Valuation of Bus Characteristics in Urban Area: Al-Najaf as a Case Study

Ibtihal Salim Abd[1]* and *Hamid* Athab Al-Jameel[1]

[1]Civil Engineering Department, University of Kufa, Iraq

Abstract. Increased population, the rapid growth of vehicles owned, and quick land-use shifts have resulted in an abnormal rise in trips generated and directed to and from the activities area; the occurrence of traffic congestion in different segments of the transportation network leads to extended travel time, resulting in inconvenience and discontent among individuals. It has become necessary to provide alternative transportation systems, as city residents need faster, safer, and more comfortable transportation systems. This study aims to evaluate current public transport in Najaf city and propose a bus line based on international standards as an alternative transport means in al-Najaf city and its effectiveness. Sustainable performance indicators were evaluated based on previous studies, such as traffic congestion**,** travel time, sustainability, and reliability. Where Traffic flow rates indicate high congestion streets, as flow rates reached 6228 (Veh. /hr.) at Karbala-Najaf Street. The more increase in flow rates the more defect in the network, and the journey time increases reached 30 minutes at Kufa-Najaf Street (8,5) km. The data of traffic mix from most of urban roads have been determined. The results of studies stated that Public The forms of transportation in the city of Najaf are generally represented by several routes starting from the Najaf internal garage and passing through small buses. These routes do not cover the entire city and the actual need for people. The percentage of transport buses and minibuses is about 0.8% and 10%, respectively. The public transport in the city is not managed by any policies and has no schedule times for travels with no considerations for passengers' comfort which indicate that public transport sector in the city of Najaf is significantly poor.

1 Introduction

The ever-increasing road traffic generates a negative impact on the well-being of societies. Despite the peak-car phenomenon, Goodwin (2012) pointed out that traffic growth can still exist in most countries and cities. Since 2010, the increasing traffic demand has been identified as one of the top challenges faced by the civil engineering community (Becerik-Gerber et al.,2013). Negative consequences of high-level traffic demand include traffic congestion, journey time delay, energy consumption rise and pollution emission. There are different types of transport available to use, the type of transportation will depend on the purpose of travelling, length of travel and cost travel. There were several research identified the influence factors on the selection between private vehicles and public transport of residents' mode choice. For example (Bolger et al,1995) (Kwon ,2001), (O'Flaherty,1997) and (Niblett & Palmer ,1993) found that saving travel time and travel costs were important factors in choosing car or the public transport system.

Urban public transportation is usually characterized by a wide scope in terms of city infrastructure and number of passengers , especially the bus system, which is one of the most important urban transportation systems. In most cases, buses have a shared right of way with other vehicular traffic (Song2023). This study aims to evaluate the performance indicators of the existing traffic and public transportation network in the holy city of Najaf

2 Public Transportation

Public transportation is one of the most vitally sustainable modes providing of travel. Its consists of regularly scheduled vehicle trips, open to all paying passengers, with the capacity to carry multiple passengers whose trips may have different origins, destination, and purposes (Walker,2012). The correct planning and management of a public transport system is the key to offering potential users a mode of transport which can be competitive with the private motor car. Sufficiently attractive overall journey times must be offered to attract travelers from other modes of transport, thereby reducing traffic congestion and obtaining derived benefits like road safety and lower atmospheric and noise pollution (Ibeas et al,2009).

Important factors affecting public transportation which are (Zhang,2014):

*Corresponding author: ibtehals.alisawi@student.uokufa.edu.iq

Travel time: At the University at Albany, 42% of students and faculty refused public transportation because of longer travel time, distance to station is one of the motivations to use public transit if the tolerable walking distance to a bus station is between 0.25 and 0.3 miles, personal safety, frequent Service: in some areas, people required more frequent services such as bus service each 15min rather than 30min and bus environment, station environment and facilities.

3 Public Transportation modes

Public transit is a form of transportation that involves moving many of people at once. It is distinguished by great speed, high passenger capacity, and low fees when compared to other forms of transportation (Wirasinghe, S. C. et al,2013). It frequently operates on confined routes or makes a distinct, specific use of a feasible general route with designated stopping spots (Feng et al,2019). This type of transportation infrastructure is vitally important in emerging nations to handle the growing population.

3.1 Paratransit

All forms of public and private mass transit that fall between driving your own car and using a traditional, fixed-route, fixed-schedule bus or train are included. Carpools and vanpools (shared ride modes), limousines, charter buses, shuttle buses, exclusive and shared-ride taxicabs, and bus transportation operating on flexible routes and flexible schedules in response to individual requests for service—the latter of which is referred to as "demand-responsive" or "dial-a-ride" services—are all included in the broad definition. Traditional exclusive-ride taxi services, though they are not shared-ride services, are frequently referred to as paratransit services due to the operational similarities between them and other demand-responsive services as well as the fact that historically they have catered to older and disabled customers—markets that other paratransit has historically catered to. Others have been added by some authors (Rosemary et al,2009).

3.2 Train and Tram

Rail transport consists of moving goods or passengers using railroads or railways. Railroads provide the most energy efficient and cost-effective transportation services over land, compared to vehicles on paved roads, railcars make much less friction when moving over rails. As a result, trains typically use less energy than road vehicles to transport a given tonnage of freight or a given number of passengers over a given distance. Nevertheless, rail is still a capital-intensive means of transport (Janic, 2014). The Tram is a comfortable, environmentally friendly, accessible, quick and safe mode of transport. It can carry up to 200 passengers or more (Tram, 2017). It is also from direct access and no need for stairs and connection corridors. If the Tram stations distribute well it helps more in transitions between urban transportation (Tram) with high speed transportation or transportation out of the cities (train stations**).**

3.3 Light Rail Transit

The capacity and speed of light rail, also known as light rail transit, are often higher than those of traditional street-running tram systems but generally lower than those of heavy rail and metro systems (Yan et al., 2012). The term is widely used to characterize rail systems with rapid transit aspects that typically use electric rail cars and run mostly in private rights of way that are isolated from other traffic, while they occasionally, if required, mix with other traffic in downtown streets

3.4 Bus system

A bus system is an important transport mode in an integrated multi-modal transport system. Buses can make more efficient use of road space compared to private vehicles in terms of the number of passengers conveyed over a unit length of road. Economically, supporting buses increases the attractiveness of bus travel relative to car travel, which in turn helps alleviate congestion, including for those still in the car. Environmentally, the increased attractiveness of bus travel relative to car travel helps reduce pollution. Socially, the existence of a bus service increases the accessibility of non-car owners to social services and employment opportunities"(DfT,2012b). Compared to rail transit, buses are labor-intensive and have no economy of scale: on heavily traveled lines for every additional 40-120 passengers, one bus and one driver must be added to service. (Vukan R. Vuchic,2002).

