صلاحية استخدام موديل (Bayesian) لتخمين الحركات المروريه المستديرة
في التقاطعات ذات المستوي الواحد
المنظمه بالاشارة الضوئية

رسالة مقدمة الى
كلية الهندسة بجامعة بابل
كجزء من متطلبات نيل شهادة الماجستير في
علوم الهندسة المدنية

من قبل:

ميعاد طه ياسين الحلو

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٢٠٠٦م

VALIDATION OF BAYESIAN MODEL
FOR ESTIMATING TURNING MOVEMENTS
OF AT-GRADE SIGNALIZED INTERSECTIONS

AThesis
Submitted to the College of Engineering
of the University of Babylon in Partial
Fulfillment of the Requirements
for the Degree of Master
of Science in Civil
Engineering

By:

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Supervised By:

Assist. Prof. Dr. Nahla Y. Ahmad

Assist. Prof. Mr. Ali A. Alwash

٢٠٠٦

TO ......My Grandmother

......My Father

...... My Mother

بســـم الله الرحمن الرحيم

وَمَا أُوتِيتُم مِّنَ الْعِلْمِ إِلاَّ قَلِيلاً

صدق الله العظيم

سورة الإسراء – الآية ٨٦

بســـم الله الرحمن الرحيم

صلاحية استخدام موديل **(Bayesian)**
لتخمين الحركات المرورية المستديرة في التقاطعات ذات المستوي الواحد المنظمة بالاشارة الضوئية

الخلاصة

يجري في هذا البحث تخمين حركة المرور المستديرة في أربعة تقاطعات منظمة بالإشارة الضوئية توجد في مناطق حضرية في مدينة الحلة وهي تقاطعات عشتار والجمعية والام وباب المشهد. تم اجراء التخمين عن طريق موديل إحصائي يدعى موديل

Bayesian

(في هذه الدراسه اعتمد هذا الموديل على إحصائيات من ثلاث سنوات سابقه مختلفة.الاحصائيه الحديثة فقد أخذت لسنه الدراسه بواسطة

طريقة التصوير الفديوي. أما المعلومات الخاصة بالشكل الهندسي فقد تم جمعها بواسطة الطرق

Event

المباشرة. استخدم برنامج Event في تحويل المعلومات المرورية

الى الحاسب . وخزنت في ملفات رقمية أمكن تحليلها بواسطة برنامج

Excel

Bayesian

تم أعداد برنامجين بخصوص موديل (Bayesian)

يهتم الأول بتخمين حركة المرور المستديرة في التقاطعات الرباعية الاذرع . البرنامج الثاني المعدل يخص التقاطعات الثلاثية ، هذا البرنامج يشبه البرنامج الأصلي مع بعض التعديل.والبرنامج الفرعي التابع للبرنامج الاصلي يقوم بتحويل التقاطعات الثلاثية الاذرع الى تقاطعات رباعية الأذرع بإضافة ذراع رابعة وهمية.

دقة التخمينات الحاصلة من التحاليل الإحصائية قيمت اولا بواسطة البرنامج الإحصائي

SPSS

باستخدام فحص البواقي. استخدم البرنامجين

HCS (٢٠٠٠),و

TRANSYT-F [٧]

(٢٠٠٢) لغرض اختبار صلاحية الموديل من خلال المقارنه بين نتائج البرنامجين

باستخدام حركة المرور المستديرة الحقيقية والمخمنة. فكان هناك تقارب بين قيم عناصر قياس

الفعالية في نتائج البرنامجين (HCS ,

) لكلا (TRANSYT-F ٧

الحالتين. بالاضافه إلى انه تم استخدام (

) لتحسين (TRANSYT-F ٧

الأداء في التقاطعات المشموله بالدراسة.

استخدم اختبار (t-test) لمعرفة دقة تخمينات الموديل.وبينت

النتائج بدرجة اهميه ٠,٠٥ انه لا يوجد فرق مهم في حالة استخدام حركة المرور القديم لسنة ٢٠٠١ بينما يكون هذا الفرق مهم في حركة المرور القديم لسنة ١٩٩٨و١٩٩٤في حركة الاستدارة اليمين. اعتمادا على نتائج هذه الدراسة فانه يمكن ملاحظة وجود تقارب بين قيم حركة

ABSTRACT

المرور المستديرة المخمنة من الموديل الإحصائي والتيارات الحقيقة كلما كانت الفترة بين الإحصائيات القديمة والحديثة قليلة والعكس بالعكس.

This research dealt with the estimation of traffic flows on four traffic signalized intersections located in urban areas of Hilla City and it is Ishtar, Al-Jamia, Al-Aum and Bab-Al-Mashhed intersections. The estimation was achieved through the application of statistical model called Bayesian model. In this study the model depended on a prior information from three different outdate years. For the recent year, the data were collected by using video

recording technique. The geometric characteristics were obtained by direct measurement. Event program was used in abstracting the video recorded traffic data from the video films. The abstracted data were stored in the form of digital files and processed using the Excel program.

Two programs were conducted for Bayesian model. The first one was carried out in estimating of the turning movements in four-arm intersections. The second modification program is carried out for three-arm intersections. It is the same original program but has some modification. And the subroutine of general program converts three-arm intersection to four-arm intersection by adding fourth imaginary arm.

First the SPSS computer program evaluates the accuracy of the obtained estimation from statistical analysis by using residual test. HCS (٢٠٠٠) and TRANSYT-٧F release ٩.٤ (٢٠٠٢) are used for validation of Bayesian model for estimating turning movements by comparison between the results of the two programs by using estimating and observed flows. There is convergence between measures of effectiveness in results of (HCS and TRANSYT-٧F) computer programs for two cases. In addition to using TRANSYT-٧F computer program for improvement the performance in intersections under study because of high congestion in this intersections.

T-test was used to investigate the accuracy of the model. Findings show that at ٠.٠٥ degree of significance, there was no significant difference when using an outdate flows from ٢٠٠١, while this difference is significant for outdate flows of ١٩٩٨ and ١٩٩٤ for right turn movements. Depending on the obtained results, it is clear that there is convergence between observed and estimated turning movements if the period between outdate and recent statistical are convergence and vice versa.

CERTIFICATION

   We certify that this thesis, entitled *"Validation of Bayesian Model for Estimating Turning Movements of At-Grade Signalized Intersections"* **was prepared by** *"Mieaad Taha Yassien"* **under our supervision at Babylon University in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering.**

Signature: Signature:

Name :**Assist. Prof. Ali A. Alwash**   Name: **Assist. Prof. Dr. Nahla Y. Ahmad**

Date: Date:

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Praise is to **ALLAH HIS MAJESTY** for this work has been completed under His benediction.

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I record my sincere gratitude to my family for their encouragement and support during the study years.

Finally, I am grateful to all my dear friends and all who have helped me in carrying out this research.

Mieaad

LIST OF CONTENTS

LIST OF FIGURES

LIST OF NOTATIONS

Symbol	Definition
A.M	Ante Meridien
A_i	Flow rate into of Intersection
ANOVA	Analysis of Variances
AR	All-Red Interval, (Sec)
B	Bayesian Method
b	Vector Follow Maximum likelihood method
B_j	Flow Rate out of Intersection
B%	Percentage of Buses

C	Cycle Length (Sec)
CBD	Central Business District
D	Average Delay, Per Vehicle in Seconds
DHV	Design Hourly Volume, (pcu)
D.I	Disutility Index
d_{ij}	Non-Constrained Distance
EB	East Bound
EM	Entropy Maximization Method
FHWA	Federal Highway Administration
G	Green Time,(Sec)
G_k	Total Inflow or Total outflow
H	Matrix Follow Bayesian Model
h	Average Discharge Headway, (Sec)
HCM ٢٠٠٠	Highway Capacity Manual ٢٠٠٠
HCM ١٩٩٤	Highway Capacity Manual ١٩٩٤
I	Total Inflow
ij	Origin and Destination
IM	Information Minimization Method
J	Total Flow in Intersection
j	Matrix Follow Maximum Likelihood Method
$J^{'}$	Transpose of J Matrix

K	Iteration Number
L	Left Turn Movement
Log L	Log Likelihood
L.O.S	Level of Service
M	Number of Observations
ML	Maximum Likelihood Method
$M.O.E_S$	Measures of Effectiveness
N	Total Flow
NB	North Bound
n_i	Number of Lanes in Link (i)
O	Origin
P	Total Inflow in Intersection
Pcu	Passenger Car Unit
P.M	Post Meridian
p_n	Inflow in Link Number n
Q	Total Iutflow in Intersection
q_n	Outflow in Link Number n
R	Right Turn Movement
R^γ	Coefficient of Determination
SB	South Bound
S_i	Saturation Flow rate of Link (i), (vphgl)

SPSS	Statistical Pakage for Social Sciences
T	Time Required to Discharge Queue, (Sec)
t	Traffic Matrix
T%	percentage of Trucks
Th	Through Movement
t_{ij}	Traffic Flow from Link i to Link j
t_{ij}^{a}	Priori Turning Movements
t_{ij}^{*}	Observed or Priori Flows
TRANSYT	Traffic Network Study Tool
TRB	Transportation Research Board
V	Volume on Link, (vph)
vph	Vehicle Per Hour
WB	West Bound
X or v/c	Degree of Saturation
X_{ij}	Flow rate from Link i to Link j
Y	Yellow Interval, (Sec)
β	Scaling Factor
ϕ_{ij}	Probability Matrix
α	Length Period Carry out the Manual Count

$\nu_{ii}^{(0)}$	Prior Variances
μ_{ij}	Flow rate from Link i to Link j

LIST OF TABLES

Chapter One

Introduction

<u>١.١ General</u>

The obvious indication of progress and development of the urban societies may be represented by high standards of traffic regulations and efficient operation of their transportation system. Therefore, road traffic congestion has become a major issue as it imposes a considerable burden on the local economy. It contributes to accidents, noise and atmospheric pollution, moreover it creates anxiety, frustration and stress among all classes of road users .

Wackrill and Wright [١٩٩٢] stated that congestion has many different causes, such as:
A-Traffic growth.
B-Bottlenecks within the road network.

The rapid growth in the numbers and types of vehicles in Iraq at last years from ٢٠٠٣ requires traffic surveys to evaluate and improve performance of at-grade intersections. There is considerable potential for reducing the cost of obtaining traffic data at intersection by replacing direct observations of turning flows with estimates based on count of the intersection entry and exit flows. For economic evaluation of road improvement schemes, selecting type of intersection, geometric

design of traffic regulation schemes, the turning flows at intersections are also needed for projects. When labours observe the routes of vehicles using the intersection, the traffic movements including vehicle classification can be obtained directly. Such an approach can be used in simple junction with light traffic flows. While for large intersections, the number of observers increases and the task of each observer becomes difficult or impossible, so that vehicle count on road links between intersections can be obtained relatively cheaply and easily by using automatic counters.

These counters cannot give the proportions of vehicles making turning movements at intersections. Therefore, several methods of estimating turning flows at intersection have been suggested and discussed in this research.

١.٢ The Traffic Conditions in Hilla City

Babylon, was one of the most important cities of the ancient world. It was capital of Babylonian in the ٢nd and ١st millennia BC and was built in ١١٠١ AC.

Al-Hilla, the capital of Babylon Governerate, ٦٠ miles south of the capital Baghdad. From the basis the map of Hilla city, it can be noticed that the city is horizontally growing and expanding longitudinally at west side of Shatt Al-Hilla.

The study intersection located within the urban area in Hilla City which it encompasses large centers and employment retail activity, as well as, the government offices. This region characterized by large number of commercial shops, private offices and industrial places. Therefore, the study intersections shown in the map of Hilla city have become the most congested in urban area.

Since Hilla City is basic connector between southern and middle cities of Iraq such main intersections within study area suffering with congestion especially in A.M and P.M periods of day. All above mentioned situations lead to increase the delays of both vehicles and personal trips, moreover the rate of traffic accident .

For the above reasons, it is clear that a study must be conducted to evaluate the performance by estimated the turning movements and improve the level of service of intersections within the study area.

١.٣ The Research Objectives

The objectives may be shown as follows:

١. Estimating the turning movements at intersections by updating the previous statistical information from knowledge of the recently total inflow and outflow from each arm.

٢. Validation of Bayesian model by using HCS-٢٠٠٠ and TRANSYT-٧F Release ٩.٤ (JANUARY ٢٠٠٢) package softwares.

١.٤ <u>Layout of Thesis</u>

Four-intersections in Hilla City were selected, Ishtar, Al-Jamia, Al-Aum and Bab-Al-Mashhed intersections. These intersections are representing the most congested area.

To achieve the objectives of this study it is necessary to conduct the research in several stages, in which are described in the flow chart shown in Figure (١-١) as follows:

١. The first chapter gives general idea about Al-Hilla City and explains the aims of research while the second chapter impression in reviewing of the literature to estimate the turning movements for the at-grade intersections and show the used programs in the research.

٢. The third chapter showed the collected data from the field using image processing.

٣. "EVENTS" program was presented in chapter four, in which it was used for analysis of the turning movements at the selected intersections and prepare the needed data for the steps of Bayesian model applications for three and four-arm intersections are given, in addition to examine the accuracy of the estimated turning movements.

٤. Validation of Bayesian model by using (HCS and TRANSYT-٧F) package softwares.

٥. The sixth chapter is concerning with the conclusion and recommendations.

Research Important and Scope of Work

↓

Review of the Related Subjects

↓

Stage I

Chapters One,

Preparing of Data According to Requirements of Adopted Programs

↓

Software Selection

↓

Analysis of Data According to Requirements of Bayesian Model

Stage I I

Application and Examining the Accuracy of the Model

↓

Stage I I I

Chapter Five

Validation of Bayesian model by using TRANSYT-$^{\vee}$F and HCS Programs

Some Improvements for Study Intersections

↓

Stage IV

Conclusions and Recommendations

↓

Figure (١-١) The Stages of Study

①
Ishtar Intersection

②

③
amia Intersection

AL - Aum Intersection

④

Bab - Al - Mashhad Intersection

Scale	١: ٤٠٠٠٠
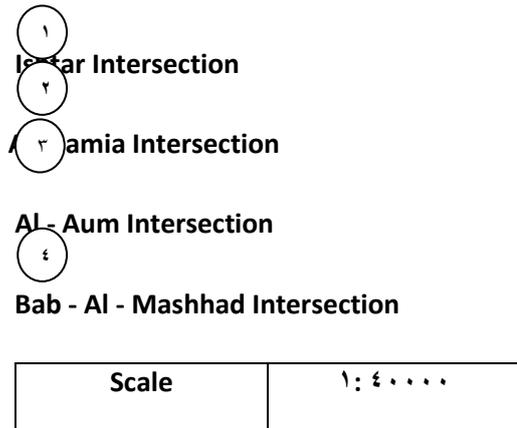
Figure (١-١): Location of Study Intersections in Hilla City [The Office of Constructional Planning- Babylon, ٢٠٠٠]

Chapter two

Review of Literature

٢.١ Introduction

This chapter consists of four parts, the first part introduces a general idea about at-grade intersections, while an overview of estimation turning movements studies is given in second part. The using method for estimating the turning flows at a junction depending on the Bayesian model was explained in the third part. The last part involves a description of software program and the selected computer models used in this study.

٢.٢ At-Grade Intersections

At-grade intersections are used by two or more different traffic streams, which intersect each other at the same road level. The traffic control methods of at-grade intersections can be divided into two major groups; Namely: unsignalized and signalized control of the intersecting traffic streams, depending on whether or not traffic signals are installed **[Khisty and Lall, ١٩٩٨]**.

At-grade intersections are probably the key point of the safety and the efficiency of road traffic flow. The capacity of an intersection is generally less than that of the street feeding into it, since two or more traffic streams pass through the same roadway area to cross, convergely or divergely, each other **[Hewes & Oglesby, ١٩٧٥]**.

The intersection area should be designed to provide sufficient space for turning and crossing movements. At-grade intersection may consist of two intersecting roads or intersection of four roads or a junction of multiple roads.

Intersection of three roads is indicated as Y or T or a branch i.e. a minor roadway. A minor roadway is that road which intersects a main road at a small defection angle. In a T-junction, two roads intersect to form a

continuous highway and third intersect at or nearly at right angles. In a Y-intersection, three roads intersect at nearly equal angles.

Flared intersection may also be used at certain places and in this additional pavement width of additional traffic lanes is provided at the intersection area **[Singh and Abdedkar, ١٩٩٦]**.

The at-grade road intersection is a complicated part of a high way system. It is the majority of vehicle and pedestrian conflicts Occur, resulting invariably in delays, accidents, and congestion. At-grade intersections are generally controlled by signals, in which case they are known as signalized intersections. Unsignalized intersections, which make up the most majority of at-grade junctions in any street system, are controlled by stop and yield signs, to assign the right-of-way to one street or approach **[Khisty and Lall, ١٩٩٨]**. Then at-grade intersections are often apt to become bottlenecks of road network. For this reason, several attempts have been made in the past to study and analyze vehicular interactions at the highway intersections.

٢.٣ <u>Right Turn on Red</u>

When right turn on red (RTOR) is permitted, the right- turn volume for analysis may be reduced by the volume of right-turning vehicle moving on the red phase. This reduction is generally done on the basis of hourly volumes before the conversion to flow rates.

The number of vehicles able to turn right on a red phase is a function of several factors, including:

- Approach lane allocation (shared or exclusive right-turn lane)
- Demand for right-turn movements
- Sight distance at the intersection approach
- Degree of saturation of the conflicting through movement
- Arrival patterns over the signal cycle

•Left-turn signal phasing on the conflicting street

•Conflicts with pedestrian

For an intersection, it is appropriate to consider the RTORs that actually occur. For both the shard lane and the exclusive right-turn lane conditions, the number of RTORs may be subtracted from the right-turn volume before analysis of lane group capacity or LOS. At an intersection, the number of RTORs should be determined by field observation **[HCM, ٢٠٠٠]**. the RTORs in study intersections was in west bound of Ishtar intersection, east bound of Al-Jamia intersection, and all directions of Bab-Al-Mashhed intersection.

٢.٤ Some Methods for Estimating Turning Movements at Road Junctions

The Turning flow matrix is generating by various methods proposed by Jeffereys and Norman [١٩٩٧] based on some linear constraint like maximizing the smallest flow. Generally, the method of Jeffreys and Norman does not yield a unique solution for the given conditions. Marshall [١٩٧٩] reported that for three-arm road junction, it is better to mention that the number of observers is sufficient only for small intersection in a one-way automatic traffic counter. Marshall described a set of linear equations for number of vehicles leaving and entering each link, and reported that a two-way automatic traffic counter could be placed a cross a link of the intersection. Mekky [١٩٧٩] described a heuristic method to generate a solution for the problem of turning traffic flows at junctions when the only known information is the link flow. Assumption of continuity

relation depended this method which means that traffic can neither generate nor terminate at the junction. Furthermore, the possibility of U-turns was excluded. Mekky [١٩٧٩], calculated a forecasting matrix of a flow for a base year depending on the forecasting link flows, based on Furness iteration method or the biproportional method, assumed that the counts for link flows are exact (without error)[Mekky, ١٩٧٩]. Van zuylen [١٩٧٩] estimated a trip matrix in general problem in minimum information approach that contains the minimum amount of information.

٢.٤.١ Estimation of Turning Flows from Automatic Counts

[Hauer et.al., ١٩٨١] presents a method for estimating the vehicle turning movements from intersection approach flows. The estimation method identifies the most likely set of flows that agree with the observed approach counts; In this method, traffic flows from ١٤٥ intersections in metropolitan Toronto have been coded. Five types of intersections have been defined:

١.Central business district (CBD).

٢.Arterial with arterial.

٣.North-south arterial with east-west collector.

٤.East -west arterial with north-south collector.

٥.Collector with collector.

To obtain realistic estimates of turning flows, prior information about

characteristic left and right-turning proportions is required as shown in Table (٢ - ١).

Table (٢- ١) Average Turning Proportions for Studied Intersections in Toronto[Hauer et.al., ١٩٨١]

No	Type of Approach	Proportion		No.of approaches in sample
		Turning Left	Turning Right	
١	CBD	٠.١٠	٠.١٢	٩٢
٢	Arterial to arterial	٠.١٢	٠.١٢	٨٣
٣	Arterial to collector	٠.٠٤	٠.٠٥	٥٢
٤	Collector to arterial	٠.٣٠	٠.٣٢	٥٣
٥	Collector to collector	٠.١٠	٠.٢٠	٣

It was concluded that the accuracy of the estimated flows varied by approach type, depending in part on the distribution of P_{ij} for that approach type. The standard deviation of the error in turning flow estimates ranged from ٤٠.٨٣ vehicles for a type ٢ approach to ٩.٧٤ vehicles for a type ٥ approach.

Surl [Mountain & Wesrwell, ١٩٨٣] adopted a similar approach in a study of ١٢٨ four-arm intersections located in ٤٣ counties throughout England and Walse. In this study location was not considered to be a relevant factor, but type of approach was. In this case a "major" approach was a dual carriageway and a "minor" approach was carriageway. The intersections were, in addition, grouped according to the method of control and, with the exception of priority intersections, separate samples

were taken of junctions with speed limits of ٣٠-٤٠ mile/hr and ٥٠-٧٠ mile/hr. In all, ٢٠ separate grouping were established for which average turning proportions were calculated. There was found to be considerable variation in turning patterns, both between the groups and, in some cases, within the groups. A variation method was also investigated in which turning probabilities were calculated as the product of O_i, D_j and a factor depending on the type of turning being made (right, left or straight ahead). This latter element was calculated as an average value for each group.

A particularly interesting result obtained by Surl was the relative accuracy which might be achieved using (i) the average turning proportions calculated for a particular intersection type, (ii) the turning proportions averaged over all intersections and (iii) equal turning proportions.

Comparison of the two methods Hauer and Surl indicated similar levels of accuracy could be achieved **[Mountain & Wesrwell, ١٩٨٣]**.

٢.٤.٢ Generating of Turning Flows from Non-Iterative Methods

Norman and Hoffman **[١٩٧٩]** developed some ideas and presented two

alternative methods which, whilst not as theoretically sound as information

theory models, nevertheless have the advantage of being non-iterative and

of possessing statistical properties that previous methods lacked.

Considering a junction within n links attached numbers in some way

١

to n, and q_i be the flow into the junction from link i and p_j be the flow

out of the junction along link j.

define

$Q = (q1, q2, \ldots\ldots, q_n)$ And $P = (p1, p2, \ldots\ldots, q_n)$

Assumed throughout that:

١. (Q, P) is known.

٢. (Q, P) forms a feasible flow pattern, i.e. $\sum\limits_{i=1}^{n} q_i = \sum\limits_{j=1}^{n} p_j = J$

٣. (Q, P) is a realistic flow pattern, i.e $q_i + p_i \leq J$ for all i.

And t_{ij} represents the traffic flow from link i to link j. A realistic flow pattern is one in which $t_{ij \geq 0}$ for all $i \neq j$ and $t_{ii=0}$ for all i. Without any other prior knowledge the probability that it had been arrived from link i is q_i/J and the probability that it is leaving via link j is p_j/J. Assuming two independent events, the probability that the vehicle is passing (through the junction) from link i to link j is $q_i * p_j/J$. Thus, the expected number of such vehicles performing this movement, under the assumptions, is

$q_i * p_j / J = t_{ij}^{*}$

The matrix T^* defined by t_{ij}^* is compatible with (Q,P)

i.e. $\sum_{j=1}^{n} t_{ij}^* = q_i$ $\sum_{i=1}^{n} t_{ij}^* = p_j$

Feasible: $t_{ij}^* \geq 0$ **for all** i **and** j **and symmetric if** $Q = P$**, however, it will hardly ever be realistic as the diagonal elements will only be zero under exceptional circumstances.**

If having initial matrix T^***, with elements** t_{ij}^***. The problem is now to 'diagonalise' this matrix in the sense of reducing the diagonal elements to zero. To do this, two methods have been evolved, both involving a sequence of rook's tours.**

Method ١. **The diagonal elements are 'killed' sequentially by subjecting them to equal rook's tours with all possible non-diagonal elements. Thus each diagonal element is reduced to zero in turn by (** $n-1)*(n-2)$**equal elementary rook's tours. The resulting matrix does not depend on the order in which the diagonal elements are killed and the final matrix** T**can be shown to have elements:**

$$t_{ij} = t_{ij} + \frac{t_{ii}^* + t_{jj}^*}{n-2} - \frac{\sum_{i=1}^{n} t_{ii}^*}{(n-1)(n-2)}, \qquad i \neq j$$

$$t_{ii} = 0, \qquad i = 1,.......n$$

Method ٢. The diagonal elements are again 'killed' sequentially., but this time by forming non-equal elementary rook's tours with all possible $(n-1)^2$ elements in the matrix. The size of rook's tour of a specific element with the current diagonal element is proportional to its magnitude relative to the total of the $(n-1)^2$ elements currently being considered. It

can again be shown that the resulting matrix is unique and thus independent of the order in that the diagonal elements are 'killed'. The elements are given by:

$$t_{ij} = \frac{t_{ij}^* + \dfrac{t_{jj}^* q_i}{Y_j} + \dfrac{t_{ii}^* p_j}{Y_i}}{1 + \sum\limits_{i=1}^{n} t_{ii}^* Y_i} \qquad i \neq j$$

$t_{ii} = 0, \qquad i = 1,.......n$ Where $Y_i = J - (q_i + p_i)$

These methods will diagonalise any initial non-realistic turning flow matrix and have no effect on already realistic turning flow matrices. Also, if the initial flow pattern is symmetric. It shown that, with respect to the matrix T^*, when first method minimizes $\sum\limits_{i,j} (t_{ij} - t_{ij}^*)^2$ the least square solution and second method minimizes $\sum\limits_{i,j} (t_{ij} - t_{ij}^*)^2 \Big/ t_{ij}^*$. To calculate the a priori turning movements, given the probability matrix $\left|\Phi_{ij}\right|$ as:

$t_{ij}^a = q_i \Phi_{ij}$ where q_i is the actual inflow from entry i. Two ways of defining d_{ij}^* have been used, $d_{ij}^* = (p_i - p_{ij}^*)^n$ this equation is a minimization of $\sum\limits_{i,j} (t_{ij}^* - t_{ij}^a)^2$ and $d_{ij}^* = q_i (p_i - p_j^a)/J$ where

$p_j^a = \sum\limits_{i=1}^{a} t_{ij}^a$ and this equation is a minimization of $\sum\limits_{i,j} (t_{ij}^* - t_{ij}^a)^2 / q_i$.

