Improvement of Multi-Lane Airport Highway in Baghdad-Iraq

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Abstract. Transportation industry is basically a service sector component. It is of great importance for traffic engineers and planners to understand and evaluate the quality of service provided by transport facilities. Highway Capacity Manual (HCM), with all its revisions since 1950, is the pioneer document in this area. It quantifies the concept of capacity for a transport facility and lays the foundations for estimating the level of service (LOS) being provided by that facility to its users. This study is an engineering project management. It is about evaluation and improving multi-lane highways in Iraq. The research study was conducted on one main multi-lane airport highway in Baghdad, including: Al-Dora intersection to Al-Rashid interchanges, where this highway is considered as a major highway with high traffic volume in Iraq. HCS-2010 program software was used to evaluate and improve the level of service and traffic conditions for the highway for existing conditions (year of the study-2018) and short-term conditions (2023). The evaluation shows that all segments are operating at LOS E or LOS F for existing conditions, short-term conditions. The segments that operated at LOS E or LOS F for existing, short-term and mid-term conditions improvements are suggested by modifying the geometric and traffic conditions and changing the highway to a freeway facility; in order to operate at better LOS. A management flow diagram was prepared for decision makers to be a guide for future planning programs.

Keywords: Airport highway in Iraq, Highway capacity manual (HCM-2010), Highway capacity software (HCS-2010), Level of service (LOS), Multi-lane highway.

1. Introduction
Roads and highways are a major part of the transportation infrastructure in Iraq and play a substantial role in the local economy and community development. High quality of service of these facilities is essential to ensure safe, cost-effective and daily traffic operations. There has been a rapid growth in the population of Iraq, which led to an increase of demand in each and every aspect of our lives. Therefore, the increase of demand is directly proportional to the increase of the usage of vehicles and highway capacity.
Highways in Iraq need to be reconsidered and future plans should be prepared to improve the quality of service of these facilities. With the growing number of vehicles, the quality of service decreased, so that it became necessary to study the causes of the problem and find the appropriate solutions, either for the current or future conditions.
Transportation industry is basically a service sector component. It is of great concern for traffic engineers and planners to understand and evaluate the quality of service provided by transport facilities. Highway Capacity Manual (HCM) [1], with all its revisions since 1950, is the pioneer document in this area. It quantifies the concept of capacity for a transport facility and lays the foundations for estimating the level of service (LOS) being provided by that facility to its users.
Multi-lane highways are an important type of facilities, in which there should be no obstructions to the
movement of vehicles along the road. Such facilities represent the majority of the highway system in most countries. Highway Capacity Manual (HCM 2010) [2] defined traffic density in terms of passenger cars per mile per lane as the primary level of service (LOS) measure for multi-lane highways. It also defined the free flow speed (FFS) as the primary capacity measure for the same type of highway facility and HCM is the pioneer document in management and evaluation of capacity and quality of service of various highway facilities, including freeways highways, arterial roads, roundabouts, signalized and un-signalized intersection, urban highways, as well as the effects of mass transit, pedestrians and bicycles on the performance of such systems.

2. Previous Researches
Jrew et al. (2018) [3], in their study "Management and Evaluation of Multi-lane Highway (case study)/Jordan" were used HCS-2000 and HCS-2010 software for the existing condition (year 2014), short-term condition (year 2019) and mid-term condition (year 2024). The evaluation shows that some of the highway segments are operating at LOS-E or LOS-F for short-term and mid-term conditions. Jrew et al. (2017) [4], in their study "Management and Evaluation of Two Lane Two way Highways in Jordan (Case Study)". The updated HCS 2010 software were used to evaluate and improve the level of service and traffic conditions at each segment for existing (year of the study-2016), short-term (2021) and mid-term (2026). The evaluation show that some segments are operating at LOS E or LOS F for existing and short-term condition.

Yadav et al. (2014) [5], in their study "Roadway Capacity Estimation for Multi-lane Interurban Highways in India", focused on the estimation of roadway capacity for multilane interurban highways in India. Two sections of 60-meter length were identified as a study case on NH-2 (Delhi-Mathura corridor), where the studied highway is a four-lane divided national highway. The sections were so chosen in order to determine the effects of varying road geometry, pavement service conditions and possible variations in traffic conditions.

