Evaluation the Performance of Al-Horh Signalized Intersection Using ArcGIS (ModelBuilder)

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Abstract

Signalized intersections are key elements in the urban transportation network where carry heavy traffic of motorized and non-motorized vehicles and pedestrians the intersection during peak periods. Intersection congestion is expressed in terms of level of service (LOS) as defined by the Highway Capacity Manual (HCM).Level of service is defined in terms of delay and ranges from LOS A (free-flow conditions) to LOS F (long delays). Delay represents an average stopped delay per vehicle fora 15-minute analysis period.

The objective of this paper is to evaluate the operational capacity of intersection (AL-Horh) in AL-Kut city.AL-Horh intersection is a ground intersection with four legs. Itrepresent one of the main intersections in Al-kut city for it links the traffic coming from Al- Zafaf Street to Al- Hora and Al- Kafaat Street. The volumes of traffic get congested in the morning and evening at this intersection.To achieve the evolution performance of intersection 700 TVL Samsung video cameras have been used to measure traffic volume in the intersections with 3.6mm lens and total station were used to survey the intersection whereas ArcGIS (ModelBuilder) were used for processing for the purposes traffic analysis process.The operational analysis of the existing conditions of this intersection indicates that the LOS is (**F**) with an intersection delay value of **175.363**sec. /vehicle.

Keywords:Signalized intersections, Level of Service (LOS), Traffic volume, Geographic Information System (GIS)

تقييم أداء تقاطع الهورة باستخدام ArcGIS (ModelBuilder)

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الخلاصة

التقاطعات الضوئية هي عناصر اساسية في شبكة النقل الحضرية حيث تحمل حركة المرور الكثيفة للمركبات الالية وغير الالية والمشاة . لهذا أسباب مثل زيادة السكان والنمو الاقتصادي وزيادة ملكية السيارات أدى الى زيادة الطلب على حركة المرور ليتجاوز القدرة الاستيعابية للتقاطع خلال فترات الذروة . يتم التعبير عن التقاطع المزدحم تحت مصطلح مستوى الخدمة(LOS) والذي يعرف بواسطة (HCM) حيث يعرف مستوى الخدمة من حيث التأخير ويرتب من LOS(A) الى LOS(F) . التأخير يمثل معدل توقف المركبة لمدة 15 ثانية

.أن الهدف الرئيسي من هذا البحث هو تقييم القدرة التشغيلية لتقاطع الهورة في مدينة الكوت . ان تقاطع الهورة هو تقاطع أرضي مؤلف من اربع اذرع ويمثل واحد من اهم التقاطعات في مركز الكوت حيث يربط حركة المرور القادمة من شارع الضفاف والهورة بشارع الكفاءات . للحصول على الاحجام المرورية الصباحية والمسائية لهذا التقاطع ولتحقيق الهدف 700 فديو كاميرا استخدمت للحصول على الاحجام المرورية ذات عدسة 3.6 ملم وجهاز Total Station استخدم لمسح التقاطع في حين أستخدم نظام المعلومات الجغرافية (GIS) لغرض تحليل حركة مرور التقاطع. ان التشغيل المروري لهذا التقاطع يشير الى ان مستوى الخدمة يساوي (F)مع تأخير قدرة 175.36 (ثانية / مركبة).

1. Introduction

Traffic engineering is that phase of transportation engineering, which deals with the planning, geometric design and traffic operation of road, street, and highways, their network, terminals, abutting lands, and relationships with other modes of transportation [1].An intersection is defined as the general area where two or more highways join or cross, including the roadway and roadside facilities for traffic movements within the area. Intersections are an important part of a highway facility because, to a great extent, the efficiency, safety, speed, cost of operation, and capacity of the facility depends on their design. Each intersection involves through- or cross-traffic movements on one or more of the highways and may involve turning movements between these highways **[2].**Signalized intersections are key elements in the urban transportation network where carry heavy traffic of motorized and non-motorized vehicles and pedestrians, which, in turn, generate many conflicts among crossing, turning and merging maneuvers. .
Forthese reasons such as increasing of the population, economic growth, and increased car ownership led to an increasing traffic demand can exceed the carrying capacity of the intersection during peak periods.Therefore, traffic condition deteriorates and safety risk worsens**.[3]**
Congested and hazardous traffic conditions increase fuel consumption, emission, accidents and noise, therefore a city's quality of life, world energy resources and global atmospheric conditions deteriorate.The concept of capacity, level of service and delay are central to the analysis of intersections, as they are for all types of facilities, therefore that both capacity and level of service must be fully considered to evaluate the overall traffic operation of the intersections **[4].** While the delay is one of problems that occur in any facility of traffic.AL-Horh intersection in AL-Kut city is an important congested intersection due to its critical location on major streets. This intersection has the following characteristics:

- It has a very high traffic volume in two approaches.
- It is located on Major Street, which intersects with two minor streets.
- Many activities are located around this intersection.

2. Description of Site

It is a ground intersection with four legs. Represent one of the main intersections in Al-kut city for it links the traffic coming from Al- Zafaf Street to Al- Hora and Al-

Kafaat Street. The volumes of traffic get congested in the morning and evening at this intersection. Figure (1) shown the satellite Image for AL-Hora Intersection.

