Management of Multi-Lane Highways in Jordan (Case Study)

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ABSTRACT

Transportation industry is basically a service sector component. It is of important concern 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 quantified the concept of capacity for a transport facility and laid the foundations for estimating the level of service (LOS) being provided by that facility to its users.

This study is concerned with traffic and highway management through evaluating and improving a multi-lane highway in Jordan. It was conducted on Amman–Jerash multi-lane rural highway as a case study. The highway is considered as a major arterial highway with high traffic volume in Jordan. The traffic data was collected from the government records at several departments in the Ministry of Public Works and Housing during summer in the year 2014.

HCS-2000 and HCS-2010 software were used to evaluate the level of service (LOS) 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.

The highway segments that operated at LOS-E or LOS-F for short-term or mid-term conditions were improved by modifying the geometric and traffic conditions in order to operate the highway on better LOS, such as LOS-C or LOS-D. Management flow diagrams were prepared to help decision makers make use of a guide planning program for all rural multi-lane highways in Jordan.

KEYWORDS: Multi-lane highways, Highway capacity manual (HCM), Highway capacity system (HCS), Level of service (LOS), Highway management.

INTRODUCTION

Roads and highways form a major part of the transportation infrastructure in Jordan and play a substantial role in local economy and community development. High quality of service of these facilities is essential to ensure safe, cost-effective and daily traffic operations. There is a rapid growth in the population of Jordan, which led to increase demand in each and every aspect of our life. Therefore, the increase of demand is directly proportional to the increase of usage of vehicles and highway capacity.

Highways in Jordan need to be reconsidered and future plans should be set to improve quality of service presented by these facilities. Growth in number of

Received on 25/2/2015.
Accepted for Publication on 15/11/2015.

vehicles led to a decrease in the quality of service, so that it became necessary to study the causes and find the appropriate solutions whether for the current or future conditions.

Highway Capacity Manual (HCM) is the pioneer document in management and evaluation of capacity and quality of service for various highway facilities, including multi-lane highways. Five editions of HCM were published since 1950. HCM-1950 was the first international document on the broad subject of capacity. It provided definitions of key terms, a compilation of maximum observed traffic flow and initial fundamentals capacity (HCM, 1950). HCM-1965 was the second edition focusing on the determination of capacity, service volume or LOS, which will be provided by either a new highway design or an existing highway under specified conditions (HCM, 1965). HCM-1985 edition refined the concept of LOS and incorporated the results of several major research projects performed since the publication of HCM-1965 (HCM, 1985). HCM-2000 provided a systematic and consistent basis for assessing capacity and LOS for elements of surface transportation systems that involve a series or a combination of individual facilities (HCM, 2000).

Updated HCM-2010 has been reorganized to make its contents more accessible and understandable. The reorganization is also intended to encourage analysts and decision makers to consider all roadway users, as well as a broader range of performance measures, when they assess transportation facility performance.

HCM-2010 defines a multi-lane highway as a highway usually with two or three lanes in each direction with posted speed limits of 40 to 55 mi/h (60 to 90 km/h), divided by median or two-way left turn lane (TWLTL). It could also be undivided with no control or partial control of access, but may have periodic interruptions to flow at signalized intersections not closer than 3 km. Typically, multi-lane highways lead into central cities or along high-volume rural corridors connecting two cities or two activities. Multi-lane highways generally could be divided or undivided suburban multi-lane highways, suburban multi-lane highways with TWLTL or divided or undivided rural multi-lane highways (HCM, 2010).

Highway capacity software (HCS) was originally founded by the Federal Highway Administration (FHWA) in 1986 as the Center for Microcomputers in Transportation (Mc Trans), which is now a full-service software support center associated with the University of Florida. HCS in general is a WINDOWS application with an extensive help system and high level of professional technical support. HCS - 2000 and HCS-2010 were developed in order to achieve the procedures defined in HCM-2000 and HCM-2010, respectively, to analyze capacity and determine level of service (LOS) for signalized intersections, un-signalized intersections, urban streets (arterials), freeways, weaving areas, ramp junctions, multi-lane highways and two-lane highways (HCS, 2000).

