of the bus service's quality from the viewpoint of passengers. In recent years, people have been using cars more; this is because dissatisfaction with public transport was primarily caused by factors like users' safety and comfort level.

A Traffic Impact Assessment (TIA) is required to be conducted for the effect of a new land use, to determine the potential traffic impacts on the existing network and it recommends remedial measures for the planners to eliminate those (Yayat et al., 2016). The trips generated from a new development should be identified; TIA is used to provide information on the level of service of the road network after the addition of new development, which addresses this issue. It recognizes the improvement of a transportation system to reduce congestion, maintain and improve safety, provide site access, and influence mitigation associated with the project. So it is important to activate the implementation of the traffic impact analysis in all the area types (provincial/district/city) (Kabir et al., 2012). Padma et al. (2020) stated that there is a necessity to analyze the effect of developed land use situated in built-up areas that generate and attract traffic to the transportation system. There is no limit to the size of the traffic impact area; it changes in extent depending on the development types, size, and location of the development surrounding land uses (Douglass and Abley, 2011). Pathiraja et al. (2019) recommended that in Sri Lanka, the minimum boundary area must be 500 meters from the development site that causes

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the traffic impact. Using the Snowballing technique and multi-criteria analysis, the best parameters and approaches were found for defining the boundaries of the traffic impact area caused by new development. Padma et al. (2020) assessed the impact of the proposed Information Technology (IT) Park located at a distance of 4 km from the periphery of the city of Madurai, Tamilnadu, India. The case study emphasizes the value of TIA and the necessity of requiring it as a fundamental component. Mammen et al. (2023) examine how the planned town shopping center would affect the current road system and the future needs for transportation infrastructure to handle the extra trips that the development would create. By contrasting the number of vehicles at various times with the road network's theoretical capacities, impact assessments were carried out. A traffic management strategy was created using PTV Vissim software to manage the effects of land use change on the road network. To guide future spatial growth, they determined the amount of traffic created in an urban area as a result of the proposed construction of new malls. Davarnia and Gürsoy (2021) examined the effects of shopping malls and retail trade on the traffic volume of major roads because these developments provide the economy with enormous direct and indirect benefits through employment, revenue generation, and Gross Domestic Product GDP participation. Wang and Shao (2013) analyzes the service level of the Hongzhou intersection by estimating delay time, capacity, and saturation to evaluate the degree of influence on new projects. The results are evaluated by delay time and saturation as the evaluation index, and they achieved good results. Minhans et al. (2013) used socio-economic data of Malaysian travelers, trip attributes, and land use for the estimation of trip rates; these values were employed to estimate the traffic that a proposed Tesco hypermarket (TH) in Skudai would likely cause in the future. The analysis was done using SIDRA software to evaluate the level of service (LOS) by the delay measure. The increase in delay values at intersections led to risk severity, which made Khudhair et al. (2025) to determine which selected intersections pose the greatest risk based on an EPDO created specifically for Iraqi conditions. Estimating the crash's cost is the first step and developing the EPDO (Iraq) is the second step. The findings indicate a strong relationship between crash frequency and intersection severity rank as determined by EPDO scores. Sharma et al. (2024) review and develop a strong framework for surrogate safety analysis. The effectiveness of different surrogate safety indicators in anticipating and averting traffic accidents is evaluated through a comparative analysis. Asmael et al. (2024) explored how traffic congestion is correlated with land use patterns and studied this interaction by statistical methods. They stated that commercial land-use intensity (size and scale of activity) affects traffic movement and represents the major influence on congestion.

To maintain a constant highway level of service, traffic operations must be managed, maintained, and improved. Unplanned development is a serious issue that occurred in Iraq due to building large-scale generation development in a congested area without considering its effect on network operation. The depth of traffic impact measurements and Traffic Impact Analysis (TIA) has not been adequately considered in Iraq's urban plans. Where land use change proposals are taking place very rapidly, most projects still do not assess or analyze the traffic impacts from the proposed developments on the existing transport networks. Due to the redevelopment site's location in an area with substantial traffic congestion, a traffic impact study is necessary for both development and redevelopment. The highest order of land use activity that contributes to private vehicle travel is complex development. Abdullah and Asmael (2023) stated that there is a need to understand the number of trips generated from complex developments, as the pattern of trips usually affects the level of service of major roads. This information helps the transportation planners to improve accessibility and recommends the necessary operational or geometric changes to safely and effectively handle the shifts in transportation demand brought about by the planned development. The study's primary goals are to observe commuters' travel patterns, assess the current state of traffic on the chosen network, calculate the amount of vehicle traffic brought on by the new development project, and forecast service operation on the nearby road network. These studies are necessary to determine the impact of the new development's generated traffic, gauge its magnitude, and make the necessary deductions that may aid in decision-making.

