Delay Predication Model at Some Signalized Intersections in Hilla City

A Thesis

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بِسْمِ اللهِ الرَّحْمَنِ الرَّحِيمِ

﴿ قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا وَإِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ ﴾

صَدَقَ اللهُ الْعَلِيُّ الْعَظِيمُ

سورة البقرة- الآية (32)

Detected To

To the symbol of devotion and sincerity,which showered us with her

love and tenderness

Dear mother

To the source of goodness ,sacrifice and altruism

…....My dear father……

To the example of giving ,pride and sacrifice

.... my brother and sister…....

To all who love me sincerely and sincerely

I dedicate my research to

Acknowledgments

"In the Name of Allah, the Most Gracious, the Most Merciful"

Praise be to Allah his Majesty before anything and after anything and to the prophet "Mohammed and Ahl-Al-Bait" for strength ,courage and wisdom that Allah gave me to complete this humble work and lengthy journey this degree.

My deep appreciation and many thanks go to my supervisor. **Prof. Dr. Nahla Yassub Ahmad** (College of engineering, University of Babylon), for his open handed support and guidance starting from proposal writing up to completion of this thesis work. Without his guidance and valuable comments, this study would not have come to outlook

All Words of love and appreciation are presented to my family, my father, my sisters and especially my lovely mother for their patience , care and encouragement.

Last but not least ,I would like to thank my friends   who helped in a certain way or another in the production of this thesis.

Ali
2023

Abstract:

Suffering from Vehicles jam at intersections are a continuous in Hilla city occurrence due to the increasing volume of traffic. Utilizing traffic simulation software to look for appropriate control methods is an efficient solution to the problem. Different simulation programs produce various evaluation results. The aim of this study is on two simulation software (SYNCHRO10.0 and SIDRA 8.0 PLUS)for predicting total delay time at signalized intersections by using microsimulation software to calibrate data and using statistical software (SPSS) to create model. This study will investigate the main differences between the two programs and select program most representative of traffic movement at signalized intersections .

Develop an empirical model for delay prediction at Signalized Intersections as a function of influence traffic and geometric features. Four signalized intersections(Zalatimo, Eishtar, Al-Thawra, Babal Mashhad)important were selected with different characteristics in Hilla city center. SYNCHRO10.0 and SIDRA 8.0 PLUS)for predicting total delay time at signalized intersections good correlation with field measurement values . Many variables affect the delay model including (degree of saturation (v/c) ratio green to cycle (g/C) and total width of exit roadway of intersection for traffic departing straight divided by total width of lane groups departing to the same exit roadway, in the same phase (We/Ws). The minimum of g/c and large flow rate cause high v/c value (g/C) with delay time has an inverse relationship. Increasing (g/C) leads to decrease the delay. The ratio of total width of exit roadway of intersection for traffic departing straight forward to total width of lane groups departing to the same exit roadway at the same phase at stop line (We/Ws) appear to affect the delay. It is found that although SYNCHRO and SIDRA 8.0 PLUS delay overestimates delay at high (v/c) range, but it does not have a significant difference with the field delay at 95%confidence level.

Field traffic volumes signal timings, phasing and control delay were measured during peak and off-peak periods using video recording technique. Geometric design elements were measured through a field survey and satellite image. A statistical approach is used to develop delay model (linear regression model with 95% confidence level).The statistical analysis indicates that both geometric and traffic variables have a significant effect on delay time.The regression model, developed to estimate delay, shows the good correlation with field values .

The three main subjects included in this study; the first subject included a comparison of actual delay time with delay time produced by software program for all each arm. The second subject included software program delay values versus actual delay values after calibrating the Basic saturation flow rate for all arm. The third subject included Software validation observed delay versus Predicted Delay Finally, the selected software packages are used to evaluate the actual delay times of the various research cases and the corresponding values.

It can be concluded that there are significant differences between the field-measured delay times and the corresponding calculated delay times using the selected software simulation. Results show that SYNCHRO10.0 software best software for prediction of the field delay time at signalized intersections (Zalatimo, Eishtar,Bab al-Mashhad) while SIDRA 8.0 PLUS software best for Al-Thawra intersection after the calibration process empirical model for predicting total delay time. This study can provide references for simulation software selection.

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Abbreviations

Abbreviations	Description
d_{vq}	Delay time-in-queue per vehicle
adj	Adjustment term for model
ANOVA	Analysis Of Variance
CF	Correction Factor
CI	controller interface
et al	and others
FHWA	Federal Highway Administration
Fig	Figure
FVS	Fraction of vehicle stopping
g/C	Green ratio
GIS	Geographic Information System
h	headway
HCM	Highway Capacity Manual
HDM	Highway Design Manual
K-S	Kolmogorov-Smirnov
LOS	Level of service
LT	Left Turn
MLR	multiple linear regression
MLR	Multiple Linear Regression
MOE	Measure Of Effectiveness
MSE	mean square error
PCE	Passenger Car Equivalent
PCU	Passenger Car Unit
PHF	Peak-hour factor
PHF	Peak Hour Factor
RT	Right Turn
SFR	Saturation Flow Rate
SORB	State Organization of Road and Bridges
SPSS	Statistical Package for Social Sciences
S-W	Shapiro-Wilk
TFF	Traffic Forecast Factor
TFF	Traffic Forecast Factor
TH	Through Turn

TRB	Transportation Research Board
Vstop	stopping vehicle
Vtot	total vehicles
Viq	vehicle-in-queue counts

Chapter One
Introduction

Chapter One
Introduction

1.1 General:

Traffic congestion is one of the major problems in many cities around the world. Local agencies try to often propose some solutions to reduce traffic delays at intersections. Some of the proposed solutions included changing roundabout intersections to signalized intersections.

Delay compares the performances of an intersection under different control demand and operating conditions.The accurate prediction of delay is therefore very important, but its accurate estimation is difficult due to random traffic flows and other uncontrollable factors.

Delay can be estimated by measurement in the field, simulation, and analytical models. One of these methods, analytical estimation is the most practical and convenient. In estimating of delay at signalized intersections, a number of analytical models have been proposed and developed using different assumptions for various traffic conditions **(Akgungor and Bullen,2014).**

Global cities face rising traffic congestion. This situation is getting worse and becoming a major concern of the public. Traffic congestion is a condition of traffic delay, because the number of vehicles using a road exceeds the operational capacity of the network to handle **(Boamah, 2010).**

One of the negative effects of congestions is the increase in large amounts of fuel consumption that affects financial terms on the car's owner and productivity terms of the state that reflects on the economy in those areas. In addition, it contributes to the air pollution, which has a harmful effect on the quality of life, and reduces the investment attractiveness in the city by some global investors **(Warid, 2004).**

For many years, measurement of the level of performance of signalized intersections has primarily focused solely on vehicle delay. Beside delay, other performance measures such as the number of vehicle stops and the spatial extent of queues on intersection approaches have also been found to play an important role in the performance evaluation of signalized intersections of developing countries, where most of the times the intersection remains near or at oversaturated condition. Hence, stop and go situation is very frequent at intersections. These measures not only relate to the level of service provided to the drivers but also to the level of fuel consumption and air pollution generated by the vehicles traversing the signalized intersections. In particular, while vehicle stop estimates play an important role in determining vehicle fuel consumption and emissions on intersection approaches, queue length estimates are important not only for the design lanes, but also to ensure that traffic signal operations do not result in vehicle queues that spillback onto upstream intersections (**Rakha et al., 2001**)

1.2 Statement of the Study

The current research aims to study the effect of traffic congestion in the Hilla city on travel time, driver behavior and causes discomfort to drivers and visitors Number of vehicles increases rapidly without considerable increase in the capacity of the road network, which leads to increase delay. Field measurement delay calculations by Highway Capacity Manual(HCM2010).A lot of simulation software will be used to calculate control delay and level of service (LOS). This study will investigate the main differences between the two simulation software. SYNCHRO10.0 and SIDRA 8.0 PLUS. Select program most representative of traffic movement at signalized intersections and predication delay Predication model at Some Signalized Intersections in Hilla City.The study methodology can be presented in Figure (1-1).

1.3 Objectives of the Study

The main objectives of this study are, as follows:

1. Field measurement delay calculations by Highway Capacity Manual 2010 for the selected signalized intersections .

2. Application of software programs (Synchro10 and SIDRA 8.0 intersection plus) to simulate traffic operations at signalized intersections to calculate control delay and level of service for the selected signalized intersections in Hilla City.

3. Developing statistical model for the prediction of vehicle delay at signalized intersections

4. Comparative Study Using of SYNCHRO10.0 and SIDRA Software with field measurement delay calculations by Highway Capacity Manual 2010 for the selected signalization intersection.

5. Evaluating the traffic performance at the study area by using the required traffic and/or geometric solutions to alleviate the congestion problem at the selected signalized intersections.

1.4 Structure of the Research:

This study is conducted in a number of stages, which are described in chapters of this thesis, as follows:

1. Chapter one presents introduction to the subject and the objectives of this study.

2. Chapter two reviews the literature which is related to previous studies

3. Chapter three describes the study area , the methodology of data collection and abstraction to be used in the selected traffic software programs.

4. Chapter four demonstrates the results of the analysis, graphical representation of the results , discussion and improvement.

5. Chapter five Provides conclusions from this study,recommendations, and suggestion for further research study.

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        │    Data Collection Using Survey Field              │
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    │ Measurement         │  │ intersection Software│ │ Software            │
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Figure (1-1): Research Methodology

Chapter Two
Literature Review

Chapter Two
Literature Review

2.1 Introduction

This chapter includes details of some characteristics .General idea about delay models for signalized intersection, and overview of software package using to evaluate signalized intersection.

The first light signal was installed on December 10, 1868, outside the British Parliament in London. This signal was designed by John Peake Knight, the railway engineer so the signal was very similar to the rail signals at that time, so that it had two mobile arms, one red and the other green, which were used to control the movement during the day, as well as gas lights that were used during the night. This signal was not automated but was controlled by a traffic policeman standing by it all the time. This signal exploded two years after its installation - on January 2, 1869**. [HDM, 2017]**

The traffic light of the current shape - with electric lights and without arms began in Utah in the United States in 1912. In 1914, the American Light Signal Company added a voice signal to the traffic signal to signal a change in signal color. In 1920, a police officer replaced the alarm clock with a third light. The first automatic control began in March 1922 in Texas. The city of Toronto was the first city to control all optical signals in it automatically. But this was only in 1963. The second-meter display was introduced in the 1990s, allowing the driver to determine whether he could cross the street before the signal turned red, but that idea was not widespread. **[Muraleetharan et al, 2003].**

2.2 Intersections:

An intersection is a general area where two or more highways join or cross at grade, within which the roadway and roadside facilities are included for traffic movements in that area. **(SORB, 2005).**

The intersection is required to control conflicting and merging streams of traffic so that delay is minimized. This is achieved through choice of geometric parameters that control and regulate the vehicle paths through the intersection These determine priority so that all movements take place with safety **(Rogers, 2008).**

The intersection as an area, shared by two or more roads whose main function is to provide for the change of route direction. Intersections vary in complexity from a simple intersection, which has only two roads crossing at a right angle to each other, and more complex intersection, where three roads or more cross within the same area **(Garber and Hoel, 2010).**

2.3 Signalized Intersections :

Traffic control signals that are properly designed, located, operated and maintained will have one or more of the following advantages**(FHWA, 2009):**

1. Providing the orderly movement of traffic.
2. Increasing the traffic-handling capacity of the intersection if proper physical layouts and control measures are used.
3. The signal operational parameters are reviewed and updated (if needed) on a regular basis as engineering judgment determines that significant traffic
   flow and/or land use changes have occurred) to maximize the ability of the
   traffic control signal to satisfy current traffic demands.
4. Reducing the frequency and severity of certain types of crashes, especially right angle collisions.

5. Using coordinated signals provide for continuous or nearly continuous movement of traffic at a definite speed along a given route under favorable conditions.

6. Using the interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to cross.

   Traffic control signals, even when justified by traffic and roadway conditions can be ill-designed, ineffectively placed, improperly operated, or poorly maintained. Improper or unjustified traffic control signals can result in one or more of the following disadvantages **(FHWA, 2009):**

1. Excessive delay.

2. Excessive disobedience of the signal indications.

3. An Increase use of less adequate routes as road users attempt to avoid the traffic control signals.

4. A significant increase in the frequency of collisions (especially rear-end collisions).

2.4 Flow Characteristics For Signalized Intersection:

For a given approach at signalized intersection, three signal indications are seen: green, yellow, and red. The indication may include a short period during which all indications are red, referred to as an all-red interval, which with the yellow indication forms the change and clearance interval between two green phases. Figure (2-1) presents some fundamental attributes of flow at signalized intersection .The diagram represents a simple situation of one-way approach to signalized intersection having two phases in the cycle **(HCM, 2000).**
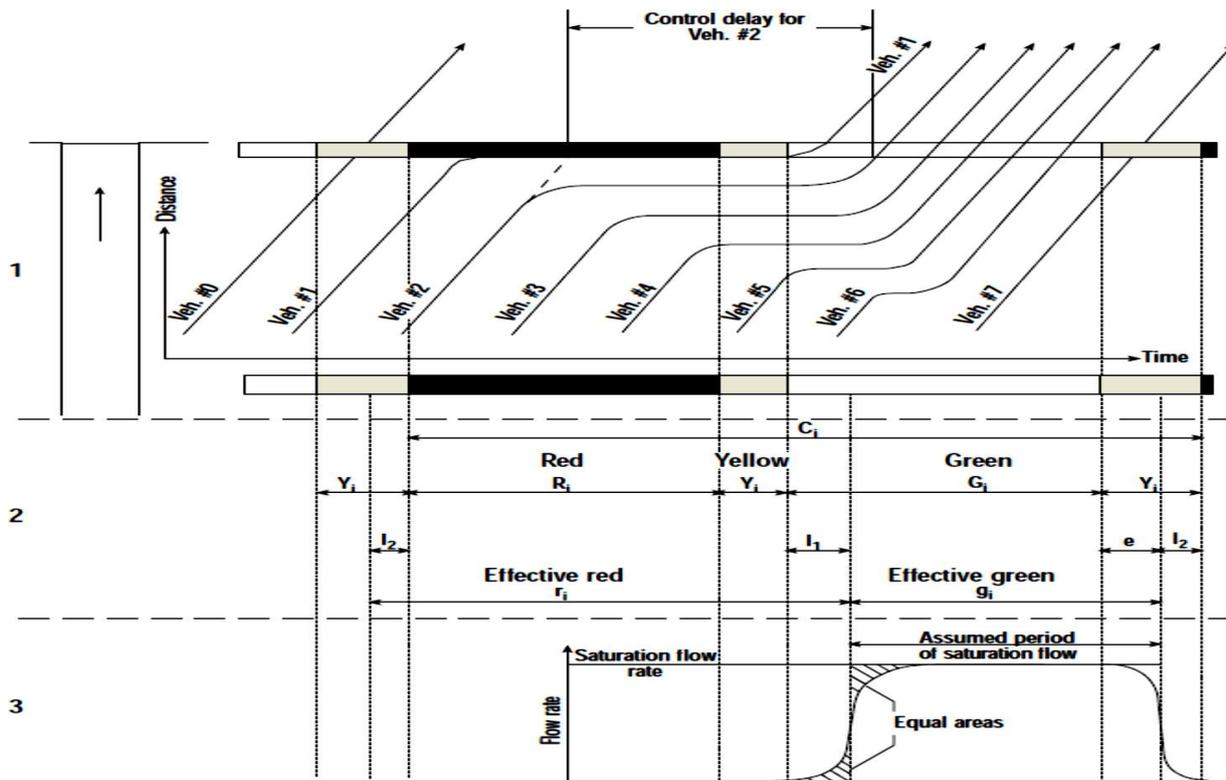
Figure (2-1): Fundamental Attributes of Flow at Signalized Intersection (**HCM, 2000**)

The diagram is divided into three parts. The first part shows a time-space plot of vehicles on the northbound approach to the intersection. Intervals for the signal cycle are indicated in the diagram. The second part repeats the timing interval, and labels the various time intervals of interest with the symbols. The third part is an idealized plot of flow rate past the stop line, indicating the saturation flow rate.

2.5 Capacity of Signalized Intersections:

The capacity of a traffic signal approach may be defined as the maximum number of vehicles that can pass when the signal turns to green under the prevailing traffic and weather conditions. Therefore, the capacity of a signal controlled junction is limited by the capacities of the individual approaches to the junction **(Sofia, 1998).**The maximum hourly rate at which persons or vehicles can reasonably be expected to traverse point or uniform section of

a lane or roadway during a given time period under prevailing roadway, traffic and control conditions (**HCM, 2000).**

The factors which affect capacity are **(Al-Azzawi,2003):**

1. **Physical and operation factor:**Includes parking condition,width of approaches one -way or two-way operation and number of lanes.

1. **Traffic characteristics:** Consist of traffic signals(length of cycle time and green to cycle time ratio for each approach) and marking of approach lanes.

2. **Environmental factors :**Include degree of utilization of an individual approach variation of demand during the peak hour and the location of the intersection
.   within the metropolitan area.

3. **Control measures**: Involve turning movements and vehicles composition (Cars, buses and trucks).

4. **Area type:** the saturation flow in central business district (CBD), where intersection geometry, pedestrian flow, and roadside friction are more restrictive is less than the saturation in other areas. Capacity of signalized intersections is based on the concept of saturation flow rate, which is defined as the maximum rate of flow that can pass through a given lane group under prevailing traffic and roadway conditions, assuming that a given lane group has 100% of real time available as an effective green time and is expressed in units of vehicles per hour of effective green time (vphg) **(TRB, 2005).** Figure(2-2) shows that, the   average rate of flow is lower during the first few seconds (while vehicles are accelerating to normal running speed) and also during the amber period (as some vehicles decide to stop and others continue to move on) It is convenient to replace the green and amber periods by an "effective green" period, during which the flow is assumed to take place at the saturation rate combined with a "lost" time during which no flow takes place .This is a

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useful because capacity is then directly proportional to green time. The capacity of the lane group is **(HCM,2000):**

. $$c = s * (g/C)$$ Eq.(2-1)

where:

c : capacity of lane group (vph),

s: saturation flow for lane group (vph),

g: effective green time for lane group ,

C: cycle length.

cycle time (c = R + G + t_y = r + g)

c   cycle time (c = R + G + t_y = r + g)
G, R   displayed green and red times
G_s, G_u   saturated and unsaturated parts of the displayed green period (G = G_s + G_u)
g, r   effective green and red times
g_s, g_u   saturated and unsaturated parts of the effective green period (g = g_s + g_u)
t_y   yellow time
t_s, t_e   start loss and end gain times
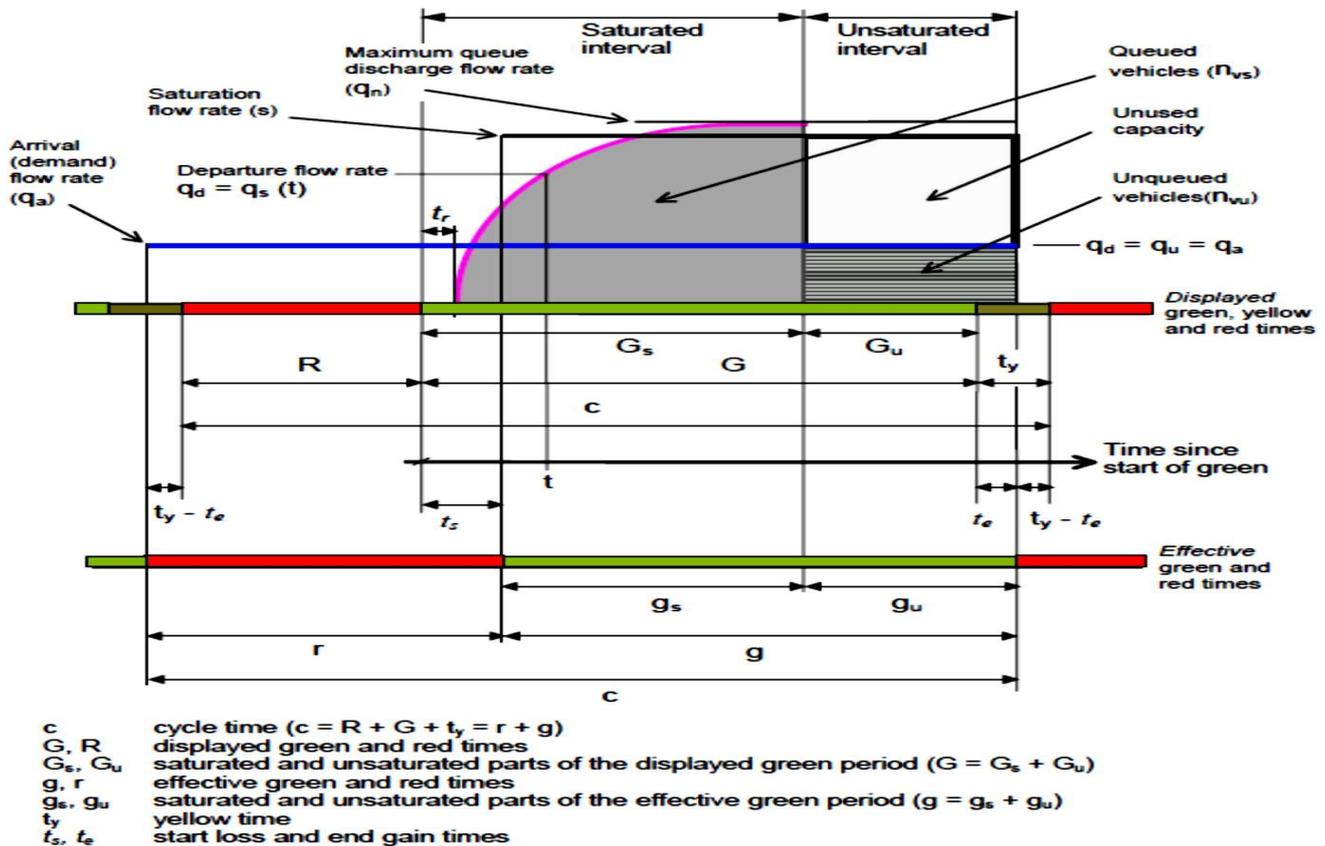
Figure (2-2): Saturation Flow and the Related Signal Timing Parameters
(Akcelik, 2009)

There are also several factors affecting saturation flow which can be summarized in Table (2-1) **(Al-Azzawi, 2003).**

Table (2-1): Principal Factors Affecting Saturation Flow (**Al-Azzawi, 2003).**

Factors	Element Affecting Saturation Flow
Geometric Condition	• Approach width • Width of lanes • Number of lanes • Grade • Turning Radius • Length of turn bay
Operating Condition	• Signal timing and phasing arrangements • Peaking characteristics • Parking activities • Bus stop operations
Traffic Characteristics	• Traffic composition • Turning movements • Pedestrian activity
Environmental and other Factors	• Weather • Driver behavior • Area population • Roadway surface conditions • Adjacent land use

2.6 Delay at Signalized Intersection:

Delay is one of the key parameters that is utilized in the optimization of traffic signal timings. Furthermore, delay is a key parameter in computing the level of service provided to motorists at signalized intersections. Delay, however is a parameter that is difficult to estimate because it includes the delay associated with decelerating to a stop, the stopped delay and the delay associated with accelerating from a stop **(Youn, 2000).**

Delay can be quantified in many different ways. The most frequently used forms of delay are defined below:

• Stopped time delay

• Approach delay

• Travel time delay

These delay measures can be quite different, depending on conditions at the signalized intersection. Figure (2-3) shows the differences among stopped time approach, and travel time delay for single vehicle traversing a signalized intersection. The desired path of the vehicle is shown, as well as the actual progress of the vehicles which includes a stop at a red signal.

The delays experienced on the arterial signalized streets are mainly associated with the intersections where conflicting movements are separated and controlled by traffic signals. These traffic signals can operate under an isolated control strategy, with the signal settings of each signal set independently of the settings of adjacent signals. The delay is defined as the difference in travel time when a vehicle is unaffected by the controlled intersection and when a vehicle is affected by the controlled intersection. This delay includes lost time due to deceleration and acceleration as well as stopped delay. Thus, intersection delay estimates are directed toward estimating total delay or simply

stopped delay   **(Youn, 2000).**

$D_1 =$ Stopped time delay
$D_2 =$ Approach delay
$D_3 =$ Travel time delay
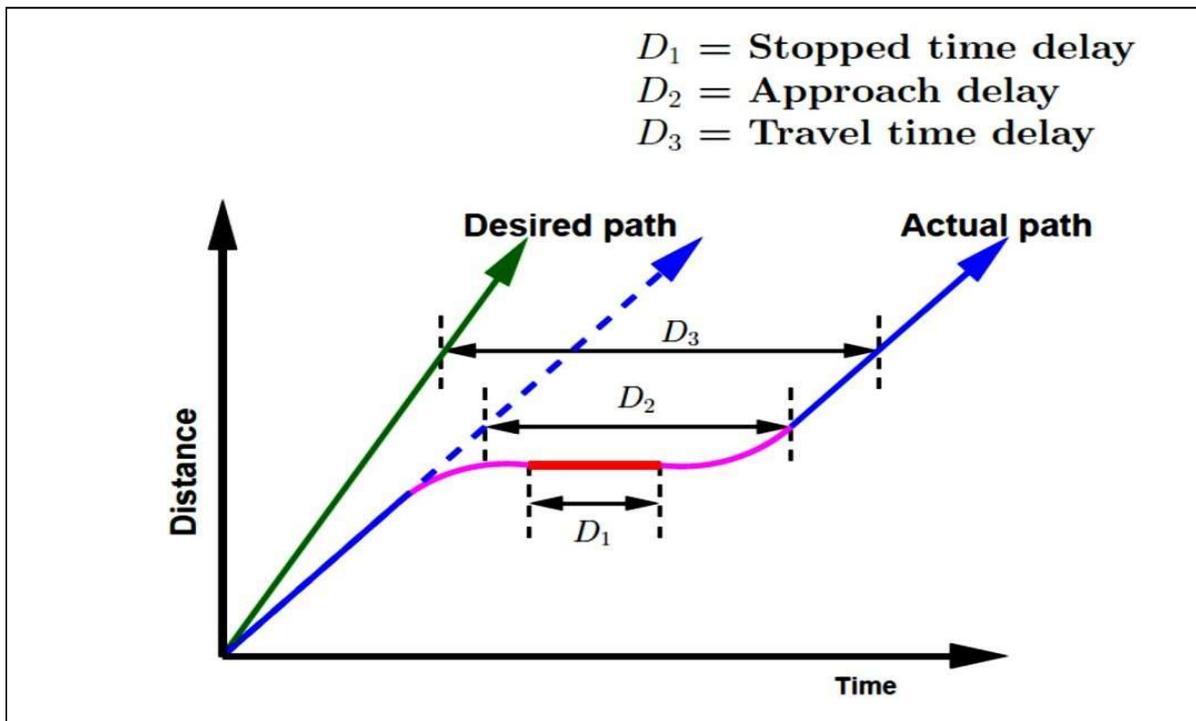
Figure (2-3): Illustration of Delay Measures **(McShane, 2004).**

Control delay is used to define the level of service at signalized intersections, since delay not only indicates the amount of lost travel time and fuel consumption but it is also a measure of the frustration and discomfort of motorists. Control or signal delay, which is that portion of total delay that is attributed to the control facility, is computed to define the level of service at the signalized intersection. This includes the delay due to the initial deceleration, queue move up time, final acceleration and stopped time. Reasonable levels of service can therefore be obtained for short cycle lengths, even though the (v/c) ratio is as high as 0.9. To the extent that signal coordination reduces delay different levels of service may also be obtained for the same (v/c) ratio when the effect of signal coordination changes **(Garber and Hoel, 2009).** The LOS for a signalized intersection are shown in Table (2-2).

Table (2-2): Level of Service Criteria for Signalized Intersections **(HCM, 2010).**

Control delay(s/veh)	LOS by volume to capacity ratio		General Description
	≤1.0	>1.0	
<10	A	F	Free Flow
>10-20	B	F	Stable Flow (slight delays)
>20-35	C	F	Stable Flow (acceptable delays)
>35-55	D	F	Approaching unstable flow (tolerable delay, occasionally wait through more than one signal cycle before proceeding)
>55-80	E	F	Unstable Flow (intolerable delays)
>80	F	F	Forced flow (jammed

(HCM, 2010) suggested the method in order to determine control delay, which is based on direct observation of vehicle in queue counts at the intersection. The delay that experienced by all vehicles that arrive during the analysis period is represented as an average control delay" as shown in

$$d = d1 + d2 + d3 \qquad \text{Equation (2-2)}$$

Where:

d = control delay (sec/veh)

d1 = uniform delay (sec/veh)

d2 = incremental delay (sec/veh)

d3 = initial queue delay (sec/veh)

These delay components are discussed briefly below, while their formulae are in Table (2-3).

Table (2-3): Delay Component and Variables **(HCM, 2010).**

Delay Component	Variables
$$d1 = 0.5C \frac{[1 - \frac{g}{C}]^2}{1 - [Min\,(1,X)\frac{g}{C}]} \qquad Eq.(2-3)$$	C=cycle length (second) g=effective green time for lane group (second) X=v/c ratio for lane group
$$d2 = 900\,T\left[(X-1) + \sqrt{(X-1)^2 + \frac{8KIX}{cT}}\right] Eq.(2-4)$$	T=duration of analysis period (hour), K=delay adjustment factor that is dependent on signal controller mode, I=upstream filtering/metering adjustment factor, C=lane group capacity (veh/hr.) X=v/c ratio for lane group.
$$d3 = \frac{3600}{vT}\left(\frac{tA\,Qb + Qe}{2} + \frac{Qe^2 + Qeo^2}{2Ce} - \frac{Qb^2}{2Ce}\right) \qquad Eq.\ (2-5)$$ $Qe = Qb + tA(v - CA)$ $if\ v \geq cA\ then:\quad Qeo = T(v - CA)$ $tA = T$ $Qeo = 0.0\ veh$ $if\ v < cA\ then:$ $tA = Qb/(CA - v) \leq T$	T=duration of analysis period (hour) v=demand flow rate (veh/h) tA=adjustment duration of un-met demand in the analysis period (hour). CA=average lane group capacity (veh/h), Qb=initial queue at the start of the analysis period. Qe= initial queue at the end of the analysis period Qeo = initial queue at the end of the analysis period when v>CA and Qb = 0.0 veh

2.7 Development of Delay Models:

Estimation of delay at signalized intersections is a complex process and depends on a number of parameters, among which the degree of saturation (x = v/c) is the most important :

(Allsop,1972) in 1952,Wardrop was one of the first delay expression developed. Wardrop assumed that vehicles enter the intersection with uniform arrivals. In this model 1/2s is generally small compared with r and can be neglected. The Wardrop's expression is expressed as :

$$d = \frac{(r - \frac{1}{2s})^2}{2C(1-y)} \qquad\qquad \text{Eq.}\,(2-6)$$

where:

d = average delay per vehicle in sec,

r = the effective red time in sec,

s = saturation flow on the approach in vps or vph,

C = cycle length in sec,

y = flow ratio.