Semeida, A. M. (2013) [6], studied the relationships between the road geometric characteristics, heavy vehicles (HV), LOS and capacity for rural multi-lane highways in Egypt using 45 different sites located in desert and agricultural highways. The result of the study found that the most influential variables on LOS and capacity in desert sites are HV then lane width (LW), while in agricultural sites are LW then existence of number of access points.

Robertson et al. (2013) [7], developed procedures for calculating free flow speed (FFS) on highway facilities with higher posted speed limits and methods for estimating LOS on multilane highways with FFS up to 80 mph. The study recommended to use Texas A&M Transportation Institute (TTI) speed prediction equations for multilane highways with speeds greater than 60 mph.

3. Study Area
The selected highway is of economic and cultural importance. It is an international highway that connects the major recreational and religious places in the southern governorates to the capital city of Baghdad and connects the southern governorates to the northern governorates. Also, it connects the capital city of Baghdad with the province of Basra in the south and the province Al-Anbar in the west. The selected section of the multi-lane highway starts from Al- Dora intersection in Baghdad to Al-Rashid interchanges which are two branches with a length of 15 km. The multi-lane highway connects the freeway system in Iraq to the expressway system in Baghdad city, including International Baghdad Airport, as shows in Figure (1).

The street suffers from serious congestations at different times of the day and has a high percent of heavy trucks which transfer goods from and to the capital city of Baghdad. The highway was divided to six segments, the segment boundary was determined based on traffic volume, number of access points, PHF and % of HV as show in Figure (1).
Figure 1. Aerial photograph (screen shot) from Al-Dora intersection to Al-Rashid interchanges (Google earth program).

4. Data Collection

The data collected for the highway was divided into three types: road geometric data, vehicle speed data and traffic volume data. All the traffic data was collected by observation, which is the main source of the data needed for this study. Through positioning of surveillance cameras at each section of the highway, necessary input data was obtained for evaluation and improvement.

The Traffic Department at the Ministry of Interior was contacted to get the registered vehicles by state institutions in governmental, public and mixed sectors, in order to obtain the yearly growth of traffic volume on Iraqi highways. Traffic volume collected in the past years shows that the number of vehicles increases with an annual growth rate (g) of 6.2%.

Field investigation of the study area was conducted several times in order to find out the geometric and traffic data for the highway, define the highway segments and collect the data needed for the analysis. For the missing data, the ideal conditions and default values were used as recommended by HCM.

The posted speed limits were determined by observation for each segment. The Base Free Flow Speed (BFFS) was estimated from the speed limit. According to HCM 2010, the BFFS on multi-lane highways under base conditions is approximately the posted speed plus 5 mph (8 kph) for a speed limit of 50 mph (80 kph) or higher and the posted speed plus 7 mph (11 kph) for speed limits less than 50 mph (80 kph). The demand volume under prevailing conditions (V) for the selected segments must be estimated and converted into the demand flow rate under equivalent base conditions ($V_p$), in order to define the LOS for each segment. Maximum peak hour volume (PHV) for each segment was obtained from the daily traffic volume.

Based on the Iraqi code of highways, the left side of the highway is for the (NB) traffic direction and the right side of the highway is for the (SB) traffic direction. Therefore, all the access points have a sign.
as (L-exit) at the north direction and a sign as (R-exit) at the south direction.
The geometric and volume input data for each segment in each direction of the selected highway were organized for the existing conditions (year 2018), short-term conditions (year 2023) and mid-term conditions (year 2028) as shown in Table 1, 2 and 3.

The highway from Al-Dora intersection to Al-Rashid interchange is a rural multi-lane highway with two lanes in each direction. 12.95 ft (3.95 m) lane width for each lane, shoulder width 3.9 ft (1.2 m) in each direction and the posted speed limit is 55 mph. (88 kph.). The existing geometric cross-section of the highway is shown in Figure (2). The following descriptions are given for each of the six segments of the highway.