2 Study area

The study area was the Al-Shaab neighborhood in the North area of Baghdad. The area of Al-Shaab is located on the northeastern side of Baghdad city, and it is one of the middle-income neighborhoods in the city with a large population density. Al-Shaab residential complex is considered one of the new projects in Baghdad that is located near one of the major entrance roads of Baghdad, in the north of Baghdad, within the Al-Shaab area. It was connected via major arterial and local streets. It is built on an area of 44,000 m^2, indicating that the project will provide 384 housing units distributed over 14 buildings with a height of seven floors indicating that

the company implemented the project according to the latest urban designs, beside that a new college is proposed to be built near it, and a parking lot with a capacity of 500 vehicles. Al-Shaab residential complex has two entrances, one from the direction of the expressway highway and the other from the front of the main north road entrance of Baghdad. The exit of cars starts from an existing local street at the end of the Al-Shaab Bridge so as not to affect the traffic of cars on the main street. Existing land use adjacent to the area to the east is predominantly residential; Fig. 1 shows the Al-Shaab residential complex. Road network assessment requires the study of the impact of the proposed development on the overall traffic plying within the influence area during the horizon year period. Horizon-year assessment is done for 5 and 10-year periods.

3 Data collection

This section deals with different surveys that have been carried out for this study. The traffic volume count was conducted beside the selected location. The duration of conducting the traffic count survey was three days (Monday through Wednesday) 8–9 a.m. period to assess the peak hour volume, directional flow, and composition (various types of cars, buses, etc.) of the traffic. The peak hour was selected as the traffic analysis period as it represents the highest potential traffic condition on the roadways. Data collection was carried out and continued for 2 months to better understand the current and future traffic impact on and off the site. Observers collected traffic data from the site, using cameras installed on top of one of the nearby buildings, and all the required data were recorded. Land use data were collected during a site visit. Programs are used to analyze traffic images captured from cameras on the road, to obtain some information such as the number of cars, their speed, and the time taken to reach the specified point. The traffic impact study should examine all access roads, neighboring roads, and intersections within a one-kilometer radius of the site's edge. The T shape intersection located beside the Al-Shaab residential complex consists of three approaches, as shown in Fig. 2:

1. The road coming from the north of the city and from the Al-Sha'ab area (NB);
2. The road coming from the Al-Tujar neighborhood (EB);
3. The road coming from the south of the city and from the Canal Expressway (SB);

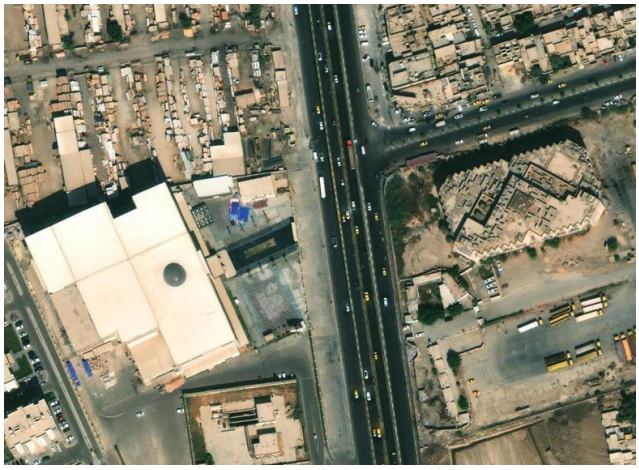


Fig. 1 The location of Al-Shaab residential complex adjacent to the major arterial road

This was a three-legged intersection under no signal control on 2/12/2020; a primary survey of vehicle counts on the adjacent roads was conducted as shown in Table 1.

Table 1 shows that during peak hours, cars and trucks make up the majority of the traffic flow, which is mostly concentrated in the north-south straight line; the number of truck traffic on this road is higher because this road represents the main entrance to Baghdad city. The traffic flow on the East approach is dominated by automobiles, with the fewest buses.