4 Bus Characteristics

4.1 Bus capacity

Conventional buses, carrying up to 80 passengers each, can carry up to about 15,000 passengers per hour, unless there is severe traffic congestion, and more if there are exclusive bus lanes.Bus capacity is affected by vehicle type, loading area performance, and dwell time of the bus vehicle. Each bus requires a certain amount of service time at stops that varies with the number of boarding and alighting passengers, door configuration, and fare collection method. The minimum safe spacing between buses in motion and the number of loading areas available at any stop also influence the total number of buses and persons that a

given facility can carry. The total passenger flow rate varies with bus capacity and the trade-off between seated capacity and standees. The largest number of seats and lowest number of standees should occur on longer suburban bus routes or on intercity bus routes where higher levels of comfort are essential. A typical 14-m urban transit bus can normally seat 43 passengers and carry up to 37 standees if the aisle circulation space is filled. Similarly, an 18-m articulated bus can carry 65 seated passengers and 55 standees. However, bus operator policy often limits the number of standees to levels below this theoretical capacity (HCM2000).

4.2 Types of Bus

4.2.1 Conventional Bus

Although conventional buses may vary in their design, internal layout and seating capacity, there are legal limits for their sizes. For example, in the UK: maximum length of 12 m and maximum width of 2.5 m (O'Flaherty, 1997). Bus vehicles typically take one of four forms.

1. Standard single-deckers (typically, 10-12m length and 50 seating capacity);
2. Double-deckers (typically 10m long and 75 seating capacity);
3. Articulated single-decker vehicles (length of around 16 m and a high proportion of standees to give a capacity of over 100 passengers); and
4. Minibuses (length of up to 7 m and a seating capacity from 16 to 20 passengers).
5. Trolleybuses are electrically powered buses having two overhead cables for power pick-up (Figure1)

Fig. 1. Types of Bus (O'Flaherty, 1997)

4.2.2 Bus Rapid Transit (BRT)

It could be defined as a rapid mean of public transportation that utilizes a rubber-tired vehicle to transform passengers from station to another one within a network of bus lanes that make up a system using technologies such as: dedicated running ways uniquely designed bus stations, improved method of fare collection, and distinctive system branding (Ulloa,2015). The characteristics of advanced BRT systems are intelligent Transportation System (ITS), queue jumps, electric/hybrid vehicles, and high-frequency service. BRT system is less expensive and easier to implement than light rail system. The average cos per mil for BRT is $13.5 million; whereas for light rail is $34.8 million (Ulloa, 2015). Moreover, this cost mainly relays on the location of the bus route, right-of way, construction of station structures, etc. In spite of BRT being less popular than other transport systems, it is slowly gaining interest in the United States. There were 66 BRT bus routes operating in the United States during 2012 (Zhang, 2014). As of 2013, there are 130 BRT systems worldwide (Suzuki, 2013). A lot of studies found that property values close to BRT stations were higher than those were farther away.

Characteristics of BRT

BRT is, different from regular bus services, it has many distinguishing characteristics. According to (Lee, 2007), the main characteristics of BRT systems include the following:

- Dedicated (bus-only) running ways
- Accessible, safe, secure, and attractive stations
- Easy-to-board attractive, and environmentally friendly vehicles
- Efficient fare collection
- ITS applications to provide real-time passenger information, signal priority, and service command/control
- Frequent, all-day service
- Distinctive system identity, these characteristics enable BRT to resolve the challenges of current public transportation to a certain degree.

BRT vehicles, which have better facilities than regular buses, are typically large capacity and stylized vehicles with low-floor boarding and different degrees of ITS integration, such as Automatic Vehicle Location (AVL), Traffic Signal Priority (TSP), Automatic Passenger Count (APC), next-stop.

4.3 Bus Lanes

For the purpose of determining capacity, a bus lane is any lane on a roadway in which buses operate. It may be used exclusively by buses, or it may be shared with other traffic (HCM2000).

4.3.1 Bus Lane type

There are three types of bus:

1. Type 1 bus lanes have no use of the adjacent lane.
2. bus lanes have partial use of the adjacent lane, which is shared with other traffic.
3. bus lanes provide for exclusive use of two lanes by buses.

The curb lane of Types 1 and 2 lanes may or may not be shared with other traffic. When the lane is primarily for mixed traffic, typically there is no formal designation of a bus lane either with signing or with pavement markings. The greater the degree of exclusivity of the bus lane and the greater the number of lanes available for buses to maneuver, the greater the bus lane capacity (HCM2000).

The vast majority of buses operate on regular streets. Being in mixed traffic, their speed and reliability of service depend on traffic conditions. Their average speed is lower than average speed of cars because they stop to pick up and drop off passengers. Buses are therefore not very competitive with car travel in the same corridor with respect to speed and reliability. Their advantage is much lower cost and convenience of not having to drive and park. **(Vuchic**, 2002).

To make buses more efficient and attractive to passengers, bus preferential measures can be introduced. These include the following:

·**Preferential signals**: buses in a separate approach lane at intersections get the green signal before other lanes, so that they can proceed through the intersection ahead of other traffic.

Alternating stop locations at near- and far-side of intersections (before or after cross street) so that buses clearing one intersection on green signal use the green at the following intersection before they make the next stop. Also, spacings between bus stops should typically be about 250-400 m.