The existing geometric conditions of the multi-lane highway are improved by widening the cross-section 12 ft (3.6 m) in each direction and 6 ft (1.8 m) width of shoulder. The highway is converted from an undivided multi-lane highway into a divided multi-lane highway with concrete barriers. Therefore, the multi-lane highway becomes of three lanes in each direction as shown in Figure (3).

The multi-lane highway is improved to a freeway highway. Therefore, the six segments are combined to two segments with a cloverleaf interchange at the middle. Segment number one in the freeway highway combines segments 1, 2 and 3 in the multi-lane highway and segment number two in the freeway highway combines segments 4, 5 and 6 in the multi-lane highway as shown in Figure (4).

| Table 1. Traffic and geometric data of each segment for two directions leading to International Baghdad Airport (existing conditions/ 2018). |
|-----------------------------------------------------|
| **Al-Dora intersection to Al-Rashid interchanges** |
| **Right Side (NB)**                                    |
| Segment Number | Length (mi) | PHV (veh/h) | HV% | PHF Access Points | Posted Speed (mi/h) | Lane Width (ft) | No. Of Lanes |
|----------------|-------------|-------------|------|-------------------|---------------------|-----------------|--------------|
| 1              | 1.2         | 3186        | 7.4  | 0.90              | 6                   | 55              | 12           |
| 2              | 1.3         | 2994        | 6.4  | 0.89              | 6                   | 55              | 12           |
| 3              | 2.36        | 3349        | 5.4  | 0.89              | 4                   | 55              | 12           |
| 4              | 0.98        | 3362        | 7.4  | 0.90              | 4                   | 55              | 12           |
| 5              | 1.6         | 2994        | 7.8  | 0.90              | 3                   | 55              | 12           |
| 6              | 1.53        | 3382        | 6.5  | 0.90              | 5                   | 55              | 12           |
| **Left Side (SB)**                                    |
| Segment Number | Length (mi) | PHV (veh/h) | HV% | PHF Access Points | Posted Speed (mi/h) | Lane Width (ft) | No. Of Lanes |
|----------------|-------------|-------------|------|-------------------|---------------------|-----------------|--------------|
| 1              | 1.2         | 3259        | 7.6  | 0.90              | 5                   | 55              | 12           |
| 2              | 1.3         | 3011        | 6.4  | 0.89              | 4                   | 55              | 12           |
| 3              | 2.36        | 3407        | 6.96 | 0.89              | 5                   | 55              | 12           |
| 4              | 0.98        | 3344        | 6.7  | 0.90              | 4                   | 55              | 12           |
| 5              | 1.6         | 2237        | 8.1  | 0.92              | 2                   | 55              | 12           |
| 6              | 1.53        | 3321        | 6.2  | 0.90              | 4                   | 55              | 12           |
Figure 2. Cross-section of the existing undivided highway.

Table 2. Traffic and geometric data of each segment for north bound direction leading to International Baghdad Airport (after 5 years/ 2023).

| Segment Number | Length (mi) | PHV (veh/h) | HV%  | PHF Access Points AP/mi | Posted Speed (mi/h) | Lane Width (ft) | No. Of Lanes |
|----------------|-------------|-------------|------|-------------------------|--------------------|-----------------|--------------|
| 1              | 1.2         | 4303        | 10   | 0.90                    | 6                  | 55              | 12           | 2            |
| 2              | 1.3         | 4048        | 8.6  | 0.89                    | 6                  | 55              | 12           | 2            |
| 3              | 2.36        | 4524        | 7.3  | 0.89                    | 4                  | 55              | 12           | 2            |
| 4              | 0.98        | 4541        | 10   | 0.90                    | 4                  | 55              | 12           | 2            |
| 5              | 1.6         | 4045        | 10.5 | 0.90                    | 3                  | 55              | 12           | 2            |
| 6              | 1.53        | 4568        | 8.8  | 0.90                    | 5                  | 55              | 12           | 2            |