4 Vissim modelling

Vissim is a microscopic traffic simulation software that has been widely used in assessing traffic conditions. Modeling a three-leg intersection in VISSIM involves creating a realistic

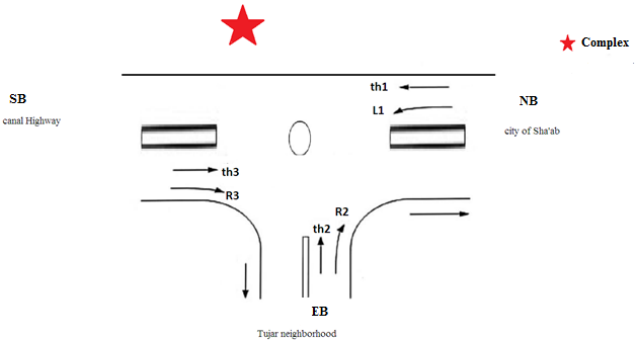


Fig. 2 T shape intersection located near Al-Shaab residential complex

Table 1 Data collection

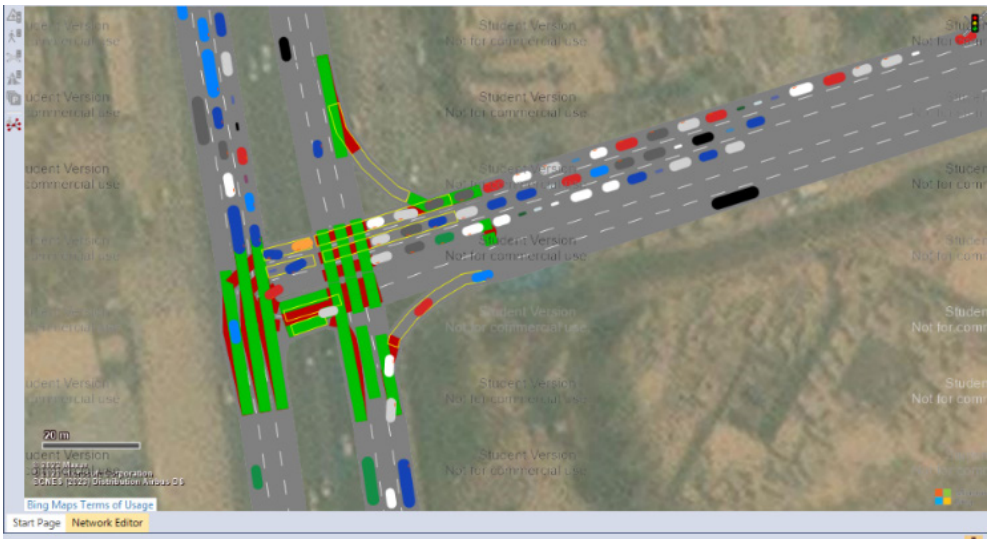
Approach	Movement	Number of vehicles veh/hr in the first year	Number of vehicles veh/hr after 4 years
NB	TH	1,090	1,269
	L	620	605
EB	TH	650	827
	R	251	320
SB	R	759	920
	TH	939	993

simulation of traffic flow, signal control, and vehicle interactions. The process starts by creating the road network using links and connectors followed by defining traffic flows for each approach, then assigning routes using the static routing decision to define possible movements at the intersection (e.g., left, through, right turns). Then conflict areas are defined at the intersection points to manage vehicle interactions and priorities. Finally, the simulation is started and vehicle movement is observed, adjusting parameters to improve traffic flow to represent real conditions. The simulation output is then compared with real-world data to ensure accuracy. The study area was modeled as shown in Fig. 3. The intersection was modeled under the existing traffic case in Vissim. The purpose of this assessment is to compare the existing intersection operations to the actual condition to forecast future scenarios under the increased traffic load.

5 Results and analysis

The traffic data were classified into car, bus, truck, and bike. In the intersection, priority rules or conflict areas were set to determine which lane has priority. In this study, conflict areas were set up at the intersection location. This is a three-legged intersection that was simulated under no signal control in the first case. The data collected at the existing junction were analyzed in detail to understand the existing level of service of all existing roads; moreover, it was also used to understand the behavior of the existing traffic. The detailed results are presented in Figs. 4–7. It appears from the results

(a)



(b)

Fig. 3 (a) Model of the study area (b) Simulation of traffic movement on the road network