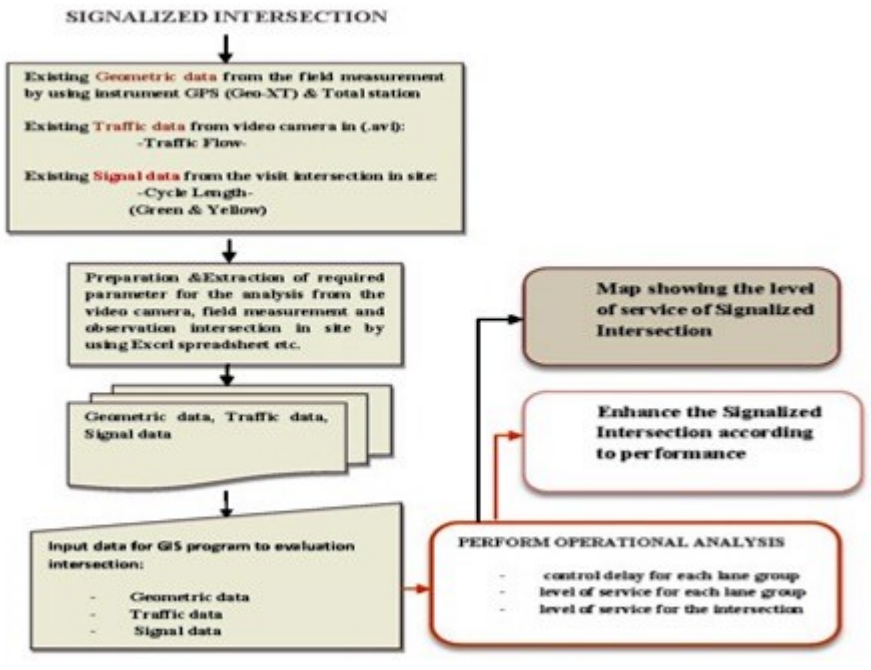
Figure (1) Satellite Image Top View for AL-Hora Intersection

3. Scope of the Study

- Specify the peak hour volume and calculate the peak hour factor (PHF) for all approaches at AL-Horh signalized intersection.
- Traffic analysis using computer software for existingconditions to get the level of service.
- Suggest alternative geometric design proposals to improve the traffic performance acrossthe intersection.

4. Methodology

This methodology provides a framework designed for the evaluation of signalized intersection .In this methodology the data, where collected through the use video camera and total station .the collected data are analyzed using several software (Excel&GIS).the analyses results are used to draw the conclusion and recommendations at signalized intersection. The figure (2) below generally clarifies and identifies the signalized performance and then does some required improving processes



5. Traffic Data Collection for Signalized Intersection

Collecting data are one essential element in the evaluation process of road networks performance of the roads. It is important to plan beforehand to identify data and the time limits for collecting it. The main data required by ArcGIS software for evaluating typical road intersection includes:

Figure (2) Signalized Intersection Methodology

- Geometric Data
- Traffic Data
- Signalization Data

5.1 Geometric Data

The main goal behind collecting geometric data for signalized intersection is to evaluate and traffic enhancement through adding a new lane, increasing the width of a lane, creating a tunnel, or a bridge… etc. These data are Area type, Number of lanes, N,Average lane width, W (m), Grade, G (%),Existence of exclusive LT or RT lanes, Length of storage bay, LT or RT lane, Ls (m),and Parking. To get the data about Number of lanes, Average lane width, Existence of exclusive LT or RT lanes, and Parking and making maps).a Reconnaissance survey was mad for the four intersection of the study area. It was founded that the actual intersections differ significantly from that shown in the satellite image of the intersection shown previously in figure (1), which are urges the need of the development of large scale geometric design maps using terrestrial instrument such as:

- GPS Trimble Geo-Xt
- Total Station Trimble

In relation to grades, all the intersections are nearly of the same flat level .The intersections of the area type lie in the city center and they are influenced by the CBD.

5.1.2 Automated Mapping Using ArcGIS

Following steps describes the process work the database and then drawing maps of the study area:

- Created item in GDB:

The GDB is the newest spatial data file format developed by ESRI.GIS stored information about the feature as a collection of thematic layers that cab be linked geographically. By ArcMap (modelbulider) software the workspace was built, which is first step. The second step was building a folder, which includes the file GDB and the feature datase as shown in figure (3)