Thus it can be construct two different formula:

Method A: Given $t_{ij}^* = t_{ij}^a + (p_j - p_j^a)/n$ **then Method ١ gives**

$$t_{ij} = t_{ij}^a + \frac{(n-1)(p_{j-}p_j^a)+ p_i - p_i^a}{n(n-2)}, \quad i \neq j$$

$t_{ii} = 0, \ i = 1,.......n$ and minimize to $\displaystyle\sum_{i,j}(t_{ij}^* - t_{ij}^a)^2$

Method B: Given $t_{ij}^* = t_{ij}^a + q_i(p_j - p_j^a)/ J$ then Method ٢ gives

$$t_{ij} = \frac{t_{ij}^a + q_i +(p_j - p_j^a)/ j + q_i C_j + p_j C_i}{1 + \displaystyle\sum_{i=1}^{n} C_i}, \quad i \neq j$$

$(q_i p_j)$

$t_{ii} = 0, \ i = 1,.......n$ where $C_i = q_i(p_i - p_i^a)/(JY_i)$ and minimize to

$$\sum_{i,j}\left[t_{ij} - t_{ij}^a \Big/ \left(1 + \sum_{i=1}^{n} C_i \right)\right]^2 \Big/ (q_i p_j) \quad \sim \quad \sum_{i,j}(t_{ij}^* - t_{ij}^a)^2 /(q_i p_j) \quad \text{as}$$

$1 + \displaystyle\sum_{i=1}^{n} C_i$ is generally very close to unity, although this tends to exception

rather than the rule and depends very much on the quality of the a prior turning movements. After having tried out the methods on real junction data, it was found that Method B could be made more stable in terms of non-negative turning movements by introducing a stronger probabilistic expression for d_{ij}^* such that: $d_{ij}^* = f_i(p_j - p_j^a)$ where f_i can be found using Bayes's theorem as

$$f_i = \sum_{j=1}^{n} t_{ij}^a \left| p_j - p_j^a \right| / \sum_{j=1}^{n} t_{ij}^a \left| p_j - p_j^a \right|$$

When inserting $t_{ij}^* = t_{ij}^a + f_i (p_j - p_j^a)$ in second method.

٢.٤.٣ Estimation of Turning Flows using Iterative Methods

Maher [١٩٨٤] was considered a typical four-arm intersection with ١٢ turning flows excluding the possibility of U-turn. The true long -term flow rate (in veh / hr, day) from arm i to arm j is μ_{ij} (i, j = ١,..., ٤). Long-term automatic counts show that the flow rate into the junction on approach road i is A_i whilst that coming out is B_i (i= ١,..., ٤). Therefore, as it is assumed that these are accurate, we have eight constraints:

$$\sum_j \mu_{ij} = A_i \quad (i = ١,..., ٤)$$

$$\sum_i \mu_{ij} = B_j \quad (j = ١,..., ٤) \quad ....(٢-١)$$

Only one of these is dependent and can be expressed in terms of the other seven. With ١٢ turning flows and only seven equations, it is clear that there are many possible solutions, and that further information must be added in order to allow a unique set of estimates to be made of the μ_{ij}. (Although the treatment here assumes four-arm junctions it should perhaps be pointed out that three-arm intersections

can be dealt with quite easily by the addition of an imaginary fourth arm, with zero manual counts, inflow and outflow).

The notation used until this point has defined flow in terms of an origin and destination pair (ij), such as μ_{ij} and X_{ij}, and the constants in the constraints in terms of the road number. A_i, B_j. For some of the models to be described, this will be the simplest notation, but for others it is preferable to number the turning flows, in a one-dimensional fashion from ١ to ١٢. This will be done in the following natural way:

$$\begin{bmatrix} - & 1 & 2 & 3 \\ 4 & - & 5 & 6 \\ 7 & 8 & - & 9 \\ 10 & 11 & 12 & - \end{bmatrix}$$

Therefore, in this alternative notation the flow rates and counts will be of the form μ_i, x_i $(i = ١,… ١٢)$, and of course, $\mu_٨$ is identical to $\mu_{٢٢}$. Also it will be convenient at the same time to denote the eight long-term automatic counts on the approach roads by g_k $(k = ١, …,٨)$; therefore

$g_k = A_k$ $(k = ١, …,٤)$ and $g_k = B_{k-٤}$ $(k = ٥, …,٨)$.

Within any one model description the notation is uniform and, it is to be hoped, no confusion will occur **[Maher, ١٩٨٤] [Mountain et.al., ١٩٨٦]**.

Therefore, Maher **[١٩٨٤]** show three models for estimating turning movements, The Information Minimizing (IM) Model, The Bayesian (B) Model and the Maximum Likelihood (ML) Model.

٢.٤.٣.١ The Information Minimizing (IM) Model

In this model, the flow pattern consistent the known inflows and out-flows and uses the prior information contained in the x_{ij} counts to a

minimal extent. Van Zuylen shows that the estimates $\hat{\mu}_{ij}$ are of the form

$$\hat{\mu}_{ij} = p_i q_j x_{ij} \text{ where } \sum_j^{\hat{\mu}ij} \hat{\mu}_{ij} = A_i (i = 1,...,4)$$

and

$$\sum_i \hat{\mu}_{ij} = B_J (j = 1,...,4).$$

The algorithm used to determine the p_i, q_j (and hence the $\hat{\mu}_{ij}$) is the well-known Furness procedure of alternately balancing rows and columns until sufficient accuracy is achieved in the balance **[Maher, ١٩٨٤]** **[Mountain et.al., ١٩٨٦]**.

٢.٤.٣.٢ The Maximum Likelihood (ML) Model

Maher **[١٩٨٣]** assumes here that the manual count is carried out over a period of length x and that the counts x_i are Poisson with means of $x\mu_i$ (i = ١, …,١٢). As there are seven independent constraints on the μ_i, it follows that is possible to express each of seven of the flows as linear functions of the other five (for example, $\mu_٣ = A_١ - \mu_١ - \mu_٢$). It is possible to write down the long likelihood function as:

$$\log L = \sum_{i=1}^{12} \left[-\alpha\mu_i + x_i \log(\alpha\mu_i) - \log x_i! \right] \qquad ....(٢\text{-}٢)$$

And then substitute for the seven dependent flows so that log L is in terms of the five independent flows only. We can then maximize this log likelihood. Maher **[١٩٨٤]** shows the five independent flows is $\mu_١, \mu_٢, \mu_٤, \mu_٥,$ $\mu_٧$ and μ^* is the vector of these flows, whilst μ is the vector of all twelve

flows. Then in matrix terms $\mu = J\mu^* + b$ where the matrix j and vector b. By finding the first and second partial derivatives of log L the Newton-Raphson iterative technique can be applied to find the ML estimates.

The scheme can be set out as follows:

(*i*) Initially set $n = \cdot$ and find any feasible set of flows $\hat{\mu}^{(0)}$ (that is, which are all $\geq \cdot$ and satisfy the constraints in Equation (٢-١)).

(*ii*) Set up the matrix $M^{(n)}$ whose main- diagonal consists of

$$(1/ \hat{\mu}_{1}^{(n)},...,1/ \hat{\mu}_{12}^{(n)})$$, and whose off-diagonal elements are all zero.

(*iii*) Calculate the new iterates

$$\hat{\mu}^{(n+1)} = \hat{\mu}^{(n)} + \alpha^{-1}J(J'M^{(n)}J)^{-1} J'M^{(n)}x \qquad ..... (٢-٣)$$

Where J' denotes the transpose of J.

(*iv*) If $\hat{\mu}^{(N+1)}$ and $\hat{\mu}^{(n)}$ are sufficiently close stop, if not, increase n by ١ and

return to (*ii*).

There are two points of particular interest here. One is that the initial 'guess' $\hat{\mu}^{(0)}$ must consist of a feasible set of flows, this can be found in a variety of ways, one of which is to use the Bayesian estimates.

The Matrix j and The Vector b used in The ML Method

Matrix j

$$
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
-1 & -1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 \\
0 & 0 & -1 & -1 & 0 \\
0 & 0 & 0 & 0 & 1 \\
-1 & -1 & -1 & -1 & -1 \\
1 & 1 & 1 & 1 & 0 \\
0 & 0 & -1 & 0 & -1 \\
0 & 1 & 1 & 1 & 1 \\
0 & -1 & 0 & -1 & 0
\end{bmatrix}
$$

Matrix b

$$
\begin{bmatrix}
0 \\
0 \\
A_1 \\
0 \\
0 \\
A_2 \\
0 \\
A_1 + A_2 + A_3 - B_4 \\
-A_1 - A_2 + B_4 \\
B_1 \\
-A_1 - A_2 - A_3 + B_2 + B_4 \\
B_3
\end{bmatrix}
$$

The second point is that the central calculation above is the inversion of the symmetric $\circ \times \circ$ matrix $J`M^{(n)}J$ in Equation (Υ-Υ).Although this is not difficult to achieve, it is worth avoiding it by using the following device. It can be shown that if the current ML estimates $\hat{\mu}^{(n)}$ are used as prior estimates in the Bayesian process so that $v_{ii}^{(\cdot)} = \hat{\mu}^{(n)}$, followed by the application of (Υ-$1\cdot$), (Υ-11) and (Υ-1Υ), the covariance matrix $v_{ij}^{(\Upsilon)}$ is exactly the same as the $1\Upsilon \times 1\Upsilon$ matrix $J(J`M^{(n)}J)^{-1}J`$ in (Υ-Υ). Each iteration in the ML process, then, uses that part of the Bayesian routine which updates the covariance matrix.

This simpler way of carrying out the ML estimation, avoiding any matrix inversion, can be summarized as follows:

(*i*) Set n = ٠ and $\hat{\mu}^{(0)}$ = Bayesian estimate (i = ١, ..., ١٢)

(*ii*) Set k = ١, $v_{ii}^{(٠)} = \hat{\mu}^{(n)}/\alpha$ (I = ١,...,١٢), $v_{ij}^{(٠)} = ٠$ (i ≠ j).

(*iii*) Calculate

$$S_i = \sum_{j=1}^{12} h_{kj} v_{ij}^{(k-1)} (i = 1....,12), \qquad ..... (٢-٤)$$

and

$$T = \sum_{i=1}^{12} h_{ki} S_i \qquad ..... (٢-٥)$$

(*iv*) $v_{ij}^{(k)} = v_{ij}^{k-1} - \dfrac{S_i S_j}{T} (i, j = 1,...,12) \qquad .... (٢-٦)$

(*v*) If $k < ٧$, increase k by ١ and return to (*iii*)

(*vi*) $\hat{\mu}_i^{(n+1)} = \hat{\mu}_i^{(n)} + \sum v_{ij}^{(7)} x_j / \hat{\mu}_j^{(n)}. \qquad .... (٢-٧)$

If all $\left| \hat{\mu}_i^{(n+1)} - \hat{\mu}_i^{(n)} \right|$ < some small amount, stop, otherwise increase

n by and return to (*ii*) **[Maher, ١٩٨٤]**.

٢.٤.٣.٣ The Bayesian (B) Model

In this thesis, the choice is focused on a special class of models called Bayesian Model. Several reasons for supporting this choice. First, this model produces standard errors of the estimates, whilst model IM cannot do so, although B, ML and IM are simple to program but B is non iterative

and is easily modified to cope with different generalizations of the basic problem. The Bayesian method is flexible in that any degree of belief can be placed on the prior information by suitably scaling the $v_{ij}^{(0)}$. Both the IM and ML methods are iterative, stopping only when some convergence criterion is met, while the Bayesian method is non-iterative that not to time consume resource.

This model appears to be the most appropriate choice of model and worthwhile for the estimation of turning flows at intersections because, in situations where the accuracy of the estimates is considered adequate, the B model can provided a more cost effective method of obtaining turning flow data than manual observation **[cooper, ٢٠٠٣]**

In statistics, when prior information about parameters is combined with observations on some functions of these parameters, the standard approach is that of Bayesian inference; that is, Bayes′ theorem is used to update the prior beliefs into posterior beliefs. Maher **[١٩٨٣]** given a detailed treatment for the estimating trip matrix from observations on link volumes. Numbering the flows from ١ to n (n-١) the prior means $\mu_i^{(٠)}$ be βx_i

(i = ١, …, n(n-١)) where β is the scaling factor $N / \sum\limits_{j=1}^{n(n-1)} x_j$, and N is the known total flow through the junction $\left(= \sum\limits_{i=1}^{n} A_i = \sum\limits_{j=1}^{n} B_j \right)$. The prior variances $v_{ii}^{(٠)}$ by $\beta\mu_i^{(٠)}$ (i = ١, …, n(n-١)), with covariance terms equal to zero.

The seven independent constraints can be expressed by the matrix equation Hμ = g where the matrix H consisting of elements h_{ij} (I = 1,…, $2n-1$; j= 1,…, n(n-1)) .

The Matrix H Used in the Bayesian Model

$$
\begin{bmatrix}
1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\
0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\
0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
$$

The calculations to produce the posterior means $\mu_i^{(2n-1)}$ are:

(*i*) Set $k = 1$, $\mu_i^{(0)} = \beta x_i$, $v_{ii}^{(0)} = \beta \mu_i^{(0)}$ (i = 1, …, n(n-1)) and

$$v_{ij}^{(0)} = 0 \quad (i \neq j , i,j = 1, …, n(n-1)). \qquad \text{.... } (2\text{-}8)$$

(*ii*) Calculate

$$v = \sum_{j=1}^{12} h_{kj}\mu_j^{(k-1)}, \qquad \text{.... } (2\text{-}9)$$

$$S_i = \sum_{j-1}^{12} h_{kj}v_{ij}^{(k-1)} \quad (i = 1, …, n(n-1)), \qquad \text{.... } (2\text{-}10)$$

$$T = \sum_{i=1}^{12} h_{ki}s_i . \qquad \text{.... } (2\text{-}11)$$

(*iii*) Calculate

$$\mu_i^{(k)} = \mu_i^{(k-1)} + \frac{S_i}{T}(g_k - v) \ (i = 1, ..., \text{n(n-1)}) \quad .... \ (٢-١٢)$$

and

$$v_{ij}^{(k)} = v_{ij}^{(k-1)} - \frac{S_i S_j}{T}(i, j = 1, ..., \text{n(n-1)}). \quad .... \ (٢-١٣)$$

(*iv*) If $k < ٢\text{n-}1$, increase k by 1 and return to (*ii*); if $k = ٢\text{n-}1$, stop.

It is necessary to mention that in addition to the point estimates $\mu_i^{(٢n-1)}$, the method also gives standard error estimates given by the square roots of the posterior variances $v_{ii}^{(٢n-1)}$ ($i = 1, ..., \text{n(n-1)}$). Furthermore that the method is non-iterative, the process stops when all constraints have been applied **[Maher, ١٩٨٤] [Mountain et.al., ١٩٨٦]**.

٢.٥ Using Software Packages for Validation of Bayesian Model

Several software packages such as HCS and TRANSYT-٧F are adopted in order to make a comparison between measures of effectiveness for the two evaluations. These programs have been introduced to help traffic engineers in the design and appraisal of traffic management schemes. Most of the available programs, though all, essentially tell the engineer how well this scheme will work, they do not generally develop the design automatically. Their use lies primarily in the appraisal of schemes, both during the iterative scheme development process and for the formal assessment of fully developed options. Some of these programs are illustrated below with brief description of their work.

٢.٥.١ Highway Capacity Software (HCS-٢٠٠٠)

HCS-٢٠٠٠ is the package software of Highway Capacity Manual ٢٠٠٠. This version of the HCS implements the procedures defined in

the Highway Capacity Manual (HCM٢٠٠٠) which Copyright ٢٠٠٠ by the Transportation Research Board (TRB).

HCS-٢٠٠٠ was developed by the Mc Trans Center at the University of Florida as a typical Windows installation for windows ٩٥/٩٨/NT/٢٠٠٠ [HCM, ٢٠٠٠]. HCS-٢٠٠٠ comprises a complete new release of the HCS, upgrading modules to incorporate procedures in both metric unit and US to faithfully implement the HCM-٢٠٠٠.

This package evaluates several types of road and its element by means of level of service (L.O.S). The major important criteria for measuring the level of service in HCS-٢٠٠٠ for signalized intersection is the total delay while it depends on delay and speed for freeway system, multilane rural, suburban arterial. The delay that used to determine the level of service is obtained from a combination of lane group capacity, lane group delay and approach delay.

Levels of service for each of the lane groups, approaches, and the intersection are determined from calculated delays. The levels of service rang from "A" to "F". If the computed delay exceeds ٩٩٩.٩ sec/veh, the value and subsequent values are suppressed (left blank) [HCM, ٢٠٠٠]. Level of Service Criteria for Signalized Intersections is shown in Table (٢-٢).

Table (٢- ٢) Level of Service for Signalized Intersection [HCM ٢٠٠٠]

L.O.S	Operation Condition	Average Stopped delay(sec/veh)
A	**Progression is extremely favorable**	<= ١٠
B	Good Progression with more vehicles **Stopped than with L.O.S A**	> ١٠ and<= ٢٠

C	**Fair Progression with a significant Number of vehicles stopped**	> ٢٠ and $<= ٣٥$
D	**Unfavorable Progression with number of vehicles stopped**	> ٣٥ and $<= ٥٥$
E	**Poor Progression with frequently individual cycle failures**	> ٥٥ and $<= ٨٠$
F	Poor progression with many individual cycle failures	> ٨٠

٢.٥.٢ TRANSYT-٧F (Traffic Network Study Tool) Program

TRANSYT-٧F computer program release ٩.٤ (٢٠٠٢) was one of the selecting software package to achieve the main objectives of the present research. This program was developed in ١٩٧٠ at England Transport and Road Research Laboratory and "Americanized" for the Federal Highway Administration [Whashburn & Larson, ٢٠٠١]**. TRANSYT-٧F is one of the most widely used computerized tools for traffic signal timing optimization and evaluation This program is a method for determining fixed-time signal timing that coordinates traffic in signalized network** [Lines & Crabtree, ١٩٨٨]**, this program was developed by Robertson of the U.K. Transport and Road Research Laboratory as a signal optimization program. This program consists of two main elements, the traffic model and the signal optimizer. The traffic model represents the behavior of traffic in network of streets in which most junctions are controlled by signals** [Coombe, ١٩٨٩]**. All the signals have a common cycle time or cycle time of twice this value, and details of all signal stage and their minimum duration are required as input. The model predicts the value of performance index for the network, for any fixed-time plan and set of average flows, which are required as input** [Robertson & Hunt, ١٩٨٢]**. The disutility index is measure of the overall cost of traffic congestion, and is usually weighted combination of the total amount of delay and the percentage of stops experienced by traffic. On the other**

hand, the optimization process adjusts the signal timing. This timing is used as input to the traffic model to assess whether the performance index is reduced. By adopting those adjustments [Robertson, ١٩٩٣].

The traffic flow model in TRANSYT-٧F is among the most realistic of those available in the family of macroscopic computerized traffic simulation models. It simulates traffic flow in small increment that its representation of traffic is more detailed than other microscopic models that assume uniform distributions within the traffic platoons [Teply & Evans, ١٩٨٩].

The total travel distance, average delay, number of stops, fuel consumption, travel time, performance index and other measures can be calculated by TRANSYT-٧F model which are called the measures of effectiveness (M.O.Es).

٢.٦ Adopted Software Packages

٢.٦.١ Events Program

This program developed by Al-Neami [١٩٩٩]. **It was written using C computer language. The program provides the user with digital representation of the observed traffic events. The program starts displaying a message that press ENTER key to start and press ESC key to finish. The program counting time for successive event, by press a key of the ten function keys, which are (F١, F٢, F٣, F٤, F٥, F٦, F٧, F٨, F٩ and F١٠), each one of these keys is given an alphabetic character that specified to be pressed for each vehicle type and its maneuver. At last stage user is asked to provide the name of the input file and the path where the user wants the output file to be stored.**

This program would simplify the process of vehicle classification, turning movements, headway and observed delay calculating. This

program produces time accuracy values of the recorded data. It was used by many studies such as Al-kubaysi [٢٠٠٠].

٢.٦.٢ Excel Program

Data files obtained from Events program are open with Excel program, which adopted abstracting these data. Excel program facilities are simplifying headway calculation.

٢.٦.٣ SPSS Program

SPSS (Statistical Package for the Social Sciences) is a data management and analysis product. It can perform a variety of data analysis and presentation functions, including statistical analysis and graphical presentation of data. In this package the residual test is used for the normality test.

Among its features are modules for statistical data analysis, including descriptive statistics such as plots, frequencies, charts, and lists, as well as sophisticated inferential and multivariate statistical procedures like analysis of variance (ANOVA), factor analysis, cluster analysis, and categorical data analysis. SPSS is particularly well-suited to survey research, though by no means is it limited to just this topic of exploration [SPSS, ٢٠٠٤].

٢.٦.٣ Visual Basic " ٦ " Program

The Visual Basic ٦٠ Package and Deployment Wizard was designed to deploy ٦٠ In Visual Basic. The functionality of the Variant and Object data types is combined into one new data type: Object. The Object data type can be assigned to primitive data types, Empty, Nothing, Null, and as a pointer to an object. In addition to numeric data type upgrades, Visual Basic ٦٠ had a fixed-length string data type which is not

supported in Visual Basic .NET, and which is upgraded to a fixed-length string wrapper class. In many cases in Visual Basic ٦.٠ it can perform the same action using a normal string.

Chapter Three

Data Collection

٣.١ **Introduction**

This chapter presents the procedures for any type of survey used for collection of the required traffic geometric data from the field to use it later in the subsequent analysis.

The procedures for data collection of traffic flow consist of:

١. Preparing geometric layouts for the nodes.

٢. Preparing outdate statistical for turning movements for all selected intersections such as in (١٩٩٤, ١٩٩٨ and ٢٠٠١) that carried out in this research.

…tion and coding of input data for TRANSYT-٧F and HCS computer

…mentioned subjects are … basic data that will be …n this chapter.

٣.٢ **Selection of Intersections**

Four signalized intersections are selected f… study. One of these junctions is a …intersection and the others are f… …tions. All selected intersections …n-area of Hilla City. It should be not… first intersection is T- junction, as shown in Figure (٣-١). This intersection connects Is…ar Street with Karbala and ٤٠ streets. The second junction is called Al-Jamia intersection, as shown in Figure (٣-٢), this …section connects ٤٠ Street … Agriculture Office street and Al-Janan and Al-Jamia …s. The third junction called Al-Aum intersection, as shown in Figure (٣-٣). This …tersection connect… …reet with Al-Nassiege and Gorfat-Al-Tigara and Safee-Al-Dieen Str… …tion showed in Figure (٣-٤) is Bab-Al-Mashhed intersection. Thi… …ts Safee Al-Dieen Street with Al-Emam and Al-Jebal and Gorfat-Al-Tigara Streets.

Input :
■ ٦ Turning Flows (Prior Variance)

Application Bayesian Method

If Number Of Iterations Equal ٧?

Application Bayesian Method

If Number Of Iterations Equle ٥?

Print Update Turning Movements

End

٣.٣ Assessment of Peak Periods for Intersections

Some consideration must conduct in order to achieve the time to collect the volume, in the A.M and P.M peak periods, such as install a camera video on high building for each intersection in study area at least, for two days, but this method required high cost.

Collected data for about one hour each for the A.M. and P.M. peak periods that would be reveale traffic volume as shown in Table (٣-١). Many of attempts were made in different periods for each intersection to investigate the time for the collection of the required data and determine peak periods, this shown in Table (٣-٢). In this table It is clear that a P.M. peak period is controlled, therefore, all analyses in this study are depended on P.M peak period.

Data collection was preformed in one stage during September ٢٠٠٣. The observations are taken on typical days of the week from (Sunday through Wednesday), while Thursday, Friday and Saturday are not included in order to conduct the survey on days that represent average weekday conditions.