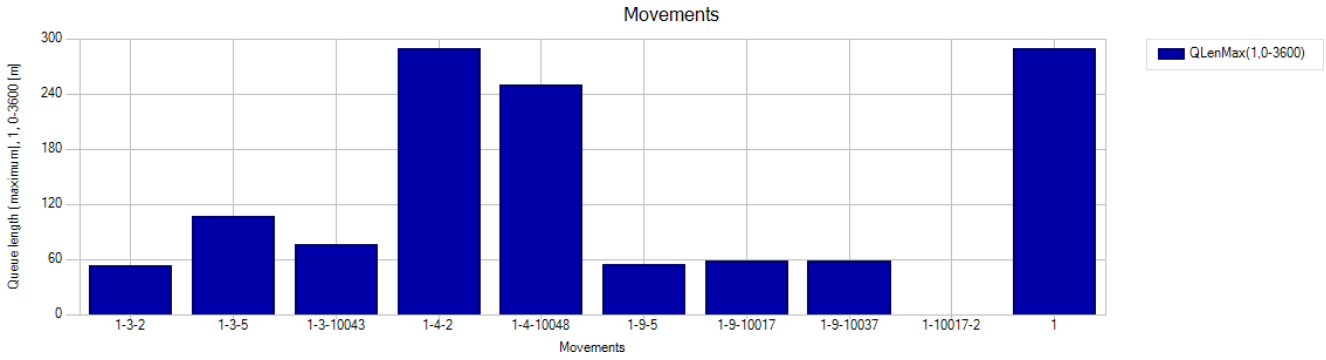


Fig. 4 Queue length along approaches

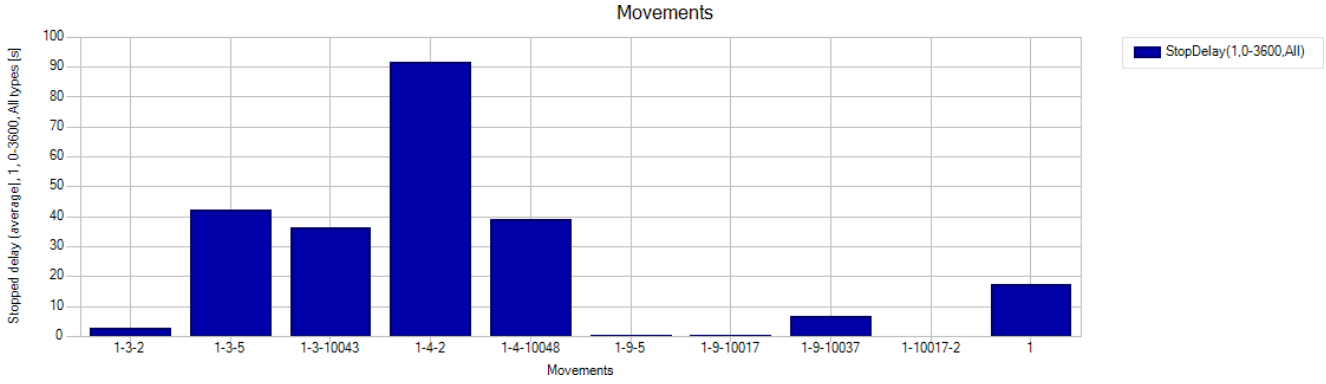


Fig. 5 Stopped delay for all movements

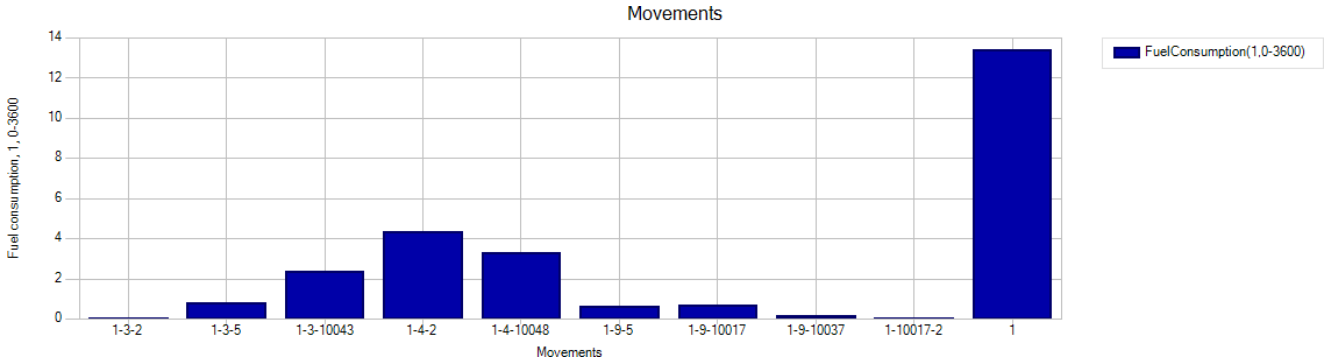


Fig. 6 Fuel consumption for all movements

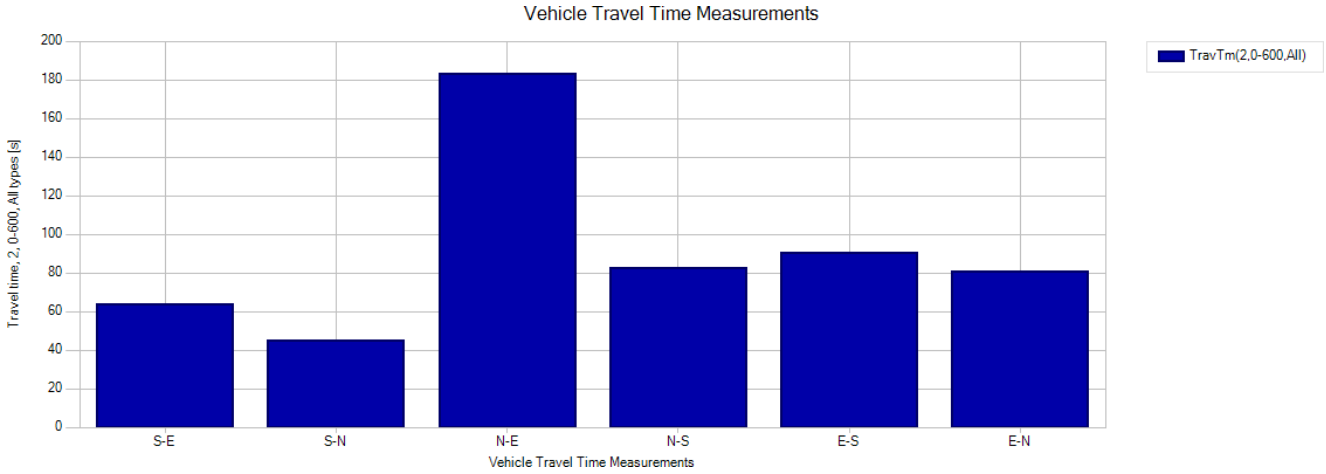


Fig. 7 Travel time for all approaches

that an increase in the number of trucks in the traffic flow is accompanied by a decrease in the number of vehicles that pass the intersection, which is explained by their lower speed, more time spent at the start of movement, and other factors. This appears in the North-South directions; the traffic situation at the intersection deteriorates as a result of the severe vehicle queuing, which causes the cars to line up one after the other. The longer queue occurs near the left lane when the vehicles tend to turn left to the east approach, this movement increases travel time and delay, as shown in the case of Movement 1-4-2 in Fig. 4.

The traffic operation presented on Figs. 4–7 is without signal control; it is operated according to priority rules. PTV Vissim can be used to quickly and easily optimize the traffic signal controllers in a few steps (Gunarathne et al., 2023). Traffic analyses were conducted to identify any deficiencies within the study area for the a.m. peak hours in 2024 in the second case. 4 years after the opening of the development, the intersection was managed by signal control with phase signal as shown in Figs. 8 and 9, and the results are shown in Figs. 10–13.

As shown on Figs. 10–13, the traffic generated by the development will have a slightly noticeable effect on the road network in terms of traffic flow as it represents the fourth year since the first day of opening the development. The existing LOS has been maintained, with a minor decrease in the average delays as shown in Table 2.