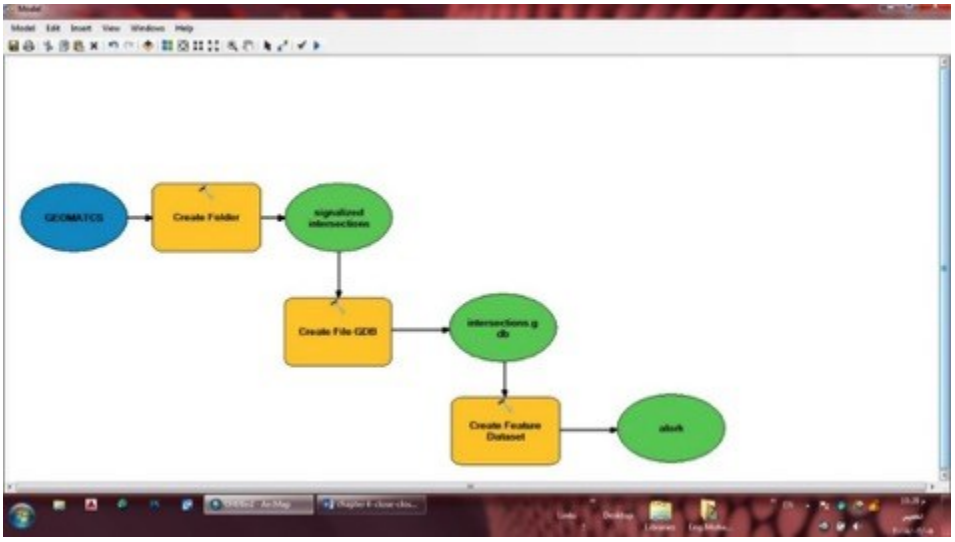


Figure (3) shown build GDB by Modelbulider

After executing this code through the running for it out the ArcMap window, it is recalled in the above-mentioned window to present the results; one may observe that a folder is built containing all the work, GDB and Feature dataset.

- **Created feature classes and network drawing:**

After determining, the network main points coordinates such as (boundary road and intersection, channelized intersection, Medians, road marking) with the total station. The coordinates are arranged in form of (.xlsx) format in the excel software, and executed by ArcMap (ModelBulider) below and the results are then presented in the ArcMap window.thise approach were used to develop the maps for all network includes (intersection, street). Figure (4) shown drawing AL-Hourh intersection. After drawing, the intersection dimension was set, and export map according to Cartographic. Figures (5), shown the geometric design map for AL-Horh.