(Webster,1958) developed a model for estimating the delay incurred by motorists at under-saturated signalized intersections that become the basis for all subsequent delay models. The mathematical form of the model :

$$d = C\,\frac{(1-\lambda)2}{2(1-\lambda X)} + \frac{x^2}{2v(1-X)} - 0.65\left(\frac{C}{v^2}\right)^{\frac{1}{3}} [X^2 + 51] \qquad \text{Eq.}\,(2-7)$$

where:

d = average overall delay per vehicle (seconds)

λ = proportion of the cycle that is effective green (*g/C*)

C = cycle length (seconds),

v = arrival rate (vehicles/hour),

c = capacity for lane group (vehicles/hour),

g = effective green time (seconds).

X= lane group v/c ratio or degree of saturation

In Equation (2-7), the first term represents the average delay to the vehicles assuming uniform arrivals. The second term estimates the additional delay due to the randomness of vehicle arrivals. This additional delay is attributed to the probability that sudden surges in vehicle arrivals may cause the temporary oversaturation of the signal operation. The third term, finally, is an adjustment factor that is introduced in the model to correct the delay estimates and that develops semi-empirically.

(**Sierpiński,2007**) proposed a signalized intersections model using the queueing theory analytical models. The developed model is the mean waiting time from both Clayton's model and the M+/G+/1 queueing model where arrivals are Markovian (modulated by a Poisson process), service times have a General distribution and there is a single server which employs compressed queueing procedures. Equation.[2-8] describes the suggested delay model:

$$dM = \frac{Tc\left[1 - \frac{Ge}{Tc}\right]}{2\left[1 - \frac{Ge}{Tc}\,\rho\right]} + \frac{\lambda.\sigma\,\mu^2 + \lambda[1\,\mu - \varDelta]^2}{2(1-\rho)}(1 - \mu\varDelta) \qquad\qquad \text{Eq.}\,(\,2-8\,)$$

where:

$\varDelta$ =Lowest time distance between vehicles (s).

$\sigma\,\mu^2$=Variance of service time (s).

Ge=Green signal duration (s).

Tc= length of the cycle (s)

dM =Average delay per vehicle (s)

μ =Service rate (veh/s).

ρ =Flow ratio (v/c).

λ =Arrival rate (veh/s).

This formula makes a generalization of the **(Webster's model,1958)**.Webster used the M/D/1 queuing model represents the queue length in a system having a single server, where arrivals are determined by a Poisson process and job service times are fixed (deterministic)and his formula has got a form, as follow

$$d = \frac{Tc\left[1 - \frac{Ge}{Tc}\right]^2}{2\left[1 - \frac{Ge}{Tc}\rho\right]} + \frac{\rho^2}{2.\lambda(1-\rho)} - 0.65\left(\frac{C}{v^2}\right)^{\frac{1}{3}}.\rho^{[2+5\frac{Ge}{Tc}]} \quad Eq.(2-17)$$

represents the queue length in a system having a single server, where arrivals are

determined by a Poisson process and job service times are fixed (deterministic)

where:

d = average delay per vehicle (s).

Tc = length of cycle (s).

Ge = effective green signal duration (s).

ρ = flow ratio (v/c).

λ= arrival rate (veh/s).

(Sofia et al.,2014) proposed a model for two Signalized Intersections with different characteristics to be selected in Sulaymaniyah city. SPSS software version 20 is used to develop the delay model. The statistical analysis indicates that both geometric and traffic variables have a significant effect on delay time. A statistical approach (linear regression model with 95%,F-value is set to 3.84 to enter and 2.71 to remove).. The model has been compared with SYNCHRO delay model. It is found that although SYNCHRO delay overestimates delay at

high (v/c) range, but it does not have a significant difference with the field delay at 95%confidence level. The proposed delay model has a form as Equation

$$d = 0.102\ C + 30.19\ v/c + 19.59\ (1\text{-We/Ws}) \qquad \text{Eq. (2 - 10)}$$

where:

d=Delay for lane group(sec/veh).

v = Vehicular flow rate(veh/h).

c = Capacity of lane group(veh/h).

C=Cycle length(sec).

Ws= Total width of lane groups departing to the same exit roadway, in the same phase at stop line (m).

We = Total width of exit roadway of intersection for traffic departing straight forward (m)

(Rahul et al,2018) developed a model field delay obtained by Simpson's one third rule as regressed against varied parameters involved in estimation of delay to determine most satisfactory model.

$$\text{Delay} = 80.640 + 0.039c - 0.048\ v - 5.539 R_p \qquad \text{Eq. (2 - 11)}$$

Where
c = capacity in vehicles/hour
v = flow rate in vehicles/hour
R_p = platoon ratio

2.8 Some overview of software package using to evaluate signalized intersections.

Simulation software is an effective evaluation tool for determining the best way to control a signalized intersection. The effectiveness and feasibility of different simulation vary, however, making it difficult to select the best

simulation software for a given project. At present, a lot of simulation software such as VISSIM, SIDRA SYNCHRO, AIMSUN, SIMTRAFFIC can be applied to evaluate the signalized intersections. it is difficult to provide an accurate description of traffic flow. While several models have been .put out thus, none of them can be considered perfect or, at the very least, universal**(Bloomberg,2000)**.Below is a review of the most important traffic simulation software used

   (Al-Omari et al,2007) compared between HCS and SIDRA. The results of the analysis showed that, for low delay ranges, HCS tends to slightly over-estimate control delay; while SIDRA has a predicted control delay that is in good agreement with the field data. At higher delay levels, HCS has noticeable scattered predictions as compared to field data with more tendencies to over-estimate, while SIDRA provides less scattering than HCS. It was found that the two models can be improved significantly by calibrating bus Passenger Car Equivalent (PCE) factor or the basic saturation flow rate. However, the best improvement could be obtained by calibrating both the basic saturation flow rate and bus PCE factor, simultaneously. It can be concluded that the two softwares can be used for traffic analysis in Jordanian conditions after calibrating both the saturation flow rate and bus PCE factor. However, SIDRA showed a better performance than HCS.

   (Jameel,2011) Estimated a delay time at two important intersections in Baghdad City using Highway Capacity Manual Model (HCM) ,which is widely used for estimating delay at signalized intersections in Iraq. Signalized and Unsignalized Intersection Design and Research Aid SIDRA INTERSECTION4.0 Model found that the method of statically comparison has been used in many research to validate the theoretical model results with the

actual value. The results of the analysis showed that the Highway Capacity Manual (HCM) model using HCS and SIDRA INTERSECTION4 with HCM model gives a predicted control delay that is best agree with the field data is SIDRA model. This study showed that traffic softwares, which are being used in the developed countries, should not be used in Iraq or other developing countries before calibrating their parameters that are believed to be different from those in developed countries such as the ones related to driver behavior .

(Tianzi et al,2013) It is a comparative Study of VISSIM and SIDRA on Signalized Intersection Based on the real traffic data takes from the West Wenhua Road and Changchun Road of Xianyang City, their features and evaluation results of signalized intersections have been analyzed from the perspective of operation simplicity and the output error. Results show that SIDRA s operation is easier while VISSIM s output is more accurate. This study can provide references for simulation software selection

2.9 Summary

Equation for vehicle delay at traffic signalized intersections is one of the recent and very rare studies in the field of traffic engineering. The simulation softwares were used and compared with field measurement delay using HCM 2010 and selected best simulation softwares regarding data entry and identification of analysis outputs with field measurement delay for main selected signalized intersections in Hilla city.

Chapter Three

Methodology and Data Collection

Chapter Three
Methodology and Data Collection

3.1 General

Traffic congestion consider the main problem for the traffic engineering increasing in the number of vehicles caused traffic congestion in the Hilla city

Vehicle delay is the most important parameter used by transportation professionals to measure the performance of signalized intersections. This importance of vehicle delay is reflected in the use of this parameter in both design and evaluation practices. For example, delay minimization is frequently used as a primary optimization criterion when determining the operating parameters of traffic signals at isolated and coordinated intersections .Delay is also a parameter that is not easily determined, for instance, indicated that a perfect match between field-measured delay and analytical formulas could not be expected. The difficulty in estimating vehicle delay at signalized intersections is also demonstrated by the variety of delay models for signalized intersections that have been proposed over the years   **(Garber and Hoel, 1997).**

Delay can be estimated by measurement in the field,simulation,analytical models. This chapter presents description of the study area in Babil city. Brief description of the used methods for data collection and abstraction is also presented with description of the computer programs used for traffic data abstraction and analysis.

3.2 Study Area Description

The area of the study consists of four main signalized intersections in Hilla city. These junctions suffer from congestions bottlenecks ,some morning peak times and the   other at evening peak times. Table (3.1) and Figure (3.1) show the names, codes, traffic control types, and geometric layout.

Table (3-1): Intersections Names, Codes, and Traffic Control Types.

Intersection code	Intersection name	Control type
1	Eishtar Intersection	Signalized Intersection / three arm
2	Al-Thawra Intersection	Signalized Intersection-Four arm and overpass E-W
3	Zalatimo Intersection	Signalized Intersection -Four arm
4	Bab al-Mashhad	Signalized Intersection - Four arm

Figure (3-1): Signalized Intersections in the study area

Abrief description of selected intersections is presented below :

3.2.1 Eishtar Intersection:

It is three-arm signalized intersection. The north approach leads to 40 Street, which consists of three lanes: one lane for right-isolated movement and two lanes left-isolated movement. The east approach leads to Al-Tayra approach, which consists of four lanes one lane U-turn movement, two lanes through movement and the right lane is permitted movement without island separation. The west approach leads to the city center approach and consists of four lanes: two lanes for each through and left movement. The presence center governorate and commercial buildings near the intersection led to traffic congestions bottlenecks during peak hour. The plate and geometry layout as shown in Plate(3-1)and Figure (3-2).

Plate (3-1): Eishtar Signalization Intersection
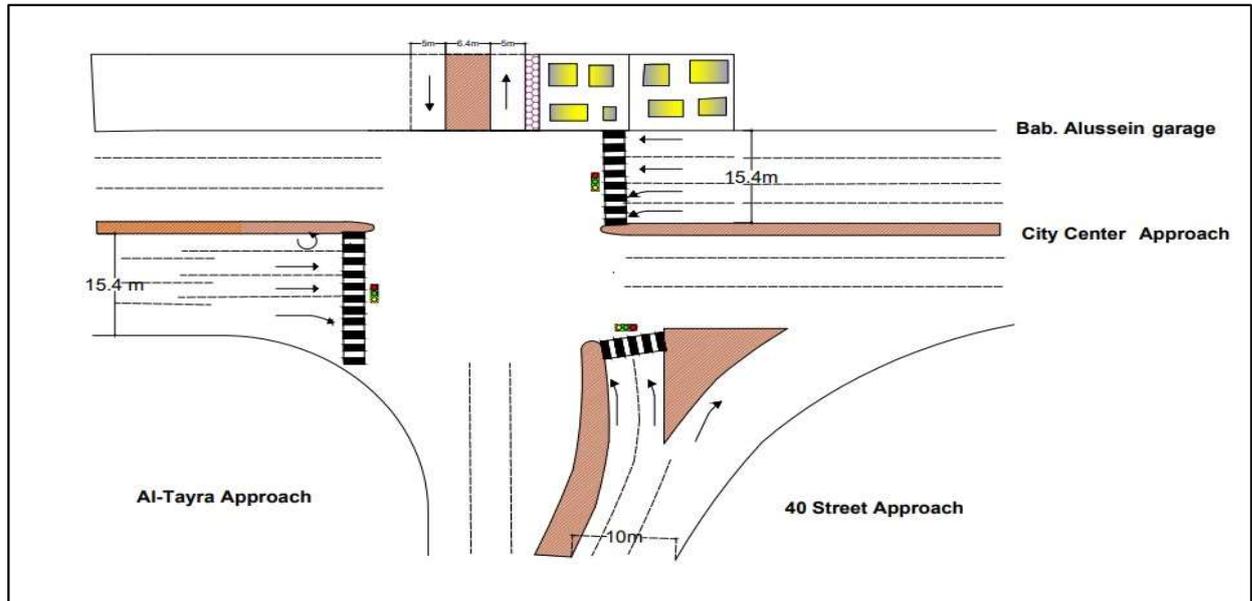
Figure (3-2): Eishtar Signalization Intersection Layout

3.2.2 Al -Thawra Intersection:

It is four-arm signalized intersection. The north leads to the AL-Tayara approach, while the south leads to the Karbala approach; both of them consist of eight lanes: each three lanes for through and left movement respectively, one lane is sharing between them ,and one lane isolated right movement. The east approach leads to 60 Street, while the west approach leads to Baghdad. Both have four lanes: three lanes left and one lane right-isolated movement. Overpass for through movement (Baghdad/60) approach. Intersection is one of the most important intersections in AL-Hilla City being a major crossing point to the governorates of holy Karbala and Baghdad. The excessive traffic volumes, during the peak periods (at morning and evening), of vehicles that entering the intersection increase traffic density, reduce travel speed, increase travel time, and increase the delay values .The plate and geometry layout as shown in Plate(3-2)and Figure (3-3).

Plate (3-2): Al -Thawra Signalization Intersection
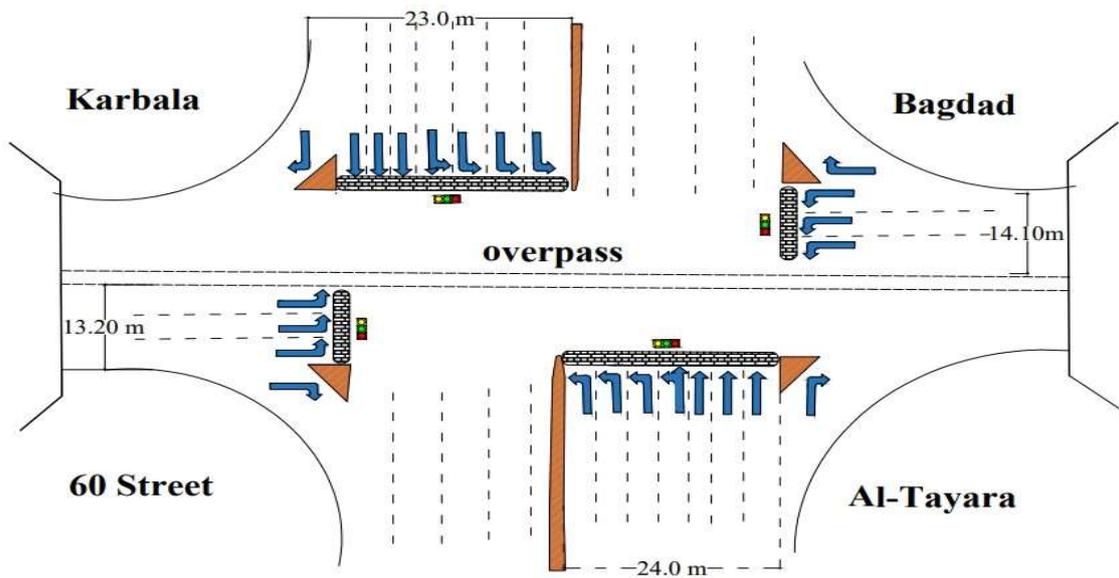
Figure (3-3): Al -Thawra Signalization Intersection Layout

3.2.3 Zalatimo Intersection:

It is four-arm signalized intersection. The north approach leads to the Alziraea approach, while the south approach leads to the 40 Street approach; both of them consist of five lanes: two lanes through movement, two lanes left movement, and one right lane isolated movement. The east approach leads to AL-gameia consisting of four lanes: one lane left movement, two lane through movement, and one lane right isolated movement. The west approach leads to AL-Tuhmazeya, consisting of five lanes, two lanes through movement, two lanes left movement, and right lane isolated movement. The presence of commercial buildings lead to traffic congestions during peak hour. The plate and geometry layout as shown in Plate(3-3)and Figure (3-4).

Plate (3-3): Zalatimo Signalization Intersection
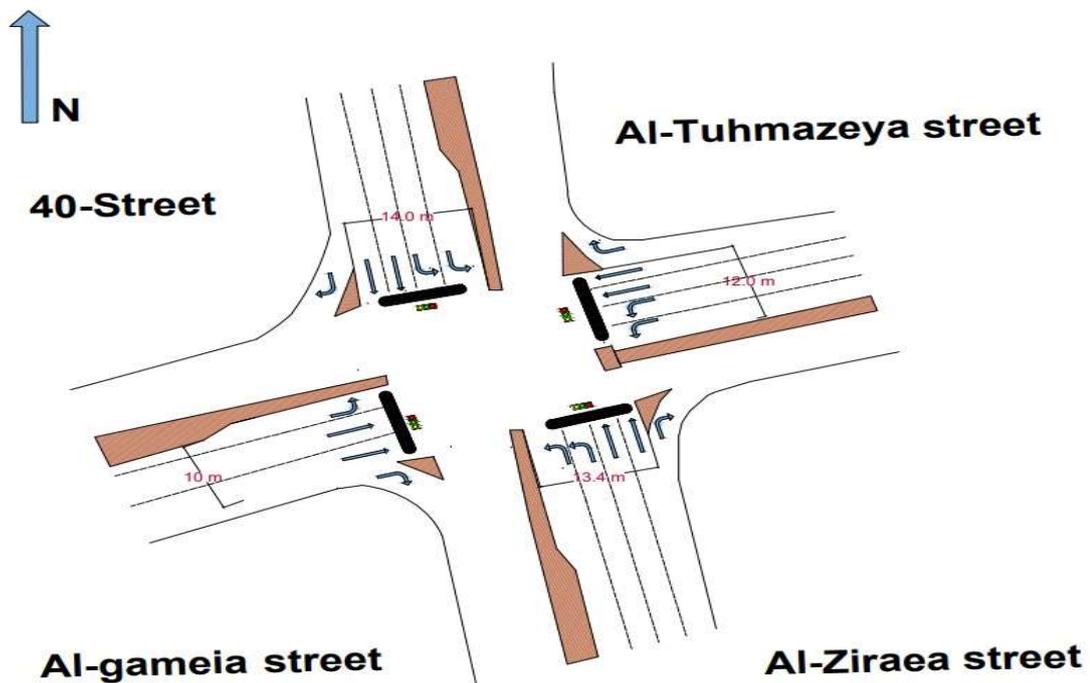
Figure (3-4): Zalatimo Signalization Intersection Layout

3.2.4 Bab al-Mashhad Intersection: It is four-arm signalized intersection. The north approach leads to Safiy AL-Din round about, consisting of three lanes: one lane through movement, one lane left movement, and right lane isolated movement. The south approach leads to Imam Ali street and consists of four lanes; two lanes through movement , one lane left movement, and one lane right isolated movement. The east approach leads to Algabel street, while the south approach leads to the AL-Shawi neighborhood; both of them consist of three lanes: one lane through movement, one lane left movement, and one lane right isolated movement. The presence of commercial buildings led to traffic congestions during peak hour. The plate and geometry layout as shown in Plate(3-4)and Figure (3-5).

Plate (3-4): Bab al-Mashhad Signalization Intersection
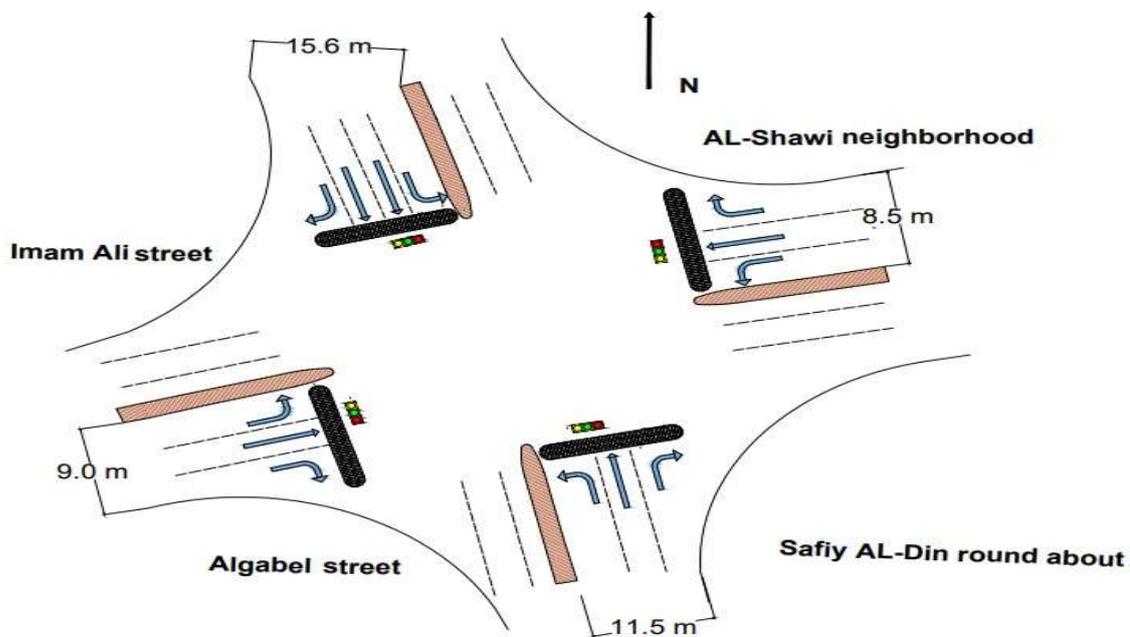
Figure (3-5): Bab al-Mashhad Signalization Intersection Layout

3.3 Data Collection Methodology:

The data collection phase aims at assembling all data required to model the traffic flow condition at the study area. The required data are collected from October/2021 to March /2022 at morning and evening peaks. All required traffic data are collected during good weather, because adverse weather condition may cause variation in the normal traffic flow pattern. Figure (3-6) shows the Procedure for traffic and geometric data collection. The methods of data collection are described in the following paragraphs.

3.4 Methods of Data Collection:

The following data are collected divided to two stages.

3.4.1 Manual Methods

The following data are collected manually from field measurement .It includes the following:

- Geometric features: data are collected through observation (number of lanes per approach , lane width group for each approach).

- Data of traffic flow : Include traffic volume of vehicles at peak period, vehicles classification(passenger car, bus, motor cycle, heavy vehicles) and Direction of turning movements

- Spot speed data are also collected manually by two observers using a stop watch marker to mark the pavement, and tape or measuring wheel for measuring section distance.

3.4.2 Video Recording Method :

Data are collected by video recording method from Hilla police cameras, department of communications and information systems allows for a large number of events to be recorded at the same time. It also has the advantage that any incident which might affect the observed data will also be recorded. The incidents can be reviewed at a later stage to resolve any apparent abnormalities

in the data. All other traffic data, which are not collected manually, are collected by a video camera based technique, which overcomes many of the difficulties in traffic data collection in the field.

3.5 Geometric Data:

Because of the absence of new maps of the studied Signalization intersections at municipality of Al-Hilla and the difficulty of getting old maps. The field measures are done by using a measuring tape to get the lane width, median width, splitter island width and so on. All signalized intersections with their geometric features are drawn to scale with AutoCAD program. Geometric features are then corrected using GIS tools in map measurements depending on the available satellite images for Al-Hilla city with accuracy of 0.7m, updated to 2016.The primary geometric features of the selected   signalization intersections are illustrated in Tables (3-2),(3-3).
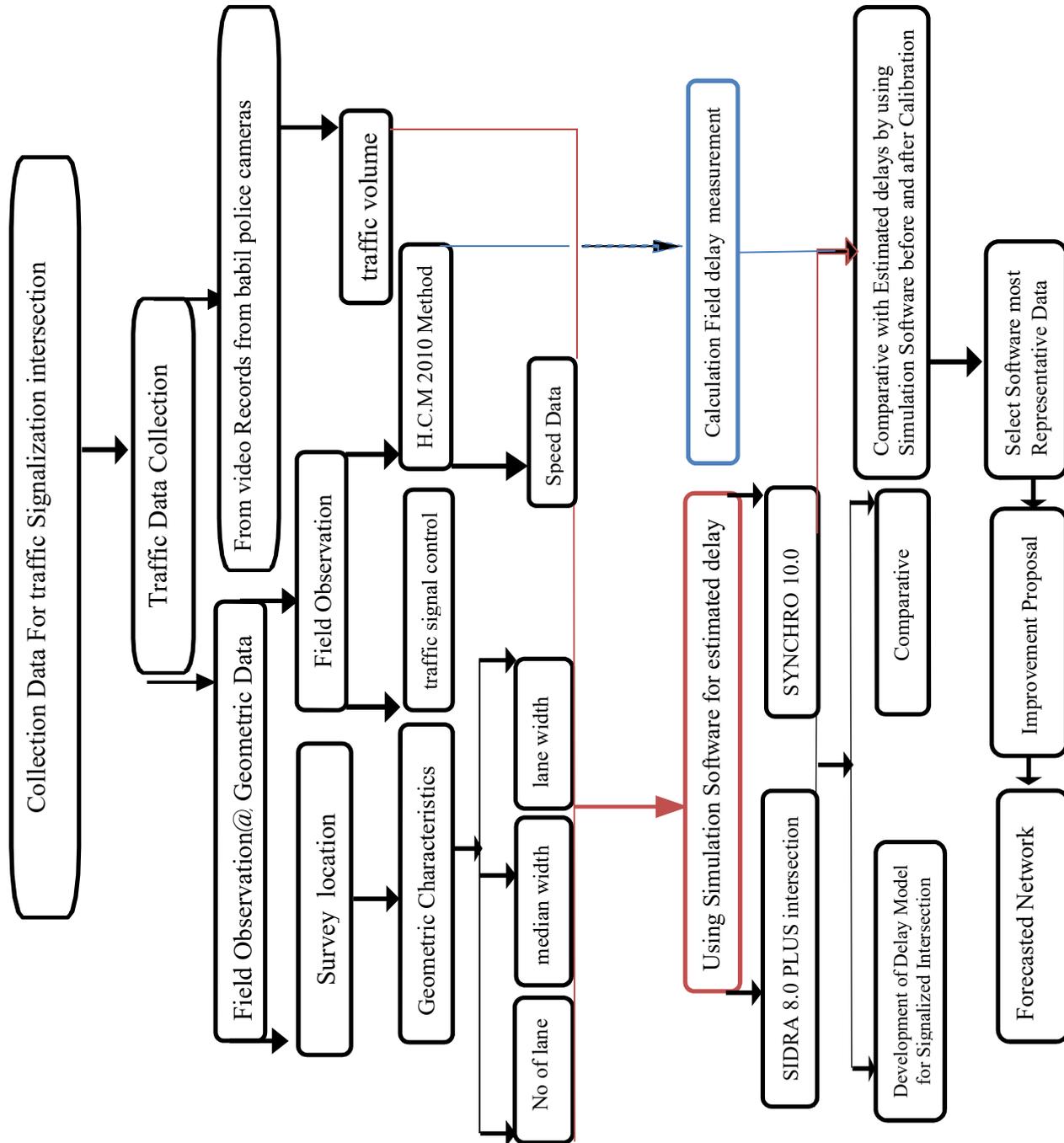
Figure (3-6): Traffic and Data Collection.

Table (3-2): Geometric Features for (Eishtar and Zalatimo) the Selected
Signalized Intersections

Intersection Name	Approach Name	Lane Group	Movement	Lane Width (m)	No. of Lanes	arm Geometry	Median Width (m)
Eishtar	40 Street	1	LT	3.3	2	Two way	5.20-6.50
		2	RT(Isolated)	------	----	Two way	
	City Center	3	TH	4.4	2	Two way	4-5
		4	LT	3.3	2	Two way	
	AL-Tayara	5	UT	3.6	1	Two way	7.5-9
		6	TH	3.6	2	Two way	
		7	RT(permitted)	4.6	1	Two way	
Zalatimo	Alziraea	1	TH	3.2	2	Two way	5.20-6.00
		2	LT	3.5	2	Two way	
		3	RT(Isolated)		----	Two way	
	AL-gameia	4	TH	3.3	2	Two way	4.0-5.0
		5	LT	3.4	1	Two way	
		6	RT(Isolated)		---	Two way	
	AL-Tuhmazeya	7	TH	3.0	2	Two way	4-5.5.5
		8	LT	3.0	2	Two way	
		9	RT(Isolated)		----	Two way	
	40Street	10	TH	3.5	2	Two way	6.20-7.00
		11	LT	3.5	2	Two way	
		12	RT(Isolated)		----	Two way	

Table (3-3): Geometric Features for the(Al-Thawra and Bab al-Mashhad) Selected Signalized Intersections

Intersection Name	Approach Name	Lane Group	Movement	Lane Width (m)	No. of Lanes	arm Geometry	Median Width (m)
Al-Thawra	AL-Tayara	1	TH	3.4	4	Two way	7-8.50
		2	LT	3.5	3	Two way	
		3	RT(Isolated)		----	Two way	
	Karbala	4	TH	3.4	3	Two way	6.5-8.5
		5	LT	3.2	4	Two way	
		6	RT(Isolated)		---	Two way	
	Bagdad	7	LT	4.7	3	Two way	Bridge
		8	RT(Isolated)		----	Two way	Bridge
	60 street	9	LT	4.4	3	Two way	Bridge
		10	RT(Isolated)		----	Two way	Bridge
Bab al-Mashhad	Safi EL-Din	1	TH	3.8	1	Two way	2.60
		2	LT	3.8	1	Two way	
		3	RT(permitted)	3.8	1	Two way	
	Imam Ali	4	TH	4.6	2	Two way	3.90-4.20
		5	LT	3.2	1	Two way	
		6	RT(permitted)	3.2	1	Two way	
	Algabel	7	TH	2.9	1	Two way	Without Island
		8	LT	2.9	1	Two way	
		9	RT(permitted)	2.9	1	Two way	
	AL-Shawi	10	TH	2.8	1	Two way	4.0
		11	LT	2.8	1	Two way	
		12	RT(permitted)	2.8	1	Two way	

3.6 Traffic Data :

The traffic data that have been collected are as follows:

3.6.1 Traffic Volume Data

Traffic volumes must be identified for each approach to the selected intersection. and for all selected intersections. Data is collected during times when there are no statutory holidays or occasions and the weather is good at intersections. Three days a week (Monday, Tuesday and Wednesday) are used to record the selected intersections.