Exclusive bus lanes, which may be curb lanes or lanes in the median. This is the most significant improvement measure because it makes buses independent of traffic conditions on the same street.

Buses on high-occupancy vehicle (HOV) lanes or roadways are used when bus lines with frequent service follow freeway alignment for a rather long distance. HOV facilities usually have traffic control that prevents congestion, but they do not provide the image of an exclusive, independent transit facility.

4.4 A loading area, or bus berth is a space for buses to stop to pick up and discharge passengers. Bus stops contain one or more loading areas. The most common form of loading area is a linear bus stop along a street curb. In this case, loading areas either can be provided in the travel lane (on-line), so that following buses cannot pass the stopped bus; or they can be pullouts out of the travel lane (off-line) so that following buses may pass. Figure 2 depicts these two types of loading areas (HCM, 2000)

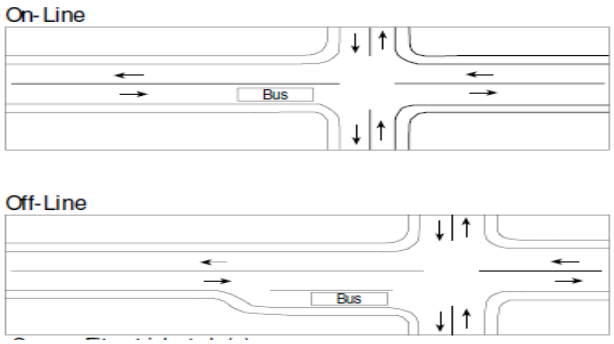


Fig. 2. Type of loading area (HCM2000)

4.5 Bus Stops

A bus stop is an area where one or more buses load and unload passengers. It consists of one or more loading areas. Bus stop capacity is related to the capacity of the individual loading areas at the stop, loading area design (linear or nonlinear). (HCM2000). The location of bus stops is an urgent task of both public network design and urban planning The objectives of the design of bus stops are: ● ensuring the effective functioning of the route network of urban public passenger transport; ● formation of multimodal environment of city streets, providing a balance of interests of all users of street space (pedestrians, cyclists and users of means of individual mobility, urban public passenger transport, road transport (Mikhailov et.al,2023).

Koshy and Arasan (2005) developed a microsimulation model to analyze the effect of bus stops on heterogeneous traffic flow. They validated the model using traffic data collected at bus stops and bus bays. The results appeared at the dock station and the bus bay on a 7.5-meter-wide road, where the numbers show reduction of average speed with increasing flow at various bus dwell times which is the defined duration of time of the transit vehicle stopped for serving passengers. It includes the total passenger boarding and alighting times and the time needed for the bus to open and close doors (HCM2000). Influence of bus bays on other vehicular traffic is observed to be less when compared to curbside stops.

4.6 A bus station

A bus station or a bus interchange is a structure where city or intercity buses stop to pick up and drop off passengers. While the term bus depot can also be used to refer to a bus station, it generally refers to a bus garage. A bus station is larger than a bus stop,

which is usually simply a place on the roadside, where buses can stop. It intended as a terminal station for a number of routes, or as a transfer station where the routes continue, Elements of bus station are route of buses, bus stop, catchment area, topography, real time Information, safety and security, amount of money payed, vehicles, passengers, and service. This element will affect the quantity and quality of bus service in any city.

The objectives of the design of bus stops are ensuring the effective functioning of the route network of urban public passenger transport; formation of multimodal environment of city streets, providing a balance of interests of all users of street space (pedestrians, cyclists and users of means of individual mobility, urban public passenger transport, road transport) and the formation of the streetscape design (Ahmed,2016).

4.6.1 The main objective

4.6.1.1. Distance between bus station and demand

This variable is very important for making people using public transportation, so that maximum walking distance is 500 meters (1640 feet) in the daytime (Monday-Saturday) and 1000 meters (3280 feet) for all other periods. The objective of this standard is to provide service to approximately 90 percent of the urban area (John Wiley & Sons 2006). Their findings in the latter case yielded optimal stop spacing distances of 600 meters for the small city case and 800 meters for the large city case. These distances were about twice times as great as the observed distances in selected systems in the Netherlands and other western European cities (Journal of the Transportation Research Board, 2006).

4.6.1.2. Cost of constructing station: It is necessary to choose the minimum number of bus station because of this cost its high where some time active price doesn't enough to constructing bus station (Ahmed, 2016).

4.6.1.3. Travel time: Travel time consists form walking time, waiting time, and on-board time. One of the goals to improve TP travel time that is minimum, so that it is necessary to choose a good location to bus station to become walking time which is minimum and with good efficiency, it reduces waiting time, and on-board time, it depends on network (Ahmed, 2016).

4.6.2 Performance indicators

4.6.2.1The sustainability

Reducing traffic improves the sustainability of transportation has become important policy in recent decades. Most of the developed countries have realized that building more roads for an unrelenting growth of vehicles is not a solution for the problems like congestion and pollution. Public transportation patronage in many developed countries with adequate public transportation systems remain low (Ahmed,2016).

Although public transportation is considered effective at reducing the external cost of driving private vehicles, many urbanizes do not use public transportation, so that the number of private vehicles grows worldwide, as well as air pollution and traffic congestion, which typically constrain economic development. To achieve transportation sustainability and continued economic development, the dependency on private vehicles must be decreased by increasing public transportation usage C.-H. (2015) Public transportation networks are deemed crucial to the sustainability of metropolitan regions for a variety of social, environmental, and economic reasons, such as ensuring access to activities and services, reducing traffic congestion, increasing productivity, and lowering carbon emissions. Daniels, R., & Mulley, C. (2013).

Table 1. shows the literature review on bus service ***Sustainability*** and the most important results obtained.