| Segment Number | Length (mi) | PHV (veh/h) | HV%  | PHF Access Points AP/mi | Posted Speed (mi/h) | Lane Width (ft) | No. Of Lanes |
|----------------|-------------|-------------|------|-------------------------|--------------------|-----------------|--------------|
| 1              | 1.2         | 4402        | 10.3 | 0.90                    | 5                  | 55              | 12           | 2            |
| 2              | 1.3         | 4067        | 8.6  | 0.89                    | 4                  | 55              | 12           | 2            |
| 3              | 2.36        | 4602        | 9.4  | 0.89                    | 5                  | 55              | 12           | 2            |
| 4              | 0.98        | 4517        | 9.05 | 0.90                    | 4                  | 55              | 12           | 2            |
| 5              | 1.6         | 3021        | 10.9 | 0.92                    | 2                  | 55              | 12           | 2            |
| 6              | 1.53        | 4486        | 8.4  | 0.90                    | 4                  | 55              | 12           | 2            |
Figure 3. Suggested divided Cross Section of the selected highway.

Table 3. Traffic and geometric data of each segment of the two directions leading to International Baghdad Airport (after 10 years / 2028).

| Segment Number | Length (mi) | PHV (veh/h) | HV% | PHF | Ramp Density (R/mi) | Posted Speed (mi/h) | Lane Width (ft) | No. of Lane |
|----------------|-------------|-------------|-----|-----|---------------------|---------------------|-----------------|-------------|
| **Right Side (NB)** |             |             |     |     |                     |                     |                 |             |
| 1              | 4.9 (7.9 km) | 5455        | 8.8 | 0.89| 1                   | 70 (112km)          | 12 (3.6m)       | 3           |
| 2              | 4.1 (6.6 km) | 5509        | 10.6| 0.90| 1                   | 70 (112km)          | 12 (3.6m)       | 3           |

| Segment Number | Length (mi) | PHV (veh/h) | HV% | PHF | Ramp Density (R/mi) | Posted Speed (mi/h) | Lane Width (ft) | No. of Lane |
|----------------|-------------|-------------|-----|-----|---------------------|---------------------|-----------------|-------------|
| **Left Side (SB)** |             |             |     |     |                     |                     |                 |             |
| 1              | 4.9 (7.9 km) | 5549        | 11  | 0.89| 1                   | 70 (112km)          | 12 (3.6m)       | 3           |
| 2              | 4.1 (6.6 km) | 5409        | 10  | 0.90| 1                   | 70 (112km)          | 12 (3.6m)       | 3           |
The HCS-2010 software is in (US units); therefore, the data is provided in both SI and US units for each segment. The data includes the length for each segment, the peak hour volume (PHV), percent of grade (terrain), percent of heavy vehicles, density of access points (AP/mi), posted speed limit, lane width (LW) and number of lanes in each direction (NL).

5. Finding
In this study, the existing traffic conditions at the selected highway (Al-Dora intersection to Al-Rashid interchanges) were evaluated to find out on which Level of Service (LOS) it is expected to be operated in the future situation after five years (as short-term evaluation - 2023) and (mid-term evaluation - 2028). Also, it is important for decision makers to find out the possibility of improvement of each segment based on the updated HCM-2010 methodology. HCS-2010 software computer program were used in this study for compression and validation on each studied segment of the selected highway to develop more accurate management improvement programs.

5.1 Output Results
According to the Policy on Geometric Design of Highways and Streets, 2011, the guideline for level of service selection for rural highways is LOS-C (stable flow). The highest level of service is acceptable for some highway agencies, such as LOS-D (approaching unstable flow), LOS-E (unstable flow or maximum capacity) and LOS-F (forced or breakdown flow) are not acceptable traffic conditions and the highway segments should be improved to better LOS [8].

A lower level of service leads to significant environmental impacts on exposed persons living nearby and may interrupt with different activities in the surrounding area. Such a condition is a major contributor to the increase in levels of unwanted gases due to increased amount of fuel burned in such area. The increase in number of vehicles due to poor LOS is usually associated with higher levels of pollutions such as gases, noises and psychological discomfort of nearby population. Furthermore, poor LOS results in an increase in traveling time, which translates into an increase in the amount of fuel consumed by vehicles, thus lifting the traveling cost for highway users.