For each junction during the day, two peak hours in the morning and three peak hours in the afternoon are investigated. The volume counting is performed at the 15 minute intervals throughout the day. During peak hours, the traffic data for each signal as captured using Babil police cameras (department of communications and information systems). Therefore, the traffic volumes have been converted by using conversion factors from various types of vehicles into PCU equivalents **(SORB,2005)** are shown in Table (3-4). The sample data traffic volume is shown in Appendix (A)

Table (3-4): Conversion Factors to Pcu**, (SORB, 2005**).

Class of vehicle	Flat Terrain
Motorcycle	0.5
Private car and taxi	1
Pick-up, van and bus up to 24 passengers	1.25
Truck and trailer combination	2
Heavy vehicle	3

3.6.2 Traffic Signal Data :

One of the most effective ways of controlling traffic at an intersection is the use of traffic signals. Traffic signals can be used to eliminate many conflicts because different traffic streams can be assigned the use of the intersection at different times.

For signalized intersections, the cycle length, phase length, green time and all red time are measured from video films, as shown in Table (3-5).

Table (3-5): Phase and Cycle Length for Signalized Intersection.

Intersection Name	Phase Timing				Cycle length
	North	*South*	*East*	*West*	
	Diagram				
Zalatimo	G +Y+AR 28+3+1	G +Y+AR 36+3+1	G +Y+AR 35+3+1	G +Y+AR 25+3+1	140
Eishtar	G +Y+AR 40+3+1	------------------	G +Y+AR 40+3+1	G +Y+AR 40+3+1	132
Al-Thawra	G +Y+AR 30+3+1	G +Y+AR 30+3+1	G +Y+AR 28+3+1	G +Y+AR 20+3+1	124
Bab al-Mashhad	G +Y+AR 34+3+1	G +Y+AR 34+3+1	G +Y+AR 38+3+1	G +Y+AR 35+3+1	149
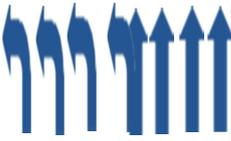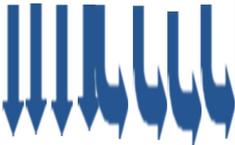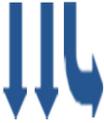
3.7 Determination of Peak Hour Periods :

Field surveys of the intersection sites in the study area are conducted in cooperation with traffic officers for a period of more than six months to find out the morning and evening peak times. Field observations and video recording technique is adopted to collect traffic volume from vantage point nearby intersection department of communications and information systems/cameras in the Babylon governorate Police Command In addition to the traffic data for each approach during peak times.. Data are gathered during times when there are no holidays or occasions and clear weather for the intersections. The selected intersections are recorded three days in a week (Monday, Tuesday and Wednesday). These observations showed that the study area is characterized by (A.M.) peak period of (7:30- 9:30) and P.M. peak period of (1:30-3:30) for typical weekdays (Monday, Tuesday, and Wednesday).Table (3-6) shows the traffic survey periods for each signalized intersections study area.

Table (3-6): Traffic survey periods for each signalized intersections study area.

Intersection	Date of Survey	Day	Time			Total Hours
			A.M.	**P.M**	**P.M**	
Eishtar	16/11/2021	Tuesday	7:30-8:30 8:30-9:30	12:30-1:30 01:30-2:30	5:00-6:00	5
Al-Thawra	24/11/2021	Wednesday	7:30-8:30 8:30-9:30	12:30-1:30 01:30-2:30	5:00-6:00	5
Zalatimo	20/12/2021	Monday	7:30-8:30 8:30-9:30	12:30-1:30 01:30-2:30	5:00-6:00	5
Bab al-Mashhad	21/4/2022	Tuesday	7:30-8:30 8:30-9:30	12:30-1:30 01:30-2:30	5:00-6:00	5

3.8 Speed Data

Speed measurement is carried out by video recording technique by measuring time taken by vehicles to pass trap length. The travel time can be converted to a speed.A sample of speed calculation in Appendix(B).The average spot speed can be computed from the following Equation **(Pignataro,1973):**

$$S = 3.6 * \frac{L}{\sum ^{ti}/_{n}} \qquad\qquad Eq.(3 - 1)$$

where:

S : the average measured spot speed of vehicle (km/hr)

L : the segment length(m),

ti: the time required for vehicle (i) to transverse the section (sec),

n: sample size.

The recommended trap length for calculating spot speed is shown in Table (3-7).**(Kennedy et al.,1986)**.This method involves the use of transverse pavement markings which are placed at each end of the 25 m course at the midblock location and the observer starts and stops the end watch as the vehicle passes the markings.

Table (3-7): Relation Spot Speed with Trap Length

Average speed of traffic stream (km/hr)	Trap Length (m)
Below 40	25
Between 40 and 64	50
Over 64	75

3.9 Saturation Flow Data for Signalized Intersection :

The start-up delay must be taken into account and sensed in order to precisely determine the saturation flow rate. The concept of startup waste of time **(Bester et.al ,2007).**

Headway, which can be defined as the time elapsed between successive cars and that the first headway is calculated when the rear wheels of the first vehicle pass the stop line and that the second headway will be the time between crossing the rear wheels of   the first vehicle and crossing the rear wheels of the second vehicle the stop line, occurs when the light signal changes to green and the vehicles begin to move and   cross the intersection .

The first progress is longer than the second. As a result, the first driver standing at the front of the line must observe and respond to the green light signal change.

The first driver must begin to accelerate through the intersection of the stationary position after observing the signal.

The second driver follows the same procedure with the exception of Since the reaction and acceleration processes take place during the time the first driver moves, the second driver has enough time to use an additional vehicle for acceleration.

This procedure continues until the headway remains constant and the acceleration and start-up reaction's impact on the headway decreases. Saturation headway is the name given to this advance. Figure (3-7),(3-8),(3-9)and (3-10)illustrate the relationship between headway and vehicle queue at Eishtar,Althawra,Zalatimo and Bab al-Mashhad signalized intersections
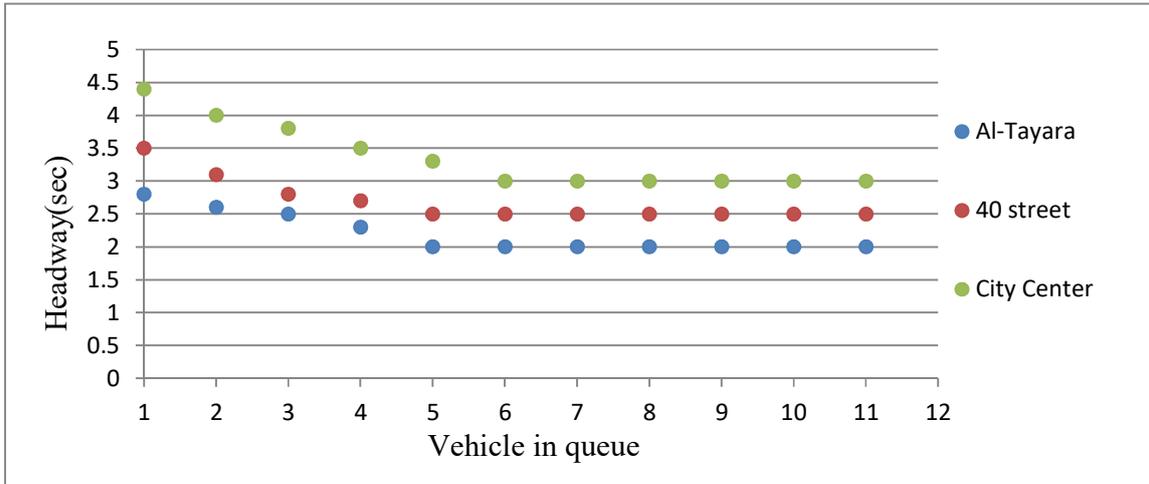
Figure (3-7) : Headway and Vehicle Queue at Eishtar intersection.
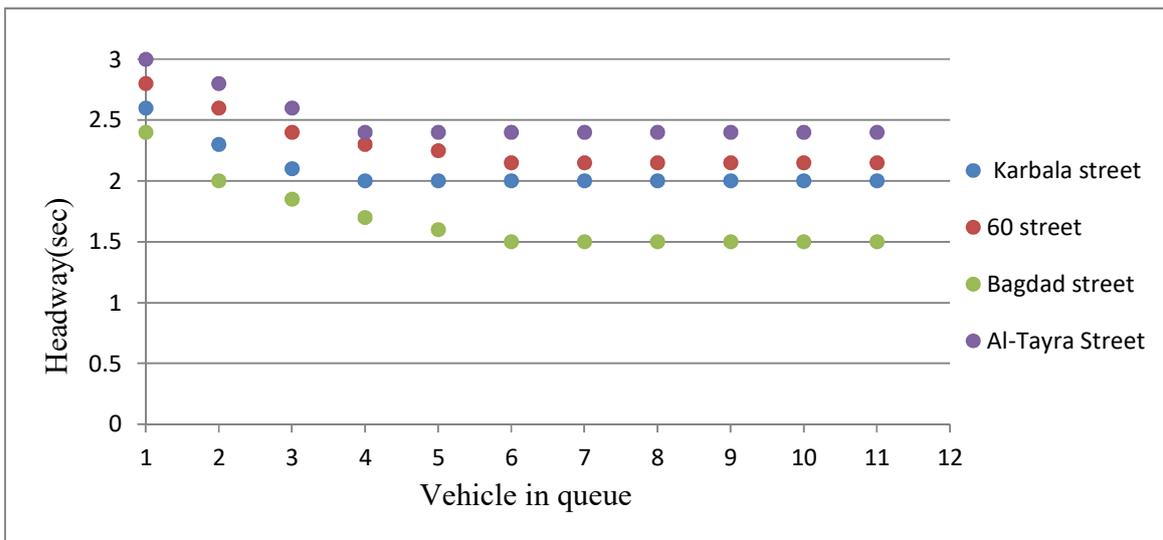
Figure (3-8): Headway and Vehicle Queue at Al-Thawra intersection.
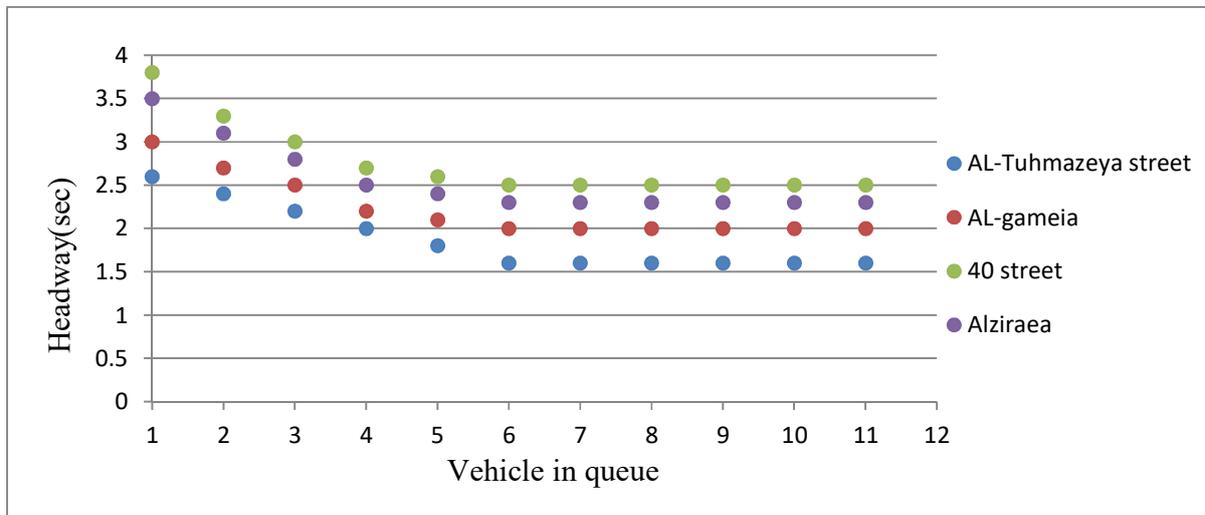
Figure (3-9) : Headway and Vehicle Queue at Zalatimo intersection.
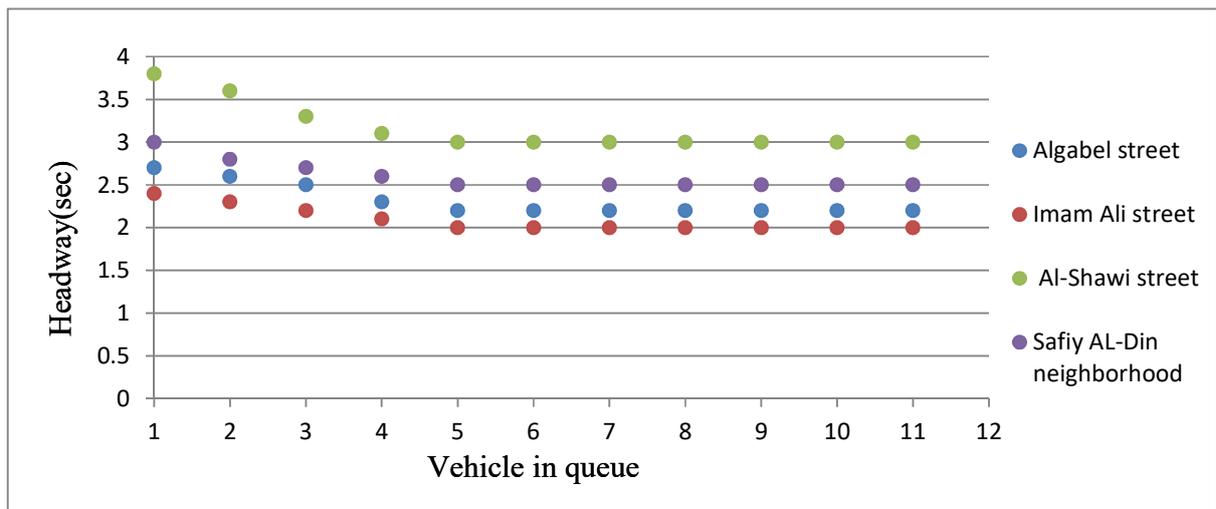
Figure (3-10): Headway and Vehicle Queue at Bab al-Mashhad intersection.

3.10 Traffic Forecast Factor :

predicted traffic volume is defined as "the current (existing) traffic volume multiplied by the ratio of future traffic volume to current traffic volume **(SORB, 2005)**. This ratio is named "Traffic Forecast Factor (TFF)" and can be calculated from Equation   (3-2).

$$TFF = (1 + \text{AR})^{n} \qquad\qquad \text{Eq.} (3-2)$$

Where:

TFF: Traffic forecast factor (composed growth factor)

AR: Annual rate of traffic increase (%).

n: Traffic analysis period (year).

The annual growth rate of traffic volume increases in Babil city which is estimated to be (2.0%) of growth collected from the census department of Babil city for the previous 5 years **(Traffic Directorate of Babil governorate, 2022).**

3.11 Data abstraction:

Data abstraction is based on sessions of 15-minute recording periods of recorded data .A 15-minute period should be chosen based on the following factors:

- To ensure that the sample is sufficient to give meaningful results.
- During the period when there are no incidents, traffic flow must effectively remain constant.
- Thereby reducing the possibility of observer fatigue and the consequent mistakes that might occur from watching videos continuously .It is essential to play a video film several times in order to extract the necessary data from it. A clock is displayed on the screen to ensure that the video starts at the same time every time. Table (3-8)

Table (3-8): Summary of Abstracted Data.

Major Category	Data Type
Traffic volume data	Through and turning traffic volume counts Vehicle Classification
Driver performance characteristics data	Headways and saturation flow rate Signal timing control.
Signal timing control	Cycle length ,Phase sequence
Data used in comparison with simulated results	Delay

3.12 Delay Measurement:

(HCM 2010) method is based on observing vehicle queue counts at the intersection in person. Delay during acceleration and deceleration, which are difficult to measure without sophisticated tracking equipment, is not directly measured by this method .A reasonable estimate of the control delay has been observed to be obtained by this method. An acceleration/deceleration delay correction factor and an adjustment for the error that may occur when employing this kind of sampling technique are included in the method.

before 1997 the primary delay measure at intersections was stopped delay since it was the easiest delay to be measured in the field. Nowadays, the measure of effectiveness for signalized and STOP-controlled intersections is total control delay**(Roess et al.,2010).**

The Highway Capacity Manual **(HCM, 2010)** defines control delay as the component of delay that results when a traffic control device causes vehicles to reduce speed or to stop. The study methodology recommended in the Highway Capacity Manual is based on direct observation of intervals frequent at queue-in-vehicles and requires a minimum of two observers .

One of the traditional methods to assess the performance (LOS) of signalized intersection is to determine the average stopped time delay for the vehicles. The method includes the counting of the number of vehicles stopped in the addition intersection approach at successive intervals (such as 10, 15, 20) seconds. In a volume counts during the same time. This sampling permits estimating the vehicle-seconds of stopped time delay(**Roess et al., 2010).**

A sample worksheet, used for recording retrieved data, is included in Appendix (C) .The survey period should begin at the start of the red phase of the approach, ideally when there is no cycle failure (no overflow queue) from the previous green period. The recorded films are replayed to retrieve data for vehicle delay time.

The procedure adopted to retrieve data is summarized below:

- The moment signal turns to red, cassette is paused and video cassette recorder (VCR) timer is set to zero. They overflow queue has been excluded from queue counts. This is due to the need for consistency with the analytical delay equation, which is based on delay to vehicles that arrive during the survey period. This time period may differ from analysis period which is typically considered as 15 minutes as per HCM(2010),because all the vehicles that join the queue within this analysis period should be included in queue count until they cross the stop line.

- Cassette is played and the number of vehicles in queue is recorded at regular interval of 10 to 20 seconds As per **(HCM 2010).**The regular interval should not be an integral divisor of the cycle length. Mean while,it is necessary to keep track of end of standing queue by observing the last vehicle in those stops because of signal.This includes vehicles arriving when the signal is actually green,but stopped because vehicles in front have not yet started moving. The vehicles in queue counts often include some vehicles that have

regained speed, but have not yet exited the intersection.

- Vehicles in the queue are counted at regular intervals for an analysis period of about 15 minutes.The end of the survey period should be clearly marked ,as the last vehicles coming and stopping in the period should be clearly identified and counted until they exit the intersection, in the next step. Stopping vehicles arriving after the end of the analysis period are not included in the final vehicle count in the queue.

- Volume counts of total vehicles (Vtot) arriving during the survey period, and total vehicles arriving during the survey period that stop one or more times.Vehicles stopping multiple times are counted only once as a stopping vehicle (Vstop).

- The average time-in-queue per vehicle arriving in the survey period is estimated as **(HCM,2010)** as shown in Equation (3-3)

$$d_{vq} = (I * \sum Viq / Vtot) * 0.9 \qquad\qquad \text{Eq.(3-3)}$$

Where:

d_{vq} Delay time-in-queue per vehicle.

I = interval between vehicle-in-queue counts, (s)

Viq= sum of vehicle-in-queue counts, (veh)

$Vtot$= total number of vehicles arriving during the survey period, (veh)

0.9 = an empirical adjustment factor accounts for the errors that may

    Occur when this type of sampling technique is used to derive actual

    delay values, which normally results in an overestimate of delay.

- The fraction of vehicles stopping and the average number of vehicles stopping in a queue in each cycle are computed as shown in Equation (3-4)

$$FVS = \frac{Vstop}{Vtotal} \qquad\qquad Eq.(3\text{-}4)$$

Where:

FVS=Fraction of vehicle stopping

$Vstop =$ Stopped vehicle count

$Vtotal =$ Total vehicle arriving

- The correction factor given by HCM is determined based on the average free flowing velocity (measured upstream of selected routes) and the average number of vehicles stopping per queue per cycle. The values of the correction factor are shown in Table No. (3-9).

- The stop-vehicle fraction is multiplied by the correction factor and the product is added to the queued time value to get the final estimate of the control delay. delay acceleration and deceleration ,as shown in Equation (3-5),(3-6)

$$dad = FVS*CF \qquad\qquad Eq.(\,3\text{-}5\,)$$

Where:

$dad =$ Accel/Decel delay.

FVS= Fraction of vehicle stopping

CF= Correction Factor

$$d = dVq + dad \qquad\qquad Eq.(3-6)$$

Where:

$d =$ Control Delay/vehicle

$dVq =$ Delay time-in-queue per vehicle

$dad =$ Accel/Decel delay

Control delay includes initial deceleration delay, queue moving time, stop delay, and final acceleration delay.

Table (3-9) Acceleration/Deceleration Delay Correction Factor (CF)
        (HCM, 2010).

Free-Flow Speed	Delay Correction Factor		
	≤7 vehicles	8-19 vehicles	20-30 vehicles
≤ 37mi/h	+5	+2	+1
>37-45 mi/h	+7	+4	+2
>45 mi/h	+9	7	+5

3.13 Software Used for Data Analysis :

For the analysis and evaluation of traffic performance on the selected signalized intersections traffic volumes and geometric data, abstracted and processed from the site have been used as inputs into two software packages. **SIDRA 8.0 PLUS** and **SYNCHRO10.0** have been used.

3.13.1 SIDRA Intersection 8.0 Plus :

SIDRA software is used as an aid for design and evaluation of signalized intersections fixed-time/pretimed and actuated, roundabouts, two- way stop sign control all-way stop sign control, and give-way (yield) sign-control **(Al-Omari et al,2007)** .SIDRA uses detailed analytical traffic models coupled with an iterate approximation method to provide estimates of capacity and performance analyses of signalized and unsignalized intersections and roundabouts.It computes average control delay, geometric delay, level of saturation, and level of service .

The following points briefly provide an overview of SIDRA (Akcelik, 2009).

- Analyze many design alternatives to optimize the intersection geometry signal phasing and timings specifying different strategies for optimization.

- It can be calibrated for local conditions. The parameters used for calibration are saturation flow rate,and lane utilization factor for signalized intersections and environment factor, and entry/circulating flow for roundabouts.

- Carry out a design life analysis to assess the impact of traffic growth.
- Carry out a parameter sensitivity analysis for calibration, optimization, evaluation and geometric design purposes.
- Analyze oversaturated conditions making use of the time-dependent delay, queue length and stop rate models.

3.13.2 SYNCHRO 10.0 :

SYNCHRO10.0 is a complete software package for modeling and Optimizing traffic signal timings.This software includes:

- Synchro10.0 is a macroscopic analysis and optimization program.
- SimTraffic is a powerful, easy-to-use traffic micro-simulation software application
- Sim Traffic 3D Viewer displays SimTraffic simulations in three dimensions
- SimTraffic CI is an application that interacts with a controller interface (CI) device connected to a controller in order to simulate the operation of the controller with simulated traffic.

Some of the key traffic engineering related tasks for which these software applications:

- **Coordinate and Optimize:**

Synchro allows for quick generation of optimum timing plans to minimize delay

- **Actuated Signals :**

Synchro provides detailed, automatic modeling of actuated signals. Synchro can model skipping and gapping behavior and apply this information to delay.Delailed coding of detector data is a critical element to replicating field conditions.

- **. Capacity Analysis:**

This method compares the current volume to the intersection's ultimate capacity. This method is very straightforward to implement and can be completed using single page worksheet. Synchro also provides an easy-to- use solution for capacity analysis and timing optimization.

- **Time-Space Diagram:**
  SYNCHRO has colorful, informative Time- Space Diagrams. Splits and offsets can be changed directly on the diagram.

- **Sim Traffic V.10**
  Is microscopic stochastic simulation model used in conjunction with SYNCHRO.

The following points briefly provide an overview of SimTraffic:

- It incorporates vehicle and driver performance characteristics developed by Federal Highway Administration (FHWA).

- It is capable of simulating different types of intersection controls, various street geometries including lane drops and turning pockets, and a wide range of traffic flow conditions. It uses "car following" logic for simulation.

- It can be calibrated for local driver/traffic behavior by headway factor as input in SYNCHRO, and vehicle\driver behavior adjustment in SimTraffic.

- It is not capable of modeling ramp metering, bus stops, bus routes, bus and carpool lanes, light rail, on-street parking and short-term events

Chapter Four

Data Presentation and Analysis

Chapter Four
Data Presentation and Analysis

4.1 General

This chapter presents the analysis of the collected data, calibration of the output results of the software used for data analysis, the development of delay statistical models for signalized intersections to evaluate traffic performance and existing geometric design. Improvement of geometric features is also proposed and the results are evaluated using traffic software. This chapter is divided into six parts:

- First part calculates the field delay measurement by H.M.C 2010 for the selected signalized intersections.

- Second part investigates the existing conditions of traffic operation schemes and geometry of studied intersections, Simulation traffic of the actual movement is required to evaluate traffic performance.

- Third part includes the application of software (Synchro10 and SIDRA 8.0 intersection plus) to simulate traffic operations at signalized intersections for calculating the control delay and level of service in the study area.

- Four part includes application of software SPSS v.23.0 statistical for prediction total delay time model for the values extracted from the software (Synchro10 and SIDRA 8.0 intersection plus).

- Five part presents the improvement strategies applied to the traffic flow for the selected signalized intersections in the study area

- Six part predicts the delay of the application of forecasting traffic volume on the improvement proposals for select signalized intersections.

4.2 Field Delay Measurement:

This study collects field delay based on direct observation of vehicle-in-queue counts at the intersection, using the approach suggested by HCM .Delay during acceleration and deceleration, which are difficult to measure without a sophisticated tracking instrument are not directly measured by this method. Nonetheless, this technique has been seen to yield a sensible gauge of control delay. Asample worksheet for recording retrieved data is included. The sample data retrieval worksheet is shown in Appendix (C)

4.3 Traffic volume:

This data includes the calculation of the traffic volumes from the video Babil police (cameras) Department of Communications and information Systems records for each approach at signalized intersection data during the day peak and off peak times (two hours in the morning and three in the afternoon).