Study Area

Amman-Jerash highway was selected as a case study. The highway is a divided multi-lane rural highway that connects Amman with the northern cities in Jordan (Jerash, Irbid and Alramtha). The highway leads to the ancient city of Jerash, as well as to different public and private universities.

The north bound (NB) and the south bound (SB) traffic directions of the highway were divided into multiple segments based on the requirements of HCM methodology, such as: change in median treatment, change in grade of 2% or more, constant upgrade over 0.76 mi (1.22 km), change in number of travel lanes, presence of traffic signals, significant change in density of access points, different speed limits and presence of bottleneck condition. Seven segments that meet the requirements were selected from this highway in order to be evaluated as shown in Figure 1.

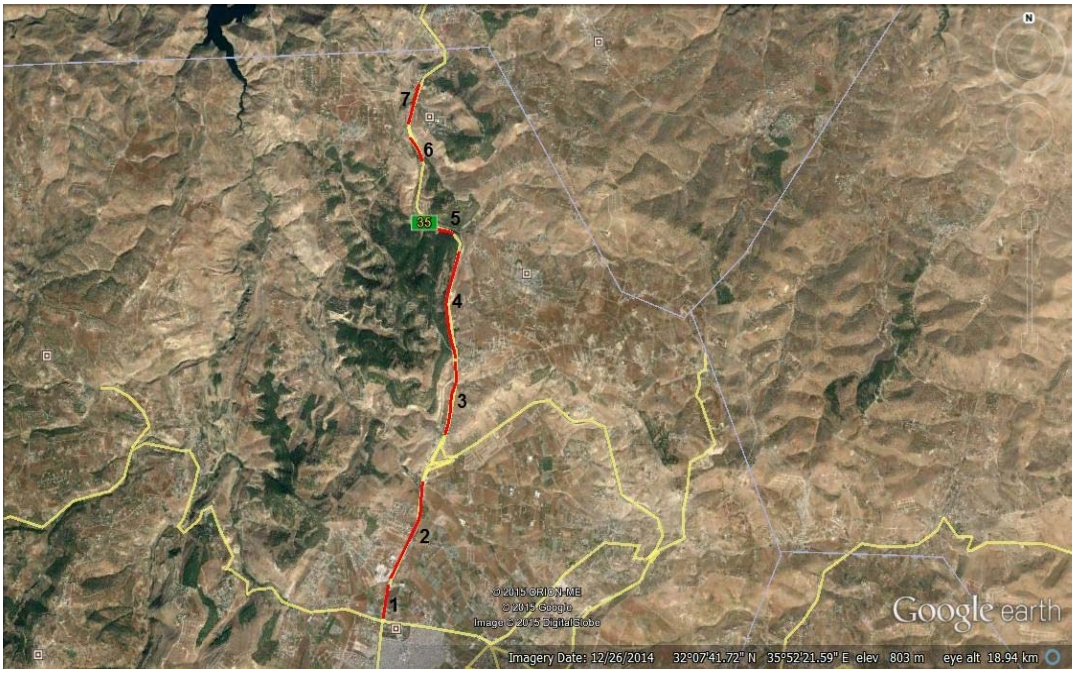

Figure (1): Aerial photograph (screen shot) of Amman-Jerash highway (Google earth program)

Data Collection

The highways in this study are classified as rural multi-lane highways which fall within the responsibility of the Ministry of Public Works and Housing (MPWH). Therefore, as engineering management study, the government records have been considered as the most dependable resource of the needed data. Such data are road geometric data, traffic volume data and vehicle speed data. Several ministry departments were visited and contacted many times in order to get the needed data. These departments include the Department of Geographic Information Systems (GIS), the Department of Road Studies and the Traffic Department.

Field investigation of the study area was conducted to check the geometric and traffic data of the highway and define the selected seven segments, along with collecting any other needed data for the analysis. For any data that couldn’t be collected, the ideal condition and the default values were used as recommended by HCM, such as driver population factor and peak hour factor (PHF).

Vehicle speed data and posted speed limits were determined for each segment. The Base Free Flow Speed (BFFS) was estimated from the posted speed limit, where according to HCM-2010, the BFFS on multi-lane highways under base conditions is approximately the posted speed plus 5 mi/h (8 km/h) for speeds of 50mi/h (80 km/h) and higher and posted speed plus 7mi/h (11 km/h) for speeds less than 50 mi/h (80 km/h).