Figure (4) shown drawing AL-Horh intersection by ModelBulider

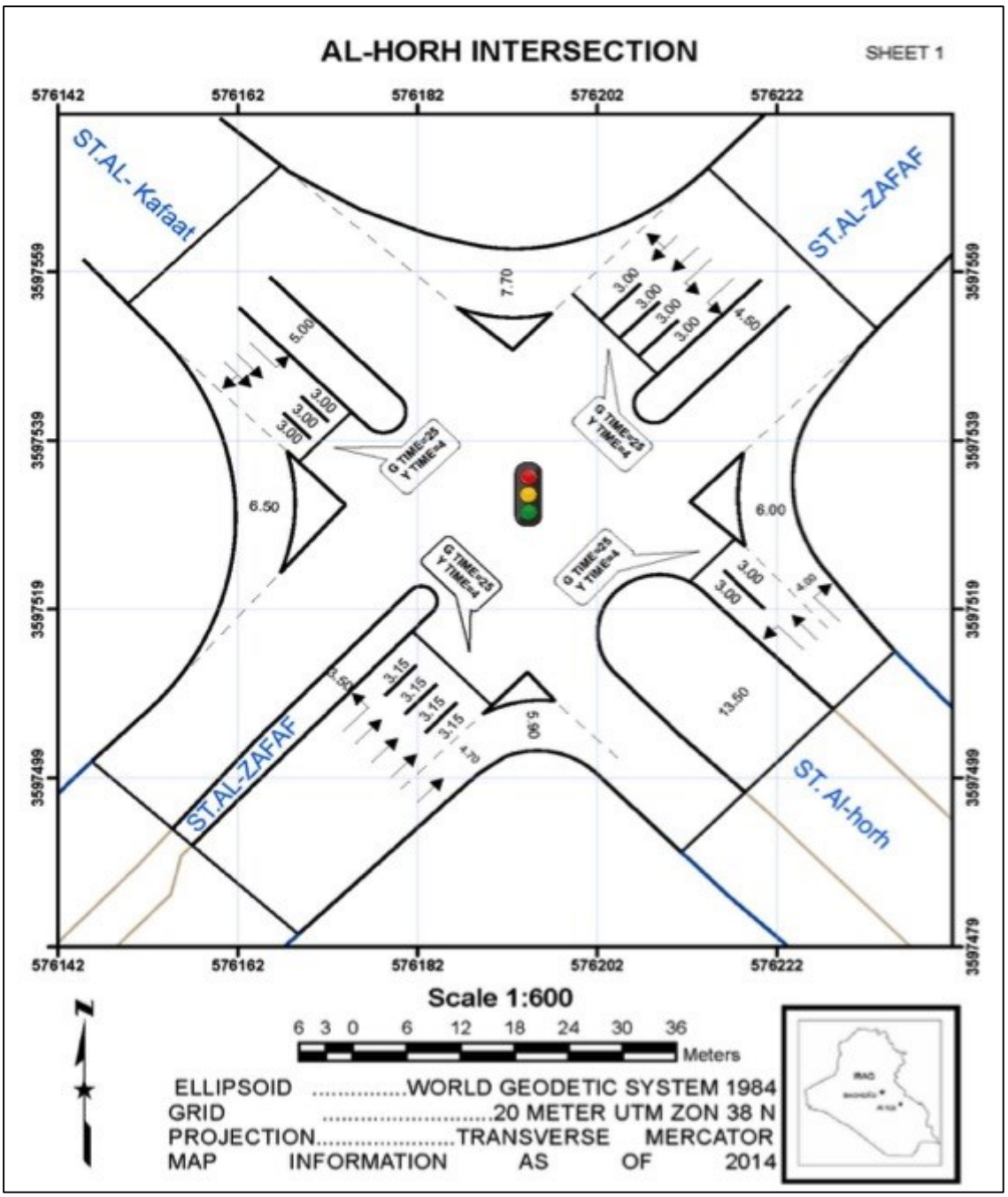


Figure (5) map for AL-Horh intersection

5.1.3 Intersections Geometric data

According to the base maps of the four intersection for the AL-Horh intersection. The geometric data collected for each intersection are given in table (1).

Table (1) General Characteristics of Al-Horh Intersection

Approach	Direction	No.0f lane	Movement	Width (m)	Cycle length (sec)	
					G	Y
1	From Al-Hourh Street.	1	L	3.00	25	4
		1	TH	3.00		
		2	R	3.00		
2	From Al-Zafaf Street.	1	L	3.15	25	4
		3	TH	3.15		
		2	R	2.95		
3	From AL-Kafa'at Street.	1	L	3.00	25	4
		2	TH	3.00		
		2	R	3.25		
4	From Al-Zafaf Street.	2	L	3.00	25	4
		2	TH	3.00		
		2	R	3.85		

5.2 Collection of Traffic Volume Data

It is well known in most of traffic studies for evaluating and enhancement of the existing intersection, the flowing data are needed: Demand volume by movement, V (veh/h), Base saturation flow rate, S_O (pc/h/ln), Peak-hour factor, PHF, Percent heavy vehicles, HV (%),Approach pedestrian flow rate, vped (p/h), Local buses stopping at intersection, NB (buses/h), Parking activity, Nm (maneuvers/h), Arrival type, AT, Proportion of vehicles arriving on green, P,and Approach speed, SA (km/h).

One of the most important required field data are traffic volumes in the intersections. In this research, 700 TVL Samsung video cameras have been used to measured traffic volume in the intersections with 3.6mm lens as they are shown in figure (6). These cameras cover all the in and into out traffics. After that, these traffics will be counted in the office. It is a precise method where there are no human mistakes, which can occur when the vehicles are counted manually. This also help in controlling the obstacles that would happen when counting manually and stopping the counting process at obstacles and then the process would be continued in the office and this would not be controlled in the field to determine the peak hour in each intersection, The traffic volumes in the intersection are counted for a period of a week and for eleven hours per a day in the intersection.

Figure (6) Samsung cameras (700TVL)

5.2.1 Determination of the Peak Hour

To identify the best time for collected data of the peak hour the traffic volumes should be counted for eleven hours a day for each intersection. Figure (7) shows the traffic volumes in Al Hora intersection from seven a.m. to five p.m. the peak hour is at (8.00-9.00 A.M.). The rest of the data adopted in this study are proposed on the basics of Highway Capacity Manual 2000 (HCM) for instance Base saturation flow rate. Which equals 1900 (pc/h/ln)…etc.