Table (٣-١) Date of Survey for Each Intersection for A.M. and P.M. Peak Periods

Node No.	Name of Intersection	Date of Data Collection		Time of Data Collection	
		A.M	P.M	A.M	P.M
١	Ishtar	٣-٩-٢٠٠٣	٧-٩-٢٠٠٣	١٠:٣٠-١١:٣٠	٤:٣٠-٥:٣٠
٢	Al-Jamia	٧-٩-٢٠٠٣	٩-٩-٢٠٠٣	١٠:٥٠-١١:٥٠	٤:٣٠-٥:٣٠
٣	Al-Aum	١٤-٩-٢٠٠٣	١٤-٩-٢٠٠٣	١٠:٠٠-١١:٠٠	٤:٤٥-٥:٤٥
٤	Bab-Al-Mashhed	١٦-٩-٢٠٠٣	١٦-٩-٢٠٠٣	١٠:٢٠-١١:٢٠	٤:٢٥-٥:٢٥

٣.٤ Traffic Data

Manual counts make use of field observers to obtain volume data and therefore they are relatively high in cost and are subjected to the limitations of human factors generally precluding ٢٤-hours continuous count. Vehicle classification is very easily produced by the manual methods that are suitable for the short terms and non-continuous counts.

In this study, Traffic volumes enter and leave the approaches at intersections was observed by video camera photo, which is made easily in

calculation of turning flows, and it classification by using (EVENTS) program. Because of the wide area of intersections, two-camera videos were used in the photo process Al-Aum and Bab-Al-Mashhed intersections.

The study has been dealt with U-turns movements that are found in the studied intersections by two methods, according to the requirements of programs that have been used. In the first method, the U- turns movements are added to the left turns movements as used in the softwares TRANSYT-٧F and HCS. While in the second method, the values of U-turns movements are distributed over other movements in conformity with the conditions of Bayesian model which required to have zero value of U-turns.

٣.٥ TRANSYT-٧F Package Software Data

TRANSYT-٧F requires a relatively large quantity of data. The data required for TRANSYT-٧F includes information from the filed. The types of input data required by TRANSYT -٧F program could be categorized as the traffic network data. The sections below will describe the four major categories of the data required as an input data to run the program **[FHWA, ١٩٨٤]**.

٣.٥.١ Traffic Network Data

Figure (٣-٥) shows the directions of the traffic movements at the intersections or nodes, as well as, the node numbers. The three types of data (nodes, links and links distances) can be defined as follows:

• **Node**: TRANSYT-٧F user's manual **[FHWA, ١٩٨٤]** defines the node as an intersection of two or more conflicting streets. Actually, any node may be signalized, sign controlled or

uncontrolled. TRANSYT-7F is dimensioned to have a maximum of (50) nodes in the network **[FHWA, 1984]**. As shown in Figure (3-5), was assigned from number one to number four.

• **Link:** A link is an unidirectional section of the roadway connecting two nodes. The link can be visualized as the starting at the stop line of the upstream intersection and ending at the downstream intersection stopline. Link is one-way traffic flow between two nodes that can carry 10 or more vehicles per hour **[FHWA, 1984]**. TRANSYT-7F is dimensioned to allow a maximum of (250) links in the network. In the present study, the through and turning traffic movement links were assigned and identified by the means of TRANSYT-7F program. The first digits, of link number is corresponding to the node number, whereas, the last digit is corresponding to the direction of traffic movement.

• **Link Distance:** In TRANSYT-7F program the link distance is defined as the distance between two adjacent intersections, this distance is extended from the stop line of the upstream node to the stop line of the down stream node **[FHWA, 1984]**. Table (3-3) tabulates the link length for the study section.

• **Approach Width Measurement**: The measurement of each approach width at the stopline for each intersection takes from the layouts of the Al- Hilla Municipality. These measurements are presented in Table (3-4)

3.5.2 Traffic Volume Data

The design hourly volume for each intersection turning movement is calculated according to the suggested formula by TRANSYT-7F user's manual, as follows **[FHWA, 1984]**:

$$\text{DHV} = \text{V} - (\text{V} * \frac{\%\,\text{Truck}}{100}) + (\text{V} * 2.25 \, \frac{\%\,\text{Truck}}{100}) \qquad \text{------(3-1)}$$

Where:
DHV= Design hourly volume (pcu)

V = Rate of flow for one hour (vph)

%Truck = Percentage of truck

Traffic volume data are recorded every 15-minutes interval for one hour for each intersection at A.M. and P.M. peak periods. For the calculation of one hourly volume, tables in Appendix (F) are presented as examples for the collected traffic volume data for each node for two hours under A.M. and P.M. peak periods, respectively. Traffic volumes for each link under study are illustrated in Table (3-5) for the A.M. and P.M. peak periods.

Table (٣-٣) Link Length

Node No.	Name of Intersection	Link No.	Link Length(m)	Node No.	Name of Intersection	Link No.	Link Length(m)
١	Ishtar	١٠٢	٢٠٥٠	٣	Al-Aum	٣٠٥	٠
		١٠٥	٠			٣٠٦	٠
		١٠٨	٠			٣٠٧	٩٤٤
٢	Al-Jamia	٢٠١	٩٠٠			٣٠٨	٩٤٤
		٢٠٢	٩٠٠	٤	Bab-Al -Mashhed	٤٠١	٠
		٢٠٣	٢٠٥٠			٤٠٢	٠
		٢٠٤	٢٠٥٠			٤٠٣	٠
		٢٠٥	٠			٤٠٤	٠
		٢٠٦	٠			٤٠٥	٩٤٤
		٢٠٧	٠			٤٠٦	٩٤٤
		٢٠٨	٠			٤٠٧	٠
		٢١١	٩٠٠			٤٠٨	٠
٣	Al-Aum	٣٠١	٠			٤٠٩	٠

		٣٠٢	٠			٤١٠	٠
		٣٠٣	٩٠٠			٤١١	٩٤٤
		٣٠٤	٩٠٠			٤١٢	٠

Table (٣-٤) Approach Width

Node No.	Name of Intersection	Width of Each Approach (m)			
		NB	SB	EB	WB
١	Ishtar	٧.٥	–	١٠.٥	١٤
٢	Al-Jamia	١١	١١	٩	١١
٣	Al-Aum	٨.٥	١٠	١٥	١٥
٤	Bab-Al - Mashhed	٧.٥	١١	١٤	١١

٣.٥.٣ Saturation Flow Data

Saturation flow rate is the term used to describe the capacity of traffic movement through a signalized intersection and is expressed in vehicle per hours of green time (vphg). The headway was collected to calculate saturation flow. When the signal turned from red to green, the headway was sampled, beginning with the third vehicle of the queue, as the platoon discharged. The average headway and saturation flows were calculated for each lane of the intersection.

According to the Highway Capacity Manual, the calculation of the headway carried out by the formula, is as follows [TRB, ١٩٩٤]:

$$h = (\sum \frac{t_r}{A-3}) \Big/ M \qquad \text{------------------(٣-٢)----}$$

where:

h = Average discharge headway, of all queued vehicles beginning with third vehicle (sec)

t_r = The time required to discharge the queued vehicle starting with

    fourth vehicle (sec)

A =Total number of vehicle in the queue

M =Number of observations

The headway data was counted as shown in Appendix (G), the saturation flow was then calculated as follows:

$$S_i = (\frac{3600}{h_i}) * n_i \qquad \text{------------------------------(٣-٣)}$$

where:

S_i =Saturation flow rate of link (i) (vphg)

h_i=Average headway for lane (sec) of link (i)

n_i=Number of lanes in link(i)

Table (٣-٦) summarizes the number of lanes in the links, average headway counted and the saturation flow rates for link movements in the present study intersections.

٣.٥.٤ Timing Data

The timing data, required for TRANSYT-٧F program, as following:

١. The start-up lost time at the beginning of green intervals.

٢. The extension of the effective green into the clearance intervals (Yellow + All red).

٣. The Green, Yellow and All red intervals for each intersections.

The value for both start-up lost time and green extension time, that are used in TRANSYT-٧F program runs, are the default values which are recommended by TRANSYT-٧F user's manual [FHWA, ٢٠٠٢]. Whereas the others (Green and Yellow + All red) are taken from Hilla Municipality. Therefore, the timing plans and phases sequence for study intersections are presented in Table (٣-٧) and Figure (٣-٦), respectively.

Table (٣-٢) Data Collection Sheet Turning Movement Cou

P.M Peak Period of Study Intersections

eak eriod	Time period	North Bound			South Bound			East Bound			We
		L	TH	R	L	TH	R	L	TH	R	L
A.M	١٠:٢٠_ ١١:٢٠	٢٨١	-	٣٣٠	-	-	-	-	٧٩٠	٣١٤	٤٢١
	١٠:٢٥_ ١١:٢٥	٢٤٠	-	٣٤٥	-	-	-	-	٧٨٨	٣٠٠	٤١٧
	١٠:٣٠_ ١١:٣٠	٢٦٦	-	٣٥٣	-	-	-	-	٧٩٤	٣٠٧	٤٠٦
	١٠:٣٥_ ١١:٣٥	٢٧٨	-	٣٣٦	-	-	-	-	٧٧٠	٢٩٢	٤٠٢
P.M	٤:٢٠_٥:٢٠	٢٦٤	-	٣٢٧	-	-	-	-	٧٧١	٣٢٠	٤٢٨

	الوقت									
	٤:٢٥_٥:٢٥	٢٧٧	-	٣٠٩	-	-	-	-	٧٧٥	٣١١	٤٣٠
	٤:٣٠_٥:٣٠	٢٨٣	-	٣٥٠	-	-	-	-	٨٠٠	٣٢٢	٤٤١
	٤:٣٥_٥:٣٥	٢٧٢	-	٣٤٢	-	-	-	-	٧٦٠	٣٠٣	٤١٢
A.M	١٠:٤٥_١١:٤٥	٩٢	٢٧٠	١٧٧	١٩٣	٣٠١	١٨٥	٨٧	٢٨٨	٧٦	٣٠٣
	١٠:٥٠_١١:٥٠	١٠٥	٢٩٥	١٨٨	٢٠٩	٣٣٤	٢٠٧	١٠٦	٣٠٩	٩٤	٣٤٦
	١٠:٥٥_١١:٥٥	١٠١	٢٩١	١٨١	١٩٦	٣٣١	٢٠١	٩٧	٣٠٠	٩٥	٣٤٠
	١١:٠٠_١٢:٠٠	٩٥	٢٨٢	١٧٠	١٩٦	٣١٧	١٩٤	٨١	٢٨٠	٨٣	٣٢٢
P.M	٤:٢٠_٥:٢٠	٨٤	٢٩١	١٨١	٢٠٥	٣٥٣	١٨٩	١٢٧	٢٨٩	٨٠	٣٦٤
	٤:٢٥_٥:٢٥	٨٧	٢٨٨	١٧٩	٢٠٤	٣٤٦	١٩٣	١٢٢	٣٠١	٨٢	٣٤٠
	٤:٣٠_٥:٣٠	١١٠	٣٠٤	١٩٤	٢١٠	٣٦٠	٢٠٣	١٣٥	٣١٢	٩٦	٣٦٧
	٤:٣٥_٥:٣٥	٩٤	٣٠٢	١٩٢	٢١٢	٣٤٠	١٩٧	١٣١	٣٠٨	٩٠	٣٠٥
A.M	٩:٥٠_١٠:٥٠	٣٠٧	٧٠	١٠	١٢٥	٢١٦	٣٢٠	٣٤٠	٢٣٥	٣٣٩	٣٢
	٩:٥٥_١٠:٥٥	٣٠٢	٩٣	١٠	١٣٠	٢٢٢	٣٤٤	٢٧٧	٢٤٥	٣٥٧	٤١
	١٠:٠٠_١١:٠٠	٣٢٣	٩٤	١١	١٣٩	٢٤١	٣٤٨	٣٦١	٢٥٤	٣٧٠	٤٦
	١٠:٠٥_١١:٠٥	٣١٤	٨٥	٩	١١١	٢٣٥	٣٣٨	٣٣٢	٢٥٠	٣٥٨	٣٧
P.M	٤:٣٥_٥:٣٥	٣٠١	٩١	١٨	١١٢	٢١٥	٣٤٧	٤٠١	٢٤٢	٣٣٣	٣٧
	٤:٤٠_٥:٤٠	٣٤٢	٩٨	١٤	١٣٤	١٩٩	٣٨٨	٤٠٣	٢٨٨	٣٦٨	٠١
	٤:٤٥_٥:٤٥	٣٠٠	١٠٩	٢٠	١٤٨	٢٥٠	٣٩٧	٤١٧	٢٩٠	٣٧٥	٠٣

٤:٥٠_٥:٥٠	٣٤٠	٨٤	١٠	١٤٧	٢٣٥	٣٨٨	٤١٤	٢٣١	٣٣٠	٥٠
١٠:١٠_١١:١٠	٨	٤١	٧٢	١٧٥	١٤	١٢٥	١٢٥	٤٠٧	٢٦	٢٠
١٠:١٥_١١:١٥	١٨	٤٣	٦٨	١٧٩	١٩	١٢٠	١٢٣	٣٨٨	٢٧	١٥
١٠:٢٠_١١:٢٠	١٧	٥٠	٦٥	١٨٣	١٤	١٣٥	١٢٠	٣٨٠	٢٧	١٩
١٠:٢٥_١١:٢٥	١٩	٥١	٦٠	١٩٠	١٥	١٣٧	١٠٧	٣٩٩	٣٠	١٨
٤:١٥_٥:١٥	٢٠	٤٧	٦٥	١٧٧	٢٧	١٥٠	١١١	٤٠٢	٢٥	٢٦
٤:٢٠_٥:٢٠	٢١	٤٠	٦٧	١٨٠	٨١	١٣٨	١٢٣	٤١٥	٣٤	٢٠
٤:٢٥_٥:٢٥	٢٧	٥٧	٧٤	١٩٢	٢٣	١٥١	١٢٨	٤٢٠	٣٧	٢٥
٤:٣٠_٥:٣٠	١٠	٥٢	٧٣	١٨٨	٢٠	١٤١	١٢١	٤١٩	٣٠	١٧

Table (٣-٥) Traffic Volume by Link for A.M. and P.M.

Node No.	Name of Intersection	Link No.	Traffic Volume (pcu/hr)		Node No.	Name of Intersection	Link No.	Traffic Volume (pcu/hr)	
			A.M.	P.M.				A.M.	P.M.
١	Ishtar	١٠٢	٣٩٦	٥١٨	٣	Al-Aum	٣٠٤	١٩٩	٢٤٤
		١٠٥	١٢١١	١٧٤٢			٣٠٥	٣٥٩	٤٠٨
		١٠٧	٧٧٧	٨٦٥			٣٠٦	٤٩٥	٦٣١
		١٠٨	٧٧٢	٨٦٨			٣٠٧	٦٢٣	٦٤٣
		١٠٩	٤٥٨	٥١٥			٣٠٨	٧٨	٦٧
		١١١	٣٩٣	٥٠٤			٣٠٩	١٧	٣٨
٤	Al-Jamia	٢٠١	٥٢٩	٦١١			٣١٠	٤٨٣	٦٠٢
		٢٠٢	٢١٥	٢٤٠			٣١١	٥٠٩	٥٥٩
		٢٠٣	٥٨٨	٦٢٩			٣١٢	١٨١	١٩٠

Name of Intersection	Link No.			Node No.	Name of Intersection	Link No.		
		٢٠٤	٣٩٩	٤٢١			٤٠١	٥٧	٧٣
		٢٠٥	٥٢٧	٥٧٧			٤٠٢	٣٣	٣٨
		٢٠٦	١٥٩	٢٠٨			٤٠٣	٣٢	٣٤
		٢٠٧	٦٠٥	٦٤٤			٤٠٤	٣٨٤	٤٢٤
		٢٠٨	٢٢٣	٢٤٥			٤٠٥	٧٨٢	٨٧٩
		٢٠٩	٢٨٥	٣٢٠	٤	Bab-Al - Mashhed	٤٠٦	١٧٨	٢٣٢
		٢١٠	٣١٢	٣٤٧			٤٠٧	٨٧٢	٩٤٤
		٢١١	١١٨	١٣٩			٤٠٨	٢٤	٢٩
		٢١٢	١٢٨	١٥٧			٤٠٩	١٠٨	١٠٩
		٣٠١	١٣٩	١٧٥			٤١٠	٢٤٦	٢٨٣
٣	Al-Aum	٣٠٢	٤٧٤	٥٧٠			٤١١	٣٧	٤١
		٣٠٣	٣٤٢	٣٨٥			٤١٢	٣٣٧	٣٥٤

Table (٣-٦) Saturation Flow by Link in Study Intersections

Name of Intersection	Link. No.	No. of Lanes	Headway (sec)	Saturation Flow (vphg)	Node No.	Name of Intersection	Link. No.	No. of lanes	Headway (sec)
Ishtar	١٠٢	٢	٢.٠٠٤	٣٥٩٣			٣٠٥	٣	٢.١٩٦
	١٠٥	٣	٢.٤٠٠	٤٥٠٠	٣	Al-Aum	٣٠٦	٢	٢.٧٥٢
	١٠٨	٢	٢.٣٣٣	٣٠٨٦			٣٠٧	٣	٢.٣٧٧
Al-Jamia ٢	٢٠١	٣	٢.١١١	٥١١٦			٣٠٨	٢	٢.٠٣٥
	٢٠٢	١	٢.٢٢٩	١٦١٥			٤٠١	٢	١.٨٩١
	٢٠٣	٣	١.٩٦٦	٥٤٩٣	٤	Bab-Al - Mashhed	٤٠٢	١	١.٨٢٧
	٢٠٤	١	١.٨٠٥	١٩٩٤			٤٠٣	٢	١.٩٦١

Al-Aum								
٢٠٥	٢	١.٨٦٤	٣٨٦٣			٤٠٤	١	١.٩٠٠
٢٠٦	١	١.٩٠٧	١٨٨٨			٤٠٥	٣	٢.٢٢٢
٢٠٧	٢	٢.٣١٠	٣١١٧			٤٠٦	١	١.٩٧٨
٢٠٨	١	٢.٨٩٩	١٢٤٢			٤٠٧	٢	١.٩٠٠
٢١١	Shared	-	-			٤٠٨	١	٣
٣٠١	١	٢.٣٤٧	١٥٣٤			٤٠٩	Shared	-
٣٠٢	١	٢.٦٩٤	١٣٣٦			٤١٠	Shared	-
٣٠٣	٣	٣.٠١١	٣٥٨٧			٤١١	Shared	-
٣٠٤	١	٢.٤٥٦	١٤٦٦			٤١٢	Shared	-

Table (٣-٧) Timing Plan for Nodes with Signal Control [Hilla Municipality, ٢٠٠٣]

Node No.	Name of Intersection	Cycle time	Phase ١ Duration (sec)			Movement type	Phase ٢ Duration (sec)			Movement type	Phase ٣ Duration (sec)			Movement type	Phase ٤ Duration (sec)			Movement type
			G	Y	AR		G	Y	AR		G	Y	AR		G	Y	AR	
١	Ishtar	٩٩	٢٧	٣	٢	WB-L& TH	٣٠	٣	٢	EB-TH	٢٧	٣	٢	NB-L	-	-	-	
٢	Al-Jamia	١٠٨	٢٥	٥	-	SB-L TH R	١٥	٥	-	WB-L TH R	١٨	٥	-	NB-L TH R	٣٠	٥	-	EB-L TH R
٣	Al-Aum	٩٦	٢٥	٥	-	EB& WB-TH	١٨	٥	-	EB& WB-L	١٨	٥	-	SB-L TH R	١٥	٥	-	NB-L TH R

| ٤ | Bab-Al -Mashhed | ١٠٥ | ١٨ | ٥ | - | SB-
L
TH
R | ٢٧ | ٥ | - | EB-
L
TH
R | ٢٥ | ٥ | - | WB-
L
TH
R | ١٥ | ٥ | - | NB-
L
TH
R |

*G=Green, Y=Yellow, AR=All-Red, L=Left, TH=Through, R=Right

Node No.	Name of Intersection	Link No. and Pattern of Phases			
		Phase ١	Phase ٢	Phase ٣	Phase ٤
١	Ishtar				
٢	Al-Jamia				
٣	Al-Aum				
٤	Bab-Al -Mashhed				

Figure (٣-٦) Existing Phase Sequence for the Signalized Intersections

Estimation of Turning Movement By Using Bayesian Model

Table (٤-١) : Iterative Procedure for Amended the Manual Traffic Matrix [Due...

Ishtar Intersection In ٢٠٠٣

Iteration No. (٠)					Iteration No. (١)					Iteration No. (٢)					Iteration No. (٣)			
	١	٢	٣	Link Inflow [VPH]		١	٢	٣	Link Inflow [VPH]		١	٢	٣	Link Inflow [VPH]		١	٢	٣
٩	٤٢٢	٥١٣	٩٥٤		١	٠	٤٣١*	٥٢٣	٩٥٤	١	٠	٤٤٣	٥١٤**	٩٥٧	١	٠	٤٤٢	٥١٢
٥٠	٣٣	٢٥٠	٦٣٣		٢	٣٦٩	٠	٢٦٤	٦٣٣	٢	٣٦٧	٠	٢٥٩	٦٢٦	٢	٣٧١	٠	٢٦٦
٩٠	٣٢٢	١٠	١١٢٢		٣	٧٩٧	٣٢٥	٠	١١٢٢	٣	٧٩٢	٣٣٤	٠	١١٢٦	٣	٧٨٩	٣٣٣	٠
١٥٩	٧٧٧	٧٧٣	٢٧٠٩		Link Outflow [VPH]	١١٦٦	٧٥٦	٧٨٧	٢٧٠٩	Link Outflow [VPH]	١١٥٩	٧٧٧	٧٧٣	٢٧٠٩	Link Outflow [VPH]	١١٦٠	٧٧٥	٧٧٤

Iteration No. (٤)			Iteration No. (٥)		

١	٢ ٣	٣	Link Inflow [VPH]		١	٢	٣	Link Inflow [VPH]
.	٤٤٣	٥١١	٩٥٤	١	.	٤٤ ٣	٥١ ١	٩٥٤
٧١	.	٢٦٢	٦٣٣	٢	٣٧ ١	.	٢٦ ٢	٦٣٣
٨٨	٣٣٤	.	١١٢٢	٣	٧٨ ٨	٣٣ ٤	.	١١٢٢
١ ٥ ٩	٧٧٧	٧٧٣	٢٧٠٩	Link Outflow [VPH]	١١ ٥٩	٧٧ ٧	٧٧ ٣	٢٧٠٩

١. All values are around to the nearest integer values.
٢. Iteration No. (٠) represents the original traffic matrix.
٣. Iteration N٠.(٥) represents the Adjusted traffic matrix.

$$* \ \ ٤٣١ = \frac{١٩ \ \ \ (٤٢٢) + ٤٢٢}{[٤٢٢ + ٥١٣]}$$

** The difference betweeen link outflow no . (٣) from

iteration No. (٠) and No. (١) = ٧٧٣ - ٧٨٧ = -١٤

$$\frac{-١٤}{٧٨٧}$$

Table (٤-٢) : Iterative Procedure for Amended the Manual Traffic Matrix

Al-Jamia Intersection In ٢٠٠٣

Iteration No. (٠) _(left edge, columns cut off)_

	٢	٣	٤	Link Inflow [VPH]
	٧٥	٣٦٠	٢٠٣	٧٧٨
	٢	١١٣	٣١٢	٥٤٣
	٩٤	١٧	٩٨	٦١٣
	٨٠	٨٧	١٠	٤٨٤
	٧١	٥٧٧	٦٢٣	٢٤١٨

Iteration No. (١)

	١	٢	٣	٤	Link Inflow [VPH]
١	٠	١٨٤	٣٨٠	٢١٤	٧٧٨
٢	١٠٠	٠	١١٨	٣٢٥	٥٤٣
٣	٣١٣	٢٠٠	٠	١٠١	٦١٤
٤	١٠٩	٢٨٦	٨٩	٠	٤٨٤
Link Outflow [VPH]	٥٢٢	٦٧٠	٥٨٧	٦٤٠	٢٤١٩

Iteration No. (٢)

	١	٢	٣	٤	Link Inflow [VPH]
١	٠	١٨٤	٣٧٤	٢٠٨	٧٦٦
٢	١٠٥	٠	١١٦	٣١٦	٥٣٧
٣	٣٢٨	٢٠٠	٠	٩٨	٦٢٦
٤	١١٤	٢٨٦	٨٧	٠	٤٨٧
Link Outflow [VPH]	٥٤٧	٦٧٠	٥٧٧	٦٢٢	٢٤١٦

Iteration No. (٣) _(right edge, columns cut off)_

	١	٢	٣
١	٠	١٨٧	٣٨٠
٢	١٠٦	٠	١١٧
٣	٣٢٢	١٩٦	٠
٤	١١٣	٢٨٤	٨٦
Link Outflow [VPH]	٥٤١	٦٦٧	٥٨٣

Iteration No. (٤) _(left edge, columns cut off)_

	٢	٣	٤	Link Inflow [VPH]
	٨٨	٣٧٦	٢١٠	٧٧٤
	٠	١١٦	٣١٧	٥٤٠
	٩٧	٠	٩٦	٦١٩
	٨٦	٨٥	٠	٤٨٥

Iteration No. (٥)

	١	٢	٣	٤	Link Inflow [VPH]
١	٠	١٨٩	٣٧٨	٢١١	٧٧٨
٢	١٠٧	٠	١١٦	٣١٨	٥٤١
٣	٣٢٣	١٩٥	٠	٩٥	٦١٣
٤	١١٤	٢٨٥	٨٥	٠	٤٨٤

Iteration No. (٦)

	١	٢	٣	٤	Link Inflow [VPH]
١	٠	١٩٠	٣٧٧	٢١١	٧٧٨
٢	١٠٨	٠	١١٦	٣١٧	٥٤١
٣	٣٢٥	١٩٦	٠	٩٥	٦١٦
٤	١١٥	٢٨٦	٨٥	٠	٤٨٦

Iteration No. (٧) _(right edge, columns cut off)_

	١	٢	٣
١	٠	١٩٠	٣٧٧
٢	١٠٨	٠	١١٦
٣	٣٢٣	١٩٥	٠
٤	١١٥	٢٨٥	٨٥

	٥٧٧	٦٢٣	٢٤١٨	Link Outflow [VPH]	٥٤٤	٦٦٩	٥٧٩	٥٢٤	٢٤١٦	Link Outflow	٥٤٨	٦٧٢	٥٧٨	٦٢٣	٢٤٢١	Link Outflow [VPH]	٥٤٦	٦٧٠	٥٧٨

Iteration No. (٨) | Iteration No. (٩) | Iteration No. (١٠)

٢	٣	٤	Link Inflow [VPH]		١	٢	٣	٤	Link Inflow [VPH]		١	٢	٣	٤	Link Inflow [VPH]
٩٠	٣٧٦	٢١١	٧٧٧	١	٠	١٩٠	٣٧٦	٢١١	٧٧٧	١	٠	١٩٠	٣٧٦	٢١١	٧٧٧
	١١٦	٣١٧	٥٤١	٢	١٠٨	٠	١١٦	٣١٧	٥٤١	٢	١٠٨	٠	١١٦	٣١٧	٥٤١
٩٥	٠	٩٥	٦١٤	٣	٣٢٣	١٩٥	٠	٩٥	٦١٣	٣	٣٢٤	١٩٥	٠	٩٥	٦١٤
٨٥	٨٥	٠	٤٨٥	٤	١١٥	٢٨٥	٨٥	٠	٤٨٥	٤	١١٥	٢٨٥	٨٥	٠	٤٨٥
٧٠	٥٧٧	٦٢٣	٢٤١٧	Link Outflow [VPH]	٥٤٦	٦٧٠	٥٧٧	٦٢٣	٢٤١٦	Link Outflow [VPH]	٥٤٧	٦٧٠	٥٧٧	٦٢٣	٢٤١٧

Iteration No. (٠) | Iteration No. (١) | Iteration No. (٢) | Iteration No.