Author	Year	Summary	Results
Xu, X	2020	Measure and evaluate network vulnerabilities	Network vulnerabilities were classified as connectivity vulnerability, accessibility vulnerability, and capacity vulnerability
Nirne et. al.,	2023	Accessibility of bus services for the visually impaired	Developing a system that helps the visually impaired navigate and benefit from the bus service smoothly by using the bus station unit to announce and alert the visually impaired about the time of bus arrival and departure.
Hong et.al.,	2023	Improving network sustainability setting up bus lanes at intersections	setting bus lanes at intersections improve bus speed and shorten travel time
Szilassy et, al.,	2023	Sustainability of charging electric buses	Developing the infrastructure of the electric bus network by improving dynamic charging methods at bus stations
Czapla and Sierpi	20023	Sustainability of charging electric buses	developed method for estimating the energy consumption of electric buses The method can also be used to choose the right electric bus model bus routes

4.6.3 The reliability

The reliability of public transport systems is considered critical by public transport users, operators and governments. Lack of reliability in public transport leads to uncertainty and delays which exacerbate anxiety and discomfort for passengers and increase costs due to lost miles and reduced fleet utilization for operators. Reliability, as a measure of service quality, is related to the operational characteristics of the public transportation system. On the other hand, passenger waiting time is more sensitive to schedule reliability than service frequency. Many factors contribute to bus unreliability: day-to-day and within-day variability in traffic flow and congestion levels cause delays and make prediction of bus journey time uncertain, excess passenger demand causes longer dwell time at bus stops; buses do not always run-on schedule, or appear in bunches; operators have insufficient spare capacity to cover for service breakdowns, etc. (Sterman & Schofer, 1976; Abkowitz & Tozzi,1987.

A bus system, especially in an urban transport network, experiences perturbations of a relatively high level. As referred to by Strathman et. al., (2000), Woodhull, (1987) categorized these perturbations as endogenous and exogenous. Endogenous perturbations arise within the bus transit system such as passenger loading, route configurations, bus schedule and driver operation. Exogenous perturbations are related to the external environment where buses are located, such as their surrounding traffic conditions, road accidents, signalized junctions, and so on. Schramm et.al., (2010) ranked the impact of various perturbations on bus service unreliability and concluded that road traffic conditions between bus stops and passenger boarding at bus stops are closely related to bus service reliability.

A reliable bus service can attract more passengers and meet their satisfaction (Boyle, 2006; Hensher et. al., 2003; Hollander,2006). If more people take public vehicles which are more efficient in terms of the number of carried passengers per unit of road space, the total traffic demand for the transport network can be relieved through the modal shift.

Table 2. shows the literature review on bus service Reliability and the most important results obtained.

Author	Year	Summary	Results
Chen et. al., Perk et. al.,	2003 2008	The reliability indicators include deviation of journey times	The discrepancy between actual bus arrival times and pre-dened times it leads to unreliability
Chen et. al., Liu et, al.,	2005 2014	Develop a dynamic model to predict bus arrival time	The proposed an inter-vehicle communication scheme to achieve a planned direct transfer. Two operational tactics were employed by using real-time information: speed control and holding at transfer point, of which speed control resembles schedule recovery behavior
Liu and Sinha	2007	The use of a dynamic microsimulation model framework includes the impact of headway on reliability	clear correlation between headway regularity and passenger wait time delays.
Hollander and. Liu	2008	Passenger ratings about reliability	passengers value travel time reliability four times higher than they do to average travel time.
Jan-Dirk Schmöcker et. al.,	2016	The effect of the bus bunching phenomenon on the headway of the bus	At downstream stops the effect is emphasized as the (small) delay to the first vehicle and the (slight) early arrival of the second vehicle result in increasingly longer dwell times for the first bus and increasingly shorter dwell times for the second bus
Liu et. al.,	2018	the effect of bus driver behavior on bus holding control strategies	the effect of schedule recovery. The recovery time is proportional to the arriving delay time
Akumu Mary	2023	Traveller Mobile application	this feature is implemented and users are now able to search book and reserve seats by filling in the booking form

4.7 Traffic congestion

Traffic congestion is a condition in transport that is characterized by slower speeds, longer trip times, and increased vehicular queueing. Traffic congestion on urban road networks has increased substantially since the 1950s (Caves, R. W,2004). When traffic demand is great enough that the interaction between vehicles slows the traffic stream, this results in congestion. While congestion is a possibility for any mode of transportation. As demand approaches the capacity of a road (or of the intersections along the road), extreme traffic congestion sets in. When vehicles are fully stopped for periods of time, this is known as a **traffic jam** (Arne2020). Most cities are now taking serious steps to manage and control congested traffic (Gao et al., 2016). Congestion mostly appears when so many vehicles try to use a common transportation infrastructure and service points with a limited capacity, which leads to worse use of existing infrastructure and, as a result, contributes to an increase in traffic congestion that leads to more destruction of infrastructure and so forth (Alharbi, 2015).

Table 3. shows the literature review on bus service ***Traffic congestion*** and the most important results obtained.

Author	Year	Summary	Results
Fernandez and Planzer	2002	Identify bottlenecks	Bus stops are major bottlenecks for busy bus systems
Zhao and Zhou	2019	The priority for bus	design the exclusive bus lane at the exit can be dynamically used for the left turn buses and the opposing through buses during the various periods of a signal cycle

Song et. al.,	2020	flow control	proposed the determination method of dynamic lane clear distance and lane control flow based on the dissipation process of queue at intersection
Bigirimana1 et. al.,	2023	bus stops performance	The dependences of the characteristics of the functioning of bus stops as a function of public transport traffic volume, the number of bus routes, as well as the characteristics of the signalized intersections
Xie et. al.,	2023	Bottlenecks problem	presents a dynamic optimal setting and associated control for intermittent bus lane modelling method to the promotion of bus priority concept
Hu et. al.,	2023	overtaking policies	develops simulation models for estimating bus-stop capacities under a large range of overtaking regulation policies and operating conditions

4.8 Travel Time

The time necessary to travel between two points of interest is known as travel time. It is a key indicator of the health of the transportation system and has far-reaching implications for society (Carrion and Levinson, 2012; Zheng et al., 2018). Although there are some differences between modes of transportation, this definition is universal and can be applied to any mode or combination of modes **(Carrion and Levinson, 2012)**. there is a negative correlation between travel time variability and travel speed (the variability of travel times increases as the mean travel speed declines) **(Fredriksson et al., 2023)**. Travel time is composed of *running time*, or time in which the mode of transport is in motion, and *stopped delay time*, or time in which the mode of transportation is stopped (or moving sufficiently slow as to be stopped, i.e., typically less than 8 kph, or 5 mph**) (Turner et al., 1998)**. Travel time and delay data is perhaps the most critical data used to evaluate and enhance road capacity, such as traffic signal optimization and incident management on freeways and arterials **(Li, 2013)**.As a response to this demand, public transportation operates along with municipalities and software engineers creating a variety of programs called trip planners that have the main purpose to inform passengers about: arriving time, routes, prices, distances, points of interest, location, connections with other means of transportation, the number of transfers and other information. Stanescu, P. et al 2014.

