IOSR Journal Of Humanities And Social Science (IOSR-JHSS)
Volume 22, Issue 12, Ver. 10 (December. 2017) PP 01-17
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

The Effect of Traffic Composition on PCU Values and Traffic Characteristics on The Northern Arc of The first Ring Road around Greater Cairo.

Abd-Elaziz, Asmaa[1], Abd-Elwahab, Sameh[2]
[1]*Lecture Assistant at Department of geography, Faculty of Arts Cairo University*
[2]*Professor at Department of geography, Faculty of Arts Cairo University*
Corresponding Author: Abd-Elwahab, Sameh

ABSTRACT: The ring road is the main traffic artery in Greater Cairo region. It has been classified as a highway provides continuous free-flow, high-speed movement without obstacles for large traffic volumes, free of car parks or pedestrian crossing. However, this classification isn't commensurate with the current operating conditions of the road, due to the population growth and the increasing of vehicles numbers in the region as well as the prevalence of traffic infringements on both roadsides, resulting in increased traffic volumes four times from 38.000 veh/day to 160.000 veh/day during the period (1990-2016) and changing the traffic composition on the road. This study presents the traffic volume on the northern arc of the ring road based on traffic data collected from three filed points which analyzed statistically by JAM software, to identify the traffic composition especially traffic stream on this arc is non-homogeneous and derivation modal split of it, as well calculating the PCU values to know the effect of various heavy vehicles on traffic characteristics and performance as the equivalent flow rate, the headway, the peak hour factor and the level of service, In addition presenting the most prominent traffic bottlenecks on the northern arc.

Keywords: Ring Road, Greater Cairo, Traffic Composition, Modal Split, Passenger Car Unit, Level of Service.

Date of Submission: 15-12-2017 Date of acceptance: 03-01-2018

I. INTRODUCTION

The ring road is one of the important structural additions adopted by many major cities and urban communities in the world, as well it plays a significant role in urban restructuring and linking it regionally to the vicinity, allows accessibility to all uses especially commercial and service uses. Greater Cairo region is the center of the Egyptian transportation network, and the link between Egypt's economic regions. It is also one of the most seven largest urban conglomerates in Middle East, Africa, and whole world [1]. In the late 1970s, the region exposed to the pressure of high population densities, unplanned urban sprawl, environmental pollution and pressure on facilities and infrastructure, especially transportation networks; because most of it is longitudinal roads, While the number of transverse roads have been dwindled, also 75% of all roads have established since more than 50 years, so its construction specifications doesn't commensurate with the volume of traffic now. It absorbs only 12% of all traffic flow [2]. Hence, the region became faces infinite number of challenges, mostly with the degradation of public transport services, which urged the government to think about structural solutions, the most important of which was the first ring road around greater Cairo metropolitan area (Figure 1).

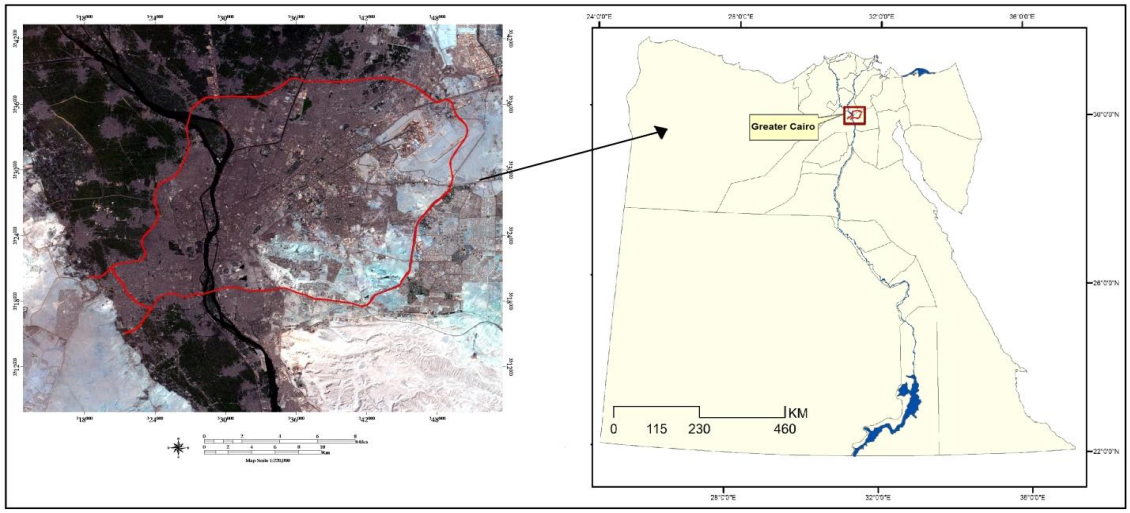


Figure 1. The first ring road around greater Cairo metropolitan area

The ring road can be defined as a road surrounding the metropolitan areas linked it with the business district center by urban road axes allowed to access from and to it, thereby reducing the pressure on the internal roads of the city center network, thence occurs urban decentralization, especially in cities that characterized with centralization and diversified in land uses. On the other hand, keeps on the historical character of an ancient city through reduce traffic within it [3], so establish such a road around Greater Cairo was the ideal structural solution, due to the fact that greater Cairo combines with the historical character and diversity of land uses.