Tables(4-1),(4-2),(4-3),(4-4)and(4-5),Figure (4-1),(4-2),(4-3).(4-4) illustrate the traffic volumes for (Zalatimo, Eishtar, Al-Thawra, Bab al-Mashhad) intersection

Table (4-1): The Traffic Volume for (Zalatimo,Eishtar,Althawra, Babal-Mashhad) intersection at (7:30-8:30) A.M

Intersection (name)	Approach name	Traffic volume(Veh/hr)
Zalatimo	N	1043
	S	1877
	E	982
	W	1371
Eishtar	N	1193
	E	1546
	W	2792
Al-Thawra	N	1698
	S	2111
	E	1009
	W	777
Bab al-Mashhad	N	731
	S	1049
	E	419
	W	384

Table (4-2): The Traffic Volume for (Zalatimo, Eishtar , Althawra, Bab al-Mashhad) intersection at (8:30-9:30) A.M

Intersection (name)	Approach name	Traffic volume (Veh/hr)
Zalatimo	N	840
	S	919
	E	817
	W	1034
Eishtar	N	1002
	E	1133
	W	1777
Al-Thawra	N	2352
	S	3502
	E	1009
	W	777
Bab al-Mashhad	N	777
	S	1039
	E	521
	W	425

Table (4-3): The Traffic Volume for (Zalatimo, Eishtar, Althawra, Bab al-Mashhad) intersection at (12:30-13:30) P.M

Intersection (name)	Approach name	Traffic volume (Veh/hr)
Zalatimo	N	1257
	S	2062
	E	1072
	W	1522
Eishtar	N	1077
	E	1320
	W	2477
Al-Thawra	N	2352
	S	3502
	E	1009
	W	777
Bab al-Mashhad	N	880
	S	1370
	E	752
	W	730

Table (4-4): The Traffic Volume for (Zalatimo, Eishtar , Althawra, Bab al-Mashhad) intersection at (13:30-14:30) P.M

Intersection (name)	Approach name	Traffic volume(Veh/hr)
Zalatimo	N	1031
	S	1680
	E	990
	W	1117
Eishtar	N	998
	E	1217
	W	1488
Al-Thawra	N	1118
	S	1421
	E	798
	W	521
Bab al-Mashhad	N	845
	S	1178
	E	481
	W	325

Table (4-5): The Traffic Volume for (Zalatimo, Eishtar, Althawra, Bab al-Mashhad) intersection at (16:30-17:30)P.M

Intersection (name)	Approach name	Traffic volume (Veh/hr)
Zalatimo	N	616
	S	877
	E	817
	W	618
Eishtar	N	821
	E	1288
	W	1117
Al-Thawra	N	1028
	S	1017
	E	212
	W	271
Bab al-Mashhad	N	823
	S	650
	E	161
	W	141
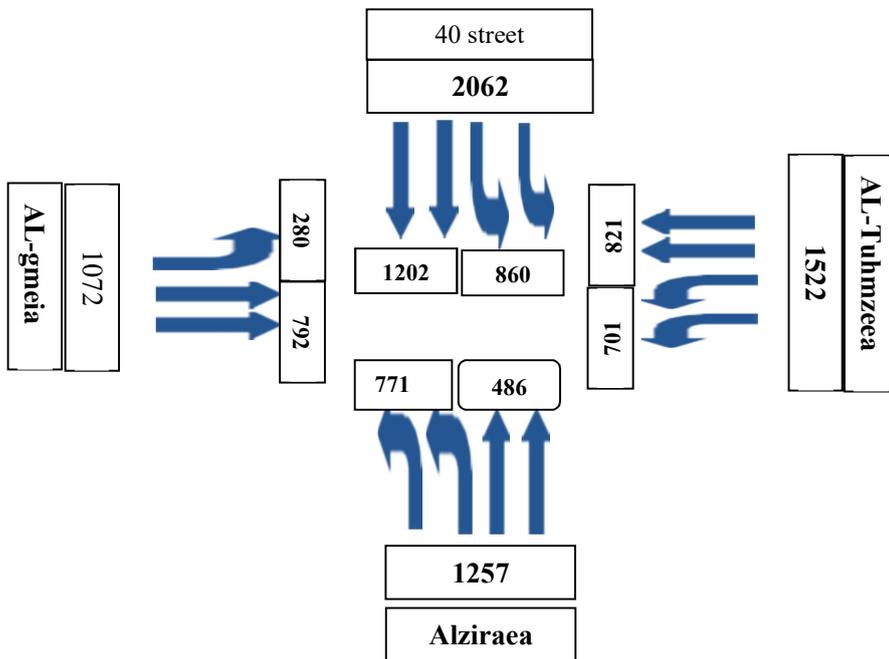
Figure (4-1): Peak Hour Volume (12:30-13:30 P.M) at Zalatimo Intersection
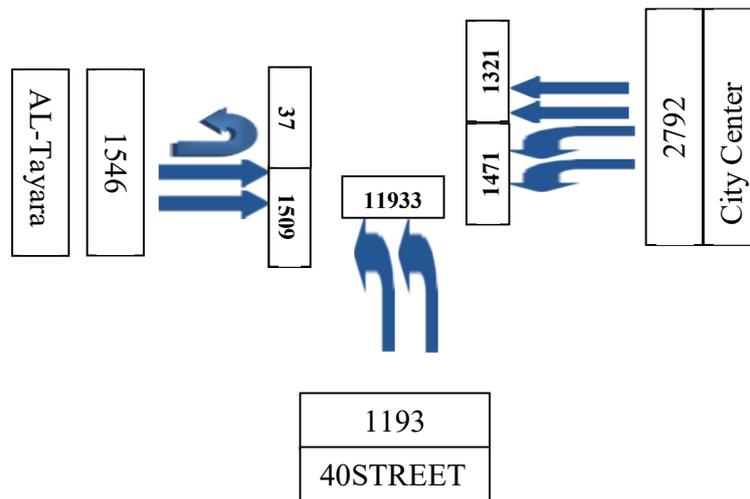
Figure (4-2) :Peak Hour Volume (7:30-8:30 A.M) at Eishtar Intersection
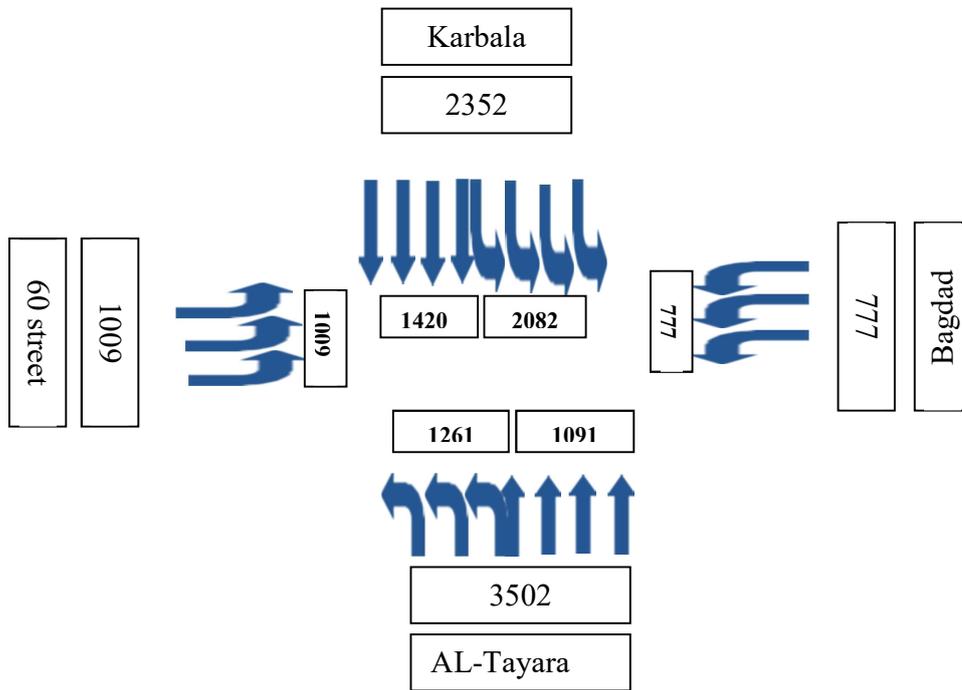
Figure (4-3) : Peak Hour Volume (8: 30-9:30 A.M) at Al-Thawra Intersection
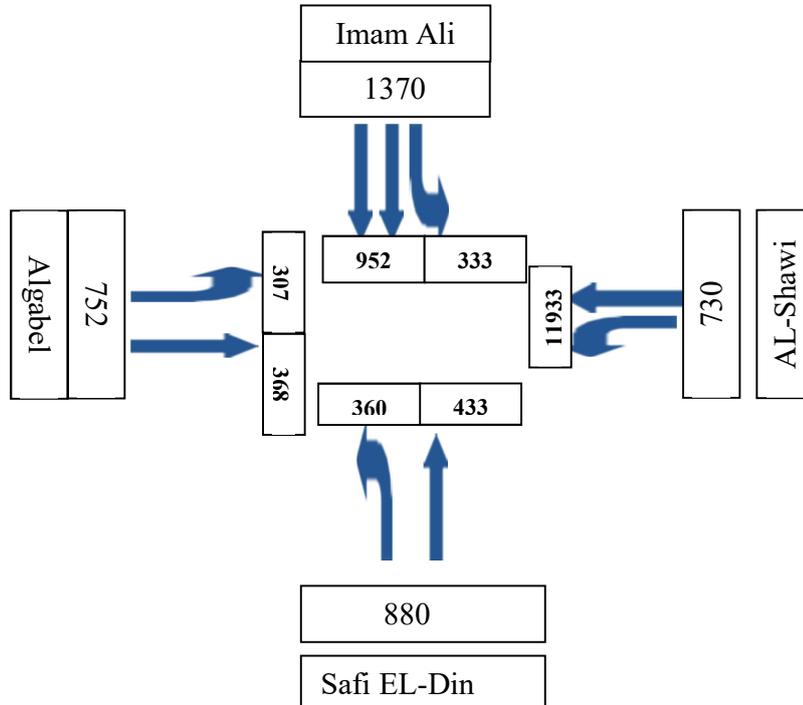
Figure (4-4): Peak Hour Volume (12:30-13:30 P.M) Bab al-Mashhad at Intersection

4.4 Calculation of the PHF (Peak Hour Factor):

The peak hour factor is defined as the ratio of total hourly volume to the maximum 15- min rate of flow within the hour as following **(HCM, 2010):**

$$PHF = (Hourly\ volume)/(4 * V15) \qquad (4\text{-}1)$$

Where:

PHF= Peak-hour factor

V15= Volume during the peak 15 min of the peak hour, on veh/15min

The peak traffic volume for the mentioned intersections are shown in Tables (4-6, 4-7 ,4-8 and 4-8)

Table (4-6) :PHF Values at Zalatimo Intersection

Approach		Lane group	PHF
direction	name		
N	AL ZERAA		0.90
			0.91
S	40 ST		0.86
			0.94
E	Al-Jameaa		0.80
			0.77
W	AL- Tuhmazeea		0.89
			0.83
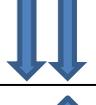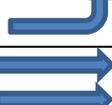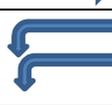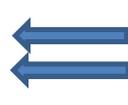
Table (4-7): PHF Values at Eishtar Intersection

Approach		Lane group	PHF
direction	name		
N	40 ST		0.86
E	AL-TAYARA ST		0.90
			0.91
W	CITY –CENTER ST		0.96
			0.71

Table(4-8) :PHF Values at Al-Thawra Intersection

Approach		Lane group	PHF
direction	name		
N	AL-Tayara		0.76
			0.90
S	Karbala		0.95
			0.93
E	60 ST		0.87
W	Baghdad		0.83

Table (4-9) :PHF Values at Bab al-Mashhad Intersection

Approach		Lane group	PHF
direction	name		
N	SafiY AL-Din	⤴	0.90
		↑	0.91
S	Imam Ali	⤵	0.86
		⇊	0.90
E	Algabel	⤴	0.90
		⇒	0.90
W	AL-Shawi	⤶	0.90
		←	0.90

4.5 Software Used for Data Analysis:

In addition to Statistical Package for the Social Sciences (SPSS 23.0) and Geographic Information System (GIS) software, the two main software are used in this study namely the SYNCHRO10.0 micro-simulation model and SIDRA 8.0 PLUS. Below is a brief description of each.

4.5.1 Application of Synchro10.0 Software Program:

SYNCHRO10.0 is used to simulate the current flow of traffic at the select intersection. It is a comprehensive traffic system modeling, optimization,and simulation programming package. The results in Table (4-10,4-11,4-12,4-13). show that the   intersection suffers from an oversaturation condition with high total delay values and   an unacceptable level of service (LOS F).

Table (4-10): Total Delay and Level of Service for Zalatimo Intersections
Produced by SYNCHRO 10.0 for Existing Condition.

Intersection	Approach Name	Movement	Lane Group Flow(veh/hr)	Saturation Flow Rate (veh/hr)	v/c	Approach Delay (sec)		LOS	
zalatimo	40 ST	LT	1000	3537	1.13	120.2		F	
		TH	1239	3684	1.35	203.1	166.1	F	F
		RT(Isolated)	------	------	------	-----		--	
	Alziraea	LT	857	3609	1.23	162.8		F	
		TH	534	3560	0.78	62.5	124.3	E	
		RT(Isolated)	-------	-------	----	---------		-----	F
	AL- Tuhmazeea	LT	788	3308	1.39	228.2		F	
		TH	989	3352	1.72	366.8	305.3	F	F
		RT(Isolated)	-------	-----	-----	-------		--	
	AL-gmeia	LT	350	1858	0.78	62.4		E	
		TH	1029	3515	1.21	148.7	126.8	F	F
		RT(Isolated)	-------	-----	-----	-------		--	
	Max v/c		Intersections Delay (sec)					LOS	
	1.72		186.0					F	

Table (4-11): Total Delay and Level of Service for Eishtar Intersections
Produced by SYNCHRO 10.0 for Existing Condition.

Intersection	Approach Name	Movement	Lane Group Flow(veh/hr)	Saturation Flow Rate (veh/hr)	v/c	Approach Delay (sec)		LOS	
Eishtar	40-ST	LT	1387	3436	1.37	208.0	208.0	F	F
		RT(Isolated)	-----	---------	-----	------			
	AL-TAYARA	UT	52	1900	0.09	34.4	195.5	C	F
		TH	1575	3614	1.47	252.6		F	
		RT (permitted)	---	------------	-----	------		-----	
	CITY –CENTER	LT	1616	3337	1.64	324.4	259.3	F	F
		TH	1468	3769	1.32	187.6		F	
	Max v/c			Intersections Delay (sec)				LOS	
	1.64			228.4				F	

Table (4-12): Total Delay and Level of Service for Al-Thawra Intersections Produced by SYNCHRO 10.0 for Existing Condition.

Intersection	Approach Name	Movement	Lane Group Flow(veh/hr)	Saturation Flow Rate (veh/hr)	v/c	Approach Delay (sec)		LOS	
Al –Thawra	AL-TAYARA	LT	1659	6148	1.38	212.8		F	
		TH	1212	6331	0.82	50.4	144.2	D	F
		RT(Isolated)	-----	------	------	-----		---	
	Karbala	LT	2192	6285	1.49	259.7		F	
		TH	1527	5087	1.28	173.5	224.3	F	F
		RT(Isolated)	-------	-------	----	---------		------	
	Baghdad	LT	936	5782	1.06	96.7		F	
		RT(Isolated)	-------	-----	-----	------	96.7	---	F
	60 street	LT	1160	5777	0.92	60.2		E	
		RT(Isolated)	-------	-----	-----	------	60.2	---	E
	Max v/c			Intersections Delay (sec)				LOS	
	1.49			162.2				F	

Table (4-13): Total Delay and Level of Service for Bab al-Mashhad Intersections Produced by SYNCHRO 10.0 for Existing Condition

Intersection	Approach Name	Movement	Lane Group Flow(veh/hr)	Saturation Flow Rate (veh/hr)	v/c	Approach Delay (sec)		LOS	
Bab al-Mashhad	Safi EL-Din	LT	400	1726	0.94	87.8		F	
		TH	476	4139	1.07	117.7	94.2	F	F
		RT(Isolated)		------	------	-----		----	
	Imam Ali	LT	387	1923	1.01	105.8		F	
		TH	1058	2004	1.16	132.5	117.8	E	F
		RT(Isolated)	-------	-------	----	---------		------	
	Algabel	LT	341	1752	0.88	79.7		F	
		TH	409	1721	1.07	120.7	91.5	F	F
		RT(Isolated)	-------	-----	-----	-------		----	
	AL-Shawi	LT	LT	356	1665	1.06		E	
		TH	TH	342	1658	1.03	102.3	F	F
		RT(Isolated)	-------	-----	-----	-------		----	
		Max v/c			Intersections Delay (sec)			LOS	
		1.16			104.0			F	

4.5.2 Application of SIDRA Software Program:

The abstracted and collected data required for this software are fed into the program for each intersection alone. Many runs are implemented to exclude the bias data SIDRA INTERSECTION 8.0 software is used to analyze the existing traffic flow patterns for intersections as isolated at the study area Table (4-14, 4-15, 4-16, 4-17) indicate the output results of simulation runs which include the degree of saturation, total delay, and level of service for each intersection in the study area.

Table (4-14): Total Delay and Level of Service for Eishtar Intersections Produced by SIDRA 8.0 PLUS for Existing Condition.

Intersection	Approach Name	Movement	Lane Group Flow(veh/hr)	Saturation Flow Rate (veh/hr)	v/c	Approach Delay (sec)		LOS	
Eishtar	40-ST	LT	1387	3740	1.29	200.3	200.3	F	F
		RT(Isolated)	-----	-----	-----	------			
	AL-TAYARA	UT	52	1451	0.12	41.2	192.6	D	F
		TH	1575	3958	1.42	247.8		F	
		RT (permitted)	-----	-----	-----	------		----	
	CITY –CENTER	LT	1616	3572	1.57	317.4	250.0	F	F
		TH	1468	4108	1.24	175.8		F	
Max v/c			Intersections Delay (sec)					LOS	
1.57			221.4					F	

Table (4-15): Total Delay and Level of Service for Zalatimo Intersections Produced by SIDRA 8.0 PLUS for Existing Condition.

Intersection	Approach Name	Movement	Lane Group Flow(veh/hr)	Saturation Flow Rate (veh/hr)	v/c	Approach Delay (sec)		LOS	
Zalatimo	40 ST	LT	1000	3777	1.09	125.7		F	
		TH	1239	3962	1.29	200.6	167.1	F	F
		RT(Isolated)		------	------	-----		----	
	Alziraea	LT	857	3779	1.18	158.4		F	
		TH	534	3901	0.71	64.7	122.4	E	F
		RT(Isolated)	-------	-------	----	---------		------	
	AL- Tuhmazeea	LT	788	3595	1.33	221.6		F	
		TH	989	3807	1.65	356.6	296.7	F	F
		RT(Isolated)	-------	-----	-----	------		----	
	AL-gmeia	LT	350	1820	0.79	63.7		E	
		TH	1029	3884	1.12	138.0	119.2	F	F
		RT(Isolated)	-------	-----	-----	------		----	
Max v/c			Intersections Delay (sec)					LOS	
1.65			182.2					F	

Table (4-16): Total Delay and Level of Service for Althawra Intersections
Produced by SIDRA 8.0 PLUS for Existing Condition.

Intersection	Approach Name	Movement	Lane Group Flow(veh/hr)	Saturation Flow Rate (veh/hr)	v/c	Approach Delay (sec)		LOS	
Al –Thawra	AL-TAYARA	LT	1659	5668	1.252	179.4		F	
		TH	1212	7704	0.697	50.9	125.2	D	F
		RT(Isolated)	-------	------	------	-----		----	
	Karbala	LT	2192	7345	1.480	275.1	219.6	F	
		TH	1527	5839	1.158	139.9		F	F
		RT(Isolated)	-------	-------	----	--------		------	
	Baghdad	LT	936	5763	1.060	110.8	110.8	F	F
		RT(Isolated)	-------	-----	-----	-----		----	
	60	LT	1160	5869	0.875	64.7	64.7	E	E
		RT(Isolated)	-------	-----	-----	-----		----	

Max v/c	Intersections Delay (sec)	LOS
1.48	156.0	F

Table (4-17): Total Delay and Level of Service for Bab al-Mashhad Intersections Produced by SIDRA 8.0 PLUS for Existing Condition

Intersection	Approach Name	Movement	Lane Group Flow(veh/hr)	Saturation Flow Rate (veh/hr)	v/c	Approach Delay (sec)		LOS	
Bab al-Mashhad	Safi EL-Din	LT	400	1844	0.951	87.6	96.0	F	F
		TH	476	2012	1.068	120.4		F	
		RT(Isolated)	------	-------	-------	-------		----	
	Imam Ali	LT	387	1663	1.020	108.4	119.0	F	F
		TH	1058	4187	1.107	132.8		F	
		RT(Isolated)	-------	-------	-------	-------		------	
	Algabel	LT	341	1694	0.882	76.1	88.4	E	F
		TH	409	1881	1.045	155.9		F	
		RT(Isolated)	--------	--------	--------	--------		----	
	AL-Shawi	LT	356	1612	1.060	122.4	102.5	E	F
		TH	342	1841	1.026	112.4		F	
		RT(Isolated)	-------	-------	-------	-------		----	

Max v/c	Intersections Delay (sec)	LOS
1.16	104.0	F

4.6 Results of a Software Program :

The analysis results for each of the four intersections according to the two software are individually listed in Tables (4-18) to (4-21), which show standard measures of effectiveness .control delay, v/c ratio, LOS are used to describe the operation by each approach in the signalization intersections

Table(4-18) : Output Parameter Software Programs for Comparing in Zalatimo intersection

Zalatimo Intersection								
Intersection ID	Approach Name	Volume of Traffic	SIDRA 8.0 PLUS			SYNCHRO 10.0		
			Approach Delay	v/c	LOS	Approach Delay	LOS	v/c
		Veh/hr	Sec.			Sec.		
1	40 street	2062	167.1	1.29	F	166.1	F	1.35
	Alziraea	1257	122.4	1.18	F	124.3	F	1.23
	Al-Tuhmazeea	1522	296.7	1.65	F	305.3	F	1.72
	AL-gmeia	1072	119.2	1.12	F	126.8	F	1.21
Overall brief for whole intersection of Zalatimo Intersection								
SIDRA 8.0 PLUS					SYNCHRO 10.0			
V/C proportion : 1.65 Intersection delay: 182.2 Second. LOS : F					V/C proportion :1. 72 Intersection delay: 186.3 Second. LOS : F			

Table(4-19) : Output Parameter Software Programs for Comparing in Eishtar
intersection

Intersection ID	Approach Name	Volume of traffic	SIDRA 8.0 PLUS			SYNCHRO 10.0		
			Approach Delay	v/c	LOS	Approach Delay	v/c	LOS
		Veh/hr	Sec.			Sec.		
	40 Street	1193	200.3	1.29	F	208.0	1.37	F
	Al-Tayara	1917	192.6	1.42	F	195.5	1.47	F
2	City Center	2792	250.0	1.57	F	259.**3**	1.64	F
Brief Overall for the Eishtar Intersection								
SIDRA 8.0 PLUS				SYNCHRO 10.0				
V/C proportion: 1.57 Intersection delay: 221.4 Second. LOS : F				V/C proportion: 1.64 Intersection delay: 228.4 Second. LOS : F				

Table(4-20) : Output Parameter Software Programs for Comparing in Al-Thawra
intersection

Intersection ID	Approach Name	Volume of Traffic	SIDRA 8.0 PLUS			SYNCHRO 10.0		
			Approach Delay	v/c	LOS	Approach Delay	v/c	LOS
		Veh/hr	Sec.			Sec.		
Al-Thawra Intersection								
3	AL-TAYARA	2352	125.2	1.25	F	144.2	1.38	F
	Karbala	3502	219.6	1.48	F	224.3	1.49	F
	Baghdad	815	110.8	1.06	F	96.7	1.06	F
	60 Street	1040	64.7	0.8**8**	E	60.2	0.92	E

Brief Overall for the Al-Thawra Intersection	
SIDRA 8.0 PLUS	SYNCHRO 10.0
V/C proportion **:** 1.48	V/C proportion : 1.49
Intersection delay 156.0 Second.	Intersection delay: 162.2Second.
LOS : F	LOS : F

Table(4-21) : Output Parameter Software Programs for Comparing in Bab al- Mashhad intersection

Bab al-Mashhad Intersection								
Intersection ID	Approach Name	Volume of Traffic	SIDRA 8.0 PLUS			SYNCHRO 10.0		
			Approach Delay	v/c	LOS	Approach Delay	v/c	LOS
		Veh/hr	Sec.			Sec.		
3	Safi EL-Din	793	96.0	1.068	F	94.2	1.07	F
	Imam Ali	1285	119.0	1.107	F	117.8	1.16	F
	Algabel	675	88.4	1.045	F	91.5	1.07	F
	AL-Shawi	628	102.5	1.060	F	102.3	1.06	F
Brief Overall for the Bab al-Mashhad Intersection								
SIDRA 8.0 PLUS				SYNCHRO 10.0				
V/C proportion : 1.17 Intersection delay 104.2 Second. LOS : F				V/C proportion : 1.16 Intersection delay: 104.0 Second. LOS : F				

in table (4-18 to 4-21) .All the output results are categorized by medium to high total delays. Thus, the level of service for most of the intersection is (F) .according to the LOS categories of the software that based on HCM method . There are Figures of programs in the Appendices (D) and (E).

4.7 Model Calibration :

Calibration is the process by which the individual components of the model are refined and adjusted so that the model accurately represents field measured or observed traffic conditions **(Turley, 2007).** With regards to calibration, traffic models contain numerous variables to define and replicate traffic control operations, traffic flow characteristics and driver behavior. The model contains default values for each variable, but also allows a range of user-applied values for each variable.

The measures of effectiveness estimated by the models delay is used for comparison with local traffic conditions in order to ensure that the model accurately represents the measured traffic parameters .The delay time estimated by models is mostly used by traffic engineers to evaluate intersection performance.

The main parameter at signalized intersection that depends on driver behavior is the saturation headway. This parameter affects mainly the saturation flow rate. Saturation flow rate is the maximum departure (queue discharge) flow rate achieved during the green period at traffic signals.

For this study, the delay has been selected to be compared with existing traffic conditions and the values of the selected parameters have been manipulated until an acceptable convergence between the observed and simulated delay SYNCHRO10.0 and SIDRA 8.0 PLUS values has been reached.

4.7.1 SYNCHRO10.0 Calibration:

SYNCHRO 10.0 Manual does not provide substantial guidance on how the user should modify these parameters for different types of conditions. Therefore the user has a great responsibility for ensuring that the appropriate changes made are based on field measured data and not on engineering judgment.

SYNCHRO 10.0 Saturation flow estimation is affected by many factors including lane width, grade, turning radius, parking, buses, pedestrian interference percentage of heavy vehicles, shared lanes, opposed turns and short lanes. Furthermore, saturation flows estimated by SYNCHRO10.0 are dependent on signal timings.

The default value of the basic saturation flow rate used by SYNCHRO 10.0 model is 1900 pcuphgpl. This is applied at the signalized intersections in the study area. The delay time produced by SYNCHRO10 for each approach is compared with the average delay times measured from the field.

The results of the comparison between measured and estimated delays are shown in Figure(4-5),(4-6)for(Zalatimo,Eishtar)intersection,Figure(4-7) (4-8)for Al-Thawra intersection ;and Figure(Bab al-Mashhad) Intersection (4-9),(4-10)

A comparison is made by using the paired samples t-test. The paired samples t-test is made by using SPSS V.23.0 program. The paired t-test results as in Table(4-22)For(Zalatimo,Eishtar)Intersection ;Table(4-23)For(Al-Thawra) Intersection and Table(Bab al-Mashhad) Intersection (4- 24)

The calibration process is to adjust the basic saturation flow rate to be 2000 pcuphgpl in lane groups with high values of v/c, as recommended by   HCM 2010

Table (4-22) :Comparison of Actual and SYNCHRO10.0 Delay Prediction for(Zalatimo, Eishtar)Intersection Signalized Intersections.

Actual Delay	Default Values of Saturation Flow rate (1900 veh/hr)	Default Values of Saturation Flow rate (2000 veh/hr)
	0.872 SYNCHRO10.0 Delay	= 0.931 SYNCHRO10.0 Delay
R^2	0.864	0.965
Adj.R^2	0.850	0.961
Sig.	0.000	0.000
Paired Sample t-test		
Mean Difference in Delay (sec)	22.2750	12.383
t	1.930	1.975
P	0.08	0.074
p-value greater than 0.05, so that there is no statistically significant difference		

Figure (4-5): SYNCHRO Average Delay Values versus Field Delay Values for All Approach

Figure (4-6): SYNCHRO Delay Values versus Field Delay Values after   Calibrating the Basic saturation flow rate for All Approach

Table (4-23) : Comparison of Actual and SYNCHRO10.0 Delay Prediction for (Al-Thawra)Intersection Signalized Intersections.

Actual Delay	Default Values of Saturation flow rate (1900 veh/hr)	Default Values of Saturation flow rate (2000 veh/hr)
	= 0.843SYNCHRO10.0 Delay	= 0.958 SYNCHRO10.0 Delay
R^2	0.776	0.955
Adj.R^2	0.720	0.944
Sig.	0.001	0.000
Paired Sample t-test		
Mean Difference in Delay (sec)	22.000	14.217
t	1.363	1.912
P	0.231	0.114
p-value greater than 0.05, so that there is no statistically significant difference		
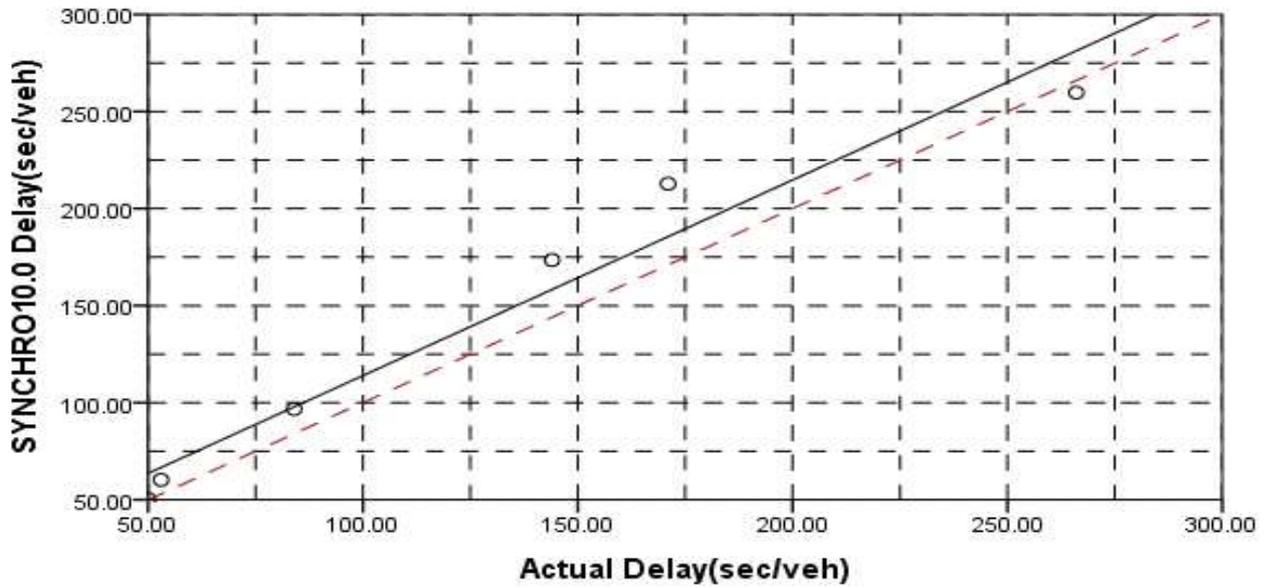
Figure (4-7): SYNCHRO Average Delay Values versus Field Delay Values for All Approach

Figure (4-8): SYNCHRO Delay Values versus Field Delay Values after Calibrating the Basic saturation flow rate for All Approach.

Table (4-24): Comparison of Actual and SYNCHRO10.0 Delay Prediction for (Bab al-Mashhad)Intersection Signalized Intersections.