Table 4. shows the literature review on bus service ***Travel time*** and the most important results obtained**.**

Author	Year	Summary	Results
Pilachowski	2009	Dynamical bunching problem	proposed to use GPS data to counteract directly the cause of the bunching by allowing the buses to cooperate with each other and
Daganzo and Pilachowski	2011	Dynamical holding problem	Proposed an adaptive bus control scheme based on a two-way bus-to-bus cooperation, where a bus adjusts its speed to both its front and rear headways.
Moreira-Matias et.al.,	2016	sources triggering bunching	integrated the bus bunching prediction model into a real-time framework to mitigate bus bunching, of which the prediction output is used to select and employ corrective actions
Liu et. al.,	2020	Study Varieties of holding control	including schedule-based control, headway-based control, and optimization-based control.

5 The Study Area

AL-Najaf is a city in central Iraq about 160 km (99 mi) south of Baghdad. It is widely considered among the holiest cities of Shia Islam and one of its spiritual capitals, whilst also remaining the center of Shia political power in Iraq. It is reputedly the burial place of Muhammad's son in law and cousin, Imam ʻAlī ibn Abī Tālib. It is also the location of the largest cemetery in the world, Wadi-us-Salaam, of one of the most important seminaries in the Shi'i Islamic world, and a major pilgrimage destination for Shia Muslims. The holy city of AL-Najaf is one of the most famous cities in the Islamic world because of its religious character. Therefore, the city witnessed an increase in the number of visitors throughout the year, in addition to the economic boom that swept the city. All this led to an increase in the number of daily trips and an increase in the flow of traffic due to the religious and economic importance for the city. During its history, Al-Najaf city has two types of urban growth: one is arbitrary (unplanned) and the second is planned (1976-2000). The first one makes the city suffering from arbitrary in distribution which led in narrowing the extension in the area and unbalanced in functional performance; Whereas, the second one was more realistic with

the city conditions and urban environmental (Fuad, 2011). However, after 2003, the illegal use of the land, extension, changing the building and their functions lead to unplanned growth and this has negative effects on the city. The population density was not considered with urban functions. It seems to be as one residential sector and other land uses are distributed in different sides of the city. This affects the land use within the master plan and has bad influence on the transportation planning (Fuad, 2011).

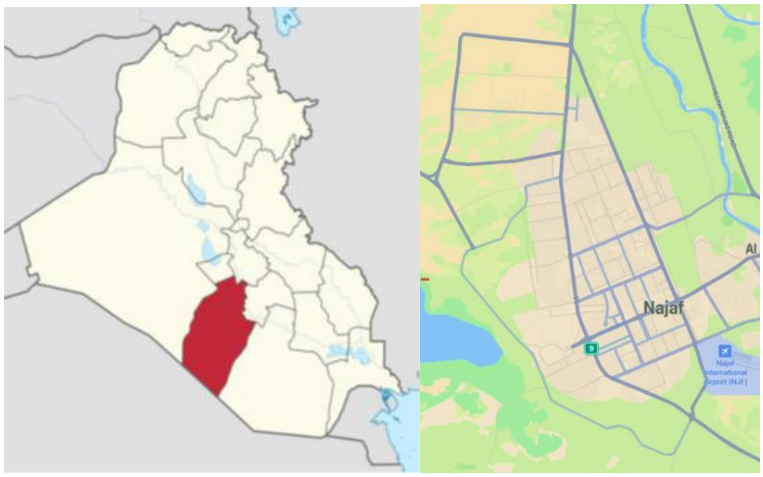


Fig. 3. Site of the city of Najaf, Iraq

6 Previous studies

The city of Najaf has one central station, which relies on vans belonging to individuals and not the government. Note that the roads leading vehicles to residential areas are not part of the government transportation planning, but according to the drivers' assessment, the roads, in their opinion, are not based on engineering principles, and therefore they have many problems. There is no scheduled time, on random trips passengers may have to leave for the station and go take a taxi because there is no trip to the area in question. This is regarding moving the station to the house, but the most difficult thing about it is the reverse movement of the house towards the station, as there is no specific time or station to the city center, (Ahmed, 2016). Studied public transportation and smart transportation system in the Najaf city and the study showed that traffic direction starting from the Najaf city road towards the city of Kufa suffers from austere congestion by 95% percent additionally to other main road in the city. And the cause for this is large trips upcoming to divers' destination for instance (hospital, universities, school, courts, and etc.) Distributed along the way without the use modern transport, as time tabled buses, rapid transit (BRT) buses trams or light rails. (AL- Jameel ,2017). Khalaf, 2023 studied traffic mixing on the main roads of the numbered (1-16) city of Najaf. As shown in Table (5) and Figure (4), the study showed that traffic mixing means the diversity of different types of vehicles on the roads, such as private cars, taxis, minibuses, trucks, and engines. Table (6) represents the percentage of buses on the main roads in the city of Najaf, which is about 0.8%, which indicates the significant weakness of the public transportation sector in the study area. In particular, a high proportion of buses were owned by private travel companies. The travel duration in the study area was high, especially when using public transportation (minibuses), which amounted to 30 minutes on the Kufa-Najaf Street, and 65 minutes on the Kufa-Najaf Street. Najaf. Najaf Street, Al-Mishkhab. With one-way travel measurements (Abdullah, 2023).