Table (٤-٣): Iterative Procedure for Amended the Manual Traffic Matrix [Due AL-Aum Intersection In ٢٠٠٣

٢	٣	٤	Link Inflow [VPH]		١	٢	٣	٤	Link Inflow [VPH]		١	٢	٣	٤	Link Inflow [VPH]		١	٢	٣
٢٦	٢٥٠	٣٩٧	٧٩٥	١	٠	١٣٨	٢٥٤	٤٠٣	٧٩٥	١	٠	١٤٠	٢٥٠	٤٠٥	٧٩٥	١	٠	١٤٠	٢٥٠
٨	٣٥	٤٥٢	٦٣٨	٢	١٣٧	٠	٣٦	٤٦٥	٦٣٨	٢	١٣٦	٠	٣٥	٤٦٨	٦٣٩	٢	١٣٦	٠	٣٥
٠	٥	٣٥٠	٤٨٤	٣	١١٠	٢٠	٠	٣٥٤	٤٨٤	٣	١٠٩	٢٠	٠	٣٥٦	٤٨٥	٣	١٠٩	٢٠	٠
٩٠	٣٧٥	٣٠	١٠٨٢	٤	٣٩٨	٢٩٨	٣٨٦	٠	١٠٨٢	٤	٣٩٦	٣٠٣	٣٨٠	٠	١٠٧٩	٤	٣٩٧	٣٠٤	٣٨١
٦٤	٦٦٥	١٢٢٩	٢٩٩٩	Link Outflow [VPH]	٦٤٥	٤٥٦	٦٧٦	١٢٢٢	٢٩٩٩	Link Outflow [VPH]	٦٤١	٤٦٣	٦٦٥	١٢٢٩	٢٩٩٨	Link Outflow [VPH]	٦٤٢	٤٦٤	٦٦٦

Iteration No. (٤) | Iteration No. (٥) | Iteration No. (٦)

٢	٣	٤	Link Inflow		١	٢	٣	٤	Link Inflow		١	٢	٣	٤	Link Inflow

			[VPH]					[VPH]						[VPH]
٤.	٢٥.	٤.٦	٧٩٦	١	.	١٤.	٢٥.	٤.٥	٧٩٥	١	.	١٤.	٢٥.	٤.٦	٧٩٦
	٣٥	٤٦٨	٦٣٩	٢	١٣٦	.	٣٥	٤٦٧	٦٣٨	٢	١٣٦	.	٣٥	٤٦٨	٦٣٩
.	.	٣٥٦	٤٨٥	٣	١.٩	٢.	.	٣٥٥	٤٨٤	٣	١.٩	٢.	.	٣٥٦	٤٨٥
.٤	٣٨.	.	١.٨.	٤	٣٩٧	٣.٥	٣٨١	.	١.٨٣	٤	٣٩٦	٣.٤	٣٨.	.	١.٨.
٤	٦٦٥	١٢٣.	٣...	Link Outflow [VPH]	٦٤٢	٤٦٥	٦٦٦	١٢٢٧	٣...	Link Outflow [VPH]	٦٤١	٤٦٤	٦٦٥	١٢٣.	٣...

Table (٤-٤) : Iterative Procedure for Amended the Manual Traffic Matrix [VPH]

Iteration No. (٠)				Iteration No. (١)					Iteration No. (٢)					Iteration No.
٢	٣	٤	Link Inflow [VPH]		١	٢	٣	٤	Link Inflow [VPH]		١	٢	٣	٤	Link Inflow [VPH]		١	٢	٣
٨٩	٢٣	١٥١	٣٦٦	١	.	١٩١	٢٣	١٥٢	٣٦٦	١	.	١٨٧	٢٤	١٠٦	٣٦٧		.	١٨٦	٢٤
٤	٢١	٤٦.	٦٩١	٢	٢.٧	.	٢١	٤٦٣	٦٩١	٢	٢.٥	.	٢٢	٤٧٤	٧.١		٢.٢	.	٢٢
٧٤	٤	٢٣	١٥٨	٣	٥٨	٧٦	.	٢٤	١٥٨	٣	٥٨	٧٤	.	٢٥	١٥٧		٥٨	٧٤	.
٢.	٣٧	٢.	٥٨٥	٤	١١٢	٤٣٥	٣٨	.	٥٨٥	٤	١١١	٤٢٦	٣٩	.	٥٧٦		١١٣	٤٣٣	٤..
٨٧	٨٥	٦٥٤	١٨..	Link Outflow [VPH]	٣٧٧	٧.٢	٨٢	٦٣٩	١٨..	Link Outflow [VPH]	٣٧٤	٦٨٧	٨٥	٦٥٥	١٨.١		٣٧٣	٦٩٣	٨٦

Iteration No. (٤)				Iteration No. (٥)					Iteration No. (٦)					Iteration No.
٢	٣٥	٤	Link Inflow [VPH]		١	٢	٣	٤	Link Inflow [VPH]		١	٢	٣	٤	Link Inflow [VPH]		١	٢	٣
٨٤	٢٤	١٥٧	٣٦٥	١	.	١٨٥	٢٤	١٥٧	٣٦٦	١	.	١٨٤	٢٤	١٥٨	٣٦٦	١	.	١٨٤	٢٤
.	٢٢	٤٧١	٦٩٦	٢	٢.٢	.	٢٢	٤٦٨	٦٩٢	٢	٢.٢	.	٢٢	٤٧١	٦٩٥	٢	٢.	.	٢٢

Top table (fragments, right-to-left):

																	١	
٧٣	٠	٢٥	١٥٦	٣	٥٨	٧٣	٠	٢٥	١٥٦	٣	٥٨	٧٣	٠	٢٥	١٥٦	٣	٥٨	٧٣	٠
٢٩	٤٠	٠	٥٨٢	٤	١١٤	٤٣٢	٤٠	٠	٥٨٦	٤	١١٤	٤٣٠	٤٠	٠	٥٨٤	٤	١١٤	٤٣١	٤٠
٨٦	٨٦	٦٥٣	١٧٩٩	Link Outflow [VPH]	٣٧٤	٦٩٠	٨٦	٦٥٠	١٨٠٠	Link Outflow [VPH]	٣٧٤	٦٨٧	٨٦	٦٥٤	١٨٠١	Link Outflow [VPH]	٣٧٣	٦٨٨	٨٦

Middle section:

Iteration No. (٨)					Iteration No. (٩)					
٢	٣	٤	Link Inflow [VPH]		١	٢	٣	٤	Link Inflow [VPH]	
١٨٤	٢٤	١٥٨	٣٦٦	١	٠	١٨٤	٢٤	١٥٨	٣٦٦	
٠	٢٢	٤٧٠	٦٩٤	٢	٢٠١	٠	٢٢	٤٦٩	٦٩٢	
٧٣	٠	٢٥	١٥٦	٣	٥٨	٧٣	٠	٢٥	١٥٦	
٣٠	٤٠	٠	٥٨٤	٤	١١٤	٤٣١	٤٠	٠	٥٨٥	

P-P plot:
- Y-axis: Estimated Cum Prob — 0.00, .25, .50, .75, 1.00
- X-axis: Observed Cum Prob — 0.00, .25, .50, .75, 1.00

Bottom table (fragment):

٨٧	٨٦	٦٥٣	١٨٠٠	Link Outflow [VPH]	٣٧٣	٦٨٨	٨٦	٦٥٢	١٧٩٩

Figure (٤-١١) Cumulative Probability Plot of Standardized Residuals in

Figure (٤-١٢ Regression Standardized Residuals in
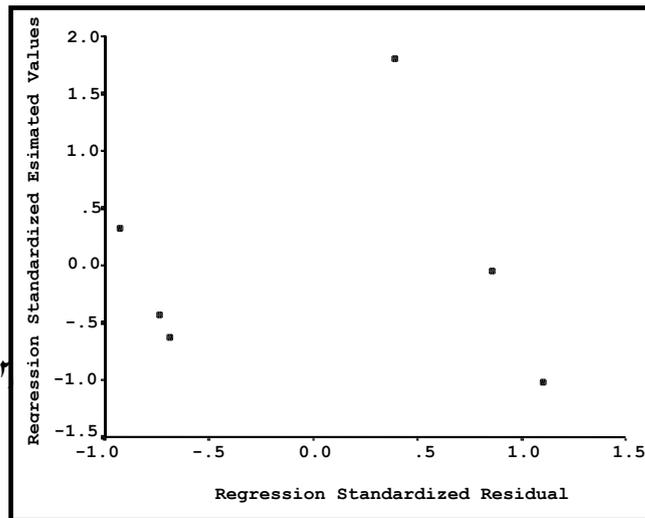
igure (٤-١٣) The Scatter plot of Predicted against Residuals Values

in Ishtar Intersection
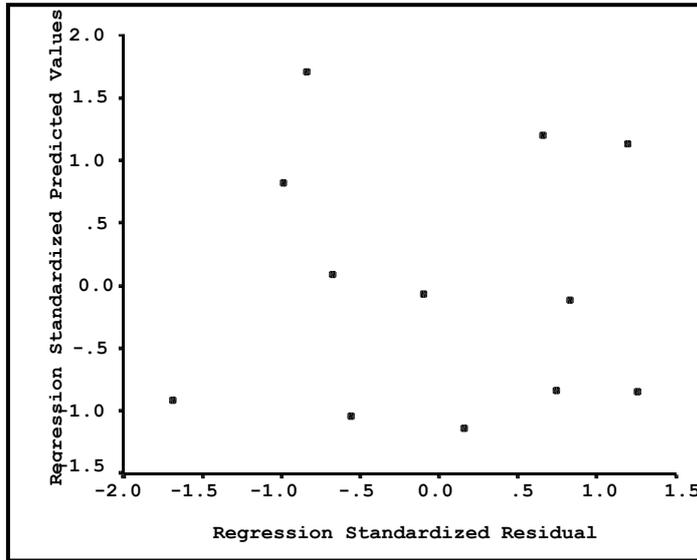
Figure (٤-١٤) The Scatter plot of Predicted against Residuals Values in Al- Jamia Intersection

It has been obtained estimates and observed values of turning flows at
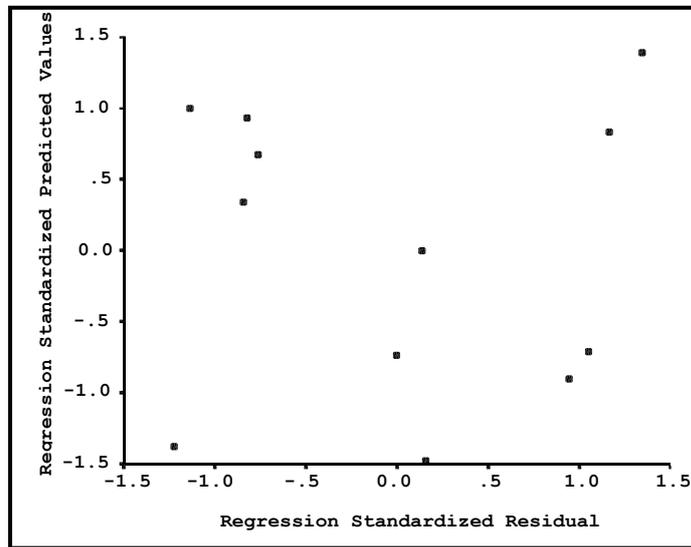
Figure (٤-١٥) The Scatter plot of Predicted against Residuals Values in Al-Aum Intersection

four intersections, therefore it is able to look at the errors in the turning flows. Within the group flow the errors values sorted from the most negative

through to the most positive and plotted the cumulative distribution function.
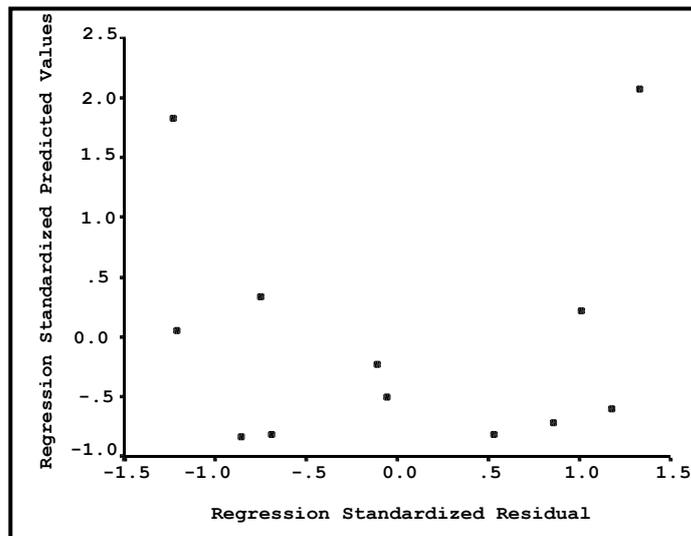
Figure (٤-١٦) The Scatter plot of Predicted against Residuals Values in Bab-Al-Mashhed Intersection

The empirical error distribution curves were plotted for all the data sets of the four intersections in Hilla City as shown in Table (٤-١٩).

Table (٤-١٩) Distribution of Errors for Study Intersections in Hilla City [Outdate Flow ٢٠٠١, Recent flow ٢٠٠٣]

Number	Cumulative Probability	Errors	Number	Cumulative Probability	Errors
١	٠.٥/٤٢	-٨٧	٢٢	٢١.٥/٤٢	١
٢	١.٥/٤٢	-٨٥	٢٣	٢٢.٥/٤٢	٣
٣	٢.٥/٤٢	-٨٥	٢٤	٢٣.٥/٤٢	٤
٤	٣.٥/٤٢	-٨٥	٢٥	٢٤.٥/٤٢	٥
٥	٤.٥/٤٢	-٧٥	٢٦	٢٥.٥/٤٢	٥
٦	٥.٥/٤٢	-٧١	٢٧	٢٦.٥/٤٢	٧
٧	٦.٥/٤٢	-٥٤	٢٨	٢٧.٥/٤٢	٨
٨	٧.٥/٤٢	-٥٢	٢٩	٢٨.٥/٤٢	١٠
٩	٨.٥/٤٢	-٣٤	٣٠	٢٩.٥/٤٢	١٢
١٠	٩.٥/٤٢	-٢٥	٣١	٣٠.٥/٤٢	١٣
١١	١٠.٥/٤٢	-٢٣	٣٢	٣١.٥/٤٢	٢٤
١٢	١١.٥/٤٢	-١٨	٣٣	٣٢.٥/٤٢	٣٠
١٣	١٢.٥/٤٢	-١٧	٣٤	٣٣.٥/٤٢	٣٤
١٤	١٣.٥/٤٢	-١٥	٣٥	٣٤.٥/٤٢	٤٣
١٥	١٤.٥/٤٢	-١٣	٣٦	٣٥.٥/٤٢	٨٠
١٦	١٥.٥/٤٢	-١٢	٣٧	٣٦.٥/٤٢	٨٠
١٧	١٦.٥/٤٢	-٩	٣٨	٣٧.٥/٤٢	٨٦
١٨	١٧.٥/٤٢	-٩	٣٩	٣٨.٥/٤٢	٨٥
١٩	١٨.٥/٤٢	-٧	٤٠	٣٩.٥/٤٢	٨٥

٢٠	١٩.٥/٤٢	٦_	٤١	٤٠.٥/٤٢	٨٥
٢١	٢٠.٥/٤٢	٤_	٤٢	٤١.٥/٤٢	٨٦

In this study, the obtained errors in estimation were grouped according to the size of the flow to be estimated and the empirical errors distribution curves are plotted for each group. Considering the errors in the estimates of flows, it could be seen from Table (٤-٢٠) that, in small flows (less than ١٠٠ veh/hr) to be underestimated and in high flows (more than ٤٠٠ veh/hr), to be overestimated. Also, it was seen that for flows of less than ١٠٠ veh/hr, approximately (٨٠) percent of errors were in the range ± 6 veh/hr. Also (٢٠) percent in the range [(-١٠) – (-١٦)] veh/hr. For flows in excess of ٤٠٠ veh/hr, approximately (١٠٠) percent of errors in the rang ± ٢٧ veh/hr. Figures (٤-٢٠) and (٤-٢١) refers to the distribution of errors for study intersections, For two distributions when using outdate flow in ٢٠٠١ for all estimating flows and for grouping flows.

Table (٤-٢٠) Distribution of Errors in the Estimated of Unclassified Flows Obtained using B.Model [An Outdate Flows in ٢٠٠١]

No.	Observed Flows ٠-١٠٠ veh/hr <	Cum. Pro ١	Errors	Observed Flows ١٠٠-٢٠٠ veh/hr	Cum. Pro ٢	Errors	Observed Flows ٢٠٠-٤٠٠ veh/hr	Cum. Pro ٣	Errors	Observed Flows >٤٠٠ veh/hr	Cum. Pro ٤	Errors
١	٩٥	٠.٥/١٠	-١٦	١٠٨	٠.٥/١١	-٣٥	٣٣٤	٠.٥/١٤	-٢٧	٥١١	٠.٥/٧	-٢٧
٢	٣٥	١.٥/١٠	-١٠	١٥٨	١.٥/١١	-٧	٣٧١	١.٥/١٤	-٢٧	٤٠٦	١.٥/٧	-٦
٣	٢٢	٢.٥/١٠	-٦	١١٤	٢.٥/١١	-١	٢٨٥	٢.٥/١٤	-١٢	٤٣١	٢.٥/٧	-٥
٤	٢٥	٣.٥/١٠	-٥	١٩٥	٣.٥/١١	-٢	٢١١	٣.٥/١٤	-١١	٤٦٩	٣.٥/٧	١٠
٥	٨٥	٤.٥/١٠	-٤	١٣٦	٤.٥/١١	-١	٣٠٤	٤.٥/١٤	-٥	٤٦٨	٤.٥/٧	١١
٦	٢٠	٥.٥/١٠	-١	١٠٩	٥.٥/١١	٥	٢٠١	٥.٥/١٤	-٤	٤٤٣	٥.٥/٧	٢٧
٧	٧٣	٦.٥/١٠	-١	١٤٠	٦.٥/١١	٦	٣٥٦	٦.٥/١٤	-٤	٧٨٨	٦.٥/٧	٢٧
٨	٢٦	٧.٥/١٠	٢	١٨٤	٧.٥/١١	٦	٣٧٦	٧.٥/١٤	-٤			
٩	٤٠	٨.٥/١٠	٤	١١٦	٨.٥/١١	٨	٣٩٦	٨.٥/١٤	-٤			

١٠	٥٨	٩.٥/١٠	٦	١٩٠	٩.٥/١١	١٤	٢٥٠	٩.٥/١٤	١			
١١				١١٥	١٠.٥/١١	١٧	٣٨٠	١٠.٥/١٤	٩			
١٢							٣٢٤	١١.٥/١٤	١٩			
١٣							٢٦٢	١٢.٥/١٤	٢٧			
١٤							٣١٧	١٣.٥/١٤	٢٨			

`*Chapter Four*

Estimation of Turning Movements by Using Bayesian Model

٤.١ Introduction

This chapter describe in some detail certain aspects of preparing the Bayesian model application, this preparing include the amended outdate and observed turning movements matrices.

The estimation of traffic flows in the selected four intersections through apply the Bayesian model. In addition to, the accuracy of the estimation in these intersections are adopted In this chapter.

٤.٢ The Traffic Flow Matrix

The matter for getting ideal results in all turning movements estimating methods in traffic intersections requires the U-turns value to be zero. Both **Mekky[١٩٧٩]** and **Al-Shaekhli [١٩٩٣]** handled this issue by using biproportional method. This method begins to diminish U-turn value into zero through several iterations. In the first iteration, the U-turn volume has been distributed in each approach over other movements within the same approach, and this is proportionally done to the volume of each movement. Therefore, in this iteration, there will be a little change in the outflow in that specific approach. While the inflow remains as it in the approach under consideration. In the second iteration, the difference between the original outflow for the approach and the one that is resulted

from the first iteration has been distributed according to the turning movement volume of that exit under consideration.

Whereas the difference between the original inflow for the approach and the inflow that is resulted from the previous iteration has been distributed in the third iteration that is similar to the second iteration except in that the latter deals with the outflow. The alternate iterations process is continued on the rows and columns of traffic matrix until the difference between the original and the corresponding iterative links inflows and outflows is disappeared or become lesser. In this study, the biproportional method is twicely applied. The first application is in a form of program that prepared the prior matrix which consists U- turn to be used for turning movement estimation program. This is explained in the output that is shown in Appendices (C), (D) and (E).

The second application for this method is manually and related to the recent matrix. The purpose of this application is to have a recent matrix empty from U- turns in order to have the ability make a comparison between this matrix and the estimation matrix from Bayesian model.

As a result this chapter handles this issue manually for each intersection as follows:

٤.٢.١ Actual and Amended Manual Count for Ishtar Intersection

The turning movements can be represented in each intersection in a form of matrix. Each cell represents by itself a turning movement and the whole of these movements in each single approach represents an inflow of that approach. The turning movements can be represented as that:

Manual Traffic Matrix for Ishtar Intersection [٢٠٠٣]

To ⟍ From	١	٢	٣	Total Inflow [VPH]
١	١٩	٤٢٢	٥١٣	٩٥٤

	٣٥٠	٣٣	٢٥٠	٦٣٣
٢	٣٥٠	٣٣	٢٥٠	٦٣٣
٣	٧٩٠	٣٢٢	١٠	١١١٢
Total Outflow [VPH]	١١٥٩	٧٧٧	٧٧٣	٢٧٠٩*
* Note: this value represents the total inflow (=outflow) from all links to the junction.				

The biproportional method used to make the diagonal of this traffic matrix equal zero. It needs (٥) iterations to reach the last matrix that represents a bigger convergence with the original matrix where if the iteration continue, the matrices would be repeated in the previous repetitions as shown in Table (٤-١). The summation of inflows for the whole entries equals the total outflows for that intersection. These turning movements in Ishtar intersection can be represented in Figure (٤-١).

٤.٢.٢ Actual and Amended Manual Count for Al- Jamia Intersection

Four turning movements at each entrance for this intersection, (right, through, left, U-turns). The total number of observed inflows showed at the top of (Events) program when escapes from it. The inflow to the junction from a link was obtained by summing up the corresponding traffic streams. Similarly, the outflow from each exit was obtained by summing up the corresponding traffic streams. The outflows were not measured but counted. The total outflow through the junction was obtained from summing up the outflows from all exits. The total inflow of [vehicles/hour] was in complete agreement with the total outflow. The traffic matrix for this intersection is following:

Manual Traffic Matrix for Al - Jamia Intersection [٢٠٠٣]

To	١	٢	٣	٤	Total Inflow

From					[VPH]
١	٤٠	١٧٥	٣٦٠	٢٠٣	٧٧٨
٢	٩٦	٢٢	١١٣	٣١٢	٥٤٣
٣	٣٠٤	١٩٤	١٧	٩٨	٦١٣
٤	١٠٧	٢٨٠	٨٧	١٠	٤٨٤
Total Outflow [VPH]	٥٤٧	٦٧١	٥٧٧	٦٢٣	٢٤١٨*
* Note: this value represents the total inflow (=outflow) from all links to the junction.					

Table (٤-٢) shows the amended manual traffic matrix for this case and obtained after (١٠) iterations using the Biproportional approach, while Figure (٤-٢) shows the corresponding traffic flow for this intersection.