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. The maximum peak hour volumes (PHV) for the segments were obtained from traffic counters that are distributed by the MPWH.The traffic volume on Jordan highways during the past years shows that the number of vehicles increased with an annual growth rate (g) of 6.57%.

Based on the Jordanian 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 2014) as shown in Table 1.

Table 1. Traffic and geometric data of each segment for Amman-Jerash highway (existing conditions- year 2014)

Amman-Jerash highway								
Left side (NB)								
Seg. no.	**Length (mi)**	**PHV (veh/h)**	**Percent of grade (%)**		**HV %**	**AP/mi**	**Posted speed (mi/h)**	**Lane width (ft)**
1	0.41	1676	1.22	Level	4.6	4	56	11.5
2	1.20	1676	1.75	Level	4.6	3	56	11.5
3	0.88	2821	3.90	Downgrade	9.3	3	56	12.0
4	1.29	2821	6.75	Downgrade	9.3	1	56	12.0
5	0.37	2821	4.80	Downgrade	9.3	-	56	12.0
6	0.34	2821	4.70	Downgrade	9.3	4	50	12.0
7	0.50	2821	3.40	Upgrade	9.3	3	50	12.0
Right side (SB)								
Seg. no.	**Length (mi)**	**PHV (veh/h)**	**Percent of grade (%)**		**HV %**	**AP/mi**	**Posted speed (mi/h)**	**Lane width (ft)**
1	0.41	1505	1.22	Level	4.2	2	56	11.5
2	1.20	1505	1.75	Level	4.2	5	56	11.5
3	0.88	2707	3.90	Upgrade	9.5	1	56	12.0
4	1.29	2707	6.75	Upgrade	9.5	-	56	12.0
5	0.37	2707	4.80	Upgrade	9.5	-	56	12.0
6	0.34	2707	4.70	Upgrade	9.5	2	50	12.0
7	0.50	2707	3.40	Downgrade	9.5	2	50	12.0

The HCS- 2010 software is in (US units); therefore, the data is provided in both metric 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 (LN). The existing data shown in Table 1 needs to be converted for future analysis according to growth rate (6.57%). Therefore, the future data were prepared for the short-term period of the next 5 years (year 2019) and for the medium-term period of the next 10 years (year 2024), as shown in Table 2 and Table 3, respectively.

Table 2. Traffic and geometric data of each segment for Amman-Jerash highway (short term – for year 2019)

Amman-Jerash highway								
Left side (NB)								
Seg. no.	**Length (mi)**	**PHV (veh/h)**	**Percent of grade (%)**		**HV%**	**AP/mi**	**Posted speed (mi/h)**	**Lane width (ft)**
1	0.41	2227	1.22	Level	5.8	4	56	11.5
2	1.20	2227	1.75	Level	5.8	3	56	11.5
3	0.88	3748	3.90	Downgrade	12.4	3	56	12.0
4	1.29	3748	6.75	Downgrade	12.4	1	56	12.0
5	0.37	3748	4.80	Downgrade	12.4	-	56	12.0
6	0.34	3748	4.70	Downgrade	12.4	4	50	12.0
7	0.50	3748	3.40	Upgrade	12.4	3	50	12.0
Right side (SB)								
Seg. no.	**Length (mi)**	**PHV (veh/h)**	**Percent of grade (%)**		**HV%**	**AP/mi**	**Posted speed (mi/h)**	**Lane width (ft)**
1	0.41	2000	1.22	Level	5.8	2	56	11.5
2	1.20	2000	1.75	Level	5.8	5	56	11.5
3	0.88	3597	3.90	Upgrade	12.4	1	56	12.0
4	1.29	3597	6.75	Upgrade	12.4	-	56	12.0
5	0.37	3597	4.80	Upgrade	12.4	-	56	12.0
6	0.34	3597	4.70	Upgrade	12.4	2	50	12.0
7	0.50	3597	3.40	Downgrade	12.4	2	50	12.0