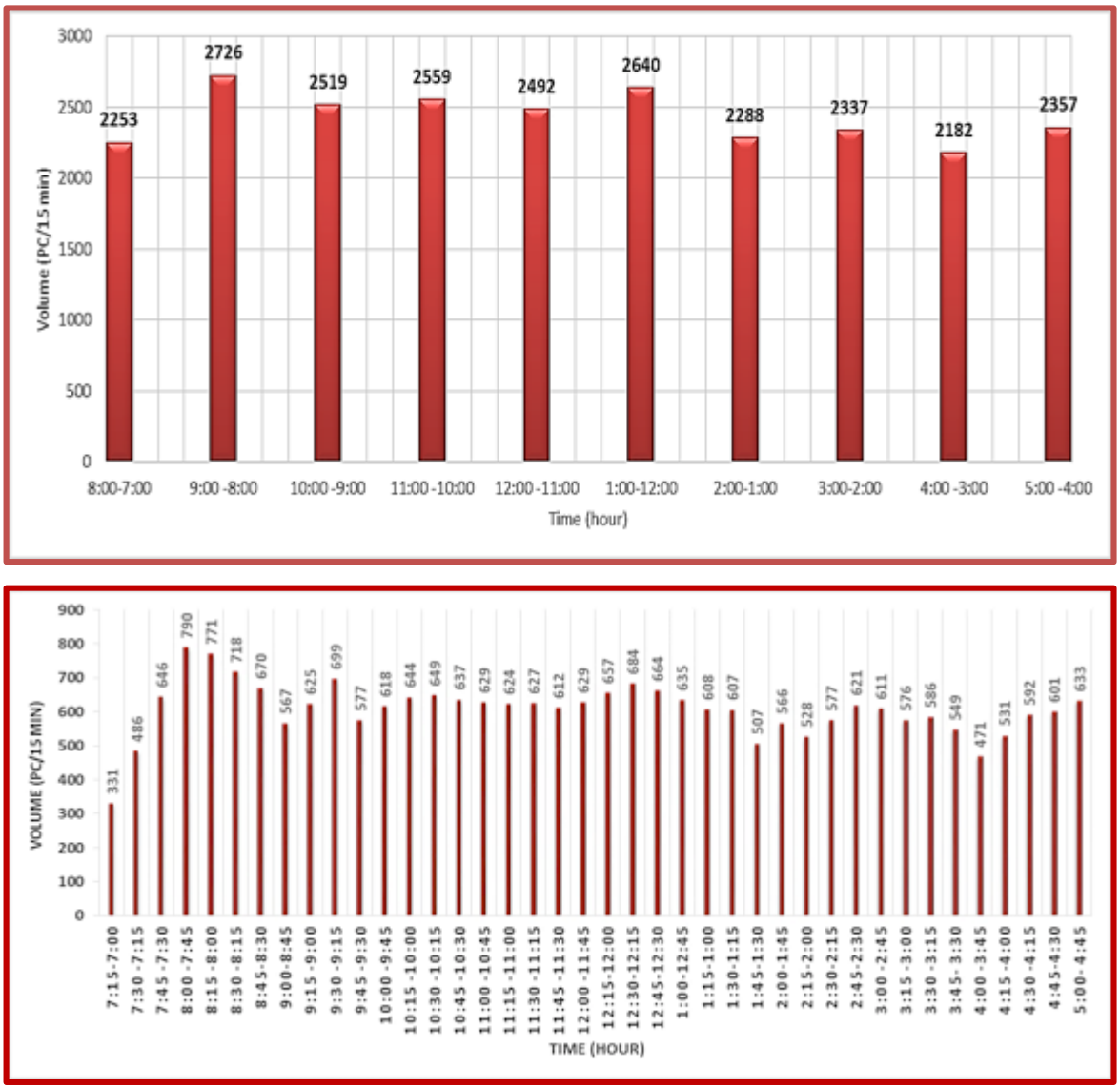


Figure (7): Total Traffic Volume at AL- Al Horh Intersection

5.3 Collection of signal data

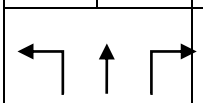
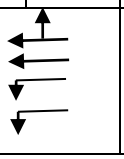
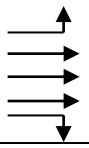
The signalization timing data required for the evaluation are as flow:

- Startup lost time at the beginning of green intervals.
- Extension of effective green at the beginning of yellow, when vehicles tend to continue to enter the intersection for a short period.
- The green, and yellow, intervals for each intersection.

The value for both startup lost time and green extension time, which are used the default values, which are recommended by highway capacity manual (HCM-2000).on the other

hand, other element of signal timings (cycle length, green, yellow) where taken by reading the electronic counter at the plate . The existing phase sequences and the timing allocation of existing phase sequences are illustrated in tables (2).

Table (2) existing phase sequences and the timing allocation

Int. No	Cycle Time (sec.)	Phase -1-		Phase -2-		Phase -3-		Phase -4-	
		G	A& AR	G	A& AR	G	A& AR	G	**A& AR**
AL-Horh int.	116	25	4	25	4	25	4	25	4
									

6. Analysis Results

The traditional methods used by traffic engineers are the use of specialized traffic software like HCS-2000 program. Where this software used by many agencies and researchers in Iraq and other countries. Initially researcher tried to use this software to show the intersections operation level of service (LOS), as indicated in last chapter.in this research anew approach with GIS technology used for traffic engineers. The flow chart shown in figure (2) Demonstrate the analysis process the tasks have been divided into two modules :(1) preparation and extraction of traffic parameter, (2) ArcGIS(Modelbuilrer) analysis, each these modules will be discussed in turn including a detailed description of each task involved.

1. Preparation and extraction of traffic parameters

Excel program used to prepare the data collected in the organization of spreadsheets to in the GIS program for the purpose of analysis. Sample of that is the data for the AL-Hora intersection.

- Geometric parameters

The physical configuration of the intersection is obtained in terms of area type, number of lanes, average lane width, grade, and parking. The base map for the AL-Hora intersection shown in figure (5).Table (3) where used to prepare the required geometric data for excel program shown the preparation data in excel program.

Table (3) Geometric data for excel program

lane group	Area type	Number of lane	Average lane width	parking	Grade %
Right Al Horh	CBD	1	4	N	0
Through Al Horh	CBD	1	3	N	0
Left AL horh	CBD	1	3	N	0
Right Al Zafaf	CBD	1	4.7	N	0
Through Al Zafaaf	CBD	3	3.15	N	0
Left Al Zafaf	CBD	1	3.15	N	0
Through Al Kafaat	CBD	2	3	N	0
Left Al Kafaat	CBD	1	3	N	0
Through Al Zafaaf2	CBD	2	3	N	0
Left Al Zafaf2	CBD	2	3	N	0

- Traffic parameters

Peak hour factor (PHF), and percentage of heavy vehicles for each lane group must be calculated before entering the data into excel program. Table (4) shown PHF and percentage HV for all intersection.