The analysis of each segment of the highway in this study was conducted by using HCS-2010 for the existing, short-term and mid-term conditions and for right direction (SB) and left direction (NB) in each segment. The results HCS-2010 are presented for the selected highway in Tables (4, 5 and 6), as shown below.
Table 4. The output results for the existing conditions of the airport highway using HCS-2010 (year 2018).

| Segment Number | Direction | Flow rate Pc/h/ln | FFS mi/h | Average travel speed mi/h | Density Pc/mi/ln | LOS |
|----------------|-----------|-------------------|---------|---------------------------|-----------------|-----|
| 1              | Right     | 1831              | 51.9    | 47.7                      | 38.4            | E   |
|                | Left      | 1855              | 52.2    | 47.6                      | 39.0            | E   |
| 2              | Right     | 1740              | 51.9    | 48.3                      | 36.0            | E   |
|                | Left      | 1742              | 52.4    | 48.3                      | 36.0            | E   |
| 3              | Right     | 1937              | 52.4    | -                         | -               | F   |
|                | Left      | 1981              | 52.2    | -                         | -               | F   |
| 4              | Right     | 1933              | 52.4    | 47.1                      | 40.8            | E   |
|                | Left      | 1922              | 52.4    | 47.1                      | 40.8            | E   |
| 5              | Right     | 1729              | 52.7    | 53.6                      | 32.3            | D   |
|                | Left      | 1264              | 52.9    | 55.0                      | 23.0            | C   |
| 6              | Right     | 1944              | 52.2    | -                         | -               | F   |
|                | Left      | 1900              | 52.4    | 47.3                      | 40.2            | E   |

Table 5. The output results for short-term conditions of the airport highway using HCS-2010 (year 2023).

| Segment Number | Direction | Flow rate Pc/h/ln | FFS mi/h | Average travel speed mi/h | Density Pc/mi/ln | LOS |
|----------------|-----------|-------------------|---------|---------------------------|-----------------|-----|
| 1              | Right     | 2510              | 51.9    | -                         | -               | F   |
|                | Left      | 2567              | 52.2    | -                         | -               | F   |
| 2              | Right     | 2376              | 51.9    | -                         | -               | F   |
|                | Left      | 2387              | 52.4    | -                         | -               | F   |
| 3              | Right     | 2630              | 52.4    | -                         | -               | F   |
|                | Left      | 2701              | 52.2    | -                         | -               | F   |
| 4              | Right     | 2648              | 52.4    | -                         | -               | F   |
|                | Left      | 2622              | 52.4    | -                         | -               | F   |
| 5              | Right     | 2370              | 52.7    | 53.6                      | 32.3            | D   |
|                | Left      | 1732              | 52.9    | 53.6                      | 32.3            | D   |
| 6              | Right     | 2651              | 52.2    | -                         | -               | F   |
|                | Left      | 2591              | 52.4    | -                         | -               | F   |

5.2 Suggestions for improvement
The analysis of the selected highway shows that all segments are operated at LOS-F or at LOS-E for the existing, short-term and mid-term conditions. In order to improve the LOS of all segments, the following suggestions should be applied:

1. Increasing the number of lanes from two in each direction to three in each direction for the existing conditions.
2. Improving the geometric condition of the segment to ideal geometric condition in order to increase the Free Flow Speed (FFS).
3. Changing the highway from an undivided multi-lane highway to a divided multi-lane highway for the short term conditions.
4. For the medium term conditions all the access points must be eliminated from all segments and construct one cloverleaf with collector distributor road (CDR) interchange at the middle of the two selected segments. The cloverleaf interchange with CDR is required to eliminate or reduce the traffic weaving in basic freeway segment.
5. The service roads also are suggested on each directions of the freeway (two-lane two-way or One-way direction). The right-of-way for constructing the service roads is available for future short-term and mid-term period in year (2023) and year (2028).