Table 3. Traffic and geometric data of each segment for Amman-Jerash highway (medium term-for year 2024)

Amman-Jarash highway								
Left side (NB)								
Seg. no.	**Length (mi)**	**PHV (veh/h)**	**Percent of grade (%)**		**HV %**	**AP/mi**	**Posted speed (mi/h)**	**Lane width (ft)**
1	0.41	2778	1.22	Level	7.3	4	56	11.5
2	1.20	2778	1.75	Level	7.3	3	56	11.5
3	0.88	4675	3.90	Downgrade	15.4	3	56	12.0
4	1.29	4675	6.75	Downgrade	15.4	1	56	12.0
5	0.37	4675	4.80	Downgrade	15.4	-	56	12.0
6	0.34	4675	4.70	Downgrade	15.4	4	50	12.0
7	0.50	4675	3.40	Upgrade	15.4	3	50	12.0
Right side (SB)								
Seg. no.	**Length (mi)**	**PHV (veh/h)**	**Percent of grade (%)**		**HV %**	**AP/mi**	**Posted speed (mi/h)**	**Lane width (ft)**
1	0.41	2494	1.22	Level	7.0	2	56	11.5
2	1.20	2494	1.75	Level	7.0	5	56	11.5
3	0.88	4486	3.90	Upgrade	15.8	1	56	12.0
4	1.29	4486	6.75	Upgrade	15.8	-	56	12.0
5	0.37	4486	4.80	Upgrade	15.8	-	56	12.0
6	0.34	4486	4.70	Upgrade	15.8	2	50	12.0
7	0.50	4486	3.40	Downgrade	15.8	2	50	12.0

RESULTS AND DISCUSSION

In this study, the existing traffic conditions at the selected highway (Amman-Jerash highway) 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 - 2019) and after ten years (as mid-term evaluation - 2024). Also, it is important for decision makers to find out the possibility of improvement of each segment based on HCM-2000 and the updated HCM-2010 methodologies. HCS-2000 and HCS-2010 software computer programs were used in this study for compression and validation on each studied segment of the selected highway to develop more accurate management improvement programs.

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 (AASHTO, 2011).

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 most important gases emitted from vehicles include, but are not limited to, CO, CO_2 and NO_X and SO_X. These gases have serious health consequences on human beings, as well as on the natural and physical environment of the area. Moreover, the increase in number of vehicles due to poor LOS is usually associated with higher levels of noise pollution that cause 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-2000 and HCS-2010 for the existing, short-term and mid-term conditions and for right direction (SB) and left direction (NB) in each segment.The comparison results between HCS-2000 and HCS-2010 are presented for the selected highway in Tables (4-6), as shown below.

Table 4. Comparison results between HCS-2000 and HCS-2010 of Amman-Jerash highway segments for existing condition

Seg. no.	Dir.	Flow rate pc/h/l	HCS-2000				HCS-2010			
			FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS	FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS
1	left	976	94	94	10	B	94	97	10	B
	right	872	96	96	9	B	94	97	9	B
2	left	976	95	95	10	B	94	97	10	B
	right	872	94	94	9	B	93	97	9	B
3	left	1674	96	93	18	D	97	95	18	D
	right	1768	97	93	19	D	98	94	19	D
4	left	1674	97	94	18	D	98	95	18	D
	right	2076	98	88	24	E	98	-	-	F
5	left	1674	98	95	18	D	98	95	18	D
	right	1691	98	95	18	D	98	95	18	D
6	left	1674	85	93	21	D	87	87	19	D
	right	1691	87	83	21	D	88	87	20	D
7	left	1747	86	82	22	D	87	86	20	D
	right	1614	87	85	19	D	88	87	19	D

Table 5. Comparison results between HCS-2000 and HCS-2010 of Amman-Jerash highway segments for short-term condition