Actual Delay	Default Values of Saturation Flow rate (1900 veh/hr)	Default Values of Saturation Flow rate (2000 veh/hr)
	= 0.936 SYNCHRO10.0 Delay	= 0.963 SYNCHRO10.0 Delay
R^2	0.901	0.906
Adj.R^2	0.885	0.89
Sig.	0.001	0.000
Paired Sample t-test		
Mean Difference in Delay (sec)	5.0375	2.2125
t	2.347	1128
P	0.052	0.297
p-value greater than 0.05, so that there is no statistically significant difference		
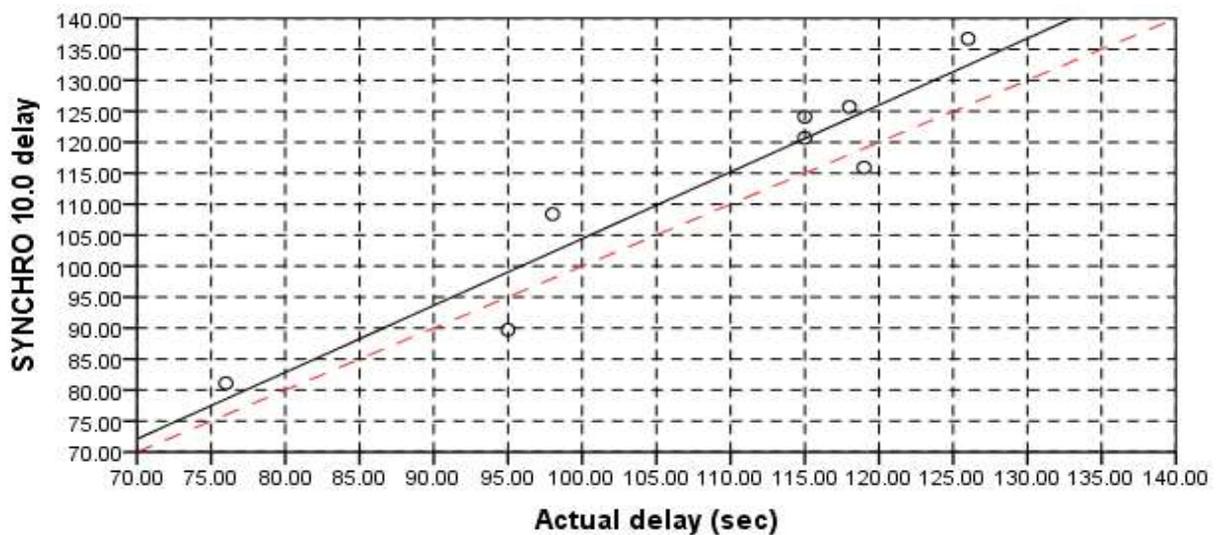
Figure (4-9): SYNCHRO Average Delay Values versus Field Delay Values for All Approach
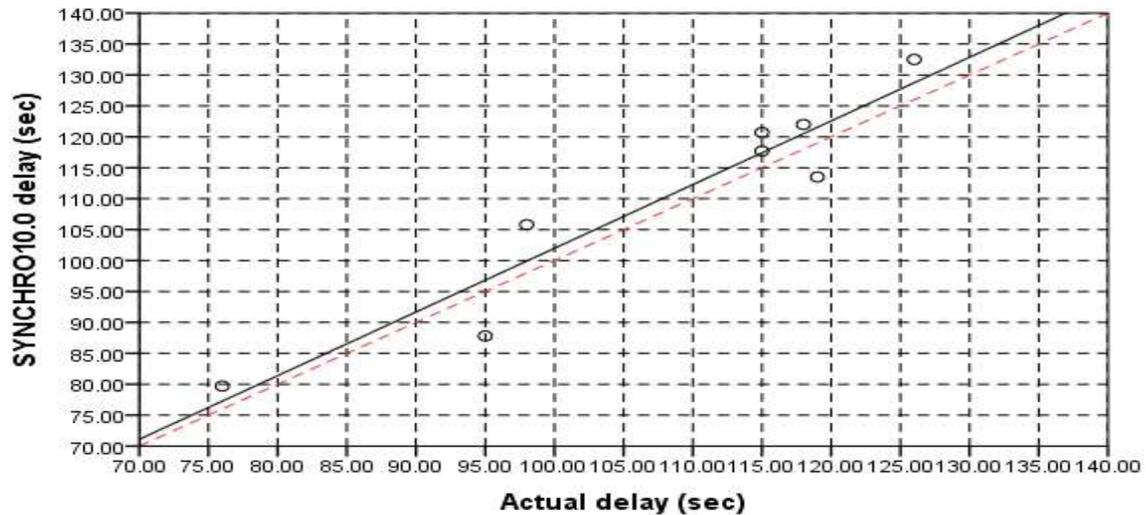
Figure (4-10): SYNCHRO Delay Values versus Field Delay Values after Calibrating the Basic saturation flow rate for All Approach.

4.7.2 SIDRA 8.0 PLUS Calibration :

For SIDRA models calibration the input data to ensure that the base case (i.e. the latest valid data representing the existing intersection) data is adequately represented in the model. The calibration process should be based on various traffic data, including surveys and site   observations. This data, for traffic signals may principally include traffic flow saturation flow, traffic signal phase sequences, phase green time splits, traffic signal timing settings for yellow, all red and pedestrian phases, and geometric parameters.

The produce a model that is sufficiently refined to provide reliability that will be able to satisfy the study objectives. In another words model calibration is a crucial step to obtaining any results from analysis **(Gagnon et al.2008)**
So, Microscopic simulation models contain several independent parameters to describe traffic control operation, traffic flow characteristics, and the driver behaviour. These models contain default values for each parameter, but the user also is allowed to input a range of values for each parameter.
Changing the value of these parameters during calibration should be based on

field measurements or conditions.

The default value of the basic saturation flow rate used by SDRA10.0 model is 1950 pcuphgpl ; Through passenger car unit per hour green per lane group (pcuphgpl) This is applied at the signalized intersections in the study area. The delay time produced by SIDRA 8.0 PLUS for each approach is compared with the average delay times measured from the field.

The results of the comparison between measured and estimated delays are shown in Figure(4-11),(4-12)for(Zalatimo,Eishtar)Intersection;Figure (4-13) (4-14) for Al- Thawra Intersection;and Figure(Bab al-Mashhad) intersection (4-15) (4-16). Comparison is made by using the paired samples t-test. The paired samples t-test is made by using SPSS V.23.0 program. The paired t-test results, as in Table (4-25) For(Zalatimo, Eishtar) intersection. Table (4-26) For(Al-Thawra) intersection and Table(Bab al-Mashhad) Intersection (4-27).

The calibration process is to adjust the basic saturation flow rate to be 2000 pcuphgpl in lane groups with high values of v/c, as recommended by HCM

Table (4-25) :Comparison of Actual and SIDRA8.0 plus Delay Prediction for(Zalatimo, Eishtar)Intersection Signalized Intersections.

Actual Delay	Default Values of Saturation Flow rate (1950 veh/hr)	Default Values of Saturation Flow rate (2000 veh/hr)
	0.916 SIDRA Delay	= 0.923SIDRA Delay
R^2	0.954	0.959
$Adj.R^2$	0.945	0.954
Sig.	0.001	0.000
Paired Sample t-test		
Mean Difference in Delay (sec)	13.1583	8.0917
t	2.013	1.381
P	0.069	0.195
p-value greater than 0.05, so that there is no statistically significant difference		
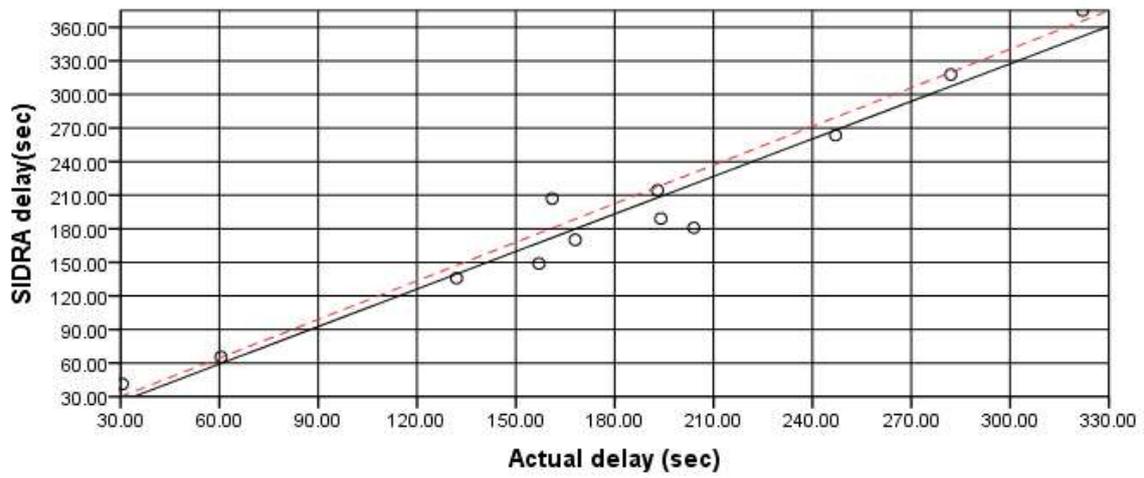
Figure (4-11): SIDRA8.0 PLUS Average Delay Values versus Field Delay Values for All
Approach
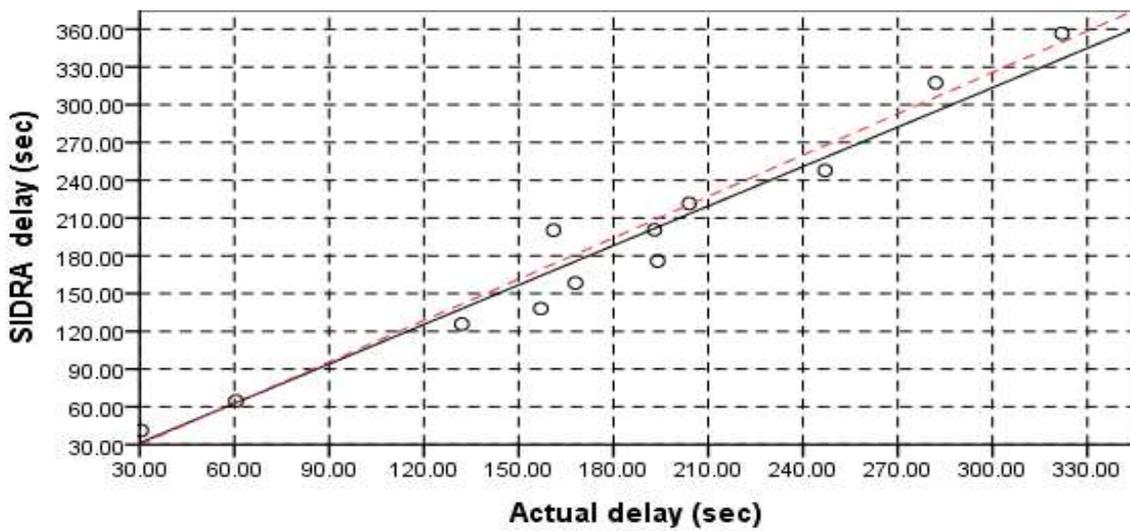
Figure (4-12): SIDRA8.0 Plus Delay Values versus Field Delay Values after Calibrating
the Basic saturation flow rate for All Approach

Table (4-26) : Comparison of Actual and SIDRA8.0 plus Delay Prediction for (Al-Thawra)Intersection Signalized Intersections.

Actual Delay	Default Values of Saturation Flow rate (1950 veh/hr) = 0.9033 SIDRA Delay	Default Values of Saturation Flow rate (2000 veh/hr) = 0.962 SIDRA Delay
R^2	0.983	0.984
Adj.R^2	0.978	0.979
Sig.	0.001	0.000
Paired Sample t-test		
Mean Difference in Delay (sec)	17.8666	8.7333
t	3.526	2.000
P	0.017	0.102
p-value greater than 0.05, so that there is no statistically significant difference		
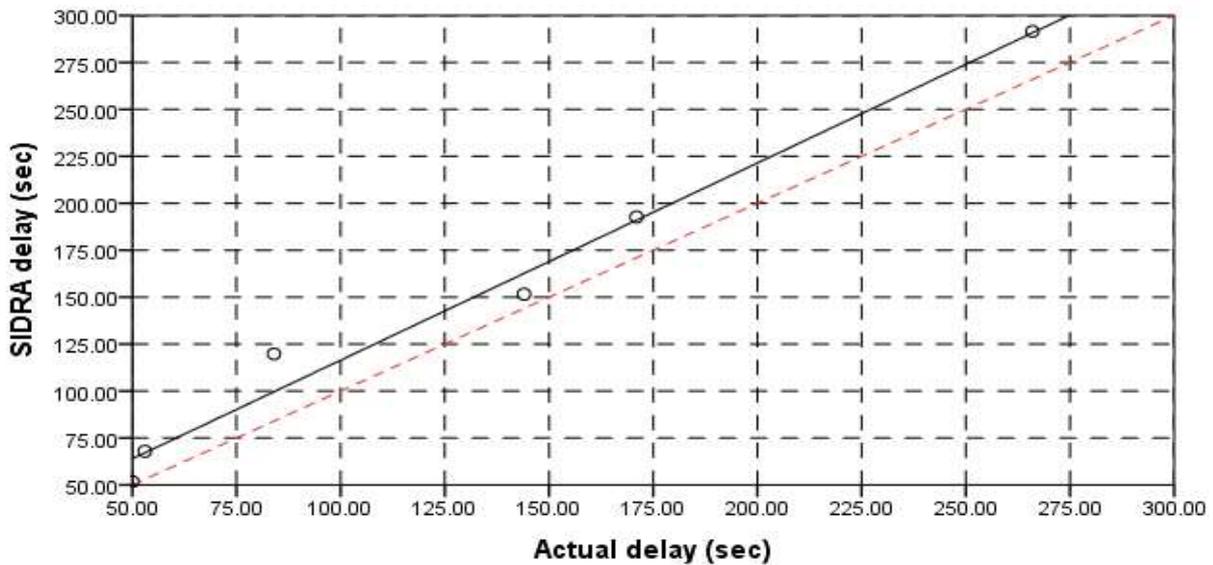
Figure (4-13): SIDRA8.0PLUS Average Delay Values versus Field Delay Values for All Approach
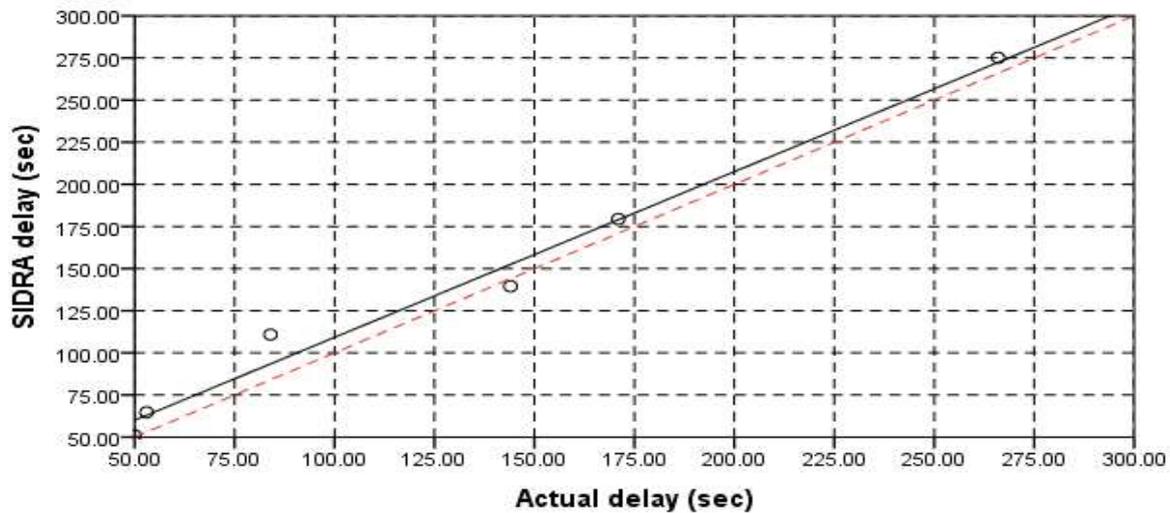
Figure (4-14): SIDRA8.0 Plus Delay Values versus Field Delay Values after Calibrating the Basic saturation flow rate for All Approach.

Table (4-27): Comparison of Actual and **SIDRA8.0 Plus** Delay Prediction for (Bab al-Mashhad)Intersection Signalized Intersections.

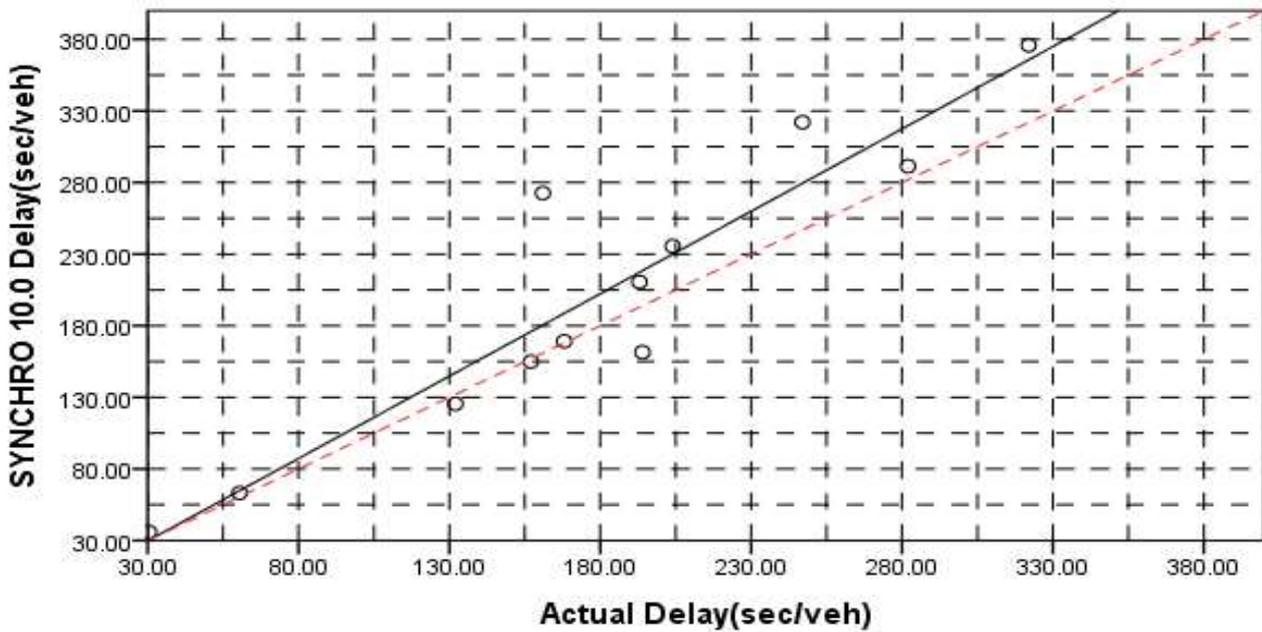| Actual Delay	Default Values of Saturation flow rate (1950 veh/hr)	Default Values of Saturation flow rate (2000 veh/hr)
	= **0.962 SIDRA Delay**	= **0.973 SIDRA Delay**
R^2	0.85	0.891
Adj.R^2	0.825	0.871
Sig.	0.002	0.000
Mean Difference in Delay (sec)	1.9125	1.725
t	0.662	0.776
P	0.529	0.463
p-value greater than 0.05, so that there is no statistically significant difference		

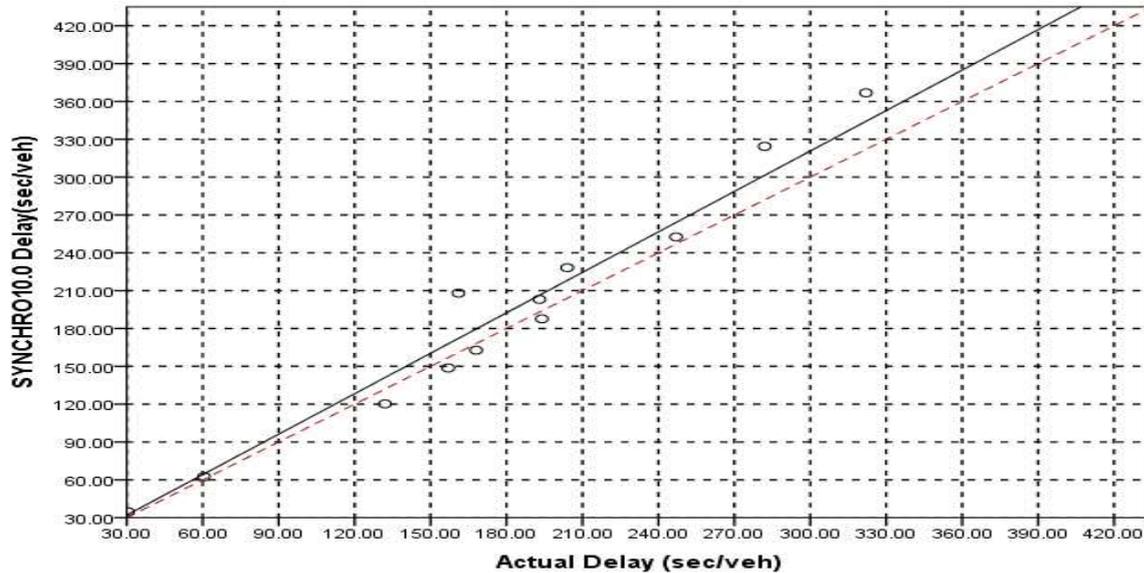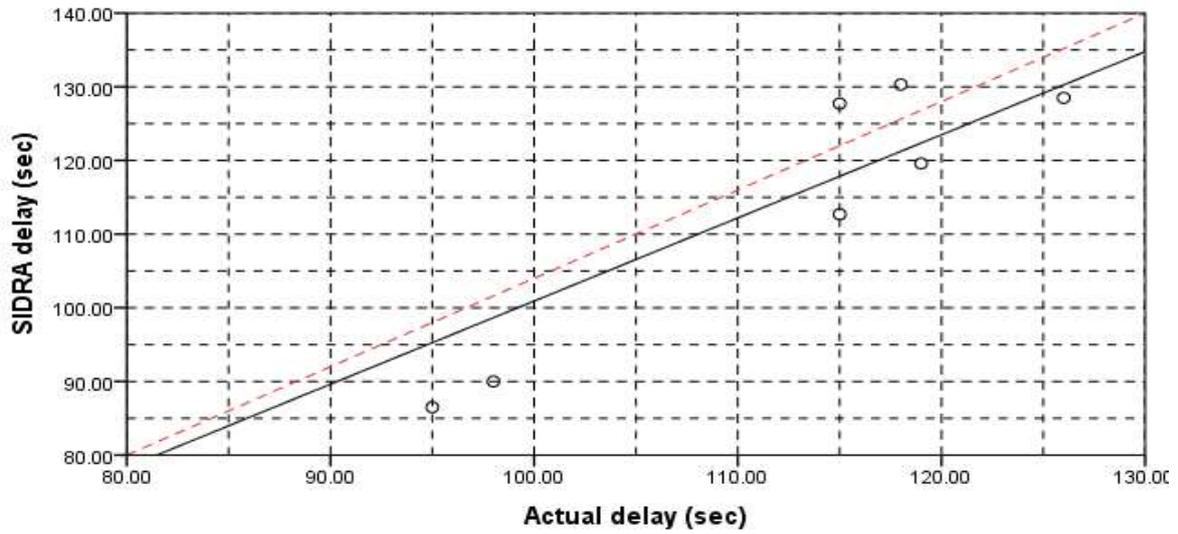**Figure (4-15):** SIDRA8.0PLUS Average Delay Values versus Field Delay Values
for All Approach
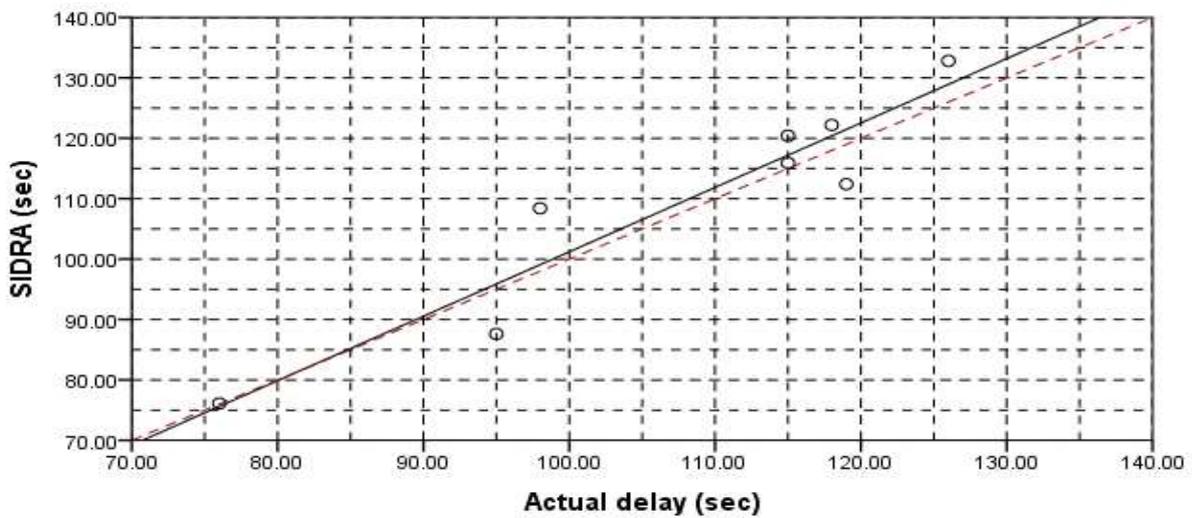
Figure (4-16): SIDRA8.0 Plus Delay Values versus Field Delay Values after
Calibrating the Basic saturation flow rate for All Approach

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4.8 Development of Statistical Models for Delay :

The traffic data, which represent many variables are extracted from video records to be used in the process of building statistical models. These data include; traffic and geometric characteristics. The next paragraphs describe the statistical techniques used for the models development are required for the prediction of delay

4.8.1 Identification of Dependent and Predictor Variables:

The variables which are used to simulate traffic and geometric characteristics as follows:

1. dependent variables:

g = Effective green time for movement or lane group (sec),

c = Capacity of lane group (veh/h),

C = Cycle length (sec),

v = Vehicular flow rate (veh/h),

w =Width of lane group at stop line (m).

Ws = Total width of lane groups departing to the same exit roadway, in the same phase at stop line (m).

We = Total width of exit roadway of intersection for traffic departing straight forward (m),

2. In dependent variables:

d = Delay for lane group (sec/veh).   These data are shown in Appendix E.

4.9 Testing of Normality

There are several methods of assessing whether data are normally distributed or not. The Kolmogorov-Smirnov test (K-S) and Shapiro-Wilk   (S-W) test are designed to test normality by comparing the data to a normal distribution with the same mean and standard deviation of the sample.   If the test is not significant, then the data are normal, so any value above 0.05 indicates normality. If the test is significant (less than 0.05), then the data are non-normal. Thus, results of tests in Table (4-28) show that all results above 0.05 follow normal distribution.

Table (4-28): K-S test and (S-W) test results for Field Delay(SPSS,V.23)

Intersection Name		Kolmogorov-Smirnov		Shapiro-Wilk	
		Statistic	Sig.	Statistic	Sig.
Zalatimo& Eishtar	Field delay	0.103	0.200	0.978	0.976
Al-Thawra	Field delay	0.202	0.200	0.917	0.485
Bab al-Mashhad	Field delay	0.203	0.200	0.919	0.418

4.9.1 Multicollinearity

Multicollinearity (collinearity and intercorrelation) is a statistical procedure to find the correlation between independent variables. The adverse effect of multicollinearity is that the estimated regression coefficients (b1, b2, etc.) tend to have large sampling variability.

The basic methodology followed in this procedure is that, predictor variables are eliminated one by one based on multicollinearity analysis with multicollinearity control, the process is repeated eliminating predictor variables remaining. At that point, interactions among the variables are considered again the process is iterated discarding terms based on significance. A correlation matrix is produced to determine the correlation coefficients for the variables. In many cases, the correlation matrix will not be able to identify whether multicollinearity is a serious problem because there are many ways for variables to be related **(Keller and Warrack, 2000)**.

SPSS software (Ver.23) is employed for the development of the models A confidence level of 95 percent is adopted, thus a significant level ($\alpha = 0.05$) is employed. By using SPSS software, the correlation coefficients between all of the variables are calculated and the correlation matrix is setup. This matrix can be seen in Tables (4-29), (4-30) and (4-31) for delay and queue models. Then, the independent variables having the highest correlation coefficient with the designated dependent variables are selected and calculated, and the regression equation is formulated.

Table (4-29): Correlation Coefficient Matrix for(Zalatimo, Eishtar) Delay Model.

	Field Delay	**Cycle (sec)**	**g/C**	**v/c**	**We/Ws**
Field Delay	1.000	-0.014	-0.254	0.960	0.030
Cycle (sec)	-0.014	1.000	-0.040	-0.380	0.081
g/C	-0.254	-0.040	1.000	-0.136	-0.513
v/c	0.960	-0.038	-0.136	1.000	0.041
We/Ws	0.030	0.081	-0.513	0.041	1.000

Table (4-30): Correlation Coefficient Matrix for Al-Thawra Delay Model.

	Field Delay	**Cycle (sec)**	**g/C**	**v/c**	**We/Ws**
Field Delay	1.000	-0.108	-0.248	0.954	-0.599
Cycle (sec)	-0.108	1.000	0.119	-0.167	0.000
g/C	-0.248	0.119	1.000	-0.197	0.277
v/c	0.954	-0.167	-0.197	1.000	-0.764
We/Ws	-0.599	0.000	0.277	-0.764	1.000

Table (4-31): Correlation Coefficient Matrix for Bab al-Mashhad Delay Model.

	Field Delay	**Cycle (sec)**	**g/C**	**v/c**	**We/Ws**
Field Delay	1.000	-0.130	-0.727	0.970	0.582
Cycle (sec)	-0.130	1.000	0.158	-0.165	0.000
g/C	-0.727	0.158	1.000	-0.640	-0.566
v/c	0.970	-0.165	-0.640	1.000	0.518
We/Ws	0.528	0.000	-0.566	0.518	1.000

4.10 Regression Modeling

Regression analysis is a statistical method that uses the relationships between two or more variable quantities to generate a model that may predict one variable from the others. The term multiple linear regression (MLR) is employed when a model is a function of more than one dependent variable.

The objective behind (MLR) is to obtain adequate models, at a selected confidence level, using the variable data, while at the same time satisfying the basic assumptions of regression analysis, which are:

- Severe multicollinearity does not exist among predictor variable
- Influential observations or outliers do not exist in the data.
- The distribution of error is normal.
- The mean of error distribution is zero.
  The objective is accomplished by selecting the model, which provides the highest adjusted coefficient of determination (R^2) and the lowest mean square error (MSE) **(Keller and Warrack, 2000).**

4.10.1 Stepwise Regression Procedure

This procedure begins by computing the simple regression model for each independent variable. The independent variable with the largest f- statistic is chosen as the first entering variable. SPSS software uses the f- statistics and the standard is usually set at F = 3.8 which is chosen because the significant level is about 5%. The standard is called the f- to enter.

If at least one variable exceeds the standard, the procedure continues, then the software will examine if the variables verify the condition of dependent variables remaining in the model or not. It then considers whether the model would be improved by adding a second independent variable. It examines all such models to determine which is the best and whether the f- statistic of the second variable (with the first variable already in the equation) is greater than f- to enter **(Ahmed, 2002).**

If two independent variables are highly correlated, only one of them will enter the equation. Once the first variable is included, the added explanatory power of the second variable will be minimal and its f-statistic will not be large enough to enter the model. In this way, multicollinearity is reduced. The procedure continues by deciding whether to add another independent variable to each step. The p-values of all variables are computed (at each step) and compared with the f- to be removed. If a variable f – statistic falls below this standard, it is removed from the equation. These steps are repeated until no more variables are added or removed.