٤.٢.٣ Actual and Amended Manual Count for Al- Aum Intersection

For this intersection an image processing is carried on for two hours, At morning and at evening peak periods as other intersections, That shows summing up the corresponding traffic streams produced the inflow to the intersection from a link. Similarly, summing up the corresponding traffic streams produced the outflow from each exit. It should be noted that the outflows were not measured but counted. The total outflow through this intersection was produced from summing the outflows from all exits. The total inflow of [vehicles/hour] was in complete agreement with the total outflow. The traffic flow matrix for Al-Aum intersection is following:

Manual Traffic Matrix for Al -Aum Intersection [٢٠٠٣]

To / From	١	٢	٣	٤	Total Inflow [VPH]
١	١٢	١٣٦	٢٥٠	٣٩٧	٧٩٥
٢	١٣٣	١٨	٣٥	٤٥٢	٦٣٨
٣	١٠٩	٢٠	٥	٣٥٠	٤٨٤
٤	٣٨٧	٢٩٠	٣٧٥	٣٠	١٠٨٢
Total Outflow [VPH]	٦٤١	٤٦٤	٦٦٥	١٢٢٩	٢٩٩٩*
* Note: this value represents the total inflow (=outflow) from all links to the junction.					

Table (٤-٣) shows the amended manual traffic matrix for this case produced after (٦) iterations using the biproportional approach, while Figure (٤-٣) shows the corresponding traffic flow diagram.

٤.٢.٤ Actual and Amended Manual Count for Bab-Al-Mashhed Intersection

The link inflows, and outflows were produced for this intersection in exactly the same way as for the previous intersections. Therefore, the total inflow of [١٨٠٠] vph was in complete agreement with the total outflow. The traffic flow matrix for Bab-Al-Mashhed intersection as following:

Manual Traffic Matrix for Bab - Al - Mashhed Intersection[٢٠٠٣]

To \ From	١	٢	٣	٤	Total Inflow [VPH]
١	٣	١٨٩	٢٣	١٥١	٣٦٦
٢	٢٠٦	٤	٢١	٤٦٠	٦٩١

٣	٥٧	٧٤	٤	٢٣	١٥٨
٤	١٠٨	٤٢٠	٣٧	٢٠	٥٨٥
Total Outflow [VPH]	٣٧٤	٦٨٧	٨٥	٦٥٤	١٨٠٠*

* Note: this value represents the total inflow (=outflow) from all links to the junction.

Table (٤-٤) shows the final manual traffic matrix amended for U-turns. Note that (٩) iterations were needed to achieve this final amended manual traffic matrix in which the total inflow (=total outflow) remained unchanged as it was in the actual traffic matrix, while Figure (٤-٤) shows the corresponding traffic flow diagram.

٤.٣ The Bayesian Model

For the general case of an intersection with (n) arms, **[Maher ١٩٨٣] [Maher ١٩٨٤]**, shows that, if the prior estimates of the turning flows are $\hat{\mu}_i^0$ and the corresponding prior variances are v_{ii}^0 (I= ١,….n(n-١)) with prior covariance terms equal to zero. Posterior estimates, $\hat{\mu}_i^{2n-1}$, and variances, v_{ii}^{2n-1}, can be obtained by applying each of the independent row and column constraints in turn using some equations.

The turning movements estimation issue has been dealt with in the four- arm intersections as it has been clarified in the flowchart of the prepared program in visual basic "٦" for this case in Appendix (A).

Where the first part of the program represents the application of biproportional method on the prior matrix which consists of sixteen turning movements through which it distributes the elements of traffic matrix diagonal over the other matrix elements, and the traffic currents being reduced up to twelve turning movements.

Then, the program moves to the preparatory stage to apply the model equations in which at this stage the program inputs are as follow:

- Twelve prior values of turning movements. They are reached at from applying the first part of the program.

- Seven independent constraints represent observations on the inflows and outflows of the four arms.

- The H matrix (with seven rows and twelve columns) as shown :

The H matrix for Four-Arm Intersection

$$
\begin{bmatrix}
1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\
0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\
0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
$$

While the followed part of the program operates to apply Bayesian model equations by using seven iterations. In each iteration there will be an invention of certain group from traffic flows until all flows have invented in the seventh iteration. Posterior estimates, $\hat{\mu}_i^7$, and variances, $\hat{v}_{ii}^7$, can be obtained by applying each of the independent row and column constraints in turn using:

$$
\mu_i^{(k)} = \mu_i^{(k-1)} + \frac{S_i}{T}(g_k - v) \quad (i = ١, ..., ١٢) \quad .... (٤-١)
$$

and

$$
v_{ij}^{(k)} = v_{ij}^{(k-1)} - \frac{S_i S_j}{T}(i, j = ١, ..., ١٢) \qquad .... (٤-٢)
$$

for values of K=١ to K=٧

where

$$
v = \sum_{j=1}^{12} h_{kj} \mu_j^{(k-1)}, \qquad\qquad .... (٤-٣)
$$

$$
S_i = \sum_{j-1}^{12} h_{kj} v_{ij}^{(k-1)} \quad (i = ١, ..., ١٢) \qquad .... (٤-٤)
$$

$$T = \sum_{i=1}^{12} h_{ki} s_i .$$
$$\quad\quad\quad \dots (٤\text{-}٥)$$

The program also fulfills the final stage by printing the standard errors of update turning movements.

It is possible to deal with the three-arm intersections as if four intersections by adding fourth imaginary arm have zero value for turning movements. In this case it can be considered subroutine from the original program. The scheme details illustrated in Appendix (A).

The program that is used in the three-arm intersection estimation is the same previous program. It can be considered this program a modification program, there are few simple differences that have been shown in the flowchart of that program as illustrated in Appendix (B). Where this program carries the same idea of the previous amendment which has followed to get a matrix empty from U-turn especially in the first part of the program and the preparatory stage in order to apply the required model, where the program inputs are as follows:

- Six prior values of turning movements. They are reached at from applying the first part of the program.
- Five independent constraints represent observations on the inflows and outflows of the four arms.
- The H matrix (with five rows and six columns) as shown :

$$
\begin{bmatrix}
1 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 1 \\
0 & 0 & 1 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
$$

The H matrix for Three-Arm Intersection

Posterior estimates, $\hat{\mu}_i^5$, and variances, $\hat{v}_{ii}^5$, can be obtained by applying each of the independent row and column constraints in turn using:

$$\mu_i^{(k)} = \mu_i^{(k-1)} + \frac{S_i}{T}(g_k - v) \;\; (i = ١, \dots, ٦) \;\; \dots (٤\text{-}٦)$$

and

$$v_{ij}^{(k)} = v_{ij}^{(k-1)} - \frac{S_i S_j}{T} \, (i, j = ١, ..., ٦). \quad .... (٤-٧)$$

for values of K=١ to K=٥

where

$$v = \sum_{j=1}^{6} h_{kj} \mu_j^{(k-1)}, \quad .... (٤-٨)$$

$$S_i = \sum_{j-1}^{6} h_{kj} v_{ij}^{(k-1)} \, (i = ١, ..., ٦), \quad .... (٤-٩)$$

$$T = \sum_{i=1}^{6} h_{ki} s_i . \quad .... (٤-١٠)$$

Also, it should be noted that the standard errors are calculated in the last stage of the program **[Maher, ١٩٨٤]**.

It is necessary to mention that Bayesian model applied in this research for three outdate statistics to previous years as in ١٩٩٤,١٩٩٨ and ٢٠٠١ and recent flows taken in ٢٠٠٣. The details of the model application for outdate turning movements in ٢٠٠١ and recent turning movements in ٢٠٠٣ are shown in the following:

٤.٤ Applying Bayesian Model on Three-Arm Intersections

Bayesian model applied on Ishtar intersection because it is a three-arm intersection. In the first application of the model depends on the treatment of Ishtar intersection as a four-arm intersection by adding a fourth imaginary arm where the values of turning movements are zero. Table (٤-٥)

represents the input form in the first application which treats the problem as four-arm intersection while Table (٤-٦) gives the estimated traffic flows with their standard errors and the details of this case are shown in the output of program given in Appendix (C). Table (٤-٧) represents the input data in the modification program, The estimated traffic flows with their standard errors for this case is shown in Table (٤-٨), and the others details are shown in output of program given in Appendix (D).

Table (٤-٥) Input Data Set for Ishtar Intersection (Three-Arm Intersection)(An Outdated Turning Flow Matrix ٢٠٠١, Recent Approaches Flow ٢٠٠٣(Inflow and Outflow)) in Original Program

An Outdated Turning Flow ٢٠٠١											
T١٢	T١٣	T١٤	T٢١	T٢٣	T٢٤	T٣١	T٣٢	T٣٤	T٤١	T٤٢	T٤٣
٣٩٢	٣١٤	٠.١	٣٠٩	٢٠٢	٠.١	٧١٦	٢٧٧	٠.١	٠.١	٠.١	٠.١

Year	Total Inflow (I)				Total Outflow (O)			
٢٠٠١	٦٧٨	٤١٢	٥٣٦	٣٤٨	٤٣٠	٥١٤	٤٧٦	٥٥٤
٢٠٠٣	٧٧٧	٥٤١	٦١٤	٤٨٥	٥٤٧	٦٧٠	٥٧٧	٦٢٣

Tij: Turning movements from i to j

Table (٤-٦) Iterations for the Estimated Turning Flow after Introduction of each Observation (Ishtar Intersection)(Three-Arm Intersection)

Iteration	T١٢	T١٣	T١٤	T٢١	T٢٣	T٢٤	T٣١	T٣٢	T٣٤	T٤١	T٤٢	T٤٣	Observation
٠	٣٩٢	٣١٤	٠.١	٣٠٩	٢٠٢	٠.١	٧١٦	٢٧٧	٠.١	٠.١	٠.١	٠.١	
١	٥٣٠	٤٢٤	٠.٠	٣٠٩	٢٠٢	٠.٠	٧١٦	٢٧٧	٠.٠	٠.٠	٠.٠	٠.٠	٩٥٤
٢	٥٣٠	٤٢٤	٠.٠	٣٨٣	٢٥٠	٠.٠	٧١٦	٢٧٧	٠.٠	٠.٠	٠.٠	٠.٠	٦٣٣
٣	٥٣٠	٤٢٤	٠.٠	٣٨٣	٢٥٠	٠.٠	٨٠٩	٣١٣	٠.٠	٠.٠	٠.٠	٠.٠	١١٢٢
٤	٥٣٠	٤٢٤	٠.٠	٣٨٣	٢٥٠	٠.٠	٨٠٩	٣١٣	٠.٠	٠.٠	٠.٠	٠.٠	٠
٥	٥٣٠	٤٢٤	٠.٠	٣٧٠	٢٦٣	٠.٠	٧٨٩	٣٣٣	٠.٠	٠.٠	٠.٠	٠.٠	١١٥٩
٦	٤٧٠	٤٨٤	٠.٠	٣٤٤	٢٨٩	٠.٠	٨١٥	٣٠٧	٠.٠	٠.٠	٠.٠	٠.٠	٧٧٧
٧	٤٧٠	٤٨٤	٠	٣٤٤	٢٨٩	٠	٨١٥	٣٠٧	٠	٠	٠.٠	٠.٠	٧٧٣
Standard errors	٧	٧	٠	٧	٧	٠	٧	٧	٠	٠	٠	٠	

Tij: Turning movements from i to j

Table (٤-٧) Input Data Set for Ishtar Intersection (Three-Arm Intersection)(An Outdated Turning Flow Matrix ٢٠٠١, Recent Approaches Flow ٢٠٠٢(Inflow and Outflow)) in Modified Program

An Outdated Turning Flow ٢٠٠١					
T١٢	T١٣	T٢١	T٢٣	T٣١	T٣٢
٣٩٢	٣١٤	٣٠٩	٢٠٢	٧١٦	٢٧٧
Year	Total Inflow (I)			Total Outflow (O)	
٢٠٠١	٧٠٦	٥١١	٩٩٣	١٠٢٥	٦٦٩	٥١٦

٢٠٠٣	٩٥٤	٦٣٣	١١٢٢	١١٥٩	٧٧٧	٧٧٣

Tij: Turning movements from i to j

Table (٤-٨) Iterations for the Estimated Turning Flow after Introduction of each Observation (Ishtar Intersection)(Three-Arm Intersection)

Iteration	T١٢	T١٣	T٢١	T٢٣	T٣١	T٣٢	Observation
•	٣٩٢	٣١٤	٣٠٩	٢٠٢	٧١٦	٢٧٧	
١	٥٣٠	٤٢٤	٣٠٩	٢٠٢	٧١٦	٢٧٧	٩٥٤
٢	٥٣٠	٤٢٤	٣٨٣	٢٥٠	٧١٦	٢٧٧	٦٣٣
٣	٥٣٠	٤٢٤	٣٨٣	٢٥٠	٨٠٩	٣١٣	١١٢٢
٤	٥٣٠	٤٢٤	٣٧٠	٢٦٣	٧٨٩	٣٣٣	١١٥٩
٥	٤٧٠	٤٨٤	٣٤٤	٢٨٩	٨١٥	٣٠٧	٧٧٧
Standard errors	١٣	١٣	٩	٩	٩	٩	

Comparison of the final values of (μ_i^7 and μ_i^5) in the two output files shows close agreement.

٤.٥ Applying Bayesian Model on Four-Arm Intersections

Three main four-arm intersections in the study area were selected in which the turning flows of these intersections are update. Tables (٤-٩), (٤-١٠) and (٤-١١) are represented the input form for intersections Al-Jamia, Al-Aum and Bab-Al-Mashhad. While Tables (٤-١٢), (٤-١٣) and (٤-١٤) are represented the iterations for update traffic flows for the mentioned intersections respectively. The details of this case in Al-Aum intersection are shown in output of program given in Appendix (E).

Table (٤-٩) Input Data Set for Al-Jamia Intersection (An Outdated Turning Flow Matrix ٢٠٠١, Recent Approaches Flow ٢٠٠٣(Inflow and Outflow))

An Outdated Turning Flow ٢٠٠١											
T١٢	T١٣	T١٤	T٢١	T٢٣	T٢٤	T٣١	T٣٢	T٣٤	T٤١	T٤٢	T٤٣
١٦٠	٣٢٣	١٩٥	٤٨	٩٠	٢٧٤	٢٨٩	١٦٢	٨٥	٩٣	١٩٢	٦٣
Year	Total Inflow (I)				Total Outflow (O)			
٢٠٠١	٦٧٨	٤١٢	٥٣٦	٣٤٨	٤٣٠	٥١٤	٤٧٦	٥٥٤
٢٠٠٣	٧٧٧	٥٤١	٦١٤	٤٨٥	٥٤٧	٦٧٠	٥٧٧	٦٢٣

Tij: Turning movements from i to j

Table (٤-١٠) Input Data Set for Al-Aum Intersection (An Outdated Turning Flow Matrix ٢٠٠١, Recent Approaches Flow ٢٠٠٣(Inflow and Outflow))

An Outdated Turning Flow ٢٠٠١											
T١٢	T١٣	T١٤	T٢١	T٢٣	T٢٤	T٣١	T٣٢	T٣٤	T٤١	T٤٢	T٤٣
١٠٣	١٩٦	٣١٤	١١٤	٢١	٤٠١	٩٧	١٤	٢٩٨	٣٢٢	٢١٨	٣١٦
Year	Total Inflow (I)				Total Outflow (O)			
٢٠٠١	٦١٣	٥٣٦	٤٠٩	٨٥٦	٥٣٣	٣٣٥	٥٣٣	١٠١٣
٢٠٠٣	٧٩٦	٦٣٩	٤٨٥	١٠٨٠	٦٤١	٤٦٤	٦٦٥	١٢٣٠

Tij: Turning movements from i to j

Table (٤-١١) Input Data Set for Bab-Al-Mashhed Intersection (An Outdated Turning Flow Matrix ٢٠٠١, Recent Approaches Flow ٢٠٠٣(Inflow and Outflow))

An Outdated Turning Flow ٢٠٠١											
T١٢	T١٣	T١٤	T٢١	T٢٣	T٢٤	T٣١	T٣٢	T٣٤	T٤١	T٤٢	T٤٣
١٥٢	١٧	١٠٣	١٨٩	١٣	٤٠١	٤٥	٥٤	١٣	٩٤	٣٧٤	٣١
Year	Total Inflow (I)				Total Outflow (O)						
٢٠٠١	٢٧٢	٦٠٣	١١٢	٤٩٩	٣٢٨	٥٨٠	٦١	٥١٧			
٢٠٠٣	٣٦٦	٦٩٢	١٥٦	٥٨٥	٣٧٣	٦٨٨	٨٦	٦٥٢			

Tij: Turning movements from i to j

Table (٤-١٢) Iterations for the Estimated Turning Flow after Introduction of each Observation (Al- Jamia Intersection)

Iteration	T١٢	T١٣	T١٤	T٢١	T٢٣	T٢٤	T٣١	T٣٢	T٣٤	T٤١	T٤٢	T٤٣	Observation
٠	١٦٠	٣٢٣	١٩٥	٤٨	٩٠	٢٧٤	٢٨٩	١٦٢	٨٥	٩٣	١٩٢	٦٣	
١	١٨٣	٣٧٠	٢٢٣	٤٨	٩٠	٢٧٤	٢٨٩	١٦٢	٨٥	٩٣	١٩٢	٦٣	٧٧٧
٢	١٨٣	٣٧٠	٢٢٣	٦٣	١١٨	٣٦٠	٢٨٩	١٦٢	٨٥	٩٣	١٩٢	٦٣	٥٤١
٣	١٨٣	٣٧٠	٢٢٣	٦٣	١١٨	٣٦٠	٣٣١	١٨٦	٩٧	٩٣	١٩٢	٦٣	٦١٤
٤	١٨٣	٣٧٠	٢٢٣	٦٣	١١٨	٣٦٠	٣٣١	١٨٦	٩٧	١٣٠	٢٦٨	٨٨	٤٨٥
٥	١٨٣	٣٧٠	٢٢٣	٦٧	١١٧	٣٥٧	٣٤٤	١٧٨	٩٣	١٣٦	٢٦٣	٨٦	٥٤٧
٦	٢٠٦	٣٥٦	٢١٤	٧٢	١١٦	٣٥٤	٣٤٢	١٩٠	٨٣	١٣٤	٢٧٤	٧٨	٦٧٠
٧	٢٠٤	٣٧٢	٢٠٠	٧٣	١٢٤	٣٤٥	٣٤٣	١٩٣	٧٩	١٣٢	٢٧٣	٨١	٥٧٧
Standard errors	٨	١٢	١١	٦	٨	٩	٨	٨	٧	٧	٨	٧	

Table (٤-١٣) Iterations for the Estimated Turning Flow after Introduction of each Observation (Al-Aum Intersection)

Iteration	T١٢	T١٣	T١٤	T٢١	T٢٣	T٢٤	T٣١	T٣٢	T٣٤	T٤١	T٤٢	T٤٣	Observation

٠	١٠٣	١٩٦	٣١٤	١١٤	٢١	٤٠١	٩٧	١٤	٢٩٨	٣٢٢	٢١٨	٣١٦	
١	١٣٤	٢٥٥	٤٠٨	١١٤	٢١	٤٠١	٩٧	١٤	٢٩٨	٣٢٢	٢١٨	٣١٦	٧٩٦
٢	١٣٤	٢٥٥	٤٠٨	١٣٦	٢٥	٤٧٨	٩٧	١٤	٢٩٨	٣٢٢	٢١٨	٣١٦	٦٣٩
٣	١٣٤	٢٥٥	٤٠٨	١٣٦	٢٥	٤٧٨	١١٥	١٧	٣٥٣	٣٢٢	٢١٨	٣١٦	٤٨٥
٤	١٣٤	٢٥٥	٤٠٨	١٣٦	٢٥	٤٧٨	١١٥	١٧	٣٥٣	٤٠٦	٢٧٥	٣٩٩	١٠٨٠
٥	١٣٤	٢٥٥	٤٠٨	١٣٢	٢٥	٤٨٢	١١٢	١٧	٣٥٦	٣٩٧	٢٧٩	٤٠٤	٦٤١
٦	١٤٦	٢٥٠	٤٠١	١٣٥	٢٥	٤٧٩	١١٤	١٩	٣٥٢	٣٩٢	٢٩٩	٣٨٩	٤٦٤
٧	١٤٦	٢٥١	٤٠٠	١٣٥	٢٥	٤٧٩	١١٤	١٩	٣٥٢	٣٩٢	٢٩٩	٣٨٩	٦٦٥
Standard errors	٧	١١	١٢	٨	٤	٩	٨	٤	٨	٩	٨	١١	

Table (٤-١٤) Iterations for the Estimated Turning Flow after Introduction of each Observation (Bab-Al-Mashhed Intersection)

Iteration	T١٢	T١٣	T١٤	T٢١	T٢٣	T٢٤	T٣١	T٣٢	T٣٤	T٤١	T٤٢	T٤٣	Observation
٠	١٥٢	١٧	١٠٣	١٨٩	١٣	٤٠١	٤٥	٥٤	١٣	٩٤	٣٧٤	٣١	
١	٢٠٥	٢٣	١٣٩	١٨٩	١٣	٤٠١	٤٥	٥٤	١٣	٩٤	٣٧٤	٣١	٣٦٦
٢	٢٠٥	٢٣	١٣٩	٢١٧	١٥	٤٦٠	٤٥	٥٤	١٣	٩٤	٣٧٤	٣١	٦٩٢
٣	٢٠٥	٢٣	١٣٩	٢١٧	١٥	٤٦٠	٦٣	٧٥	١٨	٩٤	٣٧٤	٣١	١٥٦
٤	٢٠٥	٢٣	١٣٩	٢١٧	١٥	٤٦٠	٦٣	٧٥	١٨	١١٠	٤٣٨	٣٦	٥٨٥
٥	٢٠٥	٢٣	١٣٩	٢٠٨	١٥	٤٦٩	٦١	٧٧	١٨	١٠٤	٤٤٣	٣٦	٣٧٣
٦	١٨٩	٢٥	١٥٣	١٩٦	١٥	٤٨١	٦٤	٧٢	٢٠	١١٤	٤٢٧	٤٢	٦٨٨
٧	١٩٠	٢٦	١٥١	١٩٧	١٦	٤٧٩	٦٤	٧٢	٢٠	١١٣	٤٢٦	٤٤	٨٦
Standard errors	٦	٤	٦	٦	٤	٧	٥	٥	٣	٦	٧	٥	

٤.٦ Accuracy of Estimation in the Studied Intersections

It is important investigate the accuracy of turning flow estimates from Bayesian model. This model as noted previously, needed prior information concerned with the turning flows in which to posterior it into new turning flows in conjunction with the recently entry and exit flows from the approaches. Thus, estimates of turning flows obtained from the model are compared with observed values to establish the errors in the estimates. Although previous studies suggest that the most accurate source of prior information is to be an outdated counts [Hauar et.al., ١٩٨١]. **The difference between the estimated and the observed turning movements can be counted as follows:**
Difference = Estimated Turning Movements-Observed Turning Movements

٤.٦.١ Accuracy of Estimation in Ishtar Intersection

The difference between outdate and recent total flow in Ishtar intersection causes errors in estimation where the highest value is (٢٧) veh as shown in Table (٤-١٥). Impression of accuracy could be obtained by scanning Figure (٤-٥). Points seem to be distributed approximately symmetrically around the bisector and correlation factor was ٠.٩٧, that is shows more accuracy in estimates obtains from this model in Ishtar intersection.

Table (٤-١٥) Estimated Turning Flows in Ishtar Intersection Using B. Model

Turning Movements	T١٢	T١٣	T٢١	T٢٣	T٣١	T٣٢
Estimated Turning Movements	٤٧٠	٤٨٤	٣٤٤	٢٨٩	٨١٥	٣٠٧
Observed Turning Movements	٤٤٣	٥١١	٣٧١	٢٦٢	٧٨٨	٣٣٤
Difference	٢٧	ـ٢٧	ـ٢٧	٢٧	٢٧	ـ٢٧

Tij: Turning movements from i to j

$R^2 = ٠.٩٧٨٩$

Figure (٤-٥) Correspondence of Observed and Estimated Turning Flows in Ishtar Intersection

٤.٦.٢ Accuracy of Estimation in Al-Jamia Intersection

The difference (٤٤٤) veh/hr between outdate and recent total flow, in addition to the variation distribution of flow in Al-Jamia intersection for these total flows causing differences between estimated and observed flow as shown in Table (٤-١٦). Distribution of points is appeared symmetrically around the bisector and correlation factor was ٠.٩٧ as shown in Figure (٤-٦), which refers to the more accuracy of estimation in this intersection.