Seg no.	Dir.	Flow rate pc/h/l	HCS-2000				HCS-2010			
			FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS	FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS
1	left	1303	94	94	14	C	94	97	13	C
	right	1170	96	96	12	C	94	97	12	C
2	left	1303	95	95	14	C	94	97	13	C
	right	1170	94	94	13	C	93	-	12	C
3	left	2257	96	83	27	F	97	-	-	F
	right	2362	97	82	29	F	98	-	-	F
4	left	2257	97	84	27	F	98	-	-	F
	right	2893	98	71	41	F	98	-	-	F
5	left	2257	98	85	27	F	98	-	-	F
	right	2309	98	84	28	F	98	-	-	F
6	left	2257	85	74	30	F	87	-	-	F
	right	2309	87	75	31	F	88	-	-	F
7	left	2257	86	75	30	F	87	-	-	F
	right	2309	87	75	31	F	88	-	-	F

Table 6. Comparison results between HCS-2000 and HCS-2010 of Amman-Jerash highway segments for mid-term condition

Seg. no.	Dir.	Flow rate pc/h/l	HCS-2000				HCS-2010			
			FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS	FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS
1	left	1633	94	92	18	D	94	95	17	D
	right	1466	96	95	15	C	94	96	15	C
2	left	1633	95	93	18	D	94	95	17	D
	right	1466	94	93	16	C	93	96	15	C
3	left	2855	96	70	41	F	97	-	-	F
	right	2956	97	69	43	F	98	-	-	F
4	left	2855	97	71	40	F	98	-	-	F
	right	3722	98	48	78	F	98	-	-	F
5	left	2855	98	71	40	F	98	-	-	F
	right	2956	98	69	43	F	98	-	-	F
6	left	2855	85	64	45	F	87	-	-	F
	right	2956	87	62	48	F	88	-	-	F
7	left	2855	86	60	51	F	87	-	-	F
	right	2752	87	66	42	F	88	-	-	F

Discussion of Results

The analysis of the selected highway as a case study shows that some segments are operated at LOS-F or at LOS-E. For the purpose of improving LOS, the following suggestions could be applied:

1- Increasing the lane width for segments with lane width less than 3.6 m.
2- Increasing the number of lanes from two in each direction to three in each direction.
3- Improving the geometric condition of the segment to ideal geometric condition in order to increase the Free Flow Speed (FFS).

Based on the suggestions above, the following tables show that the segments which are operating at LOS-E and LOS-F could be improved to better LOS.

Table 7 shows the output results of improvement of segment 3 for short- and medium-term periods. The segment will operate between LOS-C and LOC-D, which are acceptable for both directions.

Table 8 shows the output results of improvement of segment 4 for short- and medium-term periods. The segment will operate between LOS-C and LOC-D, which are acceptable for both directions, except that the right direction (SB) will operate at LOS-E for medium-term period (year 2024). This means that the SB direction of the segment is the only one that will operate at maximum capacity; therefore, it needs more attention for geometric and pavement conditions that may improve the operation of the segment to better LOS.

Table 9 shows the output results of improvement of segment 5 for short-and medium-term periods. The segment will operate at LOS-C for short-term period and at LOC-D for medium-term period, which are considered acceptable for both directions.

Table 10 shows the output results of improvement of segment 6 for short-term and medium-term periods. The segment will operate at LOS-D for both periods and for both directions.

Table 11 shows the output results of improvement of segment 7 for short-term and medium-term periods. The segment will operate at LOS-D for both periods and for both directions.

Table 7. Improvement of segment 3 of Amman-Jerash highway for short-term and mid-term conditions

Time period	Dir.	Flow rate pc/h/l	HCS-2000				HCS-2010			
			FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS	FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS
short-term	left	1504	95	99	15	C	95	96	16	C
	right	1575	96	100	15	C	96	95	17	D
mid-term	left	1903	95	98	13	C	95	92	21	D
	right	1971	95	98	14	C	96	91	22	D

Table 8. Improvement of segment 4 of Amman-Jerash highway for short-term and mid-term conditions

Time period	Dir.	Flow rate pc/h/l	HCS-2000				HCS-2010			
			FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS	FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS
short-term	left	1504	97	97	16	C	98	96	16	C
	right	1929	98	91	21	D	98	92	21	D
mid-term	left	1903	97	91	21	D	98	92	21	D
	right	2107	100	90	32	E	100	90	23	E

Table 9. Improvement of segment 5 of Amman-Jerash highway for short-term and mid-term conditions