Table (4) peak hour factor and percentage of heavy vehicle data

Approach	Direction	Movement	PHF	%HV
1	AL-Horh street	L	0.84	2
		TH	0.93	4
		R	0.86	2
2	AL-Zafaf street	L	0.72	4
		TH	0.87	6
		R	0.78	5
3	AL-Kafaat street	L	0.63	1
		TH	0.79	1
		R	0.55	3
4	AL-Zafaf street	L	0.62	3
		TH	0.91	1
		R	0.81	3

The above data has been entered into the excel program with other data which are : demand volume, base saturation flow rate, approach pedestrian flow rate , local buses stopping at intersection , parking activity, and arrival type. Table (5) shown the preparation of the data in excel program.

Table (5) Traffic data for excel program

lane group	volume	PHF	HV%	Pedestrian flow rat	Local buses stopping	Parking activity	Arrival type	Base Saturation flow .So(pc/h/ln)
Right Al Horh	206	0.86	2	0	0	N	3	1900
Through Al Horh	423	0.93	4	0	0	N	3	1900
Left AL horh	456	0.84	2	0	0	N	3	1900
Right Al Zafaf	66	0.78	5	0	0	N	3	1900
Through Al Zafaaf	543	0.87	6	0	0	N	3	1900
Left Al Zafaf	104	0.72	4	0	0	N	3	1900
Through Al Kafaat	267	0.7	1	0	0	N	3	1900
Left Al Kafaat	104	0.63	1	0	0	N	3	1900
Through Al Zafaaf2	727	0.85	1	0	0	N	3	1900
Left Al Zafaf2	30	0.62	3	0	0	N	3	1900

- Signalized parameters

Details of the signal system parameters should be specified including cycle length, green time, y&red clearance, actuated or pretimed, pedestrian push-button, analysis period, start up lost time, extension of effective green, upstream filtering, and incremental delay. Table (6) shown the preparation data in excel program.

Table (6) Signal data for excel program

lane group	Actuated (P/A)	START UP LOST TIME	Unit extention	Ext.eff.green	Phasing Time (G)	Phasing Time (Y)	Cycle Length. C	Duration of Analysis (hrs).T	K	I
Right Al Horh	p	2	3	2	25	4	116	0.25	0.5	1
Through Al Horh	p	2	3	2				0.25	0.5	1
Left AL horh	p	2	3	2				0.25	0.5	1
Right Al Zafaf	p	2	3	2	25	4		0.25	0.5	1
Through Al Zafaaf	p	2	3	2				0.25	0.5	1
Left Al Zafaf	p	2	3	2				0.25	0.5	1
Through Al Kafaat	p	2	3	2	25	4		0.25	0.5	1
Left Al Kafaat	p	2	3	2				0.25	0.5	1
Through Al Zafaaf2	p	2	3	2	25	4		0.25	0.5	1
Left Al Zafaf2	p	2	3	2				0.25	0.5	1

2. ArcGIS (Model builder) analysis

After the preparation of the data necessary for the analysis intersection. Arc GIS (model builder) was used for the analysis purpose. Model Builder combines several GIS operations and runs theseModules with different datasets. A model consists of threefundamental elements: input parameters, geoprocessing tools, and output data. The equation off used for evaluation are written in script language python, moreover other tools were used to complete analysis . The output of evaluation by GIS software is directed by a report in excel showing the assessment result for each lane group and intersection. With performance map, which shows the color-classified performance of each lane group and intersection. Figure (8) shown the proses model builder .whereas figure (9) shown map performance for AL-Horh intersection.Table (7) indicate the result of simulation run with (v/c) ration, control delay, and level of service for intersection.

Table (7) Analysis Result by ArcGIS (Modelbulider)

Intersection Name	lane group	(v/c) ration	Control delay (d)	LOS	Intersection delay	LOS
AL-Horh	Right Al Horh	0.747	57.259	**E**	**175.363**	**F**
	Through Al Horh	1.375	237.53	**F**		
	Left AL horh	1.695	382.516	**F**		
	Right Al Zafaf	0.298	40.832	**D**		
	Through Al Zafaaf	0.693	46.315	**D**		
	Left Al Zafaf	0.451	44.086	**D**		
	Through Al Kafaat	0.641	46.633	**D**		
	Left Al Kafaat	0.510	45.765	**D**		
	Through Al Zafaaf2	1.45	263.821	**F**		
	Left Al Zafaf2	0.078	36.558	**D**		

7. Enhancement of the traffic flow for signalized intersection

To enhancement traffic flow for signalized intersection, two scenarios were made in this study, as it will be discussed in the next section.

7.1 First scenarios: changing geometric conditions

This scenario is a combination of two changes, increasing number of lane and exclusive right turn made for approaches that do not have these elements. The number of lanes was increased in approaches that number of lanes could be increased without making any widening, and the minimum lane width not less than (3.6m) as recommended by highway capacity manual (HCM).increasing the number of lanes leads to increase saturation flow capacity results in decreasing the queue by distributing the vehicles over greater number of lanes.Exclusive right turn reduces the congestion level in intersection because the right turn movement will take full cycle time, means the right turn movement will never stop, on the other hand exclusive right turn reduces the point conflict between the vehicles. Table (8) summarizes the results obtained from ArcGIS (modelbulider) software.