The government started in building the eastern arch of the first ring road in the eastern desert to serve the new cities at the eastern of greater Cairo in 1984, followed by the work in its segments in Giza and Qalioubia till 1996, and opening for movement in 2000 [4]. Construction works completed by the end of build the El-Marioutia axis up in 2009, linked the eastern arch (Al-Mounib bridge) with the western arc (The extension of the Al-Warak Bridge) (Figure 2).

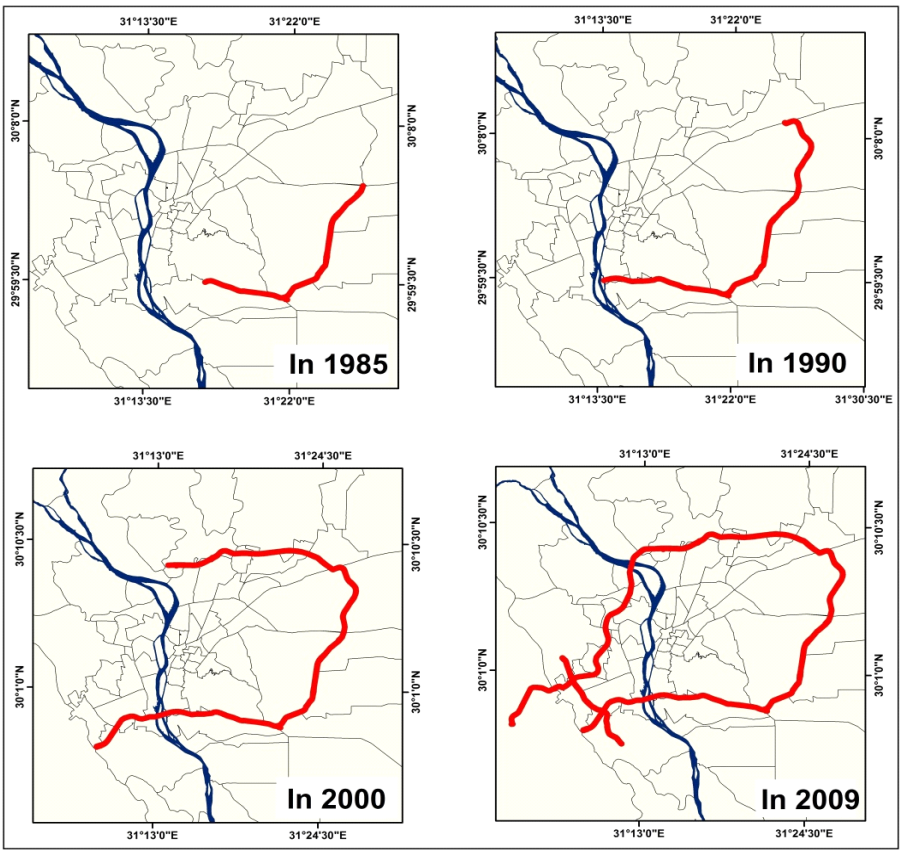


Figure 2. Construction phases of the of the ring road

No doubtful that the study of traffic characteristics on the first ring road is a necessary tool to measure the importance of its role in transporting goods and people within greater Cairo, then knowing its contribution to the development of the region's extent and function, revivification the areas which it serves economically and socially as well [5]. With the rapid population increasing in the region, the economic growth and social activities existed in adjacent areas from the road have led to sustained growth in traffic volumes above and high flow rates on the most of its segments that reflect on the traffic characteristics. For example the traffic flow rate has reached on the western arch in Maadi about 7,000 veh/h in each direction during the morning and afternoon peak; thereby the average speed has decreased on the ring road between 50 and 60 km/h which equivalent 50-60% from the free-flow speed along its segments, while it has been estimated in 2002 by JICA in Transportation Master Plan and Feasibility Study of Urban Transport Projects in Greater Cairo Region with (90-100) km/h [6].

It should be noted that the traffic characteristics changed according to the road capacity depended on its geometric design and its transverse and longitudinal segments [7], add to different types of vehicles that dominate on the traffic flow and vary by physical dimensions.

This paper focus on the analysis of traffic composition on the northern arch of the first ring road, and its modal split to determine the contribution ratio of each type of vehicles and the impact of its physical dimensions on the quality and efficiency of traffic flow. Heavy vehicles like trucks, buses and Caravans are differ in dimensions and operational characteristics from passenger cars, where the first type is the slowest and occupying a larger space of the road than to the second type that could be prevent greater number of passenger cars to pass [8].