Time period	Dir.	Flow rate pc/h/l	HCS-2000				HCS-2010			
			FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS	FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS
short-term	left	1504	98	97	15	C	98	96	16	C
	right	1539	98	97	16	C	98	96	16	C
mid-term	left	1903	98	91	21	D	98	92	21	D
	right	1971	98	90	22	D	98	91	22	D

Table 10. Improvement of segment 6 of Amman-Jerash highway for short-term and mid-term conditions

Time period	Dir.	Flow rate pc/h/l	HCS-2000				HCS-2010			
			FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS	FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS
short-term	left	1504	85	85	18	D	87	88	17	D
	right	1539	87	86	18	D	88	88	18	D
mid-term	left	1903	100	93	20	D	99	91	22	D
	right	1971	100	92	21	D	100	91	22	D

Table 11. Improvement of segment 7 of Amman-Jerash highway for short-term and mid-term conditions

Time period	Dir.	Flow rate pc/h/l	HCS-2000				HCS-2010			
			FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS	FFS km/h	Avg. travel speed km/h	Density pc/km/ln	LOS
short-term	left	1555	87	86	18	D	87	88	18	D
	right	1451	88	88	17	D	88	88	16	D
mid-term	left	1903	100	93	20	D	99	92	21	D
	right	1835	100	95	19	D	100	93	20	D

Development Management Program

The main requirement of this study is to improve quality of service for the selected segments of Amman-Jerash multi-lane highway. This improvement is achieved by increasing the posted speed limit to the maximum safe speed, eliminating number of access points, increasing lane width and increasing number of lanes in order to decrease density. This in turn leads to improve worse LOS (LOS-F or LOS-E) to better LOS (LOS-C or LOS-D). This improvement leads to decrease conjunction, delay time, pollution, stopping time and increase safety for drivers with better travel time. The cost estimation of future improvement is out of the scope of this study and is 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-2000 and HCS-2010 computer programs for the seven segments of the selected Amman-Jerash multi-lane highway, as shown in Figure 2.

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 short-term planning (year 2019) or mid-term planning (year 2024) during peak hour periods.

CONCLUSIONS

From the application of HCM-2000 and updated HCM-2010 on the Amman-Jerash rural multi-lane highway, the following conclusions can be drawn:

1. There are no significant differences between HCM-2000 and updated HCM-2010 in the analysis and improvement of the multi-lane highway. The two softwares were used for comparison and validation of the output results.
2. The existing conditions of the selected highway are for LOS-B and LOS-D, except for segment 4 for south bound direction (SB), which is operating at LOS-E.
3. Short-term and mid-term planning shows that segments 3, 4, 5, 6 and 7 for both north and south bound directions (NB and SB) will operate at LOS-F.
4. Due to the improvement of management program, all segments will operate at LOS-D and LOS-C, except for segment 4 (SB) which will operate at maximum capacity (LOS-E). This segment needs more attention for geometric and pavement conditions that may improve the segment to better LOS.
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 width of the segment’s lane, increasing the number of lanes in each direction to three lanes,

increasing the posted speed limit in order to decrease the density and upgrading the prevailing geometric conditions to ideal geometric conditions.

6.The developed flow diagram for management of Amman-Jerash highway will assist decision makers in improving the highway to better LOS.