Table 5. Street names for the urban road network in the city of Najaf.

No.	Name Of Street
1	Al-Matar Street
2	Najaf-Kufa Street
3	Al-Hizam Street
4	North Garage Street
5	Al-Zaytoon Street
6	Al-Hawlliy Matar Street
7	Najaf – Karbala Street
8	Al-Kafeel University Street
9	Al-Mujamaat Street
10	Qanbar Street
11	Ring Road
12	Salam Gamiaa Street
13	Salam Garrie Street
14	Ghadeer-Furat Street
15	Ghadeer-Karamah Street
16	Al-Iskan Street

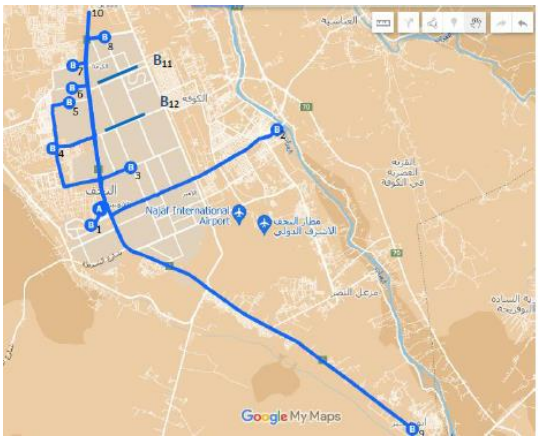
Fig. 4. Al-Najaf urban roads network.

Table 6. Percentage of buses on streets in the city of Najafy

No.	Street name	Bus volume
1	Al-Matar(Airport) street	2 %
2	Al-Najaf-Kufa Street	3,5 %
3	Al-Hizam Street	0,5 %
4	North Garage Street	0,1 %
5	Al-Zaytoon Street	0,4 %
6	Al-Hawlliy Matar Street	0,4 %
7	Najaf – Karbala Street	3 %
8	Al-Kafeel University Street	0,1 %
9	Al-Mujamaat Street	0,25 %
10	Qanbar Complex Street	0,5 %
11	Ring Road	2 %
12	Al-Salam-Gamiaa Street	0,1 %
13	Al-Salam Garri street	0,8 %
14	Al-Gadeer- Furat street	0,1 %
15	Al-Gadeer-Karama street	0,8 %
16	Al-Iskan Street	0,4 %

Existing public transport routes public transport forms in the city of Najaf represented generally by several routes start from Al-Najaf internal garage runs by minibuses, these routes don't cover the entire city and the actual need for people transit as shown in Figure (5) (Khalaf, 2023).

Table 7. Existing public transport routes in Al- Najaf city (Khalaf, 2023)



Origin	Route	Destination
Najaf Internal Garage (A)	A-B1	To Al-Medina Al-Kadima (CBD)
	A-B2	To Kufa city
	A-B3	To Al-Zahra'a District
	A-B4	To Al-Muhandiseen
	A-B5	To Al-Nasr- Muhandiseen
	A-B6	To Al-Milad- Faw
	A-B7	To Al-Nida'a Dist.
	A-B8	To Al-Askary Qubal Dist.
	A-B9	To Abu Skher and Al-Manatherah
	A-B10	To Al-Haideryah
	A-B11	To Al-Wafa'a Dist.
	A-B12	To Al-Askary Dist.

Fig. 5 Public transport routes in Al-Najaf city

7 The Proposed BUS lanes in Al-Najaf city

A bus system is an important transport mode in an integrated multi-modal transport system. Buses can make more efficient use of road space compared to private vehicles in terms of the number of passengers conveyed over a unit length of road. The proposed bus lines include all neighborhoods and residential complexes with scheduled lines that end at typical stations as s hown in the Figure (6).

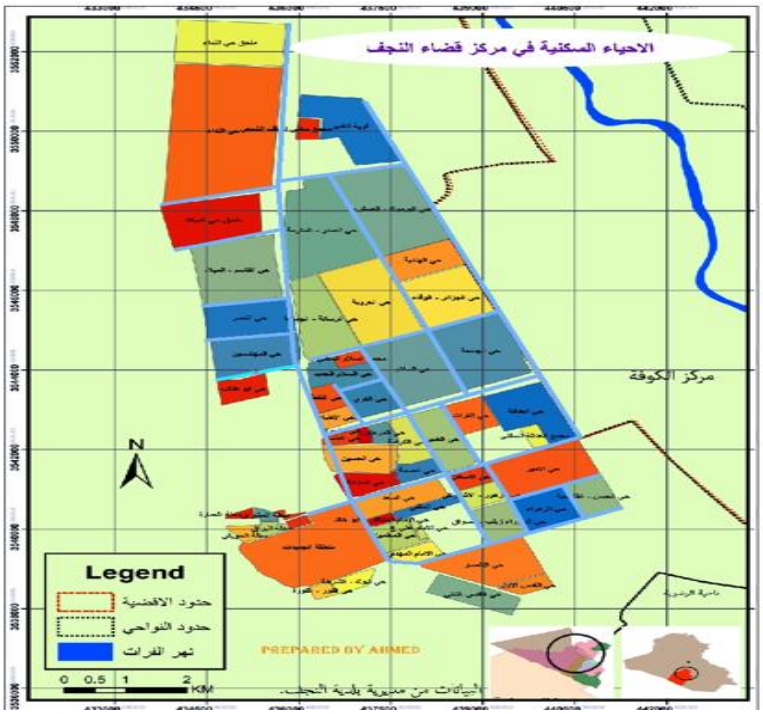


Fig. 6. Proposed Bus lines in the large Najaf city

8 CONCLUSIONS AND RECOMMENDATIONS

1. The transportation system in the city of Najaf suffers from severe congestion of 95%, especially on arterial roads, and the journey time increases reached 30 minutes at Kufa-Najaf Street(8,5)km , 65minutes at Najaf-Mishkhab Street (40) km with one way travel measurements.
2. The absence of planning from specialists of public transportation, Sustainability and reliability are not achieved within city adopt 65% on private vehicles and there is a special transportation system that doesn't have minimum international standards of so-called transportation system.