Table (8) Results enhancement First scenarios

Intersection Name	lane group	(v/c) ration	Control delay (d)	LOS	Intersection delay	LOS
AL-Horh	Right Al Horh	0.747	57.259	**E**	**56.9**	**E**
	Through Al Horh	0.72	49.4	**D**		
	Left AL Horh	0.87	59.6	**E**		
	Right Al Zafaf	0.298	40.832	**D**		
	Through Al Zafaaf	0.693	46.315	**D**		
	Left Al Zafaf	0.451	44.086	**D**		
	Through Al Kafaat	0.641	46.633	**D**		
	Left Al Kafaat	0.510	45.765	**D**		
	Through Al Zafaaf2	1.01	78.1	**E**		
	Left Al Zafaf2	0.078	36.558	**D**		
	Through AL Haidariya	0.411	27.878	**C**		
	Through Baghdad	0.669	36.963	**D**		
	Left Baghdad	0.316	27.637	**C**		
	Right AL Zafaf	0.225	18.943	**B**		
	Left AL Zafaf	0.373	19.848	**B**		
	Through Al Haidrariya	1.52	310.1	**F**		
	Right Al Haidrariya	0	52.5	**D**		
	Right Al Zitoon	0.383	60.817	**E**		
	Through Al Zitoon	0	52.5	**D**		
	Left Al Zitoon	0.551	63.58	**E**		

7.2 Second scenarios: the construction of under pass at ALHorh,

This scenarios it is suggested to construct an under pass at ALHorh (in North-south direction).where in this direction as obvious of the result to improve the performance of traffic flow patterns and reduce the congestion severity at the intersection.