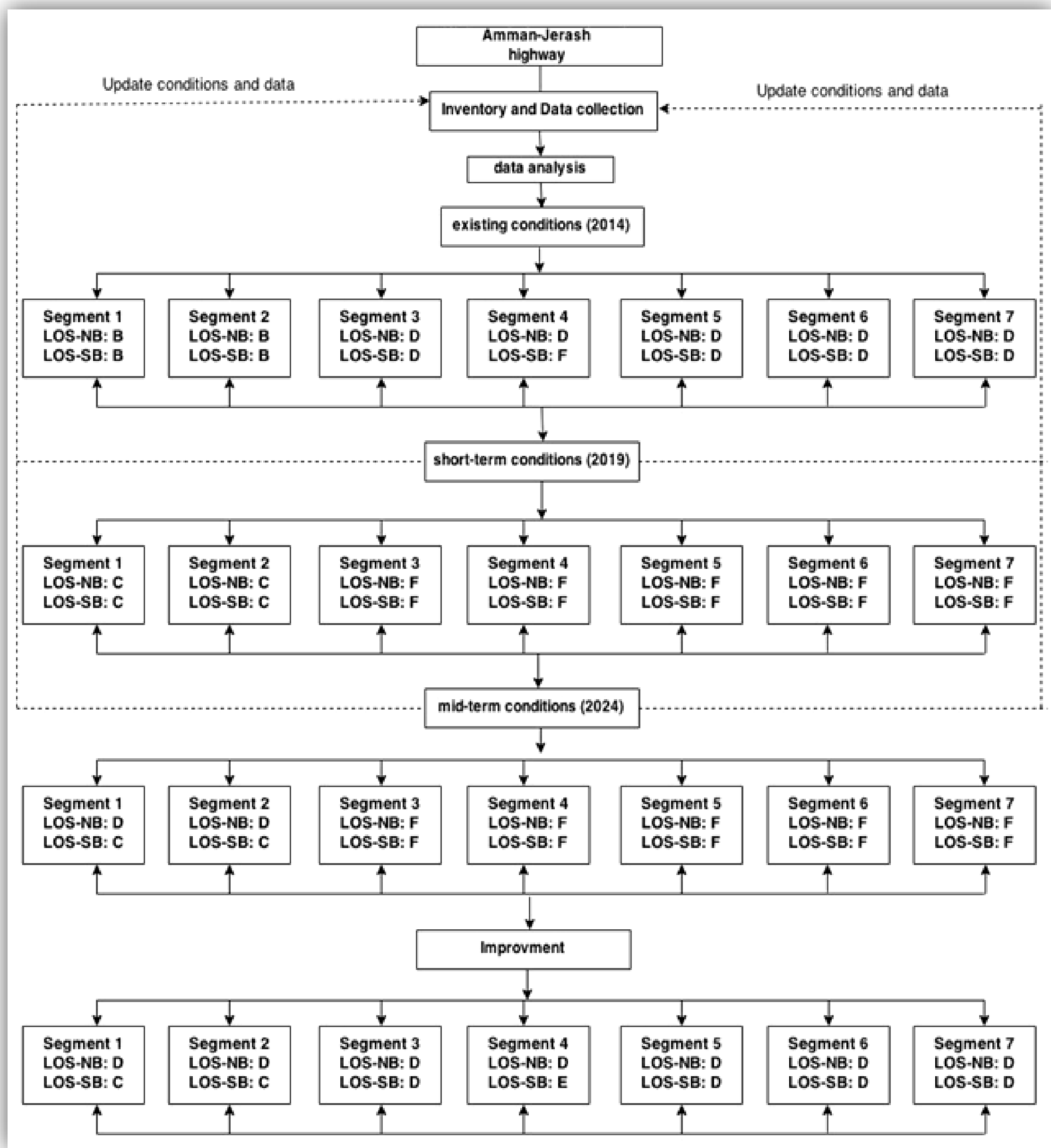

Figure (2): Flow diagram of management components for Amman-Jerash highway segments

Recommendations

The following recommendations are suggested.

1. It is recommended to use the methodology of HCM-2010 for all major rural and suburban highways in Jordan in terms of operational analysis, design and planning.
2. Increasing number of lanes and lane width and upgrading geometric conditions to ideal geometric conditions are recommended in the future improvement plan, especially for segments that are operating at LOS-E or LOS-F in Jordan.
3. Economic analysis for this improvement has to be conducted. Economic analysis is out of the scope of this study and is recommended for future work.
4. It is recommended to build and maintain a historical database, including traffic volume data and geometric data for all major rural highways in Jordan.
5. Long-term studies (15-20 years) in terms of capacity and LOS are recommended for all rural multi-lane highways in Jordan, which may need to change the class of some highways from multi-lane highways to freeways or expressways (full control of access) if the required fund is available.
6. It is recommended to use passing lane or climbing lane for specific segments on multi-lane highways which are not included in the HCM methodology.
7. Environmental impact studies are required for all highway segments that are operating at LOS-E or LOS-F.
8. More studies are required on other major multi-lane highways in Jordan.

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