3. The forms of public transportation in the city of Najaf are generally represented by several routes starting from the internal Najaf garage and passing through small buses the public transport sector is represented by about 10% and 0.8% of minibuses and buses respectively, which have no time schedule and are without fixed routes except the Najaf internal garage. These routes do not cover the entire city and the actual need for people to cross, as the percentage of serviced routes is approximately 27% of the networks.
4. The bus system strategy offers a lot of benefits for utilizing current infrastructure to enhance transit.

References

1. Abdullah,Naseer A. , Dhuha K. Khalaf, Hamid A. Al-Jameel and Mohammed J. Ali,Selected Indicators of Al-Najaf Road Network: Public Transportation Noise and Pollution Published online: 13 September 2023 DOI: 10.1051/e3sconf/202342703038
2. Alharbi, R. (2015). A GIS-based decision support system for reducing air ambulance response times: A case study on public schools in Jeddah city. *Journal of Geographic Information System*, *7*(04), 384.
3. AL-JAMEEL, H. A., & ABDABAS, A. Y. (2018). Towards Public Transportation and Intelligent Transportation System: Najaf City As a Case Study. *Journal of Duhok University*, 104-118.
4. Angel Ibeas, Luigi dell'Olio, Borja Alonso, Olivia Sainz, Received 1 February 2009, Revised 10 August 2009, Accepted 27 October 2009, Available online 14 December 2009
5. Baqer Kamil Ahmed,2016 Small scale terminal location optimization the efficiency transit system
6. Becerik-Gerber, B., Siddiqui, M. K., Brilakis, I., El-Anwar, O., El-Gohary, N., Mahfouz, T., ... & Kandil, A. A. (2014). Civil engineering grand challenges: Opportunities for data sensing, information analysis, and knowledge discovery. *Journal of Computing in Civil Engineering*, *28*(4), 04014013.
7. Berzina, L., Faghri, A., Shourijeh, M., & Li, M. (2013). Evaluation of travel time data collection techniques: A statistical analysis. *International Journal of Traffic and Transportation Engineering*, *2*(6), 149-158.
8. Bigirimana, I., Ntahizaniye, M., & Mikhailov, A. Y. (2023). Estimation of far-side bus stops reliability. In *E3S Web of Conferences* (Vol. 403, p. 07006). EDP Sciences.
9. Bolger, D., Colquhoun, D., & Morrall, J. (1992). Planning and design of park-and-ride facilities for the Calgary light rail transit system. *Transportation Rese* Kwon Y 2001 A Study On The Classification of Park-and-Ride Facilities In The Seoul Metropolitan Areas *The 9th Conference on Transportation Research* by heuristic methods.
10. Boyle, D. K. (2006). *Fixed-route transit ridership forecasting and service planning methods* (Vol. 66). Transportation Research Board.
11. Carrion, C., & Levinson, D. (2012). Value of travel time reliability: A review of current evidence. *Transportation research part A: policy and practice*, *46*(4), 720-741.
12. Caves, R. W. (2004). *Encyclopedia of the City*. Routledge.
13. Chen, A., Yang, C., Kongsomsaksakul, S., & Lee, M. (2007). Network-based accessibility measures for vulnerability analysis of degradable transportation networks. *Networks and Spatial Economics*, *7*, 241-256.
14. Chen, C., Skabardonis, A., & Varaiya, P. (2003). Travel-time reliability as a measure of service. *Transportation Research Record*, *1855*(1), 74-79.
15. Chen, M., Liu, X., & Xia, J. (2005). Dynamic prediction method with schedule recovery impact for bus arrival time. *Transportation Research Record*, *1923*(1), 208-217.
16. Chetan S.More, Harsh Bhadouria, C.Aisha, Dhiraj D.Nirne 2023 June 2023 International Journal of Scientific Research and Management Studies
17. Chiou, Y. C., Jou, R. C., & Yang, C. H. (2015). Factors affecting public transportation usage rate: Geographically weighted regression. *Transportation Research Part A: Policy and Practice*, *78*, 161-177.
18. Czapla, Z., & Sierpiński, G. (2023). Driving and Energy Profiles of Urban Bus Routes Predicted for Operation with Battery Electric Buses. *Energies*, *16*(15), 5706.
19. Daganzo, C. F., & Pilachowski, J. (2011). Reducing bunching with bus-to-bus cooperation. *Transportation Research Part B: Methodological*, *45*(1), 267-277.
20. Daniels, R., & Mulley, C. (2013). Explaining walking distance to public transport: The dominance of public transport supply. *Journal of Transport and Land Use*, *6*(2), 5-20.
21. Fernandez, R., & Planzer, R. (2002). On the capacity of bus transit systems. *Transport reviews*, *22*(3), 267-293.
22. Földes, D., Csonka, B., & Szilassy, P. Á. (2023). Urban Bus Network Electrification.
23. Fredriksson, H., Holmgren, J., Dahl, M., & Lövström, B. (2023). A Median-Based Misery Index for Travel Time Reliability. *Procedia Computer Science*, *220*, 162-169.
24. Gao, P., Liu, Z., Tian, K., & Liu, G. (2016). Characterizing traffic conditions from the perspective of spatial-temporal heterogeneity. *ISPRS International Journal of Geo-Information*, *5*(3), 34.
25. Goodwin, P. (2013). Peak travel, peak car and the future of mobility: Evidence, unresolved issues, policy implications and a research agenda.