4.11 Delay Model

The stepwise regression delay model's summary can be found in Table

Table (4-32) and Table(4-33)

4.11.1 (Zalatimo, Eishtar) Synchro 10.0 Delay Model :

Tables (4-32): Stepwise Regression Models Summary for Delay Model.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square	Adjusted R Square	Std. Error of estimate
	B	Std. Error of Estimate	Beta					
v/c	335.615	12.933	0.940	25.950	0.000			
g/C	-323.296	76.944	-0.177	-4.202	0.000	0.945	0.941	27.55
(0.731-We/Ws)	617.998	259.772	0.099	2.397	0.000			

The results of regression technique and selected developed delay model
are shown in Equation (4-1)

$$d = (335.615 \, v/c) - (323.296 \, g/C) + 617.998 \, (0.731 - We/Ws) \qquad Eq. (4 - 1)$$

4.11.2 (Zalatimo, Eishtar) SIDRA 8.0 plus Delay Model :

Tables (4-33): Stepwise Regression Models Summary for Delay Model.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square	Adjusted R Square	Std. Error of estimate
	B	Std. Error of Estimate	Beta					
(Constant)	-190.703	21.842		-8.731	0.000			
v/c	352.892	11.791	.965	29.929	0.000	0.966	0.964	22.67
g/C	-193.163	58.237	-.107	-3.317	.002			

The results of regression technique and selected developed delay model
are shown in Equation (4-2)

$$d = 352.892 \, v/c - 193.163 \, g/C + 0.987 \qquad Eq. (4 - 2)$$

From $Eq. (4 - 1)$ @ $Eq. (4-2)$ where:

d = lane groups delay (sec /veh)

v = Vehicular flow rate (veh/h)

c = Capacity of lane group (veh/h),

g = effective green time (sec).

C = cycle length (seconds)

We= Total width of lane groups departing to the same exit roadway, in the same phase
        at stop line (m)

Ws= Total width of exit roadway of intersection for traffic departing straight forward(m)

4.12 (Al-Thawra) Delay Model :

4.12.1 (Al-Thawra) SYCNCHRO10.0 Delay Model :

Tables (4-34): Stepwise Regression Models Summary for Delay Model.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square	Adjusted R Square	Std. Error of Estimate
	B	Std. Error of Estimate	Beta					
v/c	371.148	20.787	1.199	17.855	0.000			
g/C	-126.227	52.250	-0.109	-2.416	0.000	0.963	0.957	13.27
(We/Ws-1.823)	1177.291	231.945	0.348	5.076	0.000			

The results of regression technique and selected developed delay model are shown in Equation (4-3)

$$d = (371.184\ v/c) - (126.277\ g/C) + 1177.291\ (We/Ws - 1.1823) \qquad Eq.\ (4\text{-}3)$$

4.12.2 (Al-Thawra) SIDRA Delay Model :

Tables (4-35): Stepwise Regression Models Summary for Delay Model.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square	Adjusted R Square	Std. Error of Estimate
	B	Std. Error of Estimate	Beta					
v/c	360.698	23.291	1.1873	15.487	0.000			
g/C	-135.052	55.94	-0.1089	-2.414	0.025	0.962	0.954	14.42
(We/Ws-1.823)	1145.546	272.150	0.3166	4.209	0.000			

The results of regression technique and selected developed delay model are shown in Equation (4-4)

$$d = (360.698\ v/c) - (135.052\ g/C) + 1145.546\ (We/Ws - 1.142) \qquad Eq.\ (4\text{-}4)$$

From $Eq.$ (4 -2) @ $Eq.$ (4 -3) where:

d = lane groups delay (sec /veh)

v = Vehicular flow rate (veh/h)

c = Capacity of lane group (veh/h)

g = effective green time (sec).

C = cycle length (seconds)

We= Total width of lane groups departing to the same exit roadway, in the same phase at stop line (m)

Ws= Total width of exit roadway of intersection for traffic departing straight forward(m)

4.13 (Bab al-Mashhad) Delay Model :

4.13.1 (Bab al-Mashhad) Synchro 10.0 Delay Model :

Tables (4-36): Stepwise Regression Models Summary for Delay Model.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square	Adjusted R Square	Std. Error of estimate
	B	Std. Error of Estimate	Beta					
(Constant)	-43.460	27.436		-1.584	0.128	0.961	0.957	5.58
v/c	201.597	13.285	0.855	15.175	0.000			
g/C	- 244.777	76.66	-0.1799	-3.193	0.004			

The results of regression technique and selected developed delay model are shown in Equation (4-5)

d =201.597 v/c - 244.777g/C -43.460   *Eq.* **(4- 5)**

4.13.1 (Bab al-Mashhad) SIDRA 8.0 PLUS Delay Model :

Tables (4-37): Stepwise Regression Models Summary for Delay Model.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square	Adjusted R Square	Std. Error of estimate
	B	Std. Error of Estimate	Beta					
(Constant)	-64.750	29.38		-2.204	0.039	0.947	0.942	5.32
v/c	205.867	15.909	0.863	12.940	0.000			
g/C	-174.229	74.38	-0.156	-2.342	0.029			

The results of regression technique and selected developed delay model are shown in Equation (4-6)

d =205..867 v/c - 174.229 g/C -64.750   *Eq.* **(4 -6)**

Eq. (4 - 5) @ *Eq.* (4-6)   where:

d = lane groups delay (sec /veh)

v = Vehicular flow rate (veh/h)

c = Capacity of lane group (veh/h)

g = effective green time (sec).

C = cycle length (seconds)

The variables that have significant impact on total delay are explained in Table

(4-38), (4-39) and (4-40) for the linear regression model, with statistical characteristics

The minimum and maximum traffic parameters limits   represent the range at

which the model will be applicable.

Table (4-38): Data Range and Statistical Characteristics for (Zalatimo, Eishtar)
delay model.

Variable	Minimum	Maximum	Mean	Std. Deviation
g/C	0.150	0.380	0.24085	0.06206
v/c Synchro 10.0	0.78	2.24	1.237447	0.317267
v/c SIDRA 8.0 PLUS	0.618	2.17	1.21719	0.327275
Cycle (sec)	120	180	147.2340	18.21396
We/Ws	0.94	1.00	0.9794	0.01823

Table (4-39): Data Range and Statistical Characteristics for Al-Thawra delay
model

Variable	Minimum	Maximum	Mean	Std. Deviation
g/C	0.14	.32	.2292	.05555
v/c Synchro10	0.74	1.49	1.1217	.20815
v/c SIDRA 8.0 PLUS	0.62	1.48	1.0413	0.2267
Cycle (sec)	124.00	170.00	138.2500	19.27885
We/Ws	.95	1.00	.9617	.01903

Table (4-40): Data Range and Statistical Characteristics for Bab al-Mashhad
delay model

Variable	Minimum	Maximum	Mean	Std. Deviation
g/C	0.19	0.25	*0.2*142	0.01976
v/c Synchro10	0.770	1.280	1.0408	0.114052
v/c SIDRA 8.0 PLUS	0.792	1.216	1.02658	0.092403
Cycle (sec)	130	160	145	12.51086
We/Ws	0.79	0.95	0.8758	0.05587

4.14 Models Validation

Validation process is determining whether the selected model is

appropriate for the given conditions and for the given task; it compares

model prediction with measurements or observations **(TRB,2005).**The

objective of validation is to assess the adequacy of the proposed

prediction models and measure the error or accuracy of the prediction for the validation period. There are several methods used for models validation. One of these methods is to compare the model with another data set that is not included in model building The data used for this purpose is one hour data abstracted from video recording films at different times for the same intersections in the network. The data used for this purpose is one hour data abstracted from video recording films at different times for the same intersections in the network. The average field delay from one hour is regressed with the delay time predicted by the model. The regression results are shown in Figures (4-17),(4-18) and (4-19) and Table (4-41) .It can be concluded from the models values of R^2 that, the predicted values from models can represent the actual field values of delay.

Table(4-41): Regression results for the delay model (By SPSS, V.23).

Intersection Name	Model Fit	R^2 value	Adj. R2 value	Sig.
(Zalatimo, Eishtar)	0.88 * Field Delay + 1.95	0.979	0.9778	0.000
Al-Thawra	0.93 * Field Delay + 6.59	0.982	0.979	0.000
Bab al-Mashhad	0.88 * Field Delay + 10.09	0.995	0.995	0.000
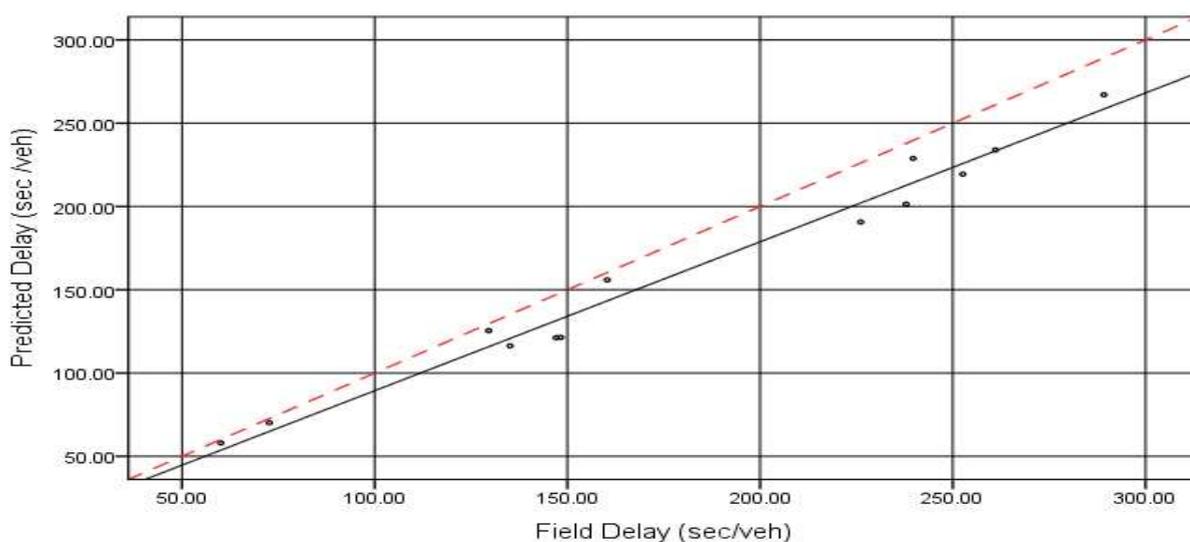
Figure: (4-17) Observed(Zalatimo,Eishtar) intersection versus predicted delay
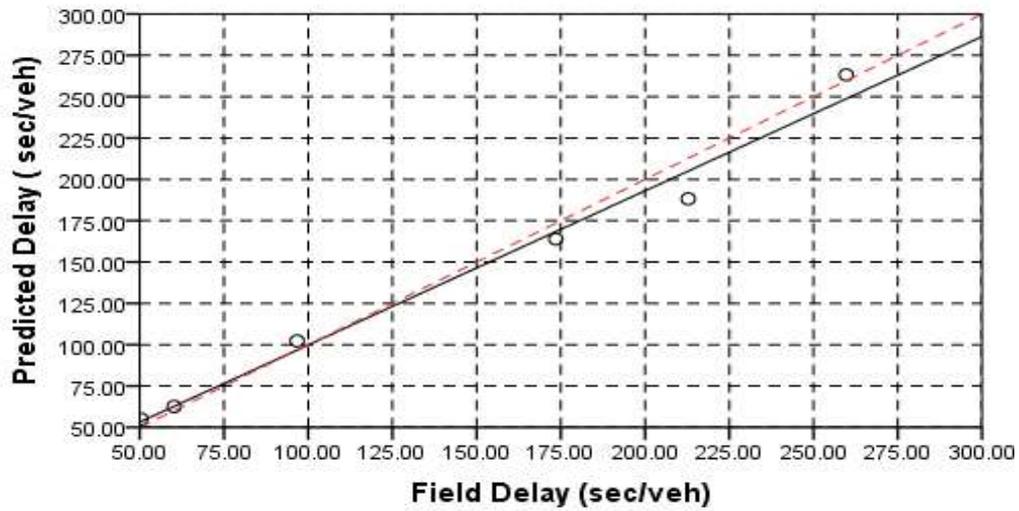
Figure(4-18): Observed Al-Thawra intersection versus predicted delay
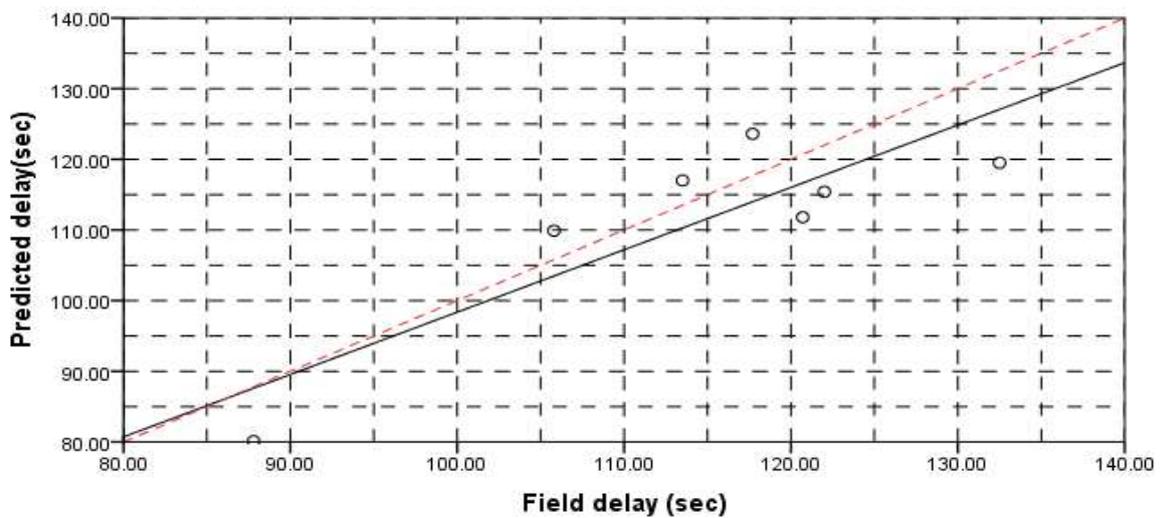
Figure(4-19): Observed Bab al-Mashhad intersection versus predicted delay

4.15 Models Analysis

Many variables affect the delay model, including (degree of saturation (v/c) ratio green to cycle (g/C) and total width of exit roadway of intersection for traffic departing straight divided by total width of lane groups departing to the same exit roadway, in the same phase (We/Ws)).From the previous model of delay, it is obvious that Synchro 10.0 & Sidra 8.0 plus Program software , delay time increases as v/c value increase. The increase in delay is attributed mainly to the increase in the effective red and hence in waiting time for vehicles before the start of green. The delay time has a proportional relationship with the degree of saturation (v/c) which is based on flow rate and proportion of cycle time effectively green (g/c).The minimum of g/c and large flow rate cause high v/c value. (g/C) with delay time has an inverse relationship. Increasing (g/C) leads to decrease the delay.

According to equation (Zalatimo, Eishtar), Synchro 10.0 delay time has an inverse relationship with (We/Ws).When (We/Ws) is more than 0.731 delay time, it is obviously decreased. The model's adopted (We/Ws) limit should   be ≥ 0.731 .

According to equation (Al-Thawra), Synchro10.0 and SIDRA 8.0 PLUS delay time has an inverse relationship with (We/Ws). When (We/Ws) is less than(1.182 , 1.142) delay time, it is obviously decreased. The model's adopted (We/Ws) limit should   be $\leq$ (1.182 , 1.142)

4.16 Improvements

This section presents the improvement strategies applied to the traffic flow in the study area of Babil city through the application of the program SYNCHRO10.0 software only ,because the difference between SYNCHRO 10.0 and SIDRA 8.0 PLUS It gives relatively higher values which represent the most dangerous case.

SYNCHRO10.0 is used to evaluate the existing traffic operations. It is also used as a tool to determine the optimum traffic signal timings for a single intersection or for a series of coordinated or uncoordinated signalized intersections.

This section divides the improvement strategies into two parts. The first part includes Signal Timing Optimization and Coordination. The improvement type is suggested and evaluated by SYNCHRO 10.0 program. The second part includes the geometric improvement.

4.16.1 Signal Timing Optimization and Coordination

Traffic signal control is a system for synchronizing the timing of any number of traffic signals in an area, with the aim of reducing stops and overall vehicle delay or maximizing throughput.

One of the most common methods for increasing the efficiency of traffic operation is coordination of consecutive traffic signals. This is because, the higher increase in the traffic demand will result in higher increase in the need of coordination.Traffic signal coordination can reduce the traffic congestion in many areas. Substantial improvements in traffic flow and reduction in delay, fuel consumption and stops and uniform flow speed links could be achieved by coordination.

Signal coordination is the process to synchronize the start of the "green light" along the major roadway, so that vehicles can travel through a group of signals with minimal or no stopping. There are three key timing parameters to

optimize   and   noticeable   to   the   driver.These   include   the   "cycle length",intersection   "offset,"or   progression,   and   the   individual   traffic movement "green+ yellow + red" phase (referred to as a movement "split"

SYNCHRO10.0 contains a number of optimization types. It optimizes cycle length, split times, offsets and phase sequence to minimize driver stops and delays. These types are applied to the network in the same order shown in Figure (4-20) **(Husch and Albeck, 2006).**

Figure (4-20) flowchart: "Setup Intersection Timing Plan Optimize Split and Cycle Length" → "Optimize Cycle Length" → "Optimize Offset Phase Order"
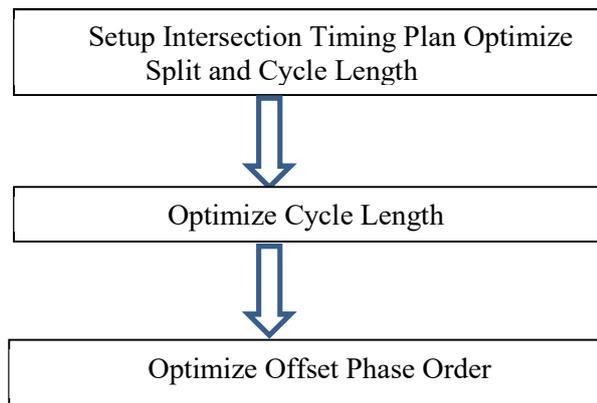
Figure (4-20): Optimization Steps in SYNCHRO10.0

The range of cycle length recommended by HCM is 60-120 seconds. Range of cycle length 100-120 seconds will be recommended to accommodate an extra 10% capacity. Long cycle lengths more than 120 seconds may have negative operation aspects including long queues, inefficient use of turning lanes, and blocking. Lower cycle lengths (30-60) may be better to reduce queues which in general increase capacity and provide smoother traffic operation **(Sofia,1998)**. The optimization results with the HCM recommended cycle range do not result in optimum cycle length, so the default range of SYNCHRO 10.0 is used to calculate the best cycle time and the optimal timing of the   existing   phase sequences of the observed intersections, SYNCHRO is used. The range of cycle times used in the optimization process is 50-200 seconds. This range is   used for each observed isolated intersection. Table (4-42),(4-43) provide a summary for the optimization results. This is together with the best cycle time for each intersection in the observed network. Table(4-42),(4-43) shows that, the use of

optimization functions for the isolated signalized intersections such as split and offset has good effect on Measuring Of the Effectiveness (MOE) for Al-Thawra intersections and has minimized the effect of (MOE) at (Zalatimo,,Eishtar, Bab al-Mashhad) intersection . It is necessary to improve the performance by coordination to reduce cycle length and delay because the optimization results show that, although the cycle time increases to high values, the isolated intersections perform oversaturation and under saturated conditions.

After the coordination process for signalized intersections in the network the delay times are reduced from 162.2 to 138.0 for Al-Thawra intersection with no effect at(Zalatimo ,Eishtar, Bab al-Mashhad) intersection.

Although the optimization and coordination runs improve the network measure of effectiveness, the degree of saturation does not reduce to a value less than (1.48,1.56,1.38,1.11) for all intersection as shown in Table (4-42)and (4-43) thus we should use another trial by improving the geometries of intersections.

Table (4-42): Measure of Effectiveness for the Improved (Zalatimo*)* Intersection with the Optimum Cycle Length Produced by SYNCHRO10.

intersection name	improvement Type	cycle Length sec/veh)	Max. v/c	Total Delay sec/veh	LOF
Zalatimo	Base Condition	140	1.72	186.0	F
	Split	140	1.48	178.2	F
	Cycle length	120	1.69	207.0	F
	Network cycle length	115	1.70	206.2	F
	Phasing Sequence	115	1.70	206.2	F

Table (4-43): Measure of Effectiveness for the Improved (Eishtar, Al-Thawra, Bab al-Mashhad) Intersections with the Optimum Cycle Length Produced by SYNCHRO10.0

intersection name	improvement Type	cycle Length (sec/veh)	Max. v/c	Total Delay sec/veh	LOF
Eishtar	Base Condition	132	1.64	228.4	F
	Split	132	1.56	220.2	F
	Cycle length	120	1.57	224.8	F
	Network cycle length	120	1.57	224.8	F
	Phasing Sequence	120	1.57	224.8	F
Al-Thawra	Base Condition	124	1.49	162.2	F
	Split	124	1.38	138.0	F
	Cycle length	120	1.40	148.8	F
	Network cycle length	120	1.40	148.8	F
	Phasing Sequence	120	1.40	148.8	F
Bab al-Mashhad	Base Condition	149	1.16	104.0	F
	Split	149	1.11	100.1	F
	Cycle length	120	1.33	127.4	F
	Network cycle length	120	1.33	127.4	F
	Phasing Sequence	120	1.33	127.4	F

4.16.2. Geometric Improvement :

The improvement proposals by Re-marking of pavement and Widening of approaches. The measure of effectiveness produced for each strategy is illustrated in Table (4-44),(4-45) for Signalized intersections analyzed by SYNCHRO10.0 The first step of the geometric improvement is to apply pavement marking. From the measurement, it can be noticed that the number of lanes in many approaches of these intersections can be increased by decreasing the lane width (with keeping the width of lanes greater than a minimum value of 2.4 m according to HCM). which is actually observed cannot to be used in

field which at intersection approaches, because   the width of the lane Group is from 2.8-4,meaning that the width cannot be reduced for all intersections.

 increasing the number of lanes , increases the capacity of affected approaches by reducing Central Refuges to a width of 2 m while maintaining the planting of trees .

Increasing the width of the lane group, which leads to improve traffic performance measures of effectiveness for some intersections in the selected network. Therefore, in this step, consideration is given to pavement marking the approaching lanes, so that re-arranging of queuing vehicles at the stop line is attained.

Table (4-44): Measure of Effectiveness for the Improved (Zalatimo**,** Eishtar) Intersections Produced by SYNCHRO10. (Geometric Improvement)

Intersection Name	Improvement Type	Cycle Length (sec/veh)	Max. v/c	Total Delay sec/veh	LOS
Zalatimo	Base Condition	120	1.69	207.0	F
	Pavement Widening	120	1.30	110.7	F
Eishtar	Base Condition	120	1.57	224.8	F
	Pavement Widening	120	1.29	112.4	F

Table (4-45): Measure of Effectiveness for the Improved (Al-Thawra, Bab al-Mashhad)Intersections Produced bySYNCHRO10.0(Geometric Improvement)

Intersection Name	Improvement Type	Cycle Length (sec/veh)	Max. v/c	Total Delay sec/veh	LOS
Al-Thawra	Base Condition	120	1.40	148.8	F
Al-Thawra	Pavement Widening	120	1.15	92.7	F
Bab al-Mashhad	Base Condition	120	1.33	127.4	F
Bab al-Mashhad	Pavement Widening	120	1.08	76.1	E

The pavement Widening is applied to(Zalatimo,Eishtar,Al-Thawra,Bab al-Mashhad) intersection to increase number of lanes with the same lane group width at approach

Zalatimo intersection.This method reduces the Maximum v/c value from 1.69 to 1.37and reduces delay from 207.0 seconds to 110.7 seconds. The improvement is shown in Figure (4-21).

Eishtar intersection.This method reduces the Maximum v/c value from 1.57 to1.29 and reduces delay from 224.8 seconds to 112.4 .The improvement is shown in Figure (4-22).

Al-Thawra intersection. This method reduces the Maximum v/c value from 1.40 to 1.15 and reduces delay from148.8 seconds to 92.8 seconds The improvement is shown in Figure (4-23).

Bab al-Mashhad intersection. This method reduces the Maximum v/c value from 1.33 to 1.08 and reduces delay from 127.4 seconds to 76.1 seconds for

Bab al- Mashhad. The improvement is shown in Figure (4-24).
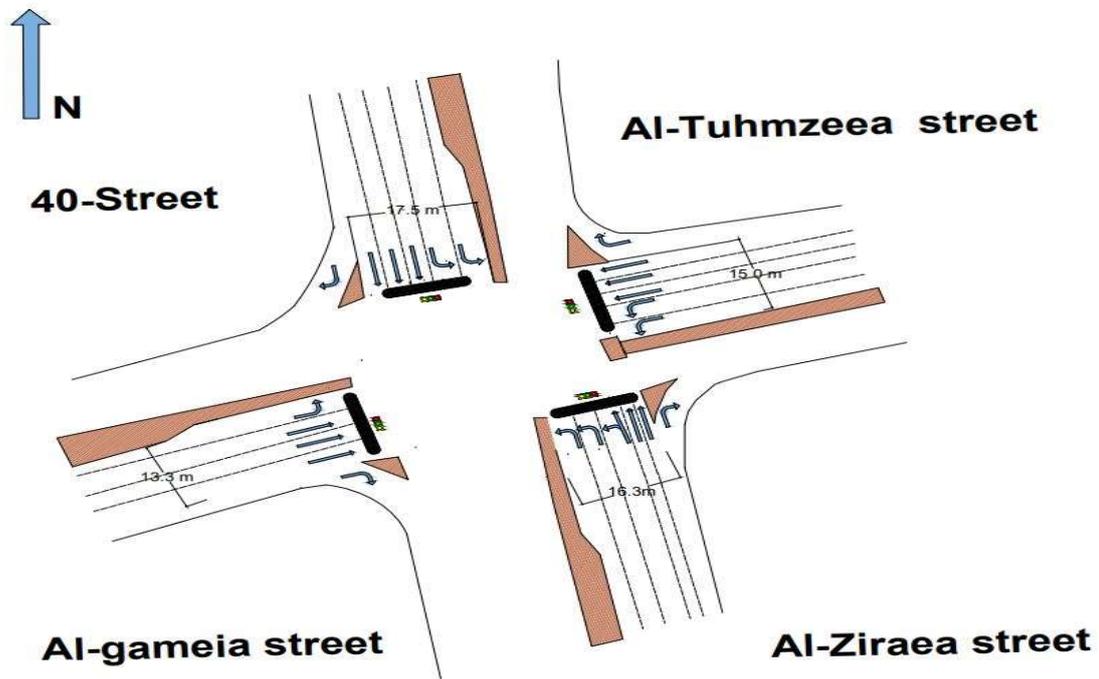
Figure (4-21): Improvement Proposal for Zalatimo Intersection.
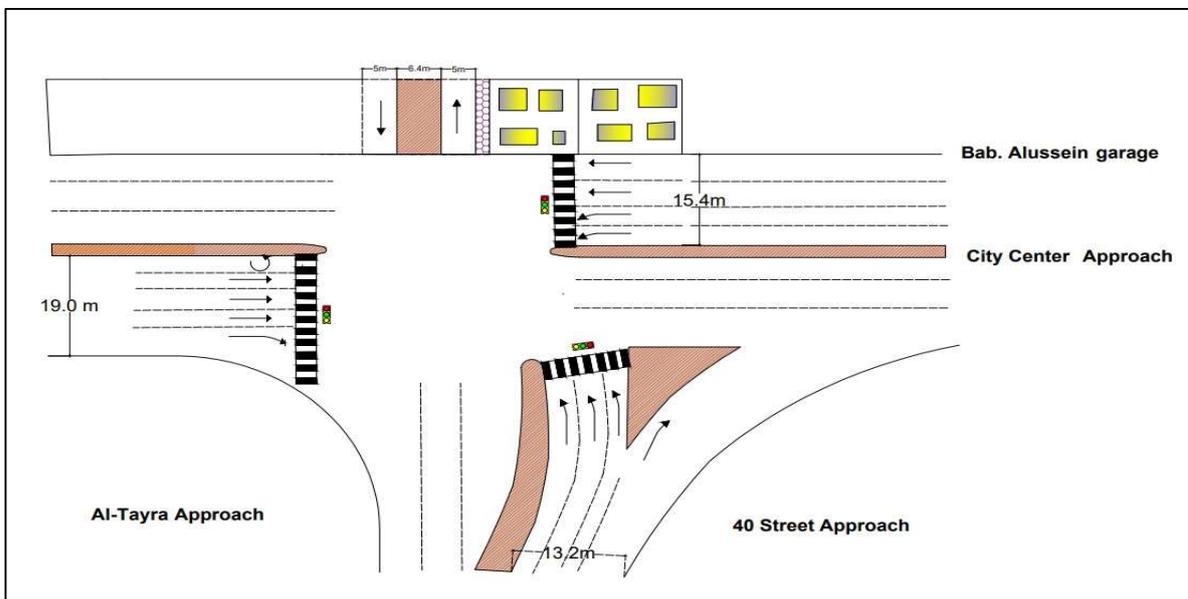
Figure (4-22): Improvement Proposal for Eishtar Intersection.
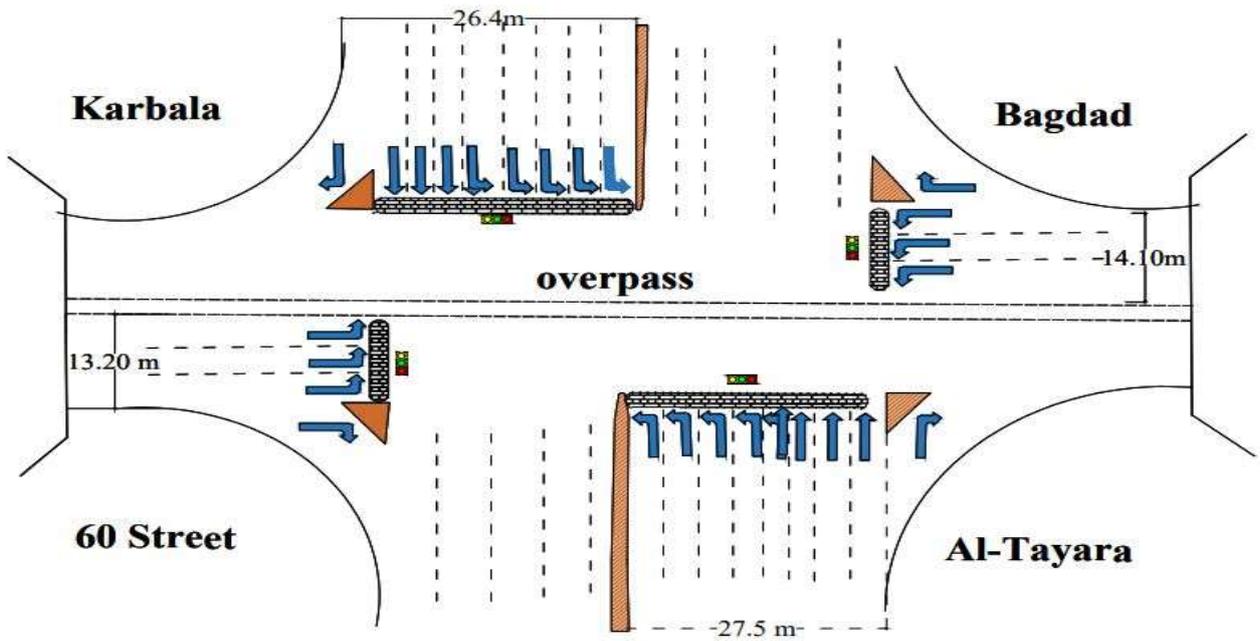
Figure (4-23): Improvement Proposal for Al-Thawra Intersection.
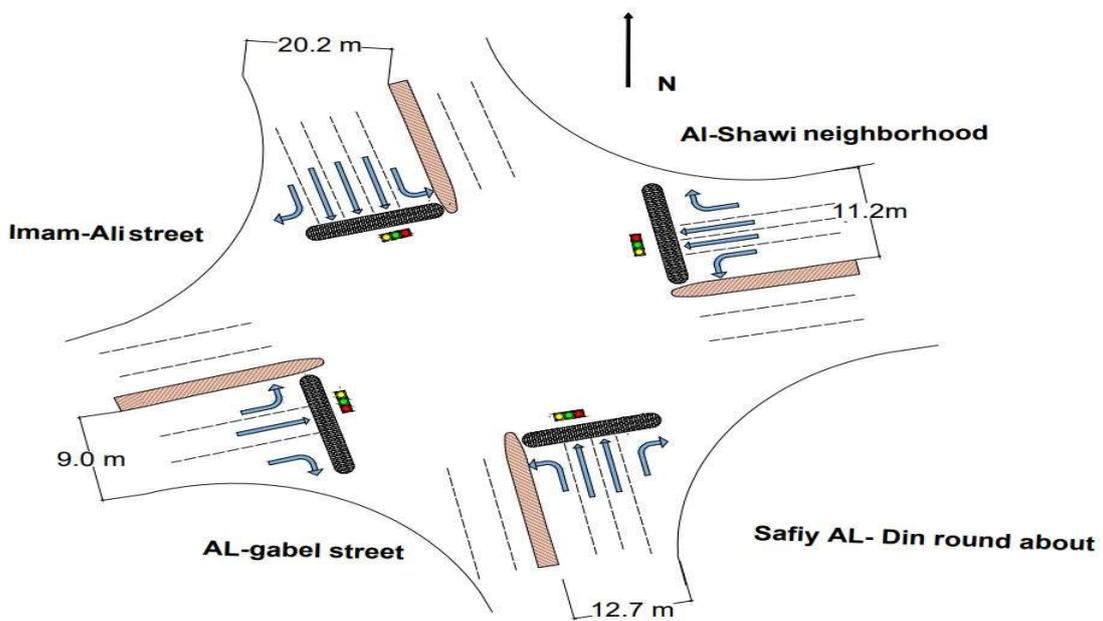
Figure (4-24): Improvement Proposal for Bab al-Mashhad Intersection.