Table (٤-١٦) Estimated Turning Flows in Al-Jamia Intersection Using B. Model

Turning Movements	T١٢	T١٣	T١٤	T٢١	T٢٣	T٢٤	T٣١	T٣٢	T٣٤	T٤١	T٤٢	T٤٣
Estimated Turning Movements	٢٠٤	٣٧٢	٢٠٠	٧٣	١٢٤	٣٤٥	٣٤٣	١٩٣	٧٩	١٣٢	٢٧٣	٨١
Observed Turning Movements	١٩٠	٣٧٦	٢١١	١٠٨	١١٦	٣١٧	٣٢٤	١٩٥	٩٥	١١٥	٢٨٥	٨٥
Difference	١٤	٤_	١١_	٣٥_	٨	٢٨	١٩	٢_	١٦_	١٧	١٢_	٤_

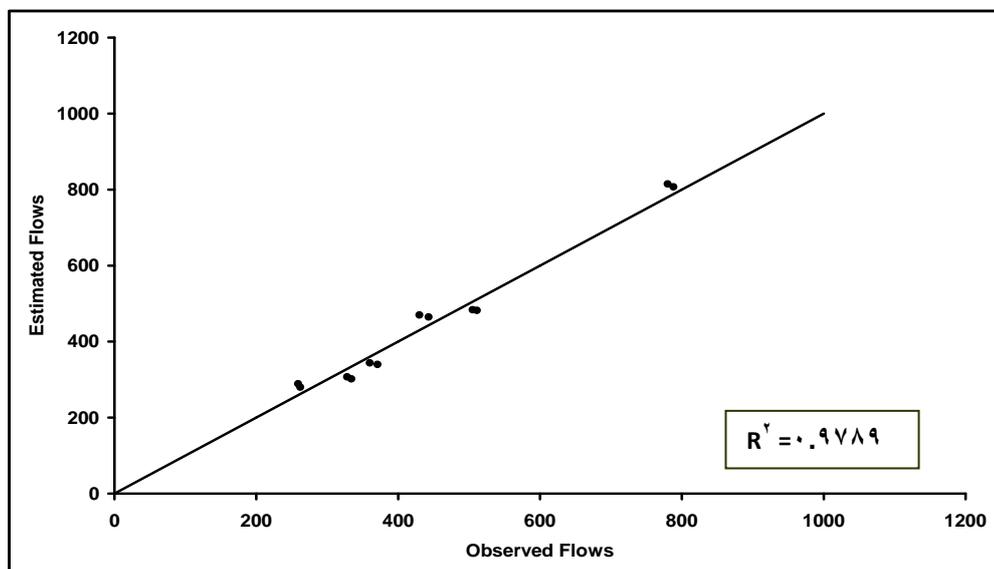Tij: Turning movements from i to j

$R^{٢} = ٠.٩٧٦٨$
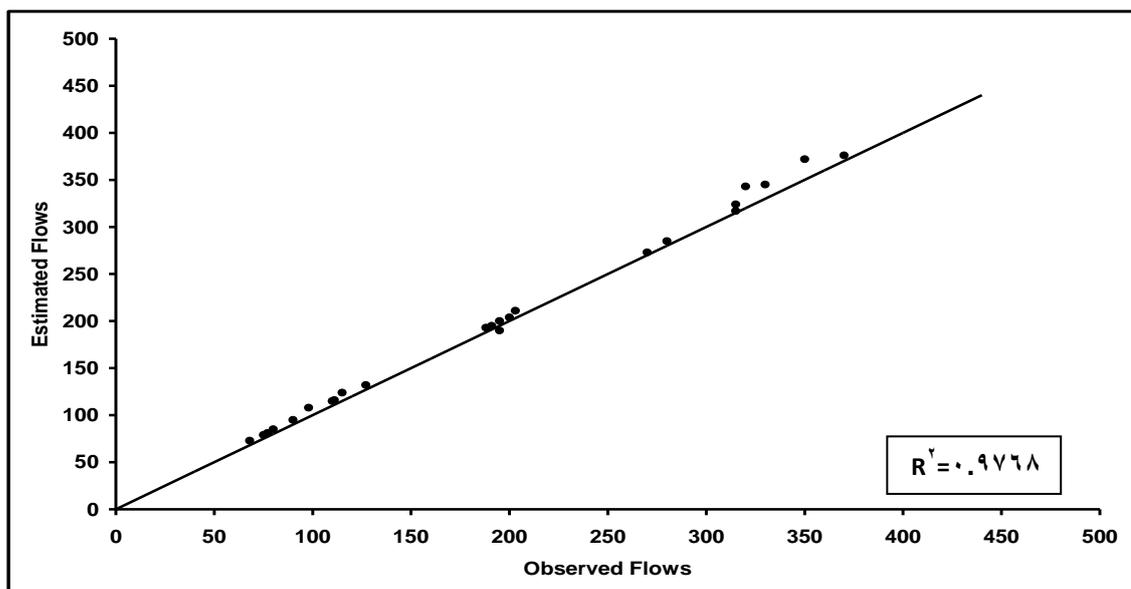
Figure (٤- ٦) Correspondence of Observed and Estimated Turning Flows in Al-Jamia Intersection

<u>٤.٦.٣</u> Accuracy of Estimation in Al-Aum Intersection

In Al-Aum intersection, outdate total flow is (٢٤١٤) veh/hr and recent total flow is (٣٠٠٠) veh/hr, it leads to the differences in the values of errors as noticed from Table (٤-١٧). From scanning Figure (٤-٧) that shows more accurate and correlation factor was ٠.٩٩. The figure explored accuracy of estimates in Al-Aum intersection.

Table (٤-١٧) Estimated Turning Flows in Al-Aum Intersection Using B. Model

Turning Movements	T١٢	T١٣	T١٤	T٢١	T٢٣	T٢٤	T٣١	T٣٢	T٣٤	T٤١	T٤٢	T٤٣
Estimated Turning Movements	١٤٦	٢٥١	٤٠٠	١٣٥	٢٥	٤٧٩	١١٤	١٩	٣٥٢	٣٩٢	٢٩٩	٣٨٩
Observed Turning Movements	١٤٠	٢٥٠	٤٠٦	١٣٦	٣٥	٤٦٨	١٠٩	٢٠	٣٥٦	٣٩٦	٣٠٤	٣٨٠
Difference	٦	١	-٦	-١	-١٠	١١	٥	-١	-٤	-٤	-٥	٩

Tij: Turning movements from i to j
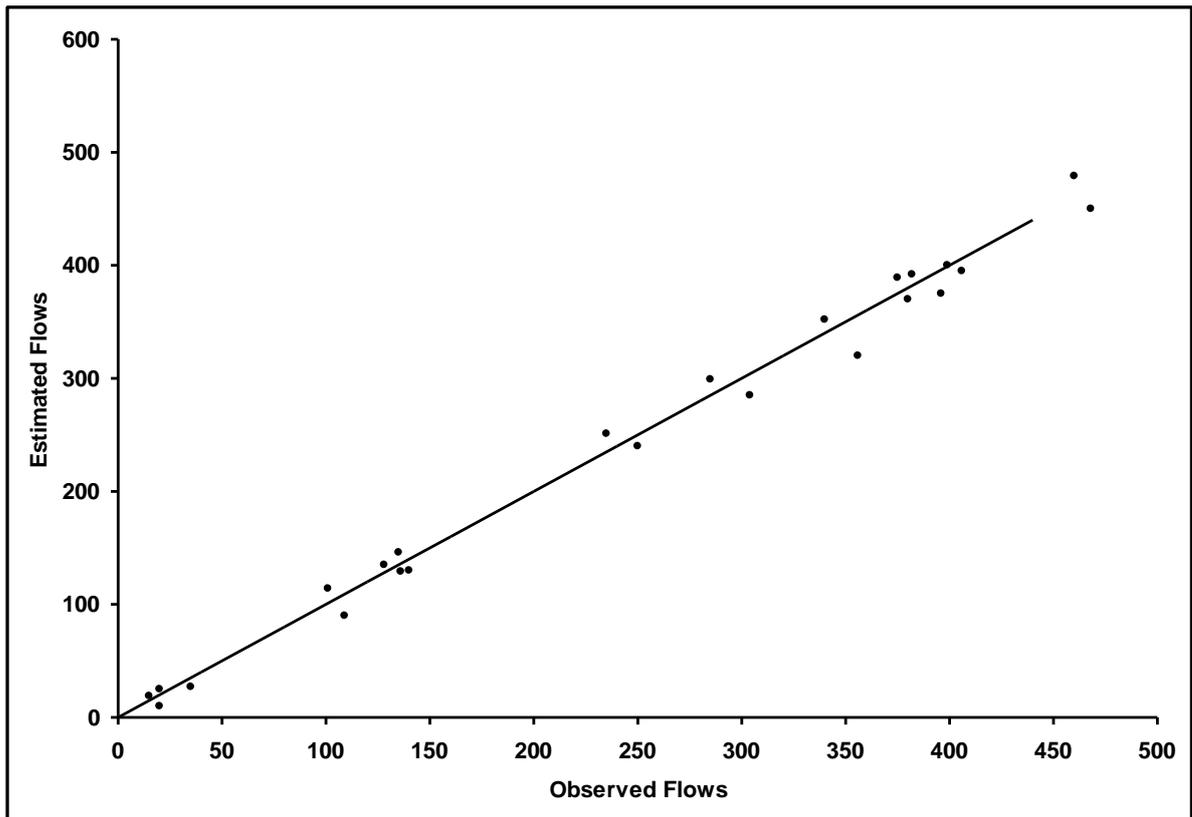
Figure (٤- ٧) Correspondence of Observed and Estimated Flows in Al-Aum Intersection

٤.٦.٤ Accuracy of Estimation in Bab-Al-Mashhed Intersection

The errors in the estimates obtained in Bab Al-Mashhed intersection are computed as shown in Table (٤-١٨). The correlation factor was ٠.٩٩ and symmetrical distribution points around the bisector refer to be more accurate from this method in Bab-Al-Mashhed intersection as shown in Figure (٤-٨).

Table (٤-١٨) Estimated Turning Flows in Bab-Al-Mashhed Intersection Using B. Model

$R^٢=٠.٩٩٨٤$

Turning Movements	T12	T13	T14	T21	T23	T24	T31	T32	T34	T41	T42	T43
Estimated Turning Movements	190	26	151	197	16	479	64	72	20	113	426	44
Observed Turning Movements	184	24	158	201	22	469	58	73	25	114	431	40
Difference	6	2	-7	-4	-6	10	6	-1	-5	-1	-5	4

Tij: Turning movements from i to j
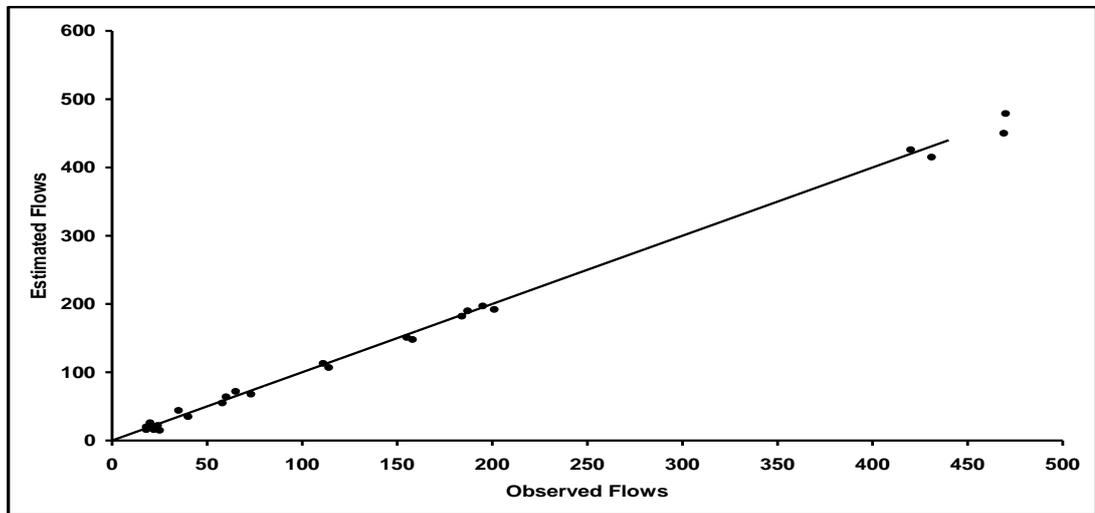
Figure (4-8) Correspondence of Observed and Estimated Flows in Bab- Al-Mashhed Intersection

Finally, residual analysis must be done to show the goodness of prediction when it was assume that the residual should be normal distributed, have independence with mean equal to zero, and variance equal to σ_e^2 **[Kinnear and Gray, ١٩٩٥]**.

The normal probability plot, shows a roughly normal curve with the observed cumulative probabilities of occurrence of the standardized residuals on the X axis, and of estimated normal probabilities of accurrence on the Y axis, such that a ٤٥- degree line will appear when observed conforms to normally excepted. Ideally, the points should lie along the diagonal. Then the zero value of mean could be shown by Figures (٤-٩), (٤-١٠), (٤-١١) and (٤-١٢) to explain the normality of residuals along the diagonal in four study intersections.

The final plot in Figures (٤-١٣), (٤-١٤), (٤-١٥) and (٤-١٦) is the scatter plot of estimated value against residual. It shows no pattern, thereby confirming that the assumptions of linearity and homogeneity of variance have been met.
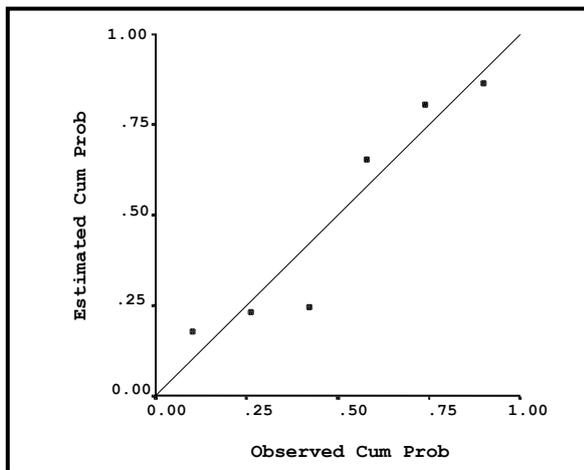
Figure (٤-٩) Cumulative Probability

Plot of Standardized Residua

in Jahtar Intersection
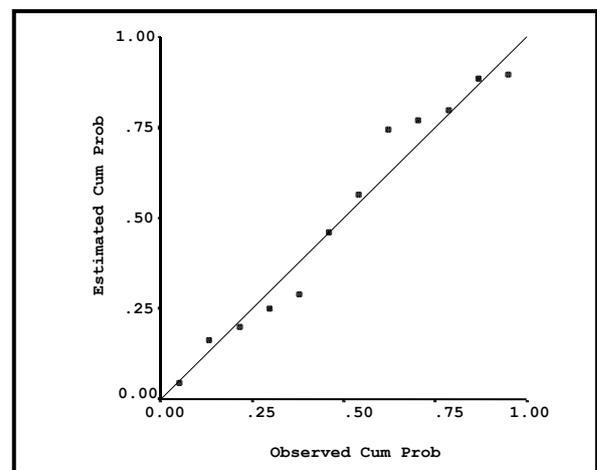
Figure (٤-١٠) Cumulative Probability

Plot of Standardized Residua

in Al-Jamia Intersection

In order to check the accuracy of the standard errors from the Bayesian model with the distribution of the errors in estimates, regression analysis was carried out using SPSS statistical program version "١١" to determine the relationship between the standard deviation of the actual error distribution, Y, and the corresponding estimated standard error, X produced by the Bayesian model. The results of this analysis for three outdate statistical years are shown in Figures (٤-٣٠), (٤-٣١) and (٤-٣٢).
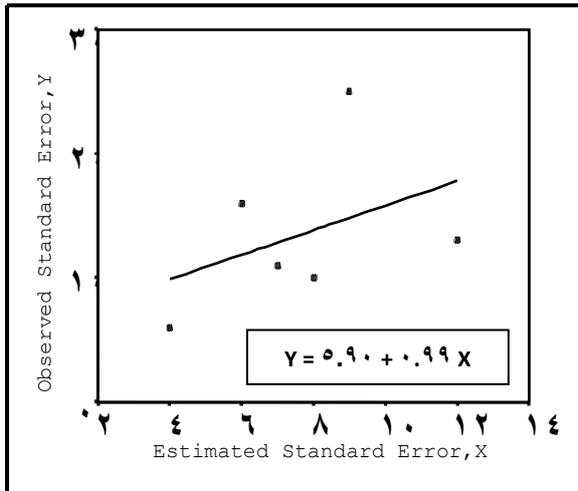
Figure (٤-٣٠) Relationship between the Observed Standard Errors and the Estimated Standard Errors Produced by the Modified Bayesian Model [Outdate Flows
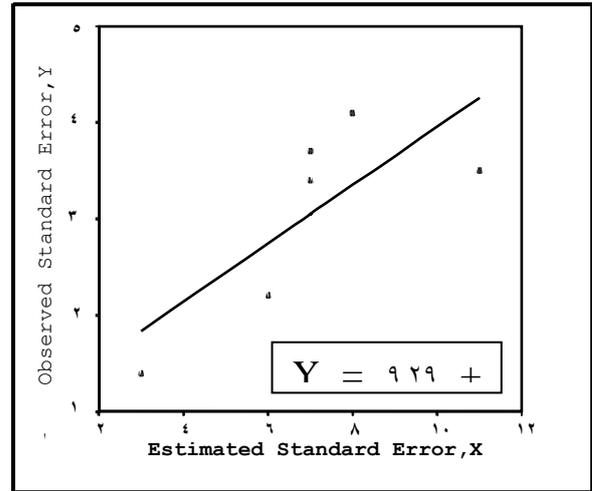
Figure (٤-٣١) Relationship between the Observed Standard Errors and the Estimated Standard Errors Produced by the Modified Bayesian Model [Outdate Flows in ١١١٨]
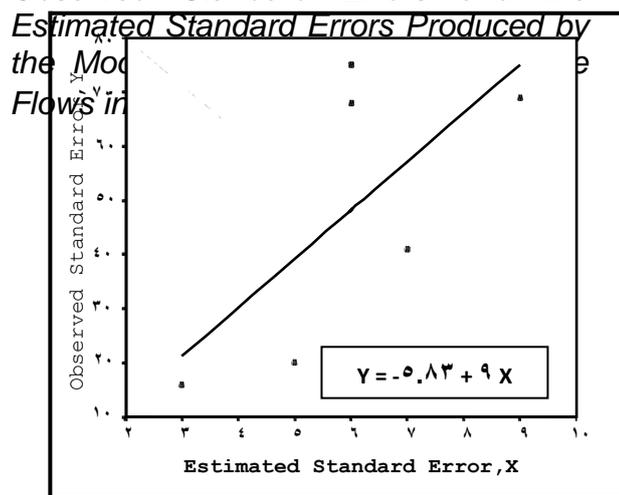
Figure (٤-٣٢) Relationship between the Observed Standard Errors and the Estimated Standard Errors Produced by the Mod... ...e Flows in ...
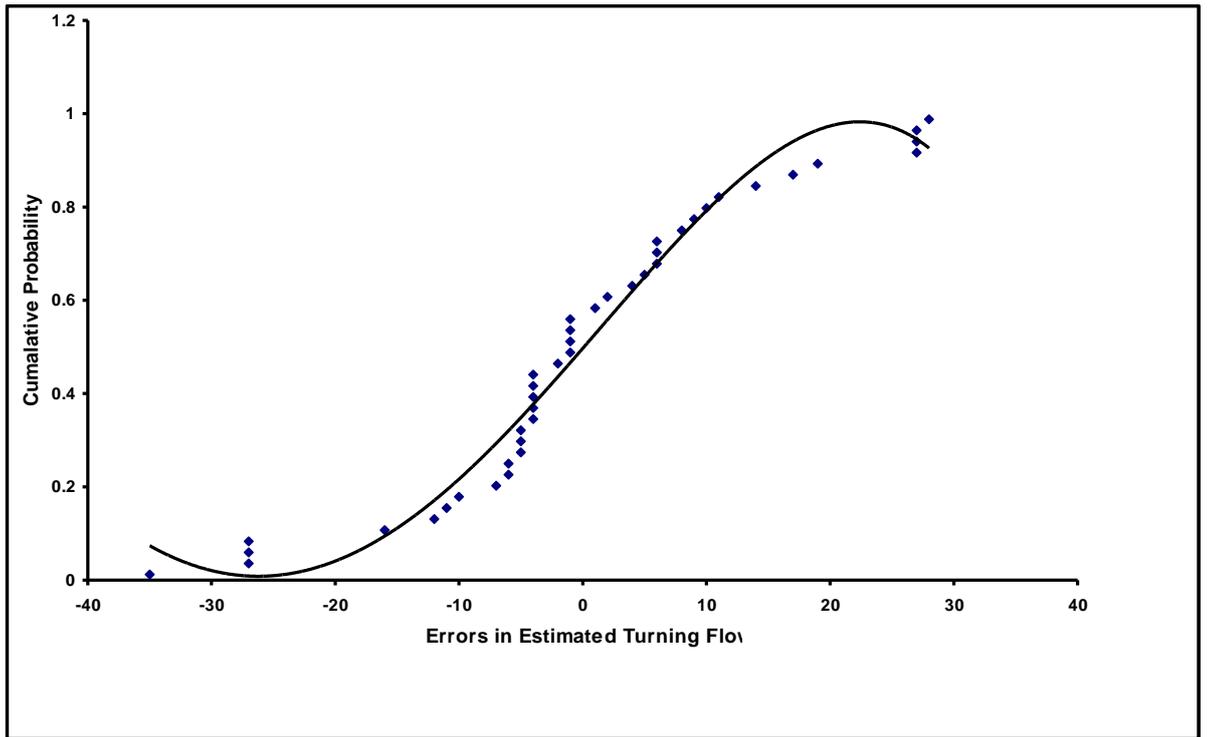
Figure (٤- ٢٠) Distribution of Errors for Study Intersections in Hilla

City (Outdate Flows in (٢٠٠١)

An outdate flows in ١٩٩٨ was used in Bayesian model application for study intersections, the errors distribution and the errors of flow grouping for this year is shown in Tables (٤- ٢١) and (٤- ٢٢) and Figures (٤- ٢٢) and (٤- ٢٣) respectively.

Table (٤- ٢٣) and Figure (٤- ٢٤) refers to errors distribution in estimation of turning movements by using Bayesian model with priori flows from ١٩٩٤, and Table (٤- ٢٤) and Figure (٤- ٢٥) represent distribution the errors of flow grouping in study intersections.

Table (٤-٢١) Distribution of Errors for Study Intersections in Hilla City [Outdate Flow ١٩٩٨, Recent flow ٢٠٠٣]

Number	Cumulative Probability	Errors	Number	Cumulative Probability	Errors
١	٠.٥ / ٤٢	٦٤-	٢٢	٢١.٥ / ٤٢	٠
٢	١.٥ / ٤٢	٦٢-	٢٣	٢٢.٥ / ٤٢	١
٣	٢.٥ / ٤٢	٥٣-	٢٤	٢٣.٥ / ٤٢	٣
٤	٣.٥ / ٤٢	٥١-	٢٥	٢٤.٥ / ٤٢	٣
٥	٤.٥ / ٤٢	٣٤-	٢٦	٢٥.٥ / ٤٢	٥
٦	٥.٥ / ٤٢	٢٩-	٢٧	٢٦.٥ / ٤٢	٥

٧	٦.٥/٤٢	ـ١٩	٢٨	٢٧.٥/٤٢	٥
٨	٧.٥/٤٢	ـ١٩	٢٩	٢٨.٥/٤٢	٥
٩	٨.٥/٤٢	ـ١٦	٣٠	٢٩.٥/٤٢	٦
١٠	٩.٥/٤٢	ـ١٤	٣١	٣٠.٥/٤٢	٨
١١	١٠.٥/٤٢	ـ١٣	٣٢	٣١.٥/٤٢	١٢
١٢	١١.٥/٤٢	ـ١٠	٣٣	٣٢.٥/٤٢	١٨
١٣	١٢.٥/٤٢	ـ٩	٣٤	٣٣.٥/٤٢	١٨
١٤	١٣.٥/٤٢	ـ٨	٣٥	٣٤.٥/٤٢	٢٢
١٥	١٤.٥/٤٢	ـ٦	٣٦	٣٥.٥/٤٢	٢٧
١٦	١٥.٥/٤٢	ـ٦	٣٧	٣٦.٥/٤٢	٣٧
١٧	١٦.٥/٤٢	ـ٥	٣٨	٣٧.٥/٤٢	٤١
١٨	١٧.٥/٤٢	ـ٥	٣٩	٣٨.٥/٤٢	٤٤
١٩	١٨.٥/٤٢	ـ٥	٤٠	٣٩.٥/٤٢	٤٨
٢٠	١٩.٥/٤٢	ـ٥	٤١	٤٠.٥/٤٢	٤٩
٢١	٢٠.٥/٤٢	ـ٢	٤٢	٤١.٥/٤٢	٧٢

Table (٤-٢٢) Distribution of Errors in the Estimated of Unclassified Flows
Obtained using B.Model [An Outdate Flows in ١٩٩٨]