26. Gu, Y., Fu, X., Liu, Z., Xu, X., & Chen, A. (2020). Performance of transportation network under perturbations: Reliability, vulnerability, and resilience. *Transportation Research Part E: Logistics and Transportation Review*, *133*, 101809.
27. Gu, Y.; Fu, X.; Liu, Z.; Xu, X.; Chen, A. Performance of transportation network under perturbations: Reliability, vulnerability, and resilience. Transp. Res. Part E Logist. Transp. Rev. 2020, 133, 101809
28. Han, C., Liu, X., Shen, X., Zhang, L., & Feng, N. (2019). Evaluating the spatial deprivation of public transportation resources in areas of rapid urbanization: accessibility and social equity. *Discrete Dynamics in Nature and Society*, *2019*, 1-11.
29. Hensher, D. A., Stopher, P., & Bullock, P. (2003). Service quality—developing a service quality index in the provision of commercial bus contracts. *Transportation Research Part A: Policy and Practice*, *37*(6), 499-517.
30. HighwayCapacityManual2000(HCM2000)//TransportationResearchBoard,NationalResearchCouncil,Washington,D.C.,U.S.A. ,1134(2000)
31. Hollander, Y. (2006). Direct versus indirect models for the effects of unreliability. *Transportation Research Part A: Policy and Practice*, *40*(9), 699-711.
32. Hollander, Y., & Liu, R. (2008). Estimation of the distribution of travel times by repeated simulation. *Transportation Research Part C: Emerging Technologies*, *16*(2), 212-231.
33. Hu, S., Shen, M., & Gu, W. (2023). Impacts of bus overtaking policies on the capacity of bus stops. *Transportation Research Part A: Policy and Practice*, *173*, 103702.
34. Lave, R. E., & Mathias, R. G. (2009). Paratransit systems. *Transp. Eng. Plan*, *1*, 207-245.
35. Liu, R., & Sinha, S. (2007). Modelling urban bus service and passenger reliability.
36. Liu, T., Ceder, A., Ma, J., & Guan, W. (2014). Synchronizing public transport transfers by using intervehicle communication scheme: Case study. *Transportation Research Record*, *2417*(1), 78-91.
37. Lv, Y., Lei, Y., Han, S., & Hong, B. (2023). Study on the installation of bus lane entrances at signal intersections. *Highlights in Science, Engineering and Technology*, *60*, 63-69.
38. Mackie, P., Laird, J., & Johnson, D. (2012). Buses and economic growth: main report. *Institute for Transport Studies. http://www. greenerjourneys. com/2012/07/buses-economic-growth-making-the-link-new-report.*
39. Moreira-Matias, L., Cats, O., Gama, J., Mendes-Moreira, J., & De Sousa, J. F. (2016). An online learning approach to eliminate Bus Bunching in real-time. *Applied Soft Computing*, *47*, 460-482.
40. Niblett, R., & Palmer, D. J. (1993). Park and ride in London and the South East. *Highways & Transportation*, *40*(2).
41. O'Flaherty, C. A. (Ed.). (2018). *Transport planning and traffic engineering*. CRC Press.
42. Perk, V. A., Flynn, J. A., & Volinski, J. (2008). *Transit ridership, reliability, and retention* (No. NCTR-776-07). National Center for Transit Research (US).
43. Pilachowski, J. M. (2009). *An approach to reducing bus bunching*. University of California, Berkeley
44. Schramm, L., Watkins, K., & Rutherford, S. (2010). Features that affect variability of travel time on bus rapid transit systems. *Transportation Research Record*, *2143*(1), 77-84.
45. Ştefănescu, P., Mocan, M., Ştefănescu, W., & Neculai, P. V. (2014). Trip planners used in public transportation. Case Study on the city of Timişoara. *Procedia-Social and Behavioral Sciences*, *124*, 142-148.
46. Stelzer, A., Englert, F., Hörold, S., & Mayas, C. (2016). Improving service quality in public transportation systems using automated customer feedback. *Transportation Research Part E: Logistics and Transportation Review*, *89*, 259-271.
47. Strathman, J. G., Kimpel, T. J., Dueker, K. J., Gerhart, R. L., Turner, K., Griffin, D., & Callas, S. (2001). Bus transit operations control: review and an experiment involving Tri-Met's automated bus dispatching system. *Journal of Public Transportation*, *4*(1), 1-26.
48. Treiber, M., & Kesting, A. (2013). Traffic flow dynamics. *Traffic Flow Dynamics: Data, Models and Simulation, Springer-Verlag Berlin Heidelberg*, 983-1000.
49. Turner, S. M., Eisele, W. L., Benz, R. J., & Holdener, D. J. (1998). *Travel time data collection handbook* (No. FHWA-PL-98-035). United States. Federal Highway Administration.
50. Vuchic, V. R. (2002). Urban public transportation systems. *University of Pennsylvania, Philadelphia, PA, USA*, *5*, 2532-2558.
51. Walker, J. (2012). *Human transit: How clearer thinking about public transit can enrich our communities and our lives*. Island Press.
52. Wirasinghe, S. C. et al. (2013) 'Bus rapid transit – a review', International Journal of Urban Sciences, 17(1).
53. Woodhull, J. (1987). Issues in on-time performance of bus systems. *Unpublished paper. Los Angeles, CA: Southern California Rapid Transit District*.
54. Wu, W., Liu, R., & Jin, W. (2018). Integrating bus holding control strategies and schedule recovery: simulation-based comparison and recommendation. *Journal of Advanced Transportation*, *2018*.
55. X. M. Song, M. Y. Zhang, Z. J. Li, X. Wang, and Y. N. Zhang ,Setting of dynamic bus lane and its simulation analysis and evaluation," Journal of Jilin University (Engineering and Technology Edition), vol. 50, no. 5, pp. 1677–1686, 2020.
56. Zhang, T. (2014). *Bus stop usage evaluation and BRT station selection strategy by machine learning methods*. State University of New York at Albany.

57. Zhang, Y., Xu, H., Lu, Q. C., Lin, S., & Song, J. (2023). Vulnerability Analysis of Bus Network Based on Land-Use Type of Bus Stops: The Case of Xi'an, China. *Sustainability*, *15*(16), 12566.
58. Zhao, J., & Zhou, X. (2018). Improving the operational efficiency of buses with dynamic use of exclusive bus lane at isolated intersections. *IEEE Transactions on Intelligent Transportation Systems*, *20*(2), 642-653.