4.17 Forecasted Network:

The growth factor of 2.0 % (i.e traffic forecast factor TFF) is introduced for the application of forecasting traffic volume on the improvement proposals for intersections. The growth rate together with the analysis period is applied with   SYNCHRO10.0 for the application of forecasting traffic volume on the   improvement proposals. Table (4-46) shows the measure of effectiveness obtained from SYNCHRO optimization runs after the   last improvement strategy for the target year 2027.

Table (4-46): Measure of Effectiveness Produced by SYNCHRO10.0 after Last Improvement Strategy for the Base Year 2022, and Target Year 2027

Intersection Name	Base Year 2022 Average Delay (sec/veh)	LOS	Target Year 2027 Average Delay (sec/veh)	LOS
Zalatimo	110.7	F	145.8	F
Eishtar	112.4	F	156.5	F
Al-Thawra	92.7	F	129	F
Bab al- Mashhad	76.1	E	96.4	F

Chapter Five

Conclusions and Recommendations

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5.1 Conclusions

The following is a summary of the main conclusions that can be drawn from this

study within the confines of the traffic and geometric features of the study area:

1. Delay time for signalized intersections produced by software program SYNCHRO10 and SIDRA 8.0 PLUS has no significant difference with the delay time measured at field with 95% confidence level.

2. SYNCHRO 10.0 and SIDRA 8.0 Plus have a good representation of field delay at low to medium values, but it is overestimated at high delay range .

3. Regression models, developed to estimate delay time, show good correlation with field Delay model can be use to estimate delay time at any intersections knowing signal timing, traffic volume, ratio of total width of exit roadway of intersection for traffic departing straight forward to total width of lane groups departing to the same exit roadway, in the same phase at stop line (We/Ws).

4. The linear relationship actual delay time with delay time produced by different Software delay times is predicted.

These relationships before calibration Software delay times are as follows:

- (Zalatimo, Eishtar) Signalized Intersections :
  Actual Delay=0.872 SYNCHRO10.0 Delay and R^2= 86.4% SYNCHRO10.0
  Actual Delay= 0.916 SIDRA Delay and R^2= 95.4% (SIDRA 8.0 PLUS).

- Al-Thawra Signalized Intersection :
  Actual Delay=0.843 SYNCHRO10.0 Delay andR^2= 77.6% SYNCHRO10.0
  Actual Delay= 0.903 SIDRA Delay and R^2= 98.3% (SIDRA 8.0 PLUS).

- Bab al-Mashhad Signalized Intersection :
  Actual Delay=0. 936 SYNCHRO10.0 Delay andR^2= 90.1% SYNCHRO10.0
  Actual Delay= 0.962 SIDRA Delay and R^2= 85.0% (SIDRA 8.0 PLUS).

These relationships after calibration Software delay times are as follows:

- (Zalatimo, Eishtar) Signalized Intersections :
  Actual Delay=0.931 SYNCHRO10.0 Delay andR^2= 96.5% SYNCHRO10.0
  Actual Delay= 0.923 SIDRA Delay and R^2= 95.9% (SIDRA8.0 PLUS).

- Al-Thawra Signalized Intersections :
  Actual Delay=0.958 SYNCHRO10.0 Delay andR^2=95.5% SYNCHRO10.0
  Actual Delay= 0.962 SIDRA Delay and R^2= 98.4% (SIDRA 8.0 PLUS).

- Bab al-Mashhad Signalized Intersections :
  Actual Delay=0.963 SYNCHRO10.0 Delay andR^2= 90.6 % (SYNCHRO10.0).
  Actual Delay= 0.973 SIDRA Delay and R^2= 89.1% (SIDRA 8.0 PLUS).

5. Delay Model for Selected Signalized Intersections in Hilla City by application of software programs (Synchro10 and SIDRA 8.0 intersection plus):

The stepwise regression method is used for delay time prediction. SPSS software version23.0 is used to develop the delay model. The variables are entered in a stepwise manner to build the models.In order to obtain a model with 95% confidence level, F-value is set to 3.84 (P=0.05) to enter and 2.71 (P=0.1) to remove. The results of regression technique and selected developed delay model are as follows:

- (Zalatimo, Eishtar) Synchro 10.0 Delay Model:

$$d =(335.615 \text{ v/c})-(323.296 \text{ g/C})+617.998 (0.731-We/Ws)$$

- (Zalatimo, Eishtar) SIDRA 8.0 plus Delay Model :

$$d = 352.892 \text{ v/c} - 193.163 \text{ g/C}+0.987$$

- (Al-Thawra) SYCNCHRO10.0 Delay Model :

$$d =(371.184 \text{ v/c})-(126.277 \text{ g/C})+1177.291 (We/Ws -1.1823)$$

- (Al-Thawra) SIDRA Delay Model :

$$d =(360.698 \text{ v/c})-(135.052 \text{ g/C})+1145.546 (We/Ws -1.142)$$

- (Bab al-Mashhad) Synchro 10.0 Delay Model:

$$d =201.597 \text{ v/c} - 244.777 \text{g/C} -43.460$$

- (Bab al-Mashhad) SIDRA 8.0 PLUS Delay Model:

d =205..867 v/c - 174.229 g/C -64.750

6. By comparison between field delay measurement and software delay times produced by SYNCHRO 10.0 and SIDRA intersection 8.0 PLUS found:

   a. p-value for select signalized intersections before calibration greater than 0.05 so that there   is   no statistically significant difference.

   b. p-value for select signalized intersections after calibration greater than 0.05 so that there is no statistically significant difference.

7. Although Pavement widening and remarking reducing control vehicle delay time , but it is   Level of Service (F),degree of saturation(v/c) ≥ 1

8. Most signalized intersections without markings , long cycle length and width of the exit roadway is less than the width at the stop line, the delay increases , as in the case of a bottlenecks

9. There are no places dedicated to stop buses and automobiles. a bus or automobile randomly stops on the right approach, isolated. This leads to increase bottlenecks and time delays.

10.SYNCHRO 10 Software is considered the most reliable Software regarding data entry and identification of analysis outputs.

5.2 Recommendations:

Based on the study results, the following recommendations may be put forward:

1. Fixing permanent video recording camera on streets and signalized intersections to measure traffic volume and speed of vehicle, which helps in the data collection process and analysis for future studies and for continuous monitoring of causes of delay and congestion.

2. Reconsideration of the existing phase timing is currently based on the traffic volumes present at those intersections.

3. Establish a unified government complex that includes most state departments and institutions outside the city center contributes greatly to reduce traffic momentum.

4. Marking and lightening all signalized intersections.

5. Reduction of the overall width of the Central Refuges to a width of 2 m while maintaining the planting of trees and reducing the width of the sidewalk to 3 m for the purpose of increasing the width of the lane group accommodating the increased traffic volumes.

6. Preventing random stops for passenger cars or buses on right-side roads, providing temporary bus parking, and constructing a parking garage near shopping centers and commercial markets.

7. Irregular turns near traffic signal intersections affect the movement of vehicle and cause traffic bottlenecks and increased time delays .

5.3 Suggestions for Future Studies :

1. Studying a comprehensive transportation in Hilla city for decreasing congestion movement within urban area. , it is necessary to encourage more studies .This can be achieved by supporting researchers modern equipment supply that requires less manpower and provide data on different parameters of traffic engineering

2. Developing Delay Models for Roundabouts in Hilla City by using software program Synchro10.0 and Sidra8.0 plus .

3. Studying the influence of pedestrian on vehicle delay at signaled intersections.

4. Studying the traffic impact by specialists in the field of road and transportation engineering before allowing the establishment of new commercial centers or markets.

References

References:

- Ahmed N.G., (2002): "The Development of Models for the prediction of Thermal Cracking in Flexible Pavements", Ph. D. Thesis, Civil Engineering Department, College of Engineering, University of Baghdad, Iraq.

- Akçelik, R., (2009) "SIDRA Intersection User Guide", Victoria, Australia.

- Al-Azzawi, Z.A. (2003): "Evaluation of Signalized Intersections Capacity in Baghdad to Attain the Traffic Flow Performance", M.Sc. thesis, Al-Mustansirya University, Baghdad, Iraq.

- Allsop, Richard E.,(1972)"Delay at a Fixed Time Traffic Signal-I: Theoretical Analysis," Transportation Science Vol. 6, No. 3, pp. 260-285.

- Akgungor, A. P., and Bullen, A. G. R. (2014). "Analytical Delay Models for Signalized Intersection". Tehnika, 69(4), 663–668

- Bashar H. Al-Omari and Madhar M. Ta'amneh, (2007) (Validating HCS and Sidra Software for Estimating Delay at Signalized Intersections in Jordan), Jordan Journal of Civil Engineering, Volume 1, No. 4, pp. 375-392.

- Bester. C. J. and Meyers. W.L., (2007), "Saturation Flow Rates" Department of Civil Engineering, University of Stellenbosch, Private Bag X1, MATIELAND 7602

- Bloomberg L, Dale J.,(2000) Comparison of Vissim and Corsim Traffic Simulation Models on a Congested Network[J]. Transportation Research Record, (1727):52-60.

- Boamah, D. S., (2010)." Spatial And Temporal Analyses of Traffic Flows In The City of Almelo", M.Sc. Thesis, Faculty of Geo- information Science and Earth Observation, University of Twente, Enschede, the Netherlands.

- FHWA , Federal Highway Administration, (2009): "Manual on Uniform Traffic Control Devices for Streets and Highways".

- Garber, N.J.,and Hoel, L.A.,(1997):"Traffic and Highway Engineering.", 2nd Edition,

- Garber,N.J., and Hoel, L.A.,(2010):"Traffic and Highway Engineering", Thomas Learning, Fourth Edition.

- Gagnon, C., Sadek, A.,Touchette, A., and Smith, M. (2008): "Calibration potential of common analytical and microsimulation roundabout models: New England case study. Transportation Research Record: Journal of the Transportation Research Board" (2071): 77-86

- Garber,N.J.,and Hoel, L.A.,(2009):"Traffic and Highway Engineering", Thomas Learning, Fourth Edition.

- HCM, (2010), "Highway Capacity Manual (2010)", TRB, National Research Council, Washington, DC

- Highway Capacity Manual",(2000), 4th Edition, Transportation Research Board, National Research Council, Washington D.C, USA.

- Highway Design Manual,(2017) New York State Department of Transportation, NYSDOT, New York State.

- Husch, D., Albeck, J., (2006): "Traffic Signal-User Guide, Synchro Studio7".

- Keller, G., and Warrack, B. (2000): "Statistics for Management and Economies", 4th Edition, USA. (Cited By Reference: Ahmed N.G., 2002).

- H. Rakha, Y. Kang and F. Dion, in Estimating Vehicle Stops at under saturated and Oversaturated Fixed-Time Signalized Intersections , (2001).

- Jameel, A. K. (2011). Estimating delay time at palestine street intersections in Baghdad City using HCM AND SIDRA models. Al-Qadisiyah Journal for Engineering Sciences, 4(1), 613-633.

- Kennedy,J .B., and Neville, A.M.(1986): "Basic Statistical Methods for Engineers and Scientists", 2nd Edition ,Thomas Y.,Crowell Company , In. U.S. (Cited By Reference: Ahmed N.G.

- McShane, W. R., Roess, P. R. (2004), "Traffic Engineering", Prentice Hall, Eaglewood Cliffs, New Jersey, USA.

- Muraleetharan, K.K., Ravichandran, N. and Taylor, L.M. (2003). "TeraDysac: TeraScale dynamic soil analysis code," Computer Code, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, Oklahoma.

- Pignataro, L.T., (1973): "Traffic Engineering", Pentice –Hall Inc., Third Edition, USA

- Rahul Sharma1,Pinakin Patel, Nekzad Umrigar, Dr. L. B. Zala.,(2018)., " International Research Journal of Engineering and Technology ",Department of Civil Engineering, Birla Vishvakarma Mahavidyalaya, Volume: 05, e-ISSN: 2395-0056 , p-ISSN: 2395-0072.

- Rogers, M., (2008): "Highway Engineering", Second Edition, Blackwell Publishing, Ireland.

- Roess, R. P., Vandehey, M. A., and Kittelson, W. (2010). Level of service 2010 and beyond. Journal of the Transportation Research Board, 2173, 20–27 (Washington, DC: Transportation Research Board of the National Academies).

- SIERPIŃSKI, (2007): "Proposition of Delay Model for Signalized Intersection with Queueing Theory Analytical Models Usage", Transport Problems, Silesian University of Technology.

- Sofia, G. G., Kadhim, A. J., & Khalil, S. M. (2014): "Development of Delay Model for Selected Signalized Intersections at CBD in Sulaymaniyah City", M.Sc Thesis, Department of Highway and Transportation Engineering, College of Engineering, Al-Mustansiriya University, Baghdad, Iraq, Journal of Engineering and Development, Vol. 18, No.5, September, ISSN 1813- 7822

- Sofia, G.G. (1998):"Development of Traffic Flow Models at Networks in

Mosul City", Ph.D. thesis, Baghdad University.

- SORB, State Organization of Roads and Bridges, (2005): "Highway Design Manual", Republic of Iraq Ministry of Housing and Construction, Baghdad, Iraq.

- Tianzi, C., Shaochen, J., and Hongxu, Y. (2013). Comparative study of VISSIM and SIDRA on signalized intersection. Procedia-Social and Behavioral Sciences, 96, 2004-2010.

- TRB, Transportation Research Board, (2005):" Highway Capacity Manual", Washington D.C, USA

- Turley C., (2007): "Calibration Procedure for a Microscopic Traffic Simulation Model", M.Sc. thesis, Brigham Young University, USA.

- Traffic Directorate of Babil Governorate" ,(2022) Department of Statistics, Vehicle Registering File.

- Traffic Directorate of Babil Governorate",(2022) Department of Statistics Vehicle Registering File.

- Warid, A. K., (2004)." Evaluation and Improvement of Traffic Flow Patterns at Al- Karrada CBD Area in Baghdad City", M.Sc. Thesis, University of Technology, Department of Building and Construction Engineering, Iraq.

- Webster, F.V. and Charles worth, G., (1958) "Some Factors Affecting the Capacity of Intersections Controlled by Traffic Signals", 4th International Study Week in Traffic Engineering, Copenhagen, Denmark. (Cited by Md. Hadiuzzaman, 2008).

- Youn-Soo Kang,(2000): " Delay, Stop and Queue Estimation for Uniform and Random Traffic Arrivals at Fixed-Time Signalized Intersections ", Ph.D. thesis, Virginia University, USA.

Appendices

APPENDIX A

SAMPLES OF TRAFFIC VOLUME DATA
Table (A-1): Traffic volume data for Eishtar signalization.

Time	NORTH	EAST			West	
	Lane Group (1+2)	Lane Group	Lane Group (2+3)	Lane Group	Lane Group (1+2)	Lane Group (3+4)
Direction	Left	U –turn	Thro	Right permitted	Left	Thro
7:30-7:45	314	5	355	99	340	314
7:45-8:00	335	11	388	78	382	335
8:00-8:15	350	13	394	104	402	350
8:15-8:30	194	8	372	90	347	194
VOLUME lane Group	1193	37	1509	371	1471	1321
TOTAL VOLUME	1193	1917			1471	1321
PHF/LANE Group	0.86	0.71	0.96	0.89	0.91	0.90
PASSENGER CAR%	97.147	100	96.090	94.340	95.33	95.94
HEAVY Vehicle%	0.503	0	1.988	0.809	1.07	1.06
Bus%	2.35	0	1.922	4.851	3.6	3

Table (A-2): Traffic volume data for Zaltimo Signalization.

Time	NORTH		South		East		West	
	Lane Group (1+2)	Lane Group (3+4)	Lane Group (1+2)	Lane Group (3+4)	Lane Group (1+2)	Lane Group (3+4)	Lane Group (1+2)	Lane Group (3+4)
Direction	Left	Thro	Left	Thro	Left	Thro	Left	Thro
12:30-12:45	167	121	250	290	74	153	177	180
12:45-13:00	187	129	228	303	87	257	198	248
13:00-13:15	206	107	214	298	68	192	186	220
13:15-13:30	211	129	168	311	51	190	140	173
VOLUME lane Group	771	486	860	1202	280	792	701	821
PHF/LANE Group	0.90	0.91	0.86	0.97	0.80	0.77	0.89	0.83
PASSENGER CAR%	97.276	94.65	99.0	98.0	94.65	98.0	96	95.739
HEAVY Vehicle%	2.724	5.35	1.05	2.0	1.78	2	4	2.071
Bus%	0	0	0	0	3.57	0	0	2.19

Table (A-3): Traffic volume data for Al-Thawra Signalization.

Time	NORTH		South		East	West
	Lane Group (1+2+3)	Lane Group (4+5+6+7)	Lane Group (1+2+3)	Lane Group (4+5+6+7)	Lane Group (1+2+3)	Lane Group (1+2+3)
Direction	Left	Thro	Left	Thro	Left	Left
8:30-8:45	239	260	516	350	180	241
8:45-9:00	413	299	534	377.00	235	290
9:00-9:15	298	282	546	372	198	248
9:15-9:30	311	250	486	321	164	230
VOLUME lane Group	1261	1091	2082	1420	777	1009
PHF/LANE Group	0.76	0.90	0.95	0.93	0.83	0.87
PASSENGER CAR%	97.9	94.3	96.54	96.41	96.0	99.0
HEAVY Vehicle%	1.031	2.016	2.017	2.11	4.0	1.0
Bus%	1.1	3.67	1.44	1.47	0	0

Table (A-4): Traffic volume data for Bab al-Mashhad Signalization.

Time	NORTH		South		East		West	
	Lane Group	Lane Group	Lane Group	Lane Group (2+3)	Lane Group	Lane Group	Lane Group	Lane Group
Direction	Left	Thro	Left	Thro	Left	Thro	Left	Thro
12:30-12:45	81	109	75	240	80	95	78	75
12:45-1:00	100	119	97	264	85	102	89	85
1:00-1:15	90	111	78	256	72	87	79	75
1:15-1:30	89	94	83	192	70	84	74	73
VOLUME lane Group	360	433	330	952	307	368	320	308
PHF/LANE Group	0.90	0.91	0.86	0.90	0.90	0.90	0.90	0.90
PASSENGER CAR%	98.9	95.61	93.7	98.0	100	94.74	96.0	91.88
HEAVY Vehicle%	1.11	2.08	3.3	2.0	0	2	4.0	2.28
Bus%	0.0	2.31	3	0.0	0	3.26	0.0	5.84

Appendix (B) Sample of Spot Speed Data .Table (B-1) Speed Data for 40 Street

Vehicle No	Time (sec)	Length (m)	Spot Speed (kph)
1	3.95	25	22.78
2	2.34	25	38.46
3	2.4	25	37.50
4	4.0	25	22.50
5	3.78	25	23.81
6	3.15	25	28.57
7	3.43	25	26.24
8	2.98	25	30.20
9	3.41	25	26.39
10	3.33	25	27.03
11	3.58	25	25.14
12	3.29	25	27.36
13	3.78	25	23.81
14	3.99	25	22.56
15	4.25	25	21.18
16	4.45	25	20.22
17	3.77	25	23.87
18	3.18	25	28.30
19	3.45	25	26.09
20	3.96	25	22.73
21	3.25	25	27.69
22	3.11	25	28.94
23	2.8	25	32.14
24	2.7	25	33.33
25	4.1	25	21.95
26	2.65	25	33.96
27	2.81	25	32.03
28	2.77	25	32.49
29	3.61	25	24.93
30	3.42	25	26.32
31	3.33	25	27.03
32	4.1	25	21.95
33	3.55	25	25.35
34	3.68	25	24.46
35	3.48	25	25.86
36	3.22	25	27.95
37	2.98	25	30.20

38	2.77	25	32.49
39	2.88	25	31.25
40	2.91	25	30.93
41	2.66	25	33.83
42	2.45	25	36.73
43	2.77	25	32.49
44	2.69	25	33.46
45	2.84	25	31.69
46	3.41	25	26.39
47	3.21	25	28.04
48	3.51	25	25.64
49	3.41	25	26.39
50	3.22	25	27.95

Average = 27.97

Appendix (C) Sample of Sheet for Delay Measurement in the Field.
Table (C-1) Sheet for Delay Measurement in the Field

Sheet for Delay Measurement in the Field																

Intersection Control Delay Worksheet

Analyst :	Intersection : AL-Tayara St / City Center St
Agency or Company : (—)	Area Type : others
Agency or Company : (—)	Analysis Year:2021
Analysis Period :7:45 to 8:00	

Input Initial Parameters

Number of Lane, L:2		total vehicle arriving, Vtot =81
Free-flow speed (Km/hr): 24.0		Stopped vehicle count, V stop =66
survey count interval(s): 15		

Input Field Data

Clock Time	Cycle Number,	count interval.														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7:45	1	0	14	17	15	17	19	16	19	17	15	21	16	12	0	0
	2	8	17	12	17	19	28	9	14	11	9	17	9	14	0	0
	3	6	25	17	19	18	17	14	11	19	12	11	14	11	0	0
	4	6	12	11	12	12	11	5	9	7	21	17	15	10	0	0
	5	5	9	15	14	11	6	5	6	7	17	9	11	3	0	0
	6	4	9	10	19	10	9	8	6	8	11	16	18	1	0	0
	7	1	6	9	10	9	7	5	7	9	9	12	13	1	0	0
	8	6	12	9	9	6	5	4	8	6	8	14	13	0	0	0
8:00																
Total	1169	36	104	100	115	102	102	66	80	84	102	117	109	52	0	0

Computations

Total vehicles in the queue, ΣViq =1169	No. of cycle surveyed, Nc =8
Time- in –queue per vehicle, dvq=)(I*ΣViq/Vtot)*0.9=194.833	Fraction of vehicle stopping, FVS=$\frac{Vstop}{Vtotal}$ =0.815
No. of vehicles stopping /lane/ cycle = $\frac{Vstop}{NcXL}$= 4.71	Accel/Decel delay,dad =FVS*CF = -0.815
Accel/Decel correction factor, CF = -1 sec/veh	Control delay = dad + dvq =194.833-0.815=194.0

Table (C-1) Sheet for Delay Measurement in the Field

Sheet for Delay Measurement in the Field		
Intersection Control Delay Worksheet		
Analyst :	Intersection : 40 St / Alziraea St	
Agency or Company : (—)	Area Type : others	
Agency or Company : (—)	Analysis Year:2021	
Analysis Period :7:45 to 8:00		

Input Initial Parameters

Number of Lane, L:2		total vehicle arriving, Vtot =28
Free-flow speed (Km/hr): 31.0		Stopped vehicle count, V stop =17
survey count interval(s): 15		

Input Field Data

Clock Time	Cycle Number,	count interval.													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7:45	1	0	4	10	15	17	19	16	19	17	15	21	16	12	0	0
	2	3	8	5	17	19	28	9	14	11	9	17	9	14	0	0
	3	2	6	7	19	18	17	14	11	19	12	11	14	11	0	0
	4	3	5	4	12	12	11	5	9	7	21	17	15	10	0	0
	5	4	5	6	14	11	6	5	6	7	17	9	11	3	0	0
	6	5	2	4	9	10	9	8	6	8	11	16	18	1	0	0
	7	4	3	2	10	9	7	5	7	9	9	12	13	1	0	0
	8	2	2	2	9	6	5	4	8	6	8	14	13	0	0	0
8:00																
Total	977	23	35	40	105	102	102	66	80	84	102	117	109	52	0	0

Computations

Total vehicles in the queue, $\sum Viq$ =760	No. of cycle surveyed, Nc =8
Time- in –queue per vehicle, dvq=)(I*$\sum$Viq/Vtot)*0.9=366.73	Fraction of vehicle stopping, FVS=$\frac{Vstop}{Vtotal}$ =0.607
No. of vehicles stopping /lane/ cycle = $\frac{Vstop}{NcXL}$= 1.214	Accel/Decel delay,dad =FVS*CF = -0.607
Accel/Decel correction factor, CF = -1 sec/veh	Control delay = dad + dvq =366.4286-0.607=365.876

Appendix (D) SYNCHRO 10.0 Output

SYNCHRO 10.0 software provides different output results in graphical and in tabular form. The main output used in present study is presented.