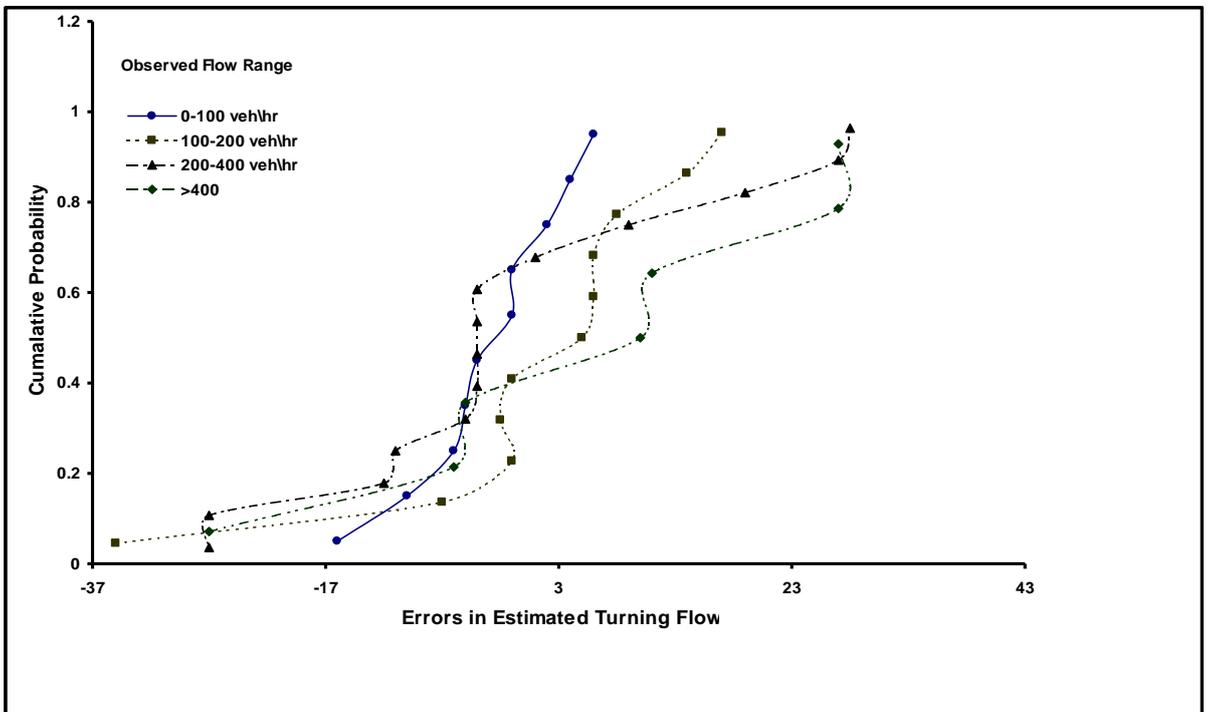| No.	Observed Flows ٠-١٠٠ veh/hr ≤١	Cum. Pro ١	Errors	Observed Flows ١٠٠-٢٠٠ veh/hr	Cum. Pro ٢	Errors	Observed Flows ٢٠٠-٤٠٠ veh/hr	Cum. Pro ٣	Errors	Observed Flows >٤٠٠ veh/hr	Cum. Pro ٤	Errors
١	٣٥	٠.٥/١٠	-١٩	١٠٨	٠.٥/١١	-٥١	٣٩٦	٠.٥/١٤	-٦٤	٤٦٨	٠.٥/٧	-١٠
٢	٢٥	١.٥/١٠	-١٦	١٩٥	١.٥/١١	-١٩	٢١١	١.٥/١٤	-٦٢	٤٤٣	١.٥/٧	-٥
٣	٢٢	٢.٥/١٠	-٦	١٤٠	٢.٥/١١	-١٣	٢٨٥	٢.٥/١٤	-٥٣	٧٨٨	٢.٥/٧	-٥
٤	٧٣	٣.٥/١٠	-٦	١١٤	٣.٥/١١	-٨	٣٥٦	٣.٥/١٤	-٣٤	١٨٤	٣.٥/٧	٣
٥	٢٠	٤.٥/١٠	-٥	١٥٨	٤.٥/١١	-٢	٢٥٠	٤.٥/١٤	-٢٩	٥١١	٤.٥/٧	٥
٦	٢٤	٥.٥/١٠	٠	١١٦	٥.٥/١١	١	٢٠١	٥.٥/١٤	-١٤	٤٦٩	٥.٥/٧	١٨
٧	٤٠	٦.٥/١٠	٦	١٨٤	٦.٥/١١	٣	٣٧٦	٦.٥/١٤	-٩	٤٠٦	٦.٥/٧	٤١
٨	٨٥	٧.٥/١٠	٨	١٣٦	٧.٥/١١	٢٧	٢٦٢	٧.٥/١٤	-٥			
٩	٩٥	٨.٥/١٠	١٢	١٠٩	٨.٥/١١	٣٧	٣٧١	٨.٥/١٤	٥			
١٠	٥٨	٩.٥/١٠	٢٢	١١٥	٩.٥/١١	٤٤	٣٣٤	٩.٥/١٤	٥			
١١				١٩٠	١٠.٥/١١	٧٢	٣٢٤	١٠.٥/١٤	٥			
١٢							٤٦٩	١١.٥/١٤	١٨			
١٣							٣٨٠	١٢.٥/١٤	٤٨			
١٤							٣١٧	١٣.٥/١٤	٤٩			

Figure (٤-٢٢) Distribution of Errors for Study Intersections in Hilla City (Outdate

Flows in ١٩٩٨)

Figure (٤-٢٣) Distribution of the Errors in the Estimates of Flow

Obtained using Bayesian Model (Outdate Flows on ١٩٩٨)

Table (٤-٢٣) Distribution of Errors for Study Intersections in Hilla City [Outdate Flow ١٩٩٤, Recent flow ٢٠٠٣]

Number	Cumulative Probability	Errors	Number	Cumulative Probability	Errors
١	٠.٥/٤٢	.٨٧	٢٢	٢١.٥/٤٢	١
٢	١.٥/٤٢	.٨٥	٢٣	٢٢.٥/٤٢	٣
٣	٢.٥/٤٢	.٨٥	٢٤	٢٣.٥/٤٢	٤
٤	٣.٥/٤٢	.٨٥	٢٥	٢٤.٥/٤٢	٥
٥	٤.٥/٤٢	.٧٥	٢٦	٢٥.٥/٤٢	٥
٦	٥.٥/٤٢	.٧١	٢٧	٢٦.٥/٤٢	٧
٧	٦.٥/٤٢	.٥٤	٢٨	٢٧.٥/٤٢	٨
٨	٧.٥/٤٢	.٥٢	٢٩	٢٨.٥/٤٢	١٠
٩	٨.٥/٤٢	.٣٤	٣٠	٢٩.٥/٤٢	١٢
١٠	٩.٥/٤٢	.٢٥	٣١	٣٠.٥/٤٢	١٣
١١	١٠.٥/٤٢	.٢٣	٣٢	٣١.٥/٤٢	٢٤
١٢	١١.٥/٤٢	.١٨	٣٣	٣٢.٥/٤٢	٣٠
١٣	١٢.٥/٤٢	.١٧	٣٤	٣٣.٥/٤٢	٣٤
١٤	١٣.٥/٤٢	.١٥	٣٥	٣٤.٥/٤٢	٤٣
١٥	١٤.٥/٤٢	.١٣	٣٦	٣٥.٥/٤٢	٨٠
١٦	١٥.٥/٤٢	.١٢	٣٧	٣٦.٥/٤٢	٨٠
١٧	١٦.٥/٤٢	.٩	٣٨	٣٧.٥/٤٢	٨٦

١٨	١٧.٥/٤٢	٩-	٣٩	٣٨.٥/٤٢	٨٥
١٩	١٨.٥/٤٢	٧-	٤٠	٣٩.٥/٤٢	٨٥
٢٠	١٩.٥/٤٢	٦-	٤١	٤٠.٥/٤٢	٨٥
٢١	٢٠.٥/٤٢	٤-	٤٢	٤١.٥/٤٢	٨٦

Figure (٤-٢٤) Distribution ٠f Errors for Study Intersections in Hilla City (Outdate Flows in ١٩٩٤)

Table (٤-٢٤) Distribution of Errors in the Estimated of Unclassified Flows Obtained using B.Model [An Outdate Flows in ١٩٩٤]

No.	Observed Flows ٠-١٠٠ veh/hr ١≥	Cum. Pro ١	Errors	Observed Flows ١٠٠-٢٠٠ veh/hr	Cum. Pro ٢	Errors	Observed Flows ٢٠٠-٤٠٠ veh/hr	Cum. Pro ٣	Errors	Observed Flows >٤٠٠ veh/hr	Cum. Pro ٤	Errors

١	٧٣	٠.٥/١٠	-١٧	١٠٨	٠.٥/٩	-٣٤	٢٨٥	٠.٥/١٦	-٨٧	٥١١	٠.٥/٧	-٨٥
٢	٢٥	١.٥/١٠	-١٥	١٥٨	١.٥/٩	-١٨	٣٧١	١.٥/١٦	-٨٥	٤٠٦	١.٥/٧	-٦
٣	٣٥	٢.٥/١٠	-١٢	١١٤	٢.٥/٩	-٧	٣٣٤	٢.٥/١٦	-٨٥	٤٦٨	٢.٥/٧	٣
٤	٢٢	٣.٥/١٠	-٩	١٠٩	٣.٥/٩	٥	٢٥٠	٣.٥/١٦	-٧٥	٤٣١	٣.٥/٧	١٢
٥	٢٠	٤.٥/١٠	-٩	١٨٤	٤.٥/٩	٥	٣٠٤	٤.٥/١٦	-٧١	٤٦٩	٤.٥/٧	٣٤
٦	٤٠	٥.٥/١٠	-٤	١٣٦	٥.٥/٩	٧	٢١١	٥.٥/١٦	-٥٤	٤٤٣	٥.٥/٧	٨٥
٧	٨٥	٦.٥/١٠	١	١٩٥	٦.٥/٩	٨	٣٢٤	٦.٥/١٦	-٥٢	٧٨٨	٦.٥/٧	٨٥
٨	٢٤	٧.٥/١٠	١٣	١١٦	٧.٥/٩	٢٤	٣٧٦	٧.٥/١٦	-٢٥			
٩	٥٨	٨.٥/١٠	٣٠	١١٥	٨.٥/٩	٨٦	٢٠١	٨.٥/١٦	-٢٣			
١٠	٩٥	٩.٥/١٠	٤٣				٣٩٦	٩.٥/١٦	-١٣			
١١							٣٠٦	١٠.٥/١٦	٤			
١٢							٣١٧	١١.٥/١٦	١٠			
١٣							٢٩٠	١٢.٥/١٦	٨٠			
١٤							٢٤٠	١٣.٥/١٦	٨٠			
١٥							٣٨٠	١٤.٥/١٦	٨٦			
١٦							٢٦٢	١٥.٥/١٦	٨٥			

Figure (٤-٢٥) Distribution of the Errors in the Estimates of Flow

Obtained using Bayesian Model (Outdate Flows on ١٩٩٤)

T-test was used to examine whether is a significance difference between turning movements. Results showed that the t-calculated was less than t-tabulated at the ٥٪ level of significance in outdate turning movements of ٢٠٠١ as shown in Table (٤-٢٥). Another examination was made for estimated and observed flows when used an outdate turning movements from ١٩٩٨ and ١٩٩٤, and the results showed the t-calculated was less than t-tabulated in left and through movements and more than this value in right turning movements in outdate statistical for ١٩٩٨. T- tabulated in left and right turning movements for ١٩٩٤ was less than t-calculated. Results indicate that there is no significance difference between estimated and observed turning movements when used an outdate statistical in ٢٠٠١, and there is a significant difference in right turn in outdate statistical from ١٩٩٨, also in left and right turning movements in ١٩٩٤.

Table (٤-٢٥) T-Test results between Estimated and Observed Flows

An Outdate Year	Type Movements	T-Calculated	T-Tabulated at the ٥٪
٢٠٠١	L	٠.٠٨	٢.١٦
	TH	٠.٠٧	٢.١٦
	R	٠.١٧	٢.١٦

		١.١٥	٢.١٦
١٩٩٨	L	١.١٥	٢.١٦
	TH	١.٩٧	٢.١٦
	R	٢.١٩	٢.١٦
١٩٩٤	L	٢.٢٣	٢.١٦
	TH	١.٩٨	٢.١٦
	R	٢.٢٧	٢.١٦

Table (٥- ١): Ishtar Intersection, Comparison between the Evaluation under Current and Estimation Flows

rrent Flow						**Estimation Flow**					
ne ov.	Max.(v/c) ratio	App.D (sec/veh)	L.O.S	Int.D (sec/veh)	L.O.S	Max.(v/c) ratio	App.D (sec/veh)	L.O.S	Int.D (sec/veh)	L.O.S
		٨٣.٨	F				٦٥.٨	E		
B	٨١	٤٢.٤	D	٦١.٢	E	٩٢	٤٣.٨	D	٥٤.١	D
		٣٢.١	C				٣٤.٧	C		

Table (٥- ٢): Al- Jamia Intersection, Comparison between the Evaluation under Current and Estimation Flows

rrent Flow						**Estimation Flow**					
ne ov.	Max.(v/c) ratio	App.D	L.O.S	Int.D	L.O.S	Max.(v/c) ratio	App.D	L.O.S	Int.D	L.O.S

		(sec/veh)		(sec/veh)			(sec/veh)		(sec/veh)	
B		٣٨.٤	D				٤٤.٩	D		
B	٩٥	١٠٤.١	F	٦٥.١	E	٩٩	٨٤.٨	F	٥٥.٣	E
B		٦٧.٨	E				٥٠.١	D		
B		٤٦.٩	D				٤٤.١	D		

Table (٥-٣): Al- Aum Intersection, Comparison between the Evaluation under Current and Estimation Flows

	Current Flow					Estimation Flow				
Lane Mov.	Max.(v/c) ratio	App.D (sec/veh)	L.O.S	Int.D (sec/veh)	L.O.S	Max.(v/c) ratio	App.D (sec/veh)	L.O.S	Int.D (sec/veh)	L.O.S
B		٢٥٦.٣	F				٢١١.٧	F		
VB		٤٧.٧	D				٤٤.٢	D		
B	٢٤٤	٩١٧	F	٣٣٥.٢	F	١٩٣	٩٠٤.٦	F	٣٠٨	F
B		١٣٣.٦	F				١١١.٧	F		

Table (٥-٤): Bab-Al-Mashhed Intersection, Comparison between the Evaluation under Current and Estimation Flows

	Current Flow					Estimation Flow				
Lane Mov.	Max.(v/c) ratio	App.D (sec/veh)	L.O.S	Int.D (sec/veh)	L.O.S	Max.(v/c) ratio	App.D (sec/veh)	L.O.S	Int.D (sec/veh)	L.O.S
EB		٣٩.٣	D				٣٥.٠	C		
VB	١٣٦	١٧٦.٥	F	٩١	F	١٠٧	١٧٤.٥	F	٩٠.٨	F
NB		٤٣.٩	D				٤٢.٨	D		
B		٤٨.٧	D				٤٢.٤	D		

Table (٥-٥) *Measures of Effectiveness Produced by TRANSYT-٧F-Release Intersections Under A.M. Peak Period for Current Traffic Flow*

e of ction	Cycle Length (sec)	No. of Over saturated Links	Max.(v/c) Ratio	Average Delay (sec/veh)	Total Uniform Stops		Total Fuel Consumption (lit/hr)	Dissu Index
					veh/hr	%		
ar	٩٩	-	٩٥*	٥٦.٩	٢٢١٤	٩٣	١٥١	٥٦
mia	١٠٨	-	٨٨	٥٣.٩	٣٠٤٤	٩١	٢٠٢	٧٤.
um	٩٦	٢	١١٧*	٢٣٠.٦	٢٥٨٥	٩٥	٥٣٤	٢١
-Al hed	١٠٥	٢	٩٨*	٧٠.٤	٢٨١٤	٩١	٢٢٦	٨٦.

Table (٥-٦) *Measures of Effectiveness Produced by TRANSYT-٧F-Release Intersections for (Current Traffic Flow Under P.M. Peak Period and Estimating F*

Over saturated

≥

	Turning Movements	Cycle Length (sec)	No. of Over saturated Links	Max.(v/c) Ratio	Average Delay (sec/veh)	Total Uniform Stops		Total Fuel Consumption (lit/hr)	Dissutili Index(D
						veh/hr	%		
	Current Flows	٩٩	٣	٩٦*	٥٨.٩	٢٩٢٨	٩٤	٢٠٤	٧٦.٩٧
	Estimating Flows	٩٩	١	٩٧*	٥١.٦	٢٩٧٨	٩٢	١٨٩	٧١.٦٨
	Current Flows	١٠٨	-	٩٠	٥٥.١	٣٣٧١	٩١	٢٢٧	٨٤.٠٣
	Estimating Flows	١٠٨	-	٨٧	٤٧.٩	٢٦١٨	٨٨	١٦٤	٥٩.٨٥
	Current Flows	٩٦	٣	١٤٦*	٣٧٩.٤	٢٩٣٢	٩٤	٩٧٣	٣٦٦.٣
	Estimating Flows	٩٦	٣	١٣٥*	٣٧٣.٩	٣٤٧٨	٩٥	١١٢٤	٤٢٥.٦

Current Flows	١٠٥	٣	١٠١*	٨٢.١	٣١٥٩	٩٢	٢٨٣	١٠٩.٣
Estimating Flows	١٠٥	٣	١٠٢*	٨٦.٧	٣١٨٣	٩٢	٢٩٦	١١٥.٢

*Over Saturated

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                          ┌─────────────────────────────────────┐
                          │  Improvement of Traffic Flow for Isolated │
                          │              Intersection                 │
                          └─────────────────────────────────────┘
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Improvement No.١	Improvement No.٢	Improvement No.٣	Improvement No.٤	Improven
"Best Phase"	"Best Cycle Length"	"Trucks Preventing"	"Change in Phase Sequence"	"Chan Geometri

Improvement No.٥.١	Improvement No
"Increasing Number of Lanes"	"Convert Four-Ar Three-Arm Interse

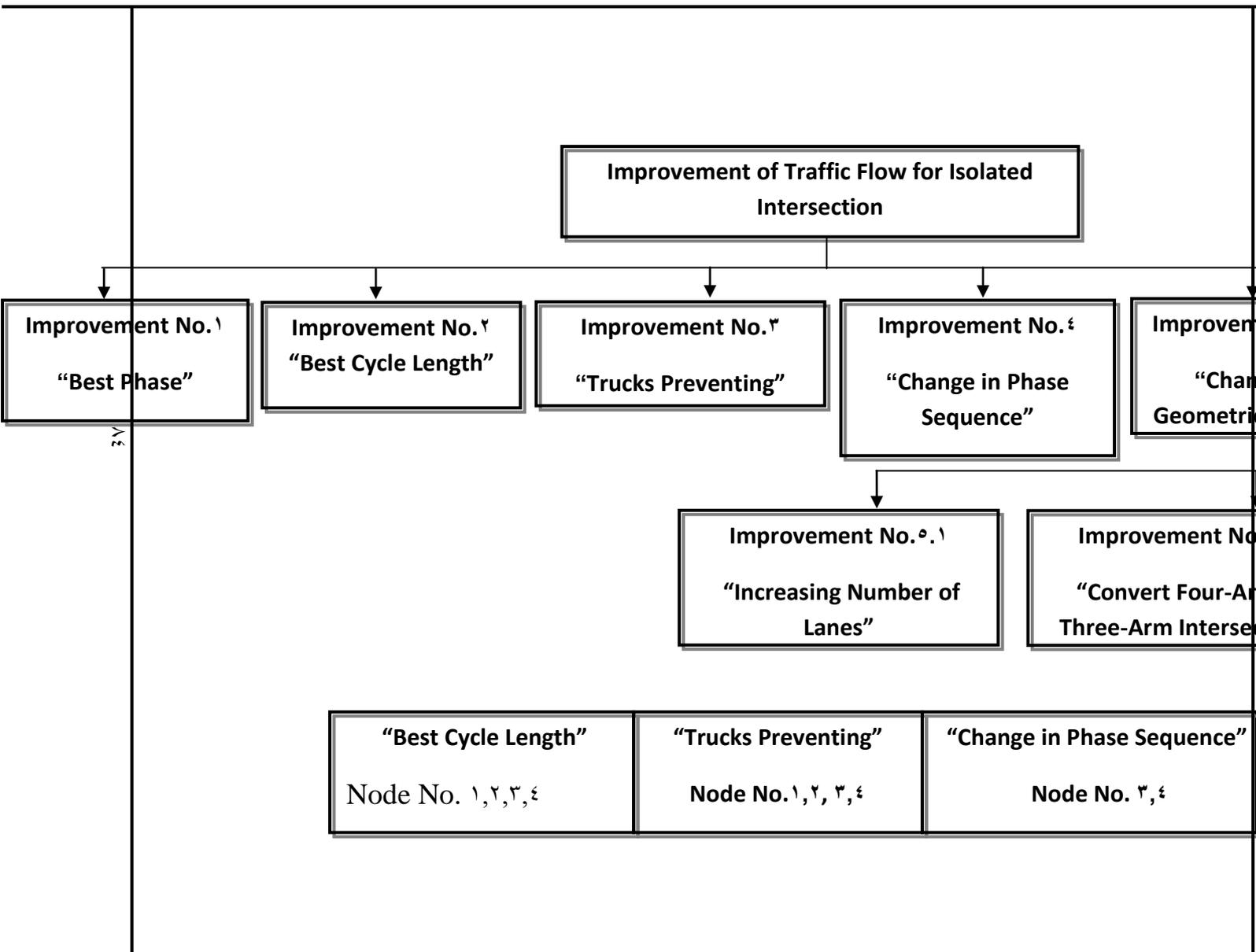| "Best Cycle Length"	"Trucks Preventing"	"Change in Phase Sequence"
Node No. ١,٢,٣,٤	Node No.١,٢, ٣,٤	Node No. ٣,٤

Figure (٥-١) Schematic Representation for Improvement of Traffic Flo

Table (٥-٧) Measures of Effectiveness Produced by TRANSYT-٧F-Release ٩.٤ (٢٠٠٢) for Isolate...

e of ction	Cycle Length (sec)	No. of Over saturated Links	Max.(v/c) Ratio	Average Delay (sec/veh)	Total Uniform Stops		Total Fuel Consumption (lit/hr)	Dissu... Index
					veh/hr	%		
ar	٩٩	-	٩٣	٤٨.١	٢٨٨٠	٩٢	١٧٨	٦٥.
mia	١٠٨	-	٨٦	٥٠.٤	٣٣٣١	٩٠	٢١٣	٧٨.
um	٩٦	٢	١٤١*	٣٢٥.٨	٢٩٠٩	٩٣	٨٤٤	٣١/
-Al hed	١٠٥	٢	٩٧*	٦١.٤	٣١١٥	٩١	٢٢٧	٨٥.

*Over Saturated

Table (٥-٨) The Existing and The Best Cycle Length Selected

Node No.	The Existing Cycle Length (sec)	The Best Cycle Length Selected (sec)
١	٩٩	١٢٠
٢	١٠٨	١١٠
٣	٩٦	١٢٠
٤	١٠٥	١٢٠

Table (٥-٩) Measures of Effectiveness Produced by TRANSYT-٧F-Release ٩.٤ (٢٠٠٢) for Isolate...

e of ction	Cycle Length (sec)	No. of Over saturated Links	Max.(v/c) Ratio	Average Delay (sec/veh)	Total Uniform Stops		Total Fuel Consumption (lit/hr)	Dissu... Index
					veh/hr	%		

ar	١٢٠	-	٩١	٥٠٠٥	٢٨٥٨	٩١	١٨١	٦٦.
mia	١١٠	-	٨٦	٥٠٠٩	٣٣٣٠	٩٠	٢١٤	٧٨.
um	١٢٠	٤	١١٦*	٢٠٨٠٣	٢٩٧١	٩٥	٥٦٢	٢٢.

* Over Saturated

-Al hed	١٢٠	-	٩١	٥٤٠٩	٣٠٧٩	٩٠	٢٠٩	٧٦.

Table (٥-١٠) Measures of Effectiveness Produced by TRANSYT-٧F-Release ٩.٤ (٢٠٠٢) for Isolate

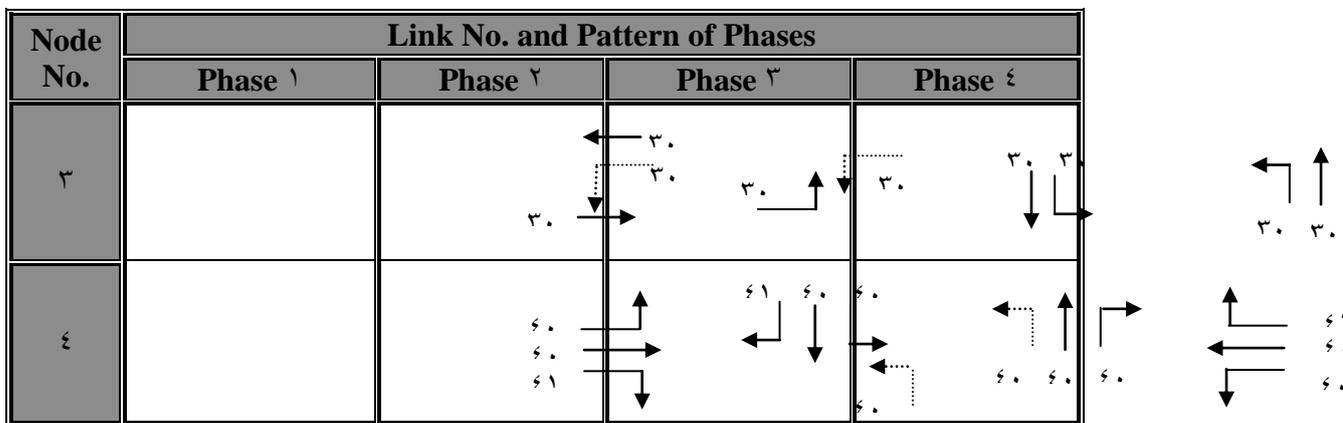| e of ction	Cycle Length (sec)	No. of Over Saturated Links	Max.(v/c) Ratio	Average Delay (sec/veh)	Total Uniform Stops		Total Fuel Consumption (lit/hr)	Dissu Index
					veh/hr	%		
ar	١٢٠	-	٨٩	٤٧٠٤	٢٧٤٤	٩٠	١٧٠	٦١.
mia	١١٠	-	٨٣	٤٩٠٢	٣٢٢١	٨٩	٢٠٤	٧٤.
um	١٢٠	٤	١١٣*	١٧٧٠٤	٢٨٨٣	٩٥	٤٧٤	١٨
-Al hed	١٢٠	-	٨٩	٥٢٠٧	٣٠٠٢	٨٩	١٩٩	٧٢.