6. The expressway for the selected study area will develop route continuity with the Airport expressway and freeway system.

Table 6. The output results for mid-term conditions of the airport highway using HCS-2010 (year 2028).

| Segment Number | Direction | Flow rate Pc/h/ln | Average travel speed FFS mi/h | Average travel speed Density Pc/mi/ln | LOS |
|----------------|-----------|-------------------|-------------------------------|-------------------------------------|-----|
| 1              | Right     | 3456              | 51.9                          | -                                   | F   |
|                | Left      | 3535              | 52.2                          | -                                   | F   |
| 2              | Right     | 3256              | 51.9                          | -                                   | F   |
|                | Left      | 3271              | 52.4                          | -                                   | F   |
| 3              | Right     | 3604              | 52.4                          | -                                   | F   |
|                | Left      | 3719              | 52.2                          | -                                   | F   |
| 4              | Right     | 3646              | 52.4                          | -                                   | F   |
|                | Left      | 3593              | 52.4                          | -                                   | F   |
| 5              | Right     | 3247              | 52.7                          | -                                   | F   |
|                | Left      | 2384              | 52.9                          | -                                   | F   |
| 6              | Right     | 3634              | 52.2                          | -                                   | F   |
|                | Left      | 3551              | 52.4                          | -                                   | F   |

5.3 Discussion of Results
Based on the suggestions the output results shows improving the LOS from E or F to better LOS. Tables 7, 8 and 9 shows the output results of improvement of all segments for existing, short-term and mid-term periods. Segments will be operated between LOS-C and LOC-D, which are acceptable for both directions.

Table 7. Improvement of existing conditions (year 2018).

| Segment Number | Direction | Flow rate Pc/h/ln | Average travel speed FFS mi/h | Average travel speed Density Pc/mi/ln | LOS |
|----------------|-----------|-------------------|-------------------------------|-------------------------------------|-----|
| 1              | Right     | 1221              | 53.5                          | 55                                  | 22.2 | C   |
|                | Left      | 1255              | 53.8                          | 55                                  | 22.8 | C   |
| 2              | Right     | 1154              | 53.5                          | 55                                  | 21.0 | C   |
|                | Left      | 1161              | 54.0                          | 55                                  | 21.1 | C   |
| 3              | Right     | 1285              | 54.0                          | 55                                  | 23.4 | C   |
|                | Left      | 1320              | 53.8                          | 55                                  | 24.0 | C   |
| 4              | Right     | 1288              | 54.0                          | 55                                  | 23.4 | C   |
|                | Left      | 1281              | 54.0                          | 55                                  | 23.3 | C   |
| 5              | Right     | 1153              | 54.3                          | 55                                  | 21.0 | C   |
|                | Left      | 842               | 54.5                          | 55                                  | 15.3 | B   |
| 6              | Right     | 1296              | 53.8                          | 55                                  | 23.6 | C   |
|                | Left      | 1266              | 54.0                          | 55                                  | 23.0 | C   |
### Table 8. Improvement of short-term conditions (year 2023).

| Segment Number | Direction | Flow rate Pc/h/ln | FFS mi/h | Average travel speed mi/h | Density Pc/mi/ln | LOS |
|----------------|-----------|-------------------|----------|--------------------------|------------------|-----|
| 1              | Right     | 1673              | 53.5     | 53.9                     | 31.0             | D   |
|                | Left      | 1711              | 53.8     | 53.7                     | 31.9             | D   |
| 2              | Right     | 1584              | 53.5     | 54.3                     | 29.1             | D   |
|                | Left      | 1591              | 54.0     | 54.3                     | 29.3             | D   |
| 3              | Right     | 1779              | 54.0     | 53.3                     | 33.4             | D   |
|                | Left      | 1801              | 53.8     | 53.2                     | 33.9             | D   |
| 4              | Right     | 1785              | 54.0     | 53.3                     | 33.5             | D   |
|                | Left      | 1801              | 54.0     | 53.2                     | 33.9             | D   |
| 5              | Right     | 1580              | 54.3     | 54.4                     | 29.1             | D   |
|                | Left      | 1154              | 54.5     | 55                       | 21.0             | C   |
| 6              | Right     | 1767              | 53.8     | 53.4                     | 33.1             | D   |
|                | Left      | 1727              | 54.0     | 53.6                     | 32.2             | D   |