Lanes, Volumes, Timings
4: Alziraea /40 street & AL-gameia St/AL-Tuhmazeya

03/09/2023

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑		↰↰	↑↑		↰↰	↑↑		↰↰	↑↑	
Traffic Volume (vph)	280	792	0	701	821	0	771	486	0	860	1202	0
Future Volume (vph)	280	792	0	701	821	0	771	486	0	860	1202	0
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Lane Width (m)	3.4	3.3	3.0	3.0	3.0	3.0	3.5	3.2	3.0	3.5	3.5	3.6
Storage Length (m)	100.0		0.0	100.0		0.0	100.0		0.0	100.0		0.0
Storage Lanes	1		0	1		0	1		0	1		0
Taper Length (m)	7.6			7.6			7.6			7.6		
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95	1.00	0.97	0.95	1.00	0.97	0.95	1.00
Ped Bike Factor												
Frt												
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1858	3515	0	3308	3352	0	3609	3560	0	3537	3684	0
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1858	3515	0	3308	3352	0	3609	3560	0	3537	3684	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)												
Link Speed (k/h)		38			38			38			38	
Link Distance (m)		249.3			285.7			217.0			217.3	
Travel Time (s)		23.6			27.1			20.6			20.6	
Confl. Bikes (#/hr)						10						
Peak Hour Factor	0.80	0.77	0.90	0.89	0.83	0.96	0.90	0.91	0.95	0.86	0.97	0.92
Heavy Vehicles (%)	0%	2%	0%	4%	2%	0%	1%	2%	0%	1%	2%	0%
Bus Blockages (#/hr)	0	12	0	0	18	0	0	0	0	10	0	0
Parking (#/hr)						0						0
Adj. Flow (vph)	350	1029	0	788	989	0	857	534	0	1000	1239	0
Shared Lane Traffic (%)												
Lane Group Flow (vph)	350	1029	0	788	989	0	857	534	0	1000	1239	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(m)		6.0			6.0			7.0			7.0	
Link Offset(m)		0.0			0.0			0.0			0.0	
Crosswalk Width(m)		4.9			4.9			4.9			4.9	
Two way Left Turn Lane												
Headway Factor	0.96	1.01	1.02	1.02	1.07	1.02	0.95	0.99	1.02	0.97	0.95	0.94
Turning Speed (k/h)	26		14	26		14	26		14	26		14
Turn Type	Split	NA		Split	NA		Split	NA		Split	NA	
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases												
Minimum Split (s)	35.0	35.0		25.0	25.0		25.0	25.0		30.0	30.0	
Total Split (s)	39.0	39.0		29.0	29.0		32.0	32.0		40.0	40.0	
Total Split (%)	27.9%	27.9%		20.7%	20.7%		22.9%	22.9%		28.6%	28.6%	
Maximum Green (s)	35.0	35.0		25.0	25.0		28.0	28.0		36.0	36.0	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	
Lost Time Adjust (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	
Total Lost Time (s)	5.0	5.0		5.0	5.0		5.0	5.0		5.0	5.0	
Lead/Lag												
Lead-Lag Optimize?												
Walk Time (s)	7.0	7.0		7.0	7.0		7.0	7.0		7.0	7.0	
Flash Dont Walk (s)	11.0	11.0		11.0	11.0		11.0	11.0		11.0	11.0	
Pedestrian Calls (#/hr)	0	0		0	0		0	0		0	0	
Act Effct Green (s)	34.0	34.0		24.0	24.0		27.0	27.0		35.0	35.0	

Lanes, Volumes, Timings
4: Alziraea /40 street & AL-gameia St/AL-Tuhmazeya
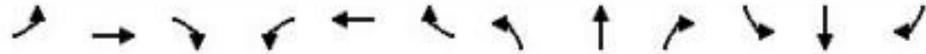
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Actuated g/C Ratio	0.24	0.24		0.17	0.17		0.19	0.19		0.25	0.25	
v/c Ratio	0.78	1.21		1.39	1.72		1.23	0.78		1.13	1.35	
Control Delay	62.4	148.7		228.2	366.8		162.8	62.5		120.2	203.1	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	62.4	148.7		228.2	366.8		162.8	62.5		120.2	203.1	
LOS	E	F		F	F		F	E		F	F	
Approach Delay		126.8			305.3			124.3			166.1	
Approach LOS		F			F			F			F	

Intersection Summary

Area Type:	Other

Cycle Length: 140

Actuated Cycle Length: 140

Offset: 32 (23%), Referenced to phase 4:EBTL, Start of Green

Natural Cycle: 145

Control Type: Pretimed

Maximum v/c Ratio: 1.72

Intersection Signal Delay: 186.0	Intersection LOS: F
Intersection Capacity Utilization 108.9%	ICU Level of Service G
Analysis Period (min) 15	

Splits and Phases: 4: Alziraea /40 street & AL-gameia St/AL-Tuhmazeya
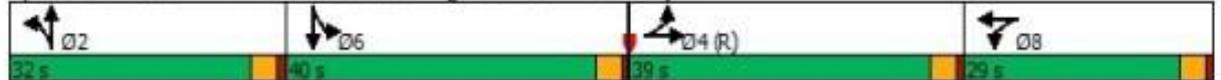
Ø2	Ø6	Ø4 (R)	Ø8
32 s	40 s	39 s	29 s

D-2

Lane Group	EBU	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	⏧	↑↑	↗	↖↖	↑↑	↖↖	
Traffic Volume (vph)	37	1509	371	1471	1321	1193	0
Future Volume (vph)	37	1509	371	1471	1321	1193	0
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000
Lane Width (m)	3.6	3.6	4.6	3.3	4.4	3.3	3.3
Storage Length (m)	0.0		0.0	25.0		25.0	0.0
Storage Lanes	1		1	0		0	0
Taper Length (m)	7.5			7.5		7.5	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95	0.97	1.00
Frt			0.850				
Flt Protected	0.950			0.950		0.950	
Satd. Flow (prot)	1900	3614	1833	3337	3769	3436	0
Flt Permitted	0.950			0.950		0.950	
Satd. Flow (perm)	1900	3614	1833	3337	3769	3436	0
Right Turn on Red			Yes				Yes
Satd. Flow (RTOR)			151				
Link Speed (k/h)		27			27	27	
Link Distance (m)		300.0			199.2	204.0	
Travel Time (s)		40.0			26.6	27.2	
Peak Hour Factor	0.71	0.96	0.89	0.91	0.90	0.86	1.00
Heavy Vehicles (%)	0%	2%	1%	1%	1%	1%	0%
Bus Blockages (#/hr)	0	15	5	27	40	13	0
Adj. Flow (vph)	52	1572	417	1616	1468	1387	0
Shared Lane Traffic (%)							
Lane Group Flow (vph)	52	1572	417	1616	1468	1387	0
Enter Blocked Intersection	No	No	No	No	No	No	No
Lane Alignment	R NA	Left	Right	Left	Left	Left	Right
Median Width(m)		6.6			6.6	6.6	
Link Offset(m)		0.0			0.0	0.0	
Crosswalk Width(m)		4.8			4.8	4.8	
Two way Left Turn Lane							
Headway Factor	0.94	0.97	0.83	1.05	0.93	1.01	0.98
Turning Speed (k/h)	15		15	25		25	15
Turn Type	Split	NA	Free	Split	NA	Prot	
Protected Phases	4	4		8	8	2	
Permitted Phases			Free				
Minimum Split (s)	30.0	30.0		30.0	30.0	30.0	
Total Split (s)	44.0	44.0		44.0	44.0	44.0	
Total Split (%)	33.3%	33.3%		33.3%	33.3%	33.3%	
Maximum Green (s)	40.0	40.0		40.0	40.0	40.0	
Yellow Time (s)	3.0	3.0		3.0	3.0	3.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	
Lost Time Adjust (s)	1.0	1.0		1.0	1.0	1.0	
Total Lost Time (s)	5.0	5.0		5.0	5.0	5.0	
Lead/Lag							
Lead-Lag Optimize?							
Walk Time (s)	7.0	7.0		7.0	7.0	7.0	
Flash Dont Walk (s)	11.0	11.0		11.0	11.0	11.0	
Pedestrian Calls (#/hr)	55	55		55	55	0	
Act Effct Green (s)	39.0	39.0	132.0	39.0	39.0	39.0	
Actuated g/C Ratio	0.30	0.30	1.00	0.30	0.30	0.30	
v/c Ratio	0.09	1.47	0.23	1.64	1.32	1.37	
Control Delay	34.4	252.6	0.3	324.4	187.6	208.0	

D-3

Lane Group	EBU	EBT	EBR	WBL	WBT	NBL	NBR
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	34.4	252.6	0.3	324.4	187.6	208.0	
LOS	C	F	A	F	F	F	
Approach Delay		195.5			259.3	208.0	
Approach LOS		F			F	F	

Intersection Summary

Area Type: Other

Cycle Length: 132

Actuated Cycle Length: 132

Offset: 0 (0%), Referenced to phase 4:EBTU, Start of Green, Master Intersection

Natural Cycle: 180

Control Type: Pretimed

Maximum v/c Ratio: 1.64

Intersection Signal Delay: 228.4   Intersection LOS: F

Intersection Capacity Utilization 124.3%   ICU Level of Service H

Analysis Period (min) 15

Splits and Phases: 4: 40 ST & AL-TAYARA ST/CITY-CENTER ST

Ø2	Ø4 (R)	Ø8
44 s	44 s	44 s

Lanes, Volumes, Timings
4: Safiel-Din/Imam Ali & Algabel/AL-Shawi

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↱	↑	↗	↱	↑	↗	↱	↑	↗	↱	↑↑	↗
Traffic Volume (vph)	307	368	77	320	308	102	360	433	87	333	952	85
Future Volume (vph)	307	368	77	320	308	102	360	433	87	333	952	85
Ideal Flow (vphpl)	2000	2000	2030	2000	2000	2030	2000	2000	2030	2000	2000	2030
Lane Width (m)	2.9	2.9	2.9	2.8	2.8	2.7	3.8	3.8	3.8	3.2	4.6	3.2
Storage Length (m)	100.0		0.0	100.0		0.0	100.0		0.0	100.0		0.0
Storage Lanes	1		1	1		1	1		1	1		1
Taper Length (m)	7.6			7.6			7.6			7.6		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00
Ped Bike Factor						0.99						
Frt			0.850			0.850			0.850			0.850
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1752	1721	1591	1665	1658	1398	1923	2004	1764	1726	4139	1484
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1752	1721	1591	1665	1658	1378	1923	2004	1764	1726	4139	1484
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			95			95			95			95
Link Speed (k/h)		38			38			38			38	
Link Distance (m)		249.3			285.7			217.0			217.3	
Travel Time (s)		23.6			27.1			20.6			20.6	
Confl. Bikes (#/hr)						10						
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.96	0.90	0.91	0.95	0.86	0.90	0.92
Heavy Vehicles (%)	0%	2%	0%	4%	2%	0%	1%	2%	0%	1%	2%	0%
Bus Blockages (#/hr)	0	12	0	0	18	0	0	0	0	10	0	0
Parking (#/hr)						0						0
Adj. Flow (vph)	341	409	86	356	342	106	400	476	92	387	1058	92
Shared Lane Traffic (%)												
Lane Group Flow (vph)	341	409	86	356	342	106	400	476	92	387	1058	92
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(m)		2.9			2.9			3.8			3.8	
Link Offset(m)		0.0			0.0			0.0			0.0	
Crosswalk Width(m)		4.9			4.9			4.9			4.9	
Two way Left Turn Lane												
Headway Factor	1.04	1.11	1.02	1.06	1.16	1.20	0.91	0.91	0.89	1.05	0.81	1.11
Turning Speed (k/h)	26		14	26		14	26		14	26		14
Turn Type	Split	NA	Free	Split	NA	Free	Split	NA	Free	Split	NA	Free
Protected Phases	4	4		8	8		2	2		6	6	
Permitted Phases			Free			Free			Free			Free
Minimum Split (s)	37.0	37.0		30.0	30.0		30.0	30.0		30.0	30.0	
Total Split (s)	38.0	38.0		35.0	35.0		38.0	38.0		38.0	38.0	
Total Split (%)	25.5%	25.5%		23.5%	23.5%		25.5%	25.5%		25.5%	25.5%	
Maximum Green (s)	34.0	34.0		31.0	31.0		34.0	34.0		34.0	34.0	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	
Lost Time Adjust (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	
Total Lost Time (s)	5.0	5.0		5.0	5.0		5.0	5.0		5.0	5.0	
Lead/Lag												
Lead-Lag Optimize?												
Walk Time (s)	7.0	7.0		7.0	7.0		7.0	7.0		7.0	7.0	
Flash Dont Walk (s)	11.0	11.0		11.0	11.0		11.0	11.0		11.0	11.0	
Pedestrian Calls (#/hr)	0	0		0	0		0	0		0	0	
Act Effct Green (s)	33.0	33.0	149.0	30.0	30.0	149.0	33.0	33.0	149.0	33.0	33.0	149.0

Lanes, Volumes, Timings
4: Safiel-Din/Imam Ali & Algabel/AL-Shawi

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Actuated g/C Ratio	0.22	0.22	1.00	0.20	0.20	1.00	0.22	0.22	1.00	0.22	0.22	1.00
v/c Ratio	0.88	1.07	0.05	1.06	1.03	0.08	0.94	1.07	0.05	1.01	1.16	0.06
Control Delay	79.7	120.7	0.1	122.0	113.5	0.1	87.8	117.7	0.1	105.8	132.5	0.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	79.7	120.7	0.1	122.0	113.5	0.1	87.8	117.7	0.1	105.8	132.5	0.1
LOS	E	F	A	F	F	A	F	F	A	F	F	A
Approach Delay		91.5			102.3			94.2			117.8	
Approach LOS		F			F			F			F	

Intersection Summary

Area Type:	Other

Cycle Length: 149

Actuated Cycle Length: 149

Offset: 0 (0%), Referenced to phase 4:EBTL, Start of Green

Natural Cycle: 150

Control Type: Pretimed

Maximum v/c Ratio: 1.16

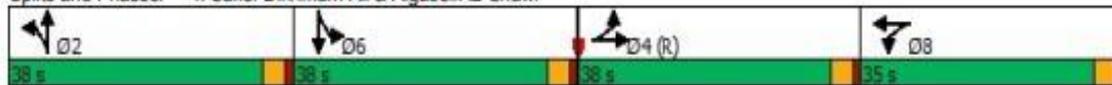|	
Intersection Signal Delay: 104.0	Intersection LOS: F
Intersection Capacity Utilization 95.9%	ICU Level of Service F

Analysis Period (min) 15

Splits and Phases: 4: Safiel-Din/Imam Ali & Algabel/AL-Shawi

Ø2	Ø6	Ø4 (R)	Ø8
38 s	38 s	38 s	35 s

Lanes, Volumes, Timings
1: AL-Tayara/Karbala & 60 St/Bagdad

03/10/2023

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↱↱↱			↱↱↱			↱↱↱	⊣↑↑↑		↱↱↱	⊣↑↑↑	
Traffic Volume (vph)	1009	0	0	777	0	0	1261	1091	0	2082	1420	0
Future Volume (vph)	1009	0	0	777	0	0	1261	1091	0	2082	1420	0
Ideal Flow (vphpl)	1900	1900	1800	1900	1900	2000	1900	1900	2000	1900	1900	2000
Lane Width (m)	4.4	2.4	3.3	4.7	3.5	3.5	3.5	3.4	3.5	3.2	3.4	3.4
Lane Util. Factor	0.94	1.00	1.00	0.94	1.00	1.00	0.71	0.71	1.00	0.71	0.71	1.00
Ped Bike Factor												
Frt												
Flt Protected	0.950			0.950			0.950	0.987		0.950	0.987	
Satd. Flow (prot)	5488	0	0	5493	0	0	3694	4913	0	3458	4998	0
Flt Permitted	0.950			0.950			0.950	0.987		0.950	0.987	
Satd. Flow (perm)	5488	0	0	5493	0	0	3694	4913	0	3458	4998	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)												
Link Speed (k/h)		30			30			30			30	
Link Distance (m)		249.3			285.7			217.0			217.3	
Travel Time (s)		29.9			34.3			26.0			26.1	
Confl. Bikes (#/hr)												10
Peak Hour Factor	0.87	0.86	1.00	0.83	0.86	1.00	0.76	0.90	1.00	0.95	0.93	1.00
Heavy Vehicles (%)	1%	0%	0%	4%	0%	0%	1%	2%	0%	2%	2%	1%
Bus Blockages (#/hr)	0	0	0	0	0	0	14	40	0	30	21	0
Adj. Flow (vph)	1160	0	0	936	0	0	1659	1212	0	2192	1527	0
Shared Lane Traffic (%)							25%			25%		
Lane Group Flow (vph)	1160	0	0	936	0	0	1244	1627	0	1644	2075	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(m)		14.1			14.1			10.5			10.5	
Link Offset(m)		0.0			0.0			0.0			0.0	
Crosswalk Width(m)		4.9			4.9			4.9			4.9	
Two way Left Turn Lane												
Headway Factor	0.89	1.20	1.12	0.86	1.01	0.95	1.04	1.08	0.95	1.12	1.06	0.96
Turning Speed (k/h)	26		14	26		14	26		14	26		14
Turn Type	Prot			Prot			Split	NA		Split	NA	
Protected Phases	3			1			2	2		4	4	
Permitted Phases												
Minimum Split (s)	30.0			22.0			30.0	30.0		30.0	30.0	
Total Split (s)	30.0			23.0			34.0	34.0		37.0	37.0	
Total Split (%)	24.2%			18.5%			27.4%	27.4%		29.8%	29.8%	
Maximum Green (s)	26.0			19.0			30.0	30.0		33.0	33.0	
Yellow Time (s)	3.0			3.0			3.0	3.0		3.0	3.0	
All-Red Time (s)	1.0			1.0			1.0	1.0		1.0	1.0	
Lost Time Adjust (s)	1.0			1.0			1.0	1.0		1.0	1.0	
Total Lost Time (s)	5.0			5.0			5.0	5.0		5.0	5.0	
Lead/Lag	Lead			Lead			Lag	Lag		Lag	Lag	
Lead-Lag Optimize?	Yes			Yes			Yes	Yes		Yes	Yes	
Walk Time (s)	7.0			7.0			7.0	7.0		7.0	7.0	
Flash Dont Walk (s)	11.0			11.0			11.0	11.0		11.0	11.0	
Pedestrian Calls (#/hr)	0			0			0	0		0	0	
Act Effct Green (s)	25.0			18.0			29.0	29.0		32.0	32.0	
Actuated g/C Ratio	0.20			0.15			0.23	0.23		0.26	0.26	
v/c Ratio	1.05			1.17			1.44	1.42		1.84	1.61	
Control Delay	88.4			137.5			240.8	228.5		412.2	309.9	
Queue Delay	0.0			0.0			0.0	0.0		0.0	0.0	

D-7

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Total Delay	60.2			96.7			212.8	50.4		259.7	173.5	
LOS	E			F			F	D		F	F	
Approach Delay		60.2			96.7			144.2			224.3	
Approach LOS		E			F			F			F	

Intersection Summary

Area Type: Other
Cycle Length: 124
Actuated Cycle Length: 124
Offset: 0 (0%), Referenced to phase 4:SBTL, Start of Green
Natural Cycle: 135
Control Type: Pretimed
Maximum v/c Ratio: 1.49
Intersection Signal Delay: 162.2   Intersection LOS: F
Intersection Capacity Utilization 79.6%   ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 1: AL-Tayara/Karbala & 60 St/Bagdad

Appendix (E) SIDRA8.0 PLUS Output

SIDRA8.0 PLUS software provides different output results in graphical

MOVEMENT SUMMARY

Site: 101 [40 street intersection]

40St
Site Category: (None)
Signals - Fixed Time Isolated   Cycle Time = 140 seconds (Site User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: 40 ST												
1	L2	1000	2.2	1.090	125.7	LOS F	50.3	355.5	1.00	1.12	1.54	9.8
2	T1	1239	2.0	1.288	200.6	LOS F	77.1	548.6	1.00	1.28	1.90	7.2
Approach		2239	2.1	1.288	167.1	LOS F	77.1	548.6	1.00	1.21	1.74	8.1
East: Al-gmeia st												
4	L2	350	6.3	0.792	63.7	LOS E	23.4	172.7	1.00	0.89	1.07	13.7
5	T1	1029	3.5	1.123	138.0	LOS F	53.5	386.0	1.00	1.15	1.61	9.3
Approach		1379	4.2	1.123	119.2	LOS F	53.5	386.0	1.00	1.08	1.47	10.1
North: Alziraea												
7	L2	857	1.0	1.176	158.4	LOS F	47.6	336.4	1.00	1.19	1.73	8.4
8	T1	534	2.0	0.710	64.7	LOS E	17.3	123.4	0.99	0.85	1.01	13.6
Approach		1391	1.4	1.176	122.4	LOS F	47.6	336.4	1.00	1.06	1.45	9.9
West: AL-Tuhmazeya												
10	L2	788	4.0	1.333	221.6	LOS F	50.7	366.9	1.00	1.30	2.01	6.7
11	T1	989	4.2	1.653	356.6	LOS F	77.3	560.9	1.00	1.49	2.41	4.7
Approach		1777	4.1	1.653	296.7	LOS F	77.3	560.9	1.00	1.41	2.23	5.4
All Vehicles		6785	2.9	1.653	182.2	LOS F	77.3	560.9	1.00	1.20	1.75	7.7

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

and in tabular form. The main output used in present study is presented.

MOVEMENT SUMMARY

Site: 101 [Al-Thawra]

Revolution
Site Category: (None)
Signals - Fixed Time Isolated   Cycle Time = 124 seconds (Site User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: AL-TAYARA												
7	L2	1659	2.1	1.252	179.4	LOS F	62.0	441.9	1.00	1.42	1.95	8.7
8	T1	1212	5.7	0.697	50.9	LOS D	17.0	125.1	0.98	0.84	0.98	21.2
Approach		2871	3.6	1.252	125.2	LOS F	62.0	441.9	0.99	1.18	1.54	11.5
East: Baghdad												
10	L2	936	4.0	1.060	110.8	LOS F	27.4	198.5	1.00	1.16	1.59	12.8
Approach		936	4.0	1.060	110.8	LOS F	27.4	198.5	1.00	1.16	1.59	12.8
North: Karbala												
1	L2	2192	3.4	1.480	275.1	LOS F	74.0	533.5	1.00	1.62	2.35	5.9
2	T1	1527	4.0	1.158	139.9	LOS F	51.0	369.6	1.00	1.42	1.76	10.2
Approach		3718	3.7	1.480	219.6	LOS F	74.0	533.5	1.00	1.54	2.10	7.1
West: 60 St												
4	L2	1160	1.0	0.875	64.7	LOS E	25.7	181.5	1.00	0.96	1.18	19.1
Approach		1160	1.0	0.875	64.7	LOS E	25.7	181.5	1.00	0.96	1.18	19.1
All Vehicles		8686	3.3	1.480	156.0	LOS F	74.0	533.5	1.00	1.30	1.74	9.6

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 101 [BAB ALMSHAD 2000]

bab almshad
Site Category: (None)
Signals - Fixed Time Isolated   Cycle Time = 149 seconds (Site User-Given Phase Times)

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Safiy AL-Din round about												
7	L2	400	1.0	0.951	87.6	LOS F	34.3	242.0	1.00	1.00	1.27	11.6
8	T1	476	2.0	1.068	120.4	LOS F	47.9	341.4	1.00	1.10	1.47	9.8
9	R2	92	0.0	0.048	5.5	LOS A	0.0	0.0	0.00	0.58	0.00	50.2
Approach		967	1.4	1.068	96.0	LOS F	47.9	341.4	0.91	1.01	1.25	11.4
East: Al gbal street												
10	L2	341	0.0	0.882	76.1	LOS E	26.9	188.0	1.00	0.95	1.18	12.3
11	T1	409	5.3	1.045	115.9	LOS F	40.1	293.3	1.00	1.09	1.44	10.1
12	R2	86	0.0	0.046	5.5	LOS A	0.0	0.0	0.00	0.58	0.00	50.2
Approach		836	2.6	1.045	88.4	LOS F	40.1	293.3	0.90	0.98	1.19	11.9
North: Imam Ali street												
1	L2	387	4.0	1.020	108.4	LOS F	37.2	269.3	1.00	1.07	1.41	10.4
2	T1	1058	2.0	1.107	132.8	LOS F	56.0	398.7	1.00	1.14	1.53	9.2
3	R2	92	0.0	0.049	5.5	LOS A	0.0	0.0	0.00	0.58	0.00	50.2
Approach		1537	2.4	1.107	119.0	LOS F	56.0	398.7	0.94	1.09	1.41	10.0
West: AL-Shawi neighborhood												
4	L2	356	4.0	1.060	122.2	LOS F	36.0	260.5	1.00	1.11	1.49	9.7
5	T1	342	7.8	1.026	112.4	LOS F	32.6	243.8	1.00	1.07	1.43	10.3
6	R2	107	0.0	0.058	5.5	LOS A	0.0	0.0	0.00	0.58	0.00	50.2
Approach		805	5.1	1.060	102.5	LOS F	36.0	260.5	0.87	1.02	1.27	11.2
All Vehicles		4145	2.7	1.107	104.2	LOS F	56.0	398.7	0.91	1.04	1.30	10.9

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 1 [Eishtar Intersection]

Three-way intersection with "Seagull" treatment (Signals)
Site Category: (None)
Signals - Fixed Time Coordinated   Cycle Time = 132 seconds (Site User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: 40 ST												
1	L2	1387	2.1	1.288	200.3	LOS F	80.7	575.1	1.00	1.42	1.86	6.9
Approach		1387	2.1	1.288	200.3	LOS F	80.7	575.1	1.00	1.42	1.86	6.9
East: CITY -CENTER ST												
3	L2	1616	2.8	1.572	317.4	LOS F	119.8	859.3	1.00	1.51	2.38	3.8
5	T1	1468	4.0	1.241	175.8	LOS F	84.6	612.6	1.00	1.27	1.85	6.8
Approach		3084	3.4	1.572	250.0	LOS F	119.8	859.3	1.00	1.40	2.13	4.9
West: AL-TAYARA ST												
10u	U	52	0.0	0.122	41.2	LOS D	2.4	17.1	0.77	0.73	0.77	18.6
11	T1	1572	3.0	1.417	247.8	LOS F	105.5	757.4	1.00	1.55	2.15	5.7
12	R2	417	2.4	0.209	3.5	LOS A	0.0	0.0	0.00	0.46	0.00	37.5
Approach		2041	2.8	1.417	192.6	LOS F	105.5	757.4	0.79	1.31	1.68	7.1
All Vehicles		6512	2.9	1.572	221.4	LOS F	119.8	859.3	0.93	1.37	1.93	5.9

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.

LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).

Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

الخلاصة:

المعاناة من ازدحام المركبات عند التقاطعات في مدينة بابل مستمرة بسبب زيادة حجم حركة المرور. يعد استخدام برامج محاكاة حركة المرور للبحث عن طرق التحكم المناسبة حلاً فعالاً للمشكلة. تنتج برامج المحاكاة المختلفة نتائج تقييم مختلفة.ينصب تركيز هذه الدراسة على برنامجين للمحاكاة (SYNCHRO10.0,SIDRA 8.0 PLUS) للتنبؤ بوقت التأخير الكلي عند التقاطعات ذات الإشارات باستخدام برامج المحاكاة الدقيقة لمعايرة البيانات وأستخدام البرامج الأحصائية(SPSS)لأنشاء نموذج ستقوم هذه الدراسة بالتحقيق في الاختلافات الرئيسية بين البرنامجين واختيار البرنامج الأكثر تمثيلاً لحركة المرور عند التقاطعات ذات الإشارات

تم تطوير نموذج تجريبي للتنبؤ بالتأخير عند التقاطعات ذات الإشارات كدالة لحركة المرور المؤثرة والميزات الهندسية. تم اختيار أربعة تقاطعات ذات إشارات ضوئية (زلاطيمو ، عشتار الثورة ،باب المشهد) ذات خصائص مختلفة في مركز مدينة الحلة.

(SIDRA 8.0 PLUS،SYNCHRO10.0) للتنبؤ بوقت التأخير الكلي عند التقاطعات التي تحتوي على إشارات ارتباط جيد مع قيم التأخير الحقلية.

العديد من المتغيرات تؤثر على نموذج التأخير بما في ذلك ((v / c)نسبة درجة التشبع، (g / C) نسبة الأخضر إلى دورة الأشارة الضوئية ، (We/Ws)إجمالي عرض طريق الخروج للتقاطع لحركة المرور المغادرة مقسومًا على العرض الإجمالي لمجموعات الممرات المغادرة إلى نفس طريق الخروج ، في نفس المرحلة. يؤدي الحد الأدنى من (g/C) ومعدل التدفق الكبير إلى ارتفاع قيمة كل من (g /C ،v / c) مع وقت التأخير. تؤدي زيادة (g/C) إلى تقليل التأخير. يبدو أن نسبة العرض الإجمالي لطريق الخروج للتقاطع لحركة المرور المغادرة للأمام مباشرة إلى العرض الإجمالي لمجموعات الممرات التي تغادر إلى نفس طريق الخروج في نفس المرحلة عند خط التوقف (We / Ws) تؤثر على التأخير. لقد وجد أنه على الرغم من أن تأخير SYNCHRO و SIDRA 8.0 PLUS يبالغ في تقدير التأخير في النطاق العالي (v/c) ، إلا أنه لا يوجد فرق كبير مع التأخير الميداني عند مستوى ثقة 95٪. تم قياس أحجام حركة المرور الميدانية، وتوقيت الإشارات، وتأخير المراحل والتحكم خلال فترات الذروة وخارج الذروة باستخدام تقنية تسجيل الفيديو. عناصر التصميم الهندسي تقاس من خلال المسح الميداني والصورالجوية. تم أستخدام النهج الأحصائي لتطوير نموذج التأخير (نموذج الانحدار الخطي مستوى ثقة 95٪). يشير التحليل الإحصائي إلى أن المتغيرات الهندسية وحركة المرور لها تأثير كبير على وقت التأخير. تم تطوير نموذج الانحدار لتقدير التأخير وتبين بأنه جيد الارتباط بالقيم الحقلية

المواضيع الرئيسية الثلاثة المدرجة في هذه الدراسة ؛ الموضوع الأول تضمن مقارنة بين وقت التأخير الفعلي ووقت التأخير الناتج عن برامج المحاكاة لجميع أذرع التقاطع. الموضوع الثاني شمل قيم التأخير الناتج عن برامج المحاكاة مقابل قيم التأخير الفعلية بعد معايرة معدل تدفق التشبع الأساسي لجميع أذرع التقاطع .

الموضوع الثالث التحقق من قيم التأخير المشاهدة مع التنبؤ بالتأخير ، يتم استخدام حزم البرامج المختارة لتقييم أوقات التأخير الفعلية لمختلف الحالات البحثية والقيم المقابلة.

يمكن استنتاج أن هناك اختلافات كبيرة بين أوقات التأخير المقاسة ميدانيًا وأوقات التأخير التي تم حسابها باستخدام برامج المحاكاة. تظهر النتائج أن برنامج .SYNCHRO10.0أفضل برنامج للتنبؤ بوقت التأخير الميداني عند التقاطعات (Zalatimo،Eishtar،Babal-Mashhad) بينما SIDRA 8.0 PLUS هو الأفضل لتقاطع الثورة بعد النموذج التجريبي لعملية المعايرة للتنبؤ بوقت التأخير الكلي . يمكن أن توفر هذه الدراسة مصادر لاختيار برامج المحاكاة.

التنبأ بنموذج التأخير لبعض التقاطعات ذات الأشارات الضوئية في مدينة الحلة

رسالة

مقدمة الى كلية الهندسة – جامعة بابل

جزء من متطلبات نيل درجة الماجستير في علوم الهندسة/ الهندسة المدنية/ المواصلات

أعداد

علي صلاح مهدي القزويني

أشراف

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2023 ميلادي

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