At the intersection of three legs (roads) in a heavy traffic area, this intersection suffers from traffic congestion due to several factors, such as high traffic density coming

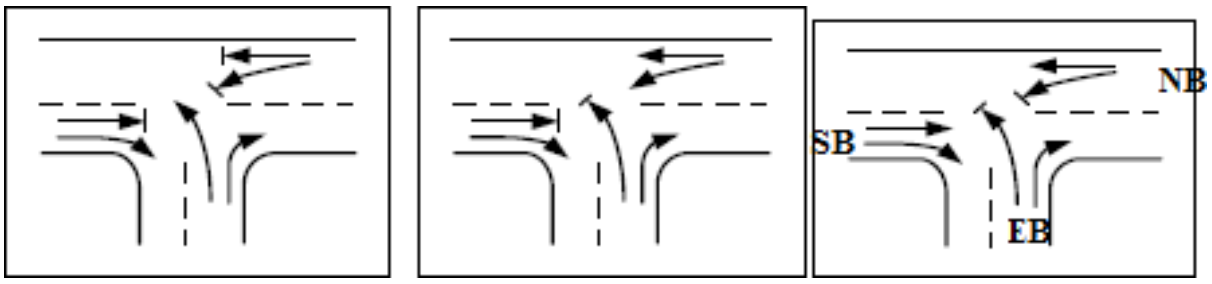


Fig. 8 Phase signal

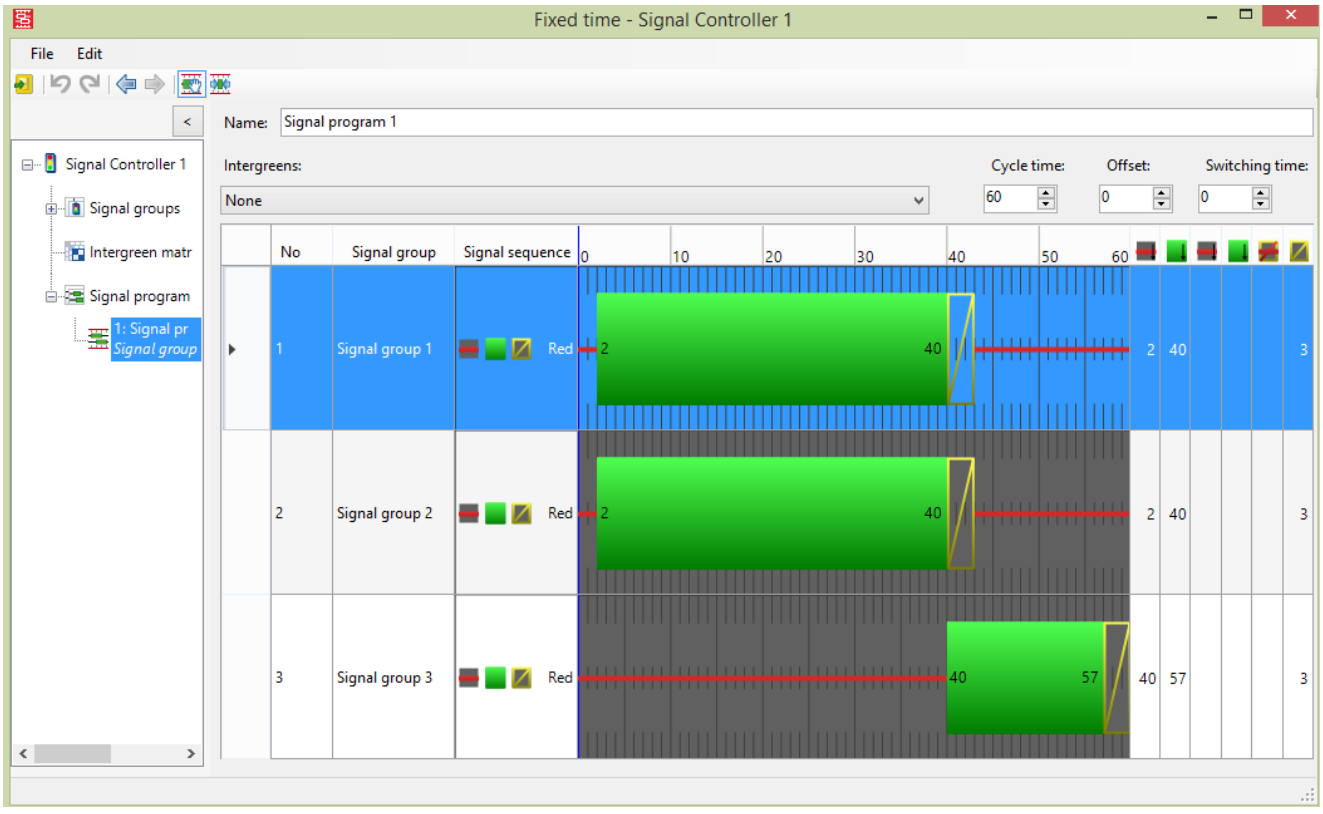


Fig. 9 Signal control data

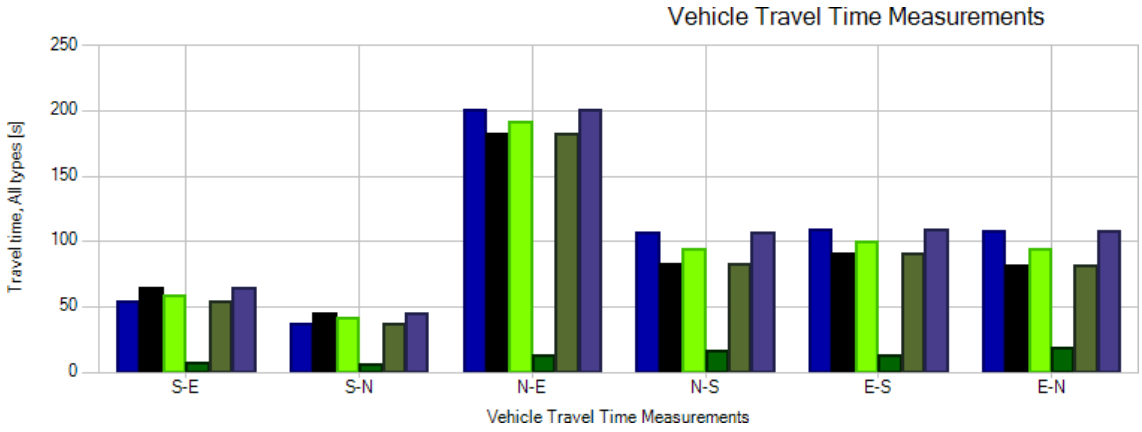


Fig. 10 Vehicle travel time

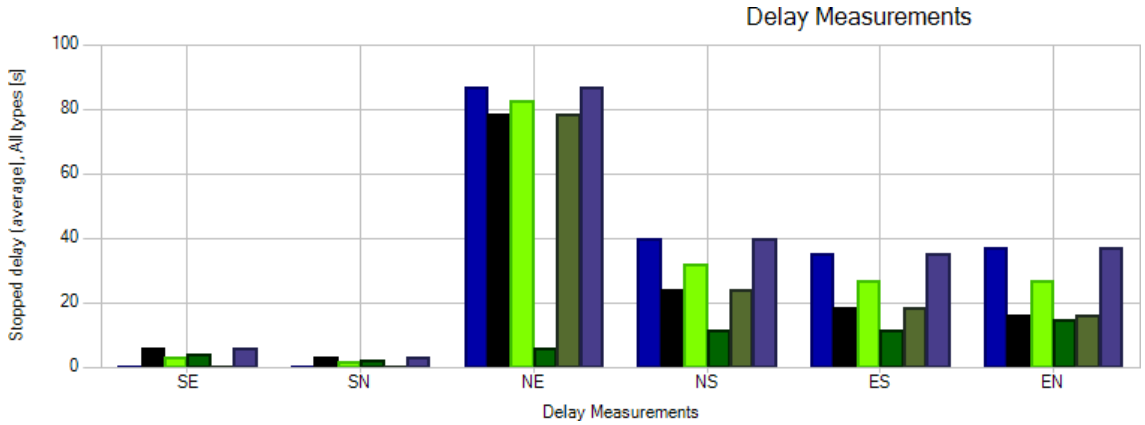


Fig. 11 Delay measurements for all approaches

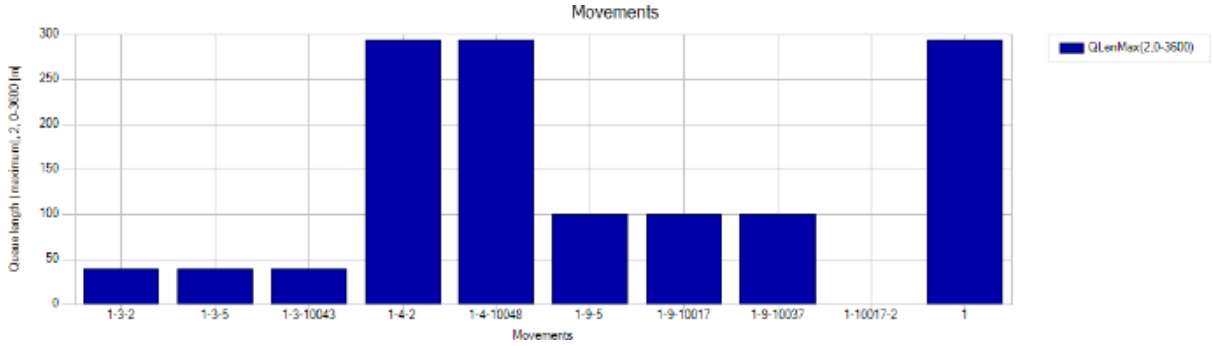


Fig. 12 Queue length

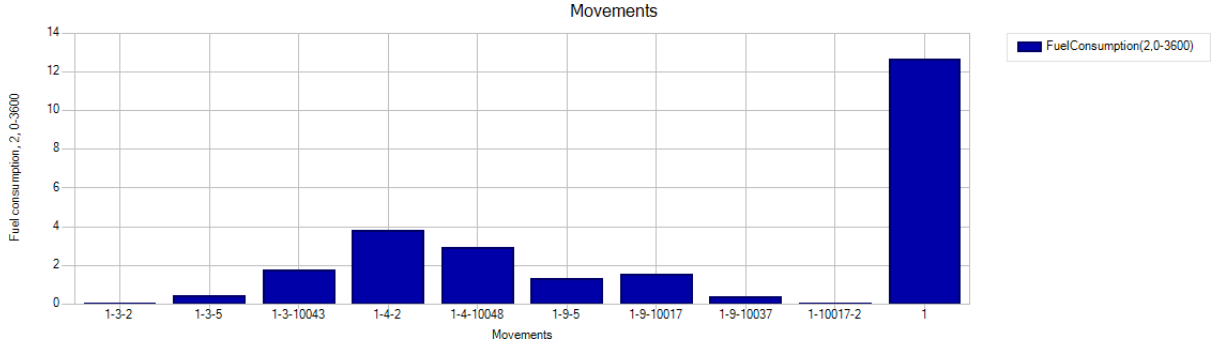


Fig. 13 Fuel consumption

Table 2 Data analysis after signal control management

Movement	LOS before signal control	LOS after signal control
EE 1 - 3@316.5 - 2@0.6	LOS_A	LOS_B
EN 1 - 3@316.5 - 5@4.6	LOS_F	LOS_C
ES 1 - 3@316.5 -10043@36.0	LOS_F	LOS_C
NE 1 - 4@245.2 - 2@0.6	LOS_F	LOS_F
NS 1 - 4@245.2 - 10048@41.3	LOS_F	LOS_D
SN 1 - 9@213.2 - 5@4.6	LOS_A	LOS_B
SE 1 - 9@213.2 - 10017@43.8	LOS_A	LOS_B
SS 1 - 9@213.2 - 10037@23.4	LOS_B	LOS_C
Average delay	62.9	56.2