* Over Saturated

١٤٣

Figure (٥-٢) Phase Sequence under Improvement No. ٤

Table (٥-١١) Measures of Effectiveness Produced by TRANSYT-٧F-Release ٩.٤ (٢٠٠٢) for Isolate

e of ction	Cycle Length (sec)	No. of Over Saturated Links	Max.(v/c) Ratio	Average Delay (sec/veh)	Total Uniform Stops		Total Fuel Consumption (lit/h)	Dissu Index
					veh/h	%		
um	١٢٠	-	٧٣	٤٦.٨	٢٧٢٨	٨٧	١٦٩	٦٠.
-Al hed	١٢٠	-	٨٧	٤٩.٩	٣٠٣٠	٨٨	١٩٥	٧٠.

Table (٥-١٣) Measures of Effectiveness Produced by TRANSYT-٧F-Release ٩.٤ (٢٠٠٢) for Isolated

e of ction	Cycle Length (sec)	No. of Over Saturated Links	Max.(v/c) Ratio	Average Delay (sec/veh)	Total Uniform Stops		Total Fuel Consumption (lit/hr)	Dissu Index
					veh/hr	%		
ar	١٢٠	-	٦٨	٣٧.٣	٢٥٩٣	٨٣	١٤٤	٥.
mia	١١٠	-	٨٠	٤٦.٤	٣٢٨٤	٨٨	٢٠١	٧٢
um	١٢٠	-	٧٣	٤٧.٢	٢٧٤٣	٨٨	١٧٠	٦١.

Table (٥-١٤) Measures of Effectiveness Produced by TRANSYT-٧F-Release ٩.٤ (٢٠٠٢) for Isolate

e of ction	Cycle Length (sec)	No. of Over Saturated Links	Max.(v/c) Ratio	Average Delay (sec/veh)	Total Uniform Stops		Total Fuel Consumption (lit/hr)	Dissu Index
					veh/hr	%		
-Al hed	٧٥	-	٨٤	٣١.١	٢٧٣٣	٨٥	١٣٤	٤٩.

Table (٥-١٥) Measures of Effectiveness Produced by TRANSYT-٧F-Release ٩.٤ (٢٠٠٢) for Isolate

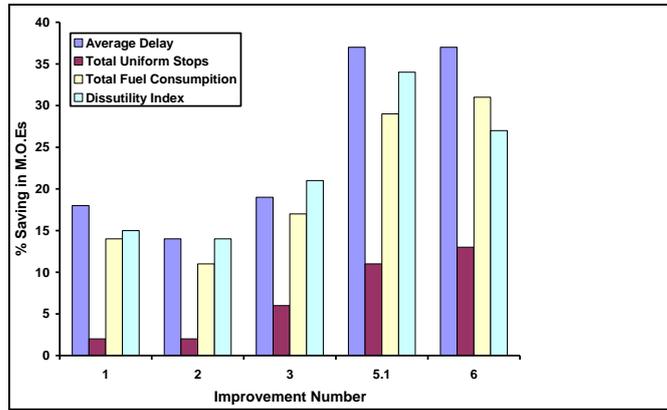| e of ction	Cycle Length (sec)	No. of Over Saturated Links	Max.(v/c) Ratio	Average Delay (sec/veh)	Total Uniform Stops		Total Fuel Consumption (lit/hr)	Dissu Index
					veh/hr	%		
ar	١٢٠	-	٦٨	٣٧	٢٥٥١	٨٣	١٤٠	٤٩.
mia	١١٠	-	٧٧	٤٥	٣١٦٧	٨٨	١٩١	٦٩.
um	١٢٠	-	٧١	٤٦.٢	٢٦١٤	٨٧	١٦١	٥٧
Al-hed	١٢٠	-	٨٤	٤٧.٩	٢٩٠٠	٨٧	١٨٢	٦٥.

Figure (٥-٤) Percentage of Saving in Total M.O.Es. for P.M. Peak Period in Ishtar Intersection
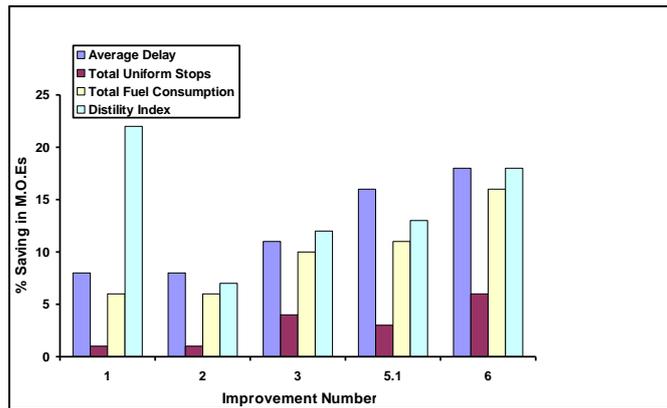

Figure (٥-٥) Percentage of Saving in Total M.O.Es. for P.M. Peak Period in Al-Jamia Intersection
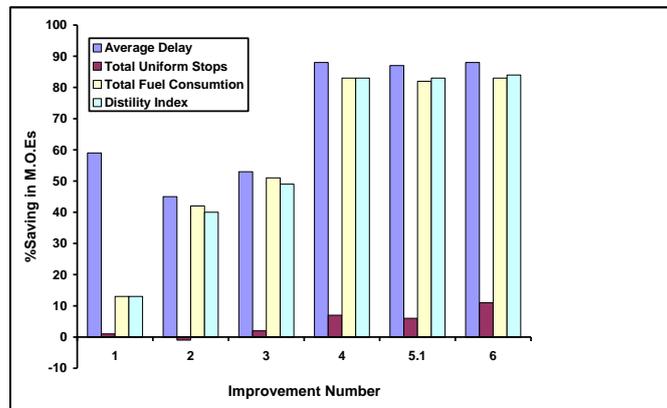

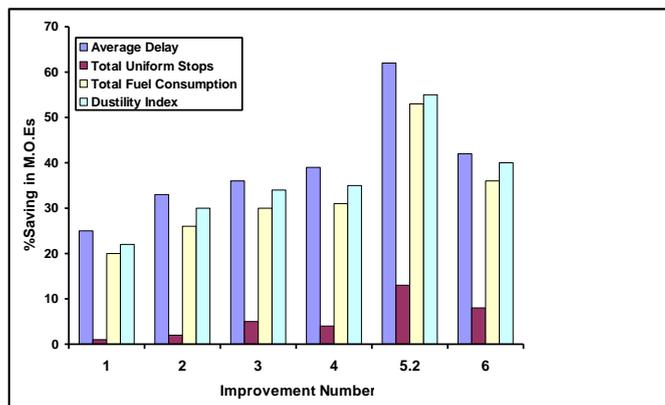Figure (٥-٦) Percentage of Saving in Total M.O.Es. for P.M. Peak Period in Al-Aum Intersection

Figure (٥-٧) Percentage of Saving in Total M.O.Es. for P.M. Peak Period in

hapter Five

Validation of Bayesian Model

٥.١ General

This chapter contains a comparison between results of the analysis and evaluation of the current and estimated turning traffic flow for each intersection, and could be divided into two parts:

The first part involved the applications of HCS-٢٠٠٠ computer program for isolated intersections, while the second part involved two applications of TRANSYT-٧F release ٩.٤ January (٢٠٠٢) for isolated intersections. The first one is a comparison procedure between the measurement of effectiveness for (current) and (estimating) traffic flow, while the other is improvement strategies for the case of operation.

The first part represented the application of HCS-٢٠٠٠ computer program to make the comparison between current and estimated simulate traffic flow for each of the isolated intersections at the studied area by computing average delay, max degree of saturation (volume to capacity) (v/c) ratio and level of service for each intersection.

A total of (١٢) simulation in TRANSYT-٧F were performed for the (٤) nodes in the second part of this chapter two simulation runs were executed for each intersection to simulate its current and estimation conditions as isolated intersection. And there are six trials for improvement the performance of these intersections by this program.

٥.٢ Comparison between Measurement of Effectiveness using Current and Estimated Turning Traffic Flows by Application of HCS-٢٠٠٠ Computer Program

Tables (٥-١) to (٥-٤) summarize the evaluation of the L.O.S for each of the studied intersections under current and estimated conditions for Ishtar, Al- Jamia, Al-Aum and Bab-Al-

Mashhad intersections, while Appendix (H) shows HCS program runs for Al-Aum intersection as a sample. It is noticeable from

these tables that little difference between results of the two conditions where L.O.S was E, E, F, F for current flows and D, E, F, F for estimating flows in Ishtar, Al-Jamia, Al-Aum and Bab-Al-Mashhed intersections respectively. The resulting lane group delay for all intersection is high. Therefore, it can be concluded that the intersections operate at high L.O.S during current and estimating condition.

From these results, it could be concluded that these intersections were suffer from a high congestion because of the high passing traffic volume and the high percentage of heavy vehicles (busses and mini busses). In addition to long start up lost time and queue length of these vehicles.

٥.٣ Comparison between Measurement of Effectiveness using Current and Estimated Turning Traffic Flows by Application of TRANSYT-٧F Computer Program

Appendix (H) represented the output of TRANSYT-٧F program for Al-Aum intersection at P.M. peak periods as a sample. Tables (٥-٥) and (٥-٦) summarized the results for all intersections for current flows in A.M. and P.M. peak periods and using estimated turning flows, These results of simulation runs show that all nodes were over saturated except node No.٢. Also there is a convergence between the results of this program for current and estimated traffic flows, where L.O.S was E, E, F, F for current flows and D, D, F, F for estimating flows in Ishtar, Al-Jamia, Al-Aum and Bab-Al-Mashhed intersections respectively.

Measurement of effectiveness (M.O.Es) (average delay, maximum (v/c), total uniform stops, fuel consumption and disutility index) indicate high traffic congestion at all nodes, therefore, the level of service was E and F.

٥.٤ Improvement of the Operation in Study Intersections

Most intersections are operating with v/c greater than ٩٥٪. In order to improve the operation at these intersections.

Six types of traffic improvements are considered. One of these is traffic signal improvements that achieve optimal design (the best phase and cycle length and phase sequences-schemes), while the other improvements represent
of controlling the passing of certain kinds of vehicles in particaly times, in addition to changes in the geometric design of intersections, The above mentioned improvements could be described, as shown in Figure (٥-١).

٥.٤.١ Improvement NO.١:

In this stage the optimization run are carried out selecting the best phasing time for each node by using T٧FACT program. The selection of the best phasing time, which gives the minimum value of (v/c) ratios for over saturated links in the intersection, will be considered.

The best phase time for each node is selected for the existing cycle length. Table (٥-٧) shows that for all measurements of effectiveness there are decreasing and level of service of the nodes (١, ٢and ٤) change from (E, E and

F) to (D, D and E) while node No.٣ still F. Appendix (H) show T٧FACT runs for Al-Aum intersection.

٥.٤.٢ Improvement NO.٢:

During this improvement stage, the determination of the best cycle length is conducted for the study intersections by using CYCOPT program module that is available for selection from TRANSYT-٧F release ٩.٤ (٢٠٠٢) processor interface and provided mechanism for through cycle length optimization, then select the best phasing time by using T٧FACT program for the best cycle length selected.

The best cycle length is the search between the range (minimum and maximum) values of the cycle time. Table (٥-٨) shows the best cycle length selected for each node. Table (٥-٩) shows the measurement of effectiveness under the second improvement stage for the studied intersections. The level of

service of the nodes (١, ٢ and ٤) change from (E, E and F) to (D, D and D) while node No.٣ still F. Appendix (H) represented the output of CYCOPT program model for Al-Aum intersection as a sample.

When comparing the result of this improvement in Table (٥-٩) with the result of simulation run in Table (٥-٦), it is noted that the measures of effectiveness (v/c) ratio, average delay, fuel consumption, total uniform stops and disutility index for all nodes are little decreased because of the high traffic volumes passing through them. While the level of service is increasing one level for all nodes except node No.٣ still F.

٥.٤.٣ Improvement NO.٣:

Although of little percentage of trucks entered to intersections, preventing trucks from entering intersections in peak periods and permitting for passing after six o'clock lead to decrease in measures of effectiveness. Also increase in level of service of the nodes (١, ٢ and ٤) from (E, E and F) to (D, D and D) while node No.٣ still F as shown in Table (٥-١٠).

٥.٤.٤ Improvement NO.٤:

The present stage is applied to Al-Aum, Bab-Al-Mashhed intersections links, which, have (v/c) ratio grater than ٩٥٪. This stage presents the filtration concepts with sequence schemes, as shown in Figure (٥-٢), respectively, which considered the best plans. Table (٥-١١) represents the results of this improvement, which contain changing in level of service from F to D for the two nodes.

٥.٤.٥ Improvement NO.٥:

Because all of the mention improvements increasing one level of service, the suggestions of changing in geometric design are made in many trails such as:

• Improvement NO.٥.١:

Increasing of the number of lanes in over saturated links gives some improvements to the measurement of effectiveness. The changes include: Ishtar, Al-Jamia and Al-Aum intersections while Bab-AL-Mashhed intersection does not have the required area to enlarge its approaches as:

١. Increasing the wide approaches (٢.٥m) in the north bound of Ishtar intersection, also redesign and creep channelized island in same direction to add one lane to link ١٠٢.

٢. Reducing the wide of divisional island and refuge islands (٢.٥m) in the east bound of Ishtar intersection, results in adding two lanes to link ١٠٥ in this direction.

٣. Reducing the wide of refuge islands (٥m) in the east bound of Al-Jamia intersection results in adding two lanes to ٢٠٥ and ٢٠٦ links.

٤. In Al-Aum intersection, reducing the wide of refuge island in the north, the south and the east bound add to divisional island creeping in the east bound, that result to increase one lane with (٢.٥m) for all of ٣٠٢, ٣٠٤ and ٣٠٦ links.

Table (٥-١٢) shows the existing and proposed numbers of lanes for each links. This application contains increasing a number of lanes with an optimum cycle. Table (٥-١٣) shows that the max (v/c) for Ishtar, Al-Jamia and Al-Aum intersections were reduced from ٩٦, ٩٠ and ١٤٦ in current condition to ٦٨, ٨٠ and ٧٣, respectively, also the average delay reduce from ٥٨.٩, ٥٥.١ and ٣٧٩.٤ in current condition to ٣٧.٣, ٤٦.٤ and ٤٧.٢ respectively. The levels of service are increased to D for the three mention intersections.

Table (٥-١٢) Proposed Number of Lanes for Improvement No ٥.١

Node No.	Name of Intersection	Link No.	Number of Lanes Before Change	Number of Lanes After Change
١	Ishtar	١٠٢	٢	٣
		١٠٥	٣	٥
٢	Al-Jamia	٢٠٥	٢	٣
		٢٠٦	١	٢
٣	Bab-Al - Mashhed	٣٠٢	١	٢
		٣٠٤	١	٣
		٣٠٦	٢	٣

- **Improvement NO.٥.٢:**

Due to the little traffic flow to and from the north bound of Bab-Al-Mashhed, one suggestion is made to improve the level of the service in this intersection. It is represented by converted the four-arm intersection (Bab-Al-Mashhed) intersection to the three-arms by neglect the fourth arm (Gorfat Al-Tigara) arm as shown in Figure (٥-٣). This step is causing an improvement in the performance of this intersection where level of service becomes C as shown in Table (٥-١٤).

٥.٤.٦ Improvement NO.٦:

This strategy is the lump sum of all previous improvements. The analysis results are shown in Table (٥-١٥). It can be seen clearly, that no over saturated link is found, and v/c ratios are below (٩٥٪) also level of service becomes D.

٥.٥ Results of Operating with the Best Improvement for Traffic Flow (for Study Intersection)

The saving is considered for the operation of traffic flow for each of the selected isolated intersections. The percent of saving (i.e. percent of improvement) can be estimated through the formula (٦.١).

$$\% \text{ Saving in M.O.Es} = \frac{\text{M.O.Es (Existing) - M.O.Es (Improved)}}{\text{M.O.Es (Existing)}} * ١٠٠$$

M.O.Es: Measures of Effectiveness

Tables (٥-١٦) to (٥-١٩) summarize the percentage of saving in M.O.Es for study intersection. These tables show that the maximum reduction in all M.O.Es is achieved by the application of improvement No.six for Ishtar, Al-

Jamia and Al-Aum intersections, while, improvement No.5.2 comes as the first successful improvement in Bab-Al-Mashhed intersection.

For Ishtar intersection, the percentage of saving in average delay and total uniform stops is equal to (+14% and +37%) and (+2% and +13%) respectively. Saving in fuel consumption is equal to (+11% and +31%) and the percentage of saving for disutility index is equal to (+14% and +34%) respectively.

For Al-Jamia intersection, as presented in Table (5-18), the percentage of saving in average delay and total uniform stops and fuel consumption is equal to (+8% and +18%), (+1% and +6%) and (+6% and +16%) respectively. The percentage of saving in disutility index will range between (+7% and +22%).

In Al-Aum intersection, the percentage of saving in average delay is equal to (+45% and +88%). Saving in total uniform stops and fuel consumption and disutility index is equal to (-1% and +11%), (+13% and +83%) and (+13% and +84%) respectively.

For Bab-Al-Mashhed intersection, saving in average delay and total uniform stops is equal to (+25% and +62%) and (+1% and +13%) respectively. The percentage of saving in fuel consumption and disutility index is equal to (+20% and +53%) and (+22% and +55%) respectively.

Figures (٥-٤) to (٥-٧) show results in terms of relationships between percentage of saving in (average delay, total uniform stops, fuel consumption and disutility index) and improvement number, for each intersection.

Table (٥-١٦) Percentage of Saving in M.O.Es. for the Operation of Ishtar Intersection

Improvement No.	Average Delay (sec/veh)		Total Uniform Stops (veh/hr)		Total Fuel Consumption (lit/hr)		Disutility Index	
	Existing (٥٨.٩)		Existing (٢٩٢٨)		Existing (٢٠٤)		Existing (٧٦.٩٧)	
	Imp.	Saving %	Imp.	Saving %	Imp.	Saving %	Imp.	Saving %
١	٤٨.١	+١٨	٢٨٨٠	+٢	١٧٨	+١٤	٦٥.٤	+١٥
٢	٥٠.٥	+١٤	٢٨٥٨	+٢	١٨١	+١١	٦٦.١٤	+١٤
٣	٤٧.٤	+١٩	٢٧٤٤	+٦	١٧٠	+١٧	٦١.٠٩	+٢١
٥.١	٣٧.٣	+٣٧	٢٥٩٣	+١١	١٤٤	+٢٩	٥١	+٣٤
٦	٣٧	+٣٧	٢٥٥١	+١٣	١٤٠	+٣١	٤٩.٩٦	+٢٧

Table (٥-١٧) Percentage of Saving in M.O.Es. for the Operation of Al-Jamia Intersection

Improvement No.	Average Delay (sec/veh)		Total Uniform Stops (veh/hr)		Total Fuel Consumption (lit/hr)		Disutility Index	
	Existing (٥٥.١)		Existing (٣٣٧١)		Existing (٢٢٧)		Existing (٨٤.٠٣)	
	Imp.	Saving%	Imp.	Saving %	Imp.	Saving %	Imp.	Saving %
١	٥٠.٤	+٨	٣٣٣١	+١	٢١٣	+٦	٦٥.٤	+٢٢

Improvement No.	Average Delay Imp.	Saving%	Total Uniform Stops Imp.	Saving%	Total Fuel Imp.	Saving%	Disutility Index Imp.	Saving%
٢	٥٠.٩	+٨	٣٣٣٠	+١	٢١٤	+٦	٧٨.١٤	+٧
٣	٤٩.٢	+١١	٣٢٢١	+٤	٢٠٤	+١٠	٧٤.٣١	+١٢
٥.١	٤٦.٤	+١٦	٣٢٨٤	+٣	٢٠١	+١١	٧٢.٧١	+١٣
٦	٤٥	+١٨	٣١٦٧	+٦	١٩١	+١٦	٦٩.١٨	+١٨

Table (٥-١٨) Percentage of Saving in M.O.Es. for the Operation of Al-Aum Intersection

Improvement No.	Average Delay (sec/veh) Existing (٣٧٩.٤)		Total Uniform Stops (veh/hr) Existing (٢٩٣٢)		Total Fuel Consumption (lit/hr) Existing (٩٧٣)		Disutility Index Existing (٣٦٦.٣)	
	Imp.	Saving%	Imp.	Saving %	Imp.	Saving %	Imp.	Saving %
١	٣٢٥	+٥٩	٢٩٠٩	+١	٨٤٤	+١٣	٣١٨.٧	+١٣
٢	٢٠٨.٣	+٤٥	٢٩٧١	-١	٥٦٢	+٤٢	٢٢٠.٩	+٤٠
٣	١٧٧.٤	+٥٣	٢٨٨٣	+٢	٤٧٤	+٥١	١٨٧.٩	+٤٩
٤	٤٦.٨	+٨٨	٢٧٢٨	+٧	١٦٩	+٨٣	٦٠.٦٧	+٨٣
٥.١	٤٧.٢	+٨٧	٢٧٤٣	+٦	١٧٠	+٨٢	٦١.١٣	+٨٣
٦	٤٦.٢	+٨٨	٢٦١٤	+١١	١٦١	+٨٣	٥٧.٧١	+٨٤

Table (٥-١٩) Percentage of Saving in M.O.Es. for the Operation of Bab-Al-Mashhed Intersection

Imp. en	Average Delay	Total Uniform Stops	Total Fuel	Disutility Index

	(sec/veh)		(veh/hr)		Consumption (lit/hr)			
	Existing (٨٢.١)		Existing (٣١٥٩)		Existing (٢٨٣)		Existing (١٠٩.٣)	
	Imp.	Saving%	Imp.	Saving %	Imp.	Saving %	Imp.	Saving %
١	٦١.٤	+٢٥	٣١١٥	+١	٢٢٧	+٢٠	٨٥.٥٠	+٢٢
٢	٥٤.٩	+٣٣	٣٠٧٩	+٢	٢٠٩	+٢٦	٧٦.٥٤	+٣٠
٣	٥٢.٧	+٣٦	٣٠٠٢	+٥	١٩٩	+٣٠	٧٢.٤٢	+٣٤
٤	٤٩.٩	+٣٩	٣٠٣٠	+٤	١٩٥	+٣١	٧٠.٧٢	+٣٥
٥.٢	٣١.١	+٦٢	٢٧٣٣	+١٣	١٣٤	+٥٣	٤٩.٠٩	+٥٥
٦	٤٧.٩	+٤٢	٢٩٠٠	+٨	١٨٢	+٣٦	٦٥.٨٦	+٤٠

Chapter Five

Validation of Bayesian Model

Chapter Six

Conclusions and Recommendations

<u>*٦.١ Conclusions*</u>

On the basis of the research findings and within the limitations of the test programs, the following conclusions are appropriate:

١. From t-test, t-tabulated was ٢.١٦ at the ٥٪ level of significance that is lead to no significance difference in three directions of movements (left, through and right) In ٢٠٠١, where t-calculated was ٠.٠٨, ٠.٠٧ and ٠.١٧ and less than t-tabulated. Also results indicate that there is no significance difference in left and through movements when using priori turning movements from ١٩٩٨, the t-calculated was ١.١٥ and ١.٩٧ for two movements left and through. The results refers to significance difference in left and right turns when using priori turning movements from ١٩٩٤ where t-calculated was ٢.٢٣ and ٢.٢٧ for both left and right turning movements.

٢. From the evaluation of the performance in the two applications for current and estimated conditions has been noticed the converges between measures of effectiveness in the two software programs (HCS and TRANSYT-٧F).

٣. From the evaluation of the performance for the selected intersections by both HCS-٢٠٠٠ computer program and TRANSYT-٧F release ٩.٤ (٢٠٠٢) computer program it is found that more delays, total uniform stops and fuel consumption during the peak periods. Also the level of service is between E-F for all studied intersections.

٤. From the results obtained from the simulation of isolated intersection by TRANSYT-٧F release ٩.٤ (٢٠٠٢) program and six improvements, it was concluded that a significant saving in average delay, uniform stops, fuel consumption and disutility index. It was found that the max percent of saving in average delay was (٨٨٪) at node No. ٣ while in the

total uniform stops was (١٣٪) percentage at nodes No.١ and No.٤ and in the fuel consumption was (٨٣٪) at node No.٣ and disutility index is found (٨٤٪) at node No. ٣.

٥. Reduction in measurements of the effectiveness may be obtained if the sixth improvement is considered for Ishtar, Al-Jamia and Al-Aum intersections. In other words, the traffic congestion problems are so difficult to be solved by only giving consideration to traffic cycle length or phasing, it extends to change in geometric design for intersections. Thus, lower values in number of oversaturated links, average delay, degree of saturated and total uniform stops at intersections are obtained.

٦.٢ Recommendations

There are some recommendations that can be drawn from this work as follows:

١. It is recommended to using Bayesian model to update the turning movements in all intersections in Hilla City depending on recent flows.

٢. Bayesian model with the HCS (٢٠٠٠) and TRANSYT-٧F release ٩.٤ (٢٠٠٢) package programs, can be used to evaluate the measures of effectiveness for all urban at- grade intersections in Hilla City.

Chapter Six

Conclusions and Recommendations

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