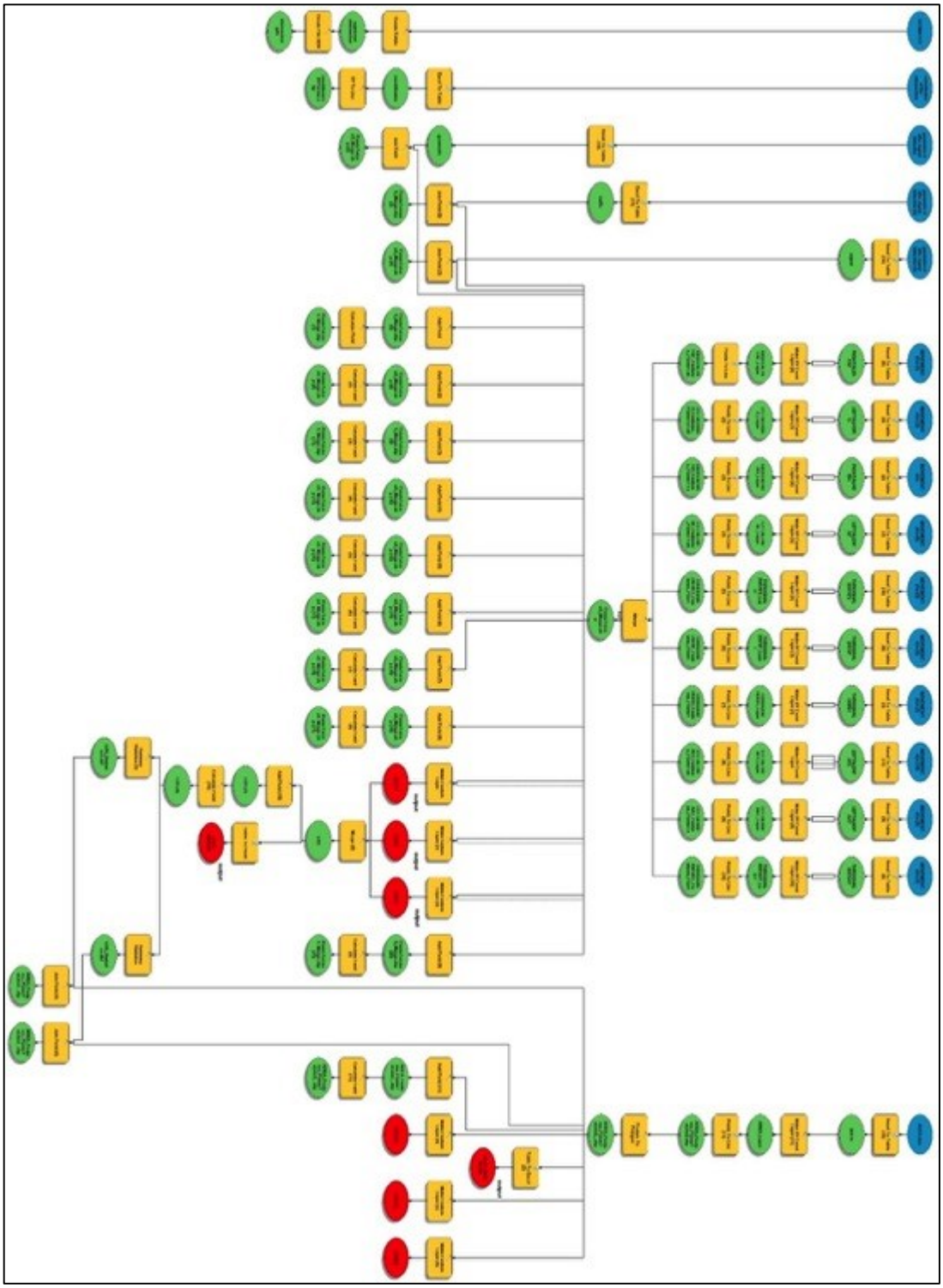


Figure (8) process modelbulider for AL-Horh

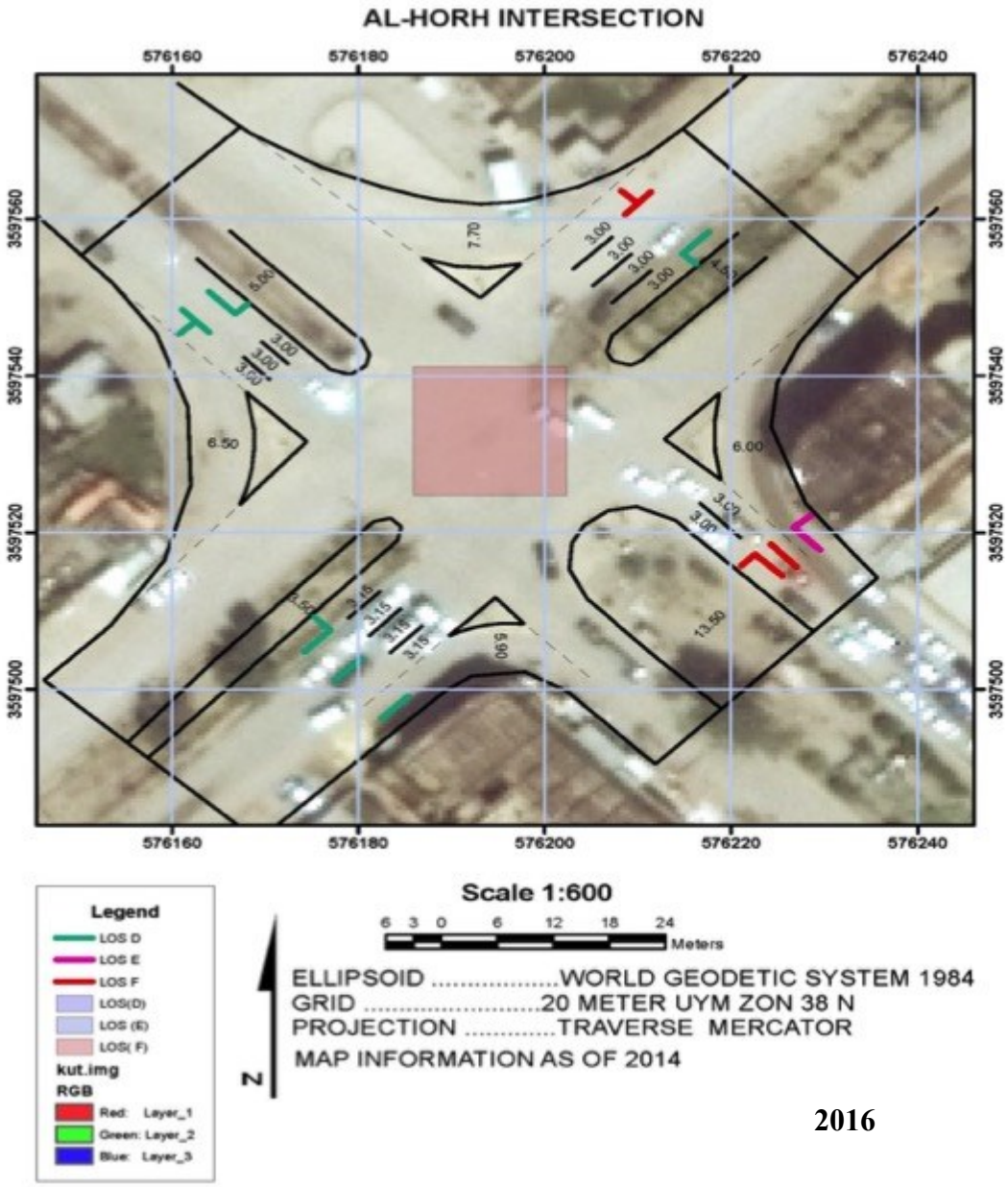


Figure (9) map performance for AL-Horh intersection

8. Conclusions

AL-Horh signalized intersection is one of the most important intersections in AL-kut city, and serves of about 8000000 passages of vehicles yearly.

The operational analysis of the existing conditions of this intersection by the ArcGIS (Modelbulider) indicates that the LOS equal to (F) with an intersection delay value of

175.363 sec. /vehicle. Therefore, and because of the reasons above, two enhancement proposals were suggested. The study showed that increasing number of lane to right turn for AL-Horh and AL-Zafaf approach is the best solution to enhance the intersection performance.

9. References.

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