### Table 9. Improvement of mid-term conditions (year 2028).

| Segment Number | Direction | Flow rate Pc/h/ln | FFS mi/h | Average travel speed mi/h | No. of lanes | Density Pc/mi/ln | LOS |
|----------------|-----------|-------------------|----------|--------------------------|--------------|------------------|-----|
| 1              | Right     | 1286              | 72.2     | 69.9                     | 3            | 18.4             | C   |
|                | Left      | 1321              | 72.2     | 69.9                     | 3            | 18.9             | C   |
| 2              | Right     | 1296              | 72.2     | 69.9                     | 3            | 18.5             | C   |
|                | Left      | 1267              | 72.2     | 69.9                     | 3            | 18.1             | C   |

### 6. Development Management Program

The main objective of this study is to improve the quality of service for the selected segments. This improvement is achieved by increasing the posted speed to the maximum safe speed and increasing the number of lanes in order to decrease density, which in turn improving LOS (LOS F or LOS E) to better LOS (LOS C or LOS D). This improvement will lead to decrease conjunction, delay time, pollution and stopping time and increase safety for drivers with better travel time. The cost estimation for this improvement has to be carried out in order to determine the benefit to cost ratio. The cost estimation is out of the scope of this study and is strongly recommended for any future work in this field.

Management flow diagram is developed for the existing, short-term and mid-term period planning based on the analysis, evaluation and improvement resulting from using HCS-2010 computer programs for the six segments of the selected Al- Dora intersection to Al- Rashid interchange, as shown in Figure (5). The management flow diagram will assist decision makers to improve the breakdown traffic condition segments that operate at LOS-F or operate at maximum capacity (LOS-E) for existing planning (year 2018), short-term planning (year 2023) and mid-term planning (year 2028) during peak hour periods.
Figure 5. Flow diagram of management components for Al- Dora intersection to Al- Rashid interchange.
7. Conclusions
From the application of updated HCM-2010 on the Al-Dora intersection to Al-Rashid interchange, the following conclusions can be drawn:

1. The existing conditions of the selected highway are operated on LOS-E and LOS-F, except for segment 5 for south bound direction (SB), which is operating at LOS-C and north bound direction (NB), which is operating at LOS-D.

2. Short-term planning shows that segments 1, 2, 3, 4 and 6 for both north and south bound directions (NB and SB) will be operated at LOS-F, except for segment 5 for south bound direction (SB), which will be operated at LOS-D.

3. Mid-term planning shows that segments 1, 2, 3, 4, 5 and 6 for both north and south bound directions (NB and SB) will be operated at LOS-F.

4. Due to the improvement of management program, all segments will be operated at LOS-C and LOS-D, except for segment 5 (SB) for existing condition which will be operated at LOS-B.

5. The improvement in LOS for the previous segments that are operating at LOS-E or LOS-F was due to modified geometric and traffic conditions, such as: increasing the number of lanes from two lanes to three lanes in each direction, changing the highway from an undivided multi-lane highway to a divided multi-lane highway, increasing the posted speed limit in order to decrease the density and upgrading the prevailing geometric conditions to ideal geometric conditions, and changing the highway from multi-lane highway to a freeway.

6. The developed flow diagram for management of Al-Dora intersection to Al-Rashid interchange will assist decision makers in improving the highway to better LOS.

8. Recommendations
The following recommendations are suggested.

1. It is recommended to use the methodology of HCS 2010 for all major rural and suburban highways in Iraq in terms of operational analysis, design and planning.

2. Changing all undivided multilane highways in Iraq to divided multilane highways with ideal geometric conditions for short term period (year 2023).

3. Modifying the airport multilane highway in Iraq to a freeway with full control of access for medium term of period (year 2028).

4. Cost effectiveness is highly recommended for any improvement in a future research.

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