from the north, lack of clarity of movement paths (such as the absence of designated lanes for turning), presence of pedestrians or other means of transport that impede smooth flow, and overlapping vehicle lanes: where cars may need to change lanes or stop to turn, which impedes movement in other directions. It can be found that the service level of the intersection in peak hours has been changed from F to D in the north-south direction, while the movement from north to east is the same, and the overall traffic efficiency of the intersection has been significantly improved after applying signal control. Moreover, no provision of pedestrian facilities under the existing conditions has been made within the laneway. Due to the proposed development, it is envisaged that pedestrian paths would be required to ensure safe pedestrian access around the site and within the surrounding locality of the site.

6 Conclusions

Due to the importance of the entrance location in the north direction of Baghdad city and due to its unique geographic location, an analysis of the impact of traffic in subsequent years is required. It is necessary to analyze the traffic influence in future years. To perform the analysis, this paper uses evaluation indicators such as travel time, travel speed, queue length, and delay. The area is modeled using the Vissim simulation, before and after the road control change, and the simulation results are thoroughly assessed. The findings demonstrate that the optimized intersection's service level during peak hours has improved from F to D in terms of road capacity, and the traffic situation has been successfully reduced. However, traffic signals are not the solution to decrease traffic congestion. The exit and entrance of the complex to the major entrance road should be limited and converted to other locations to decrease the pressure on the north road entrance of Baghdad. For in-depth analysis in the future, we recommend mitigation measures to manage increased traffic demand, such as road capacity improvements, signal optimization, or promoting public transport and non-motorized transport options, and simulation of these scenarios in PTV Vissim.

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