Consequently, it becomes more difficult to manage flow movement in between lanes of the road at the same speed, as well as drivers choose specific lane based on free space [9], which has effects on traffic variables such as (headway – density – speed ... etc.), thence influence on functional performance of the road and level of service (Figure 3).

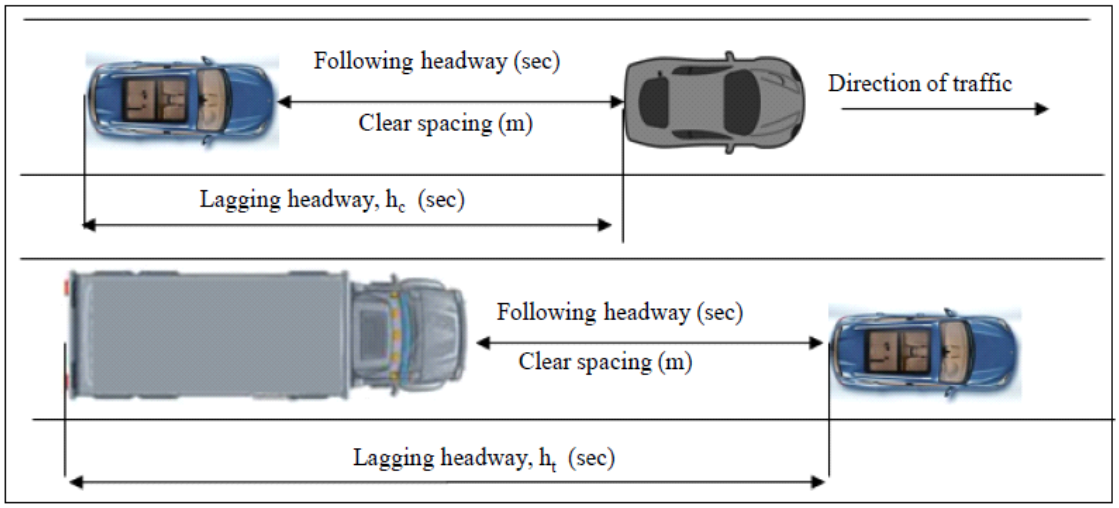


Figure3. Effect of heavy vehicles on the headway and spacing between cascading cars [10]

Research Objective:

This study purposes to compare traffic volume before and after calculating the PCU value and the equivalent flow rate; To know mixed traffic effect on headway between vehicles, generating traffic jams and decreasing level of service on the northern arc of the ring road around greater Cairo.

II. METHODOLOGY

The studies of traffic composition require to obtain a realistic data about the numbers and types of vehicles passing over the day hours that also used as a base for calculating the passenger car unit values to identify the impact of different vehicles types on traffic flow characteristics. There are different Techniques to collect traffic data such as floating cars driven along selected routes where travel distances as well as qualitative observations recorded at specified time intervals, in addition to portable traffic counters classified traffic stream at selected locations manually. Owing to the difficulty of getting any of those Techniques, so it has been relied on animated visual imaging as an alternative Technique to traffic monitoring, then the raw data has been unloaded for statistical analyzing on Excel and JMP statistical software to calculate the equivalent flow rate by conducting the modal split for vehicles and calculating PCU values to stand on the actual flow Characteristics and level of service (Figure 4).

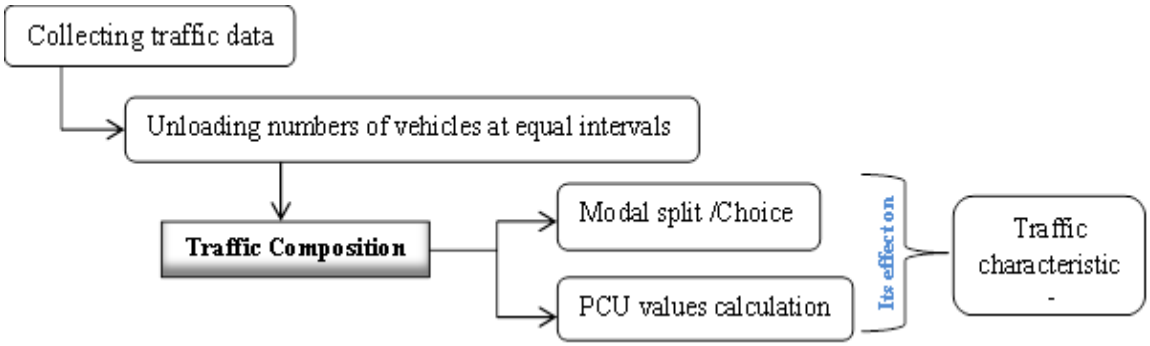


Figure 4. Overview of the methodology

3.1 Area of Study

The first ring road turns around the Greater Cairo Metropolitan Area, its total length is 104 km (50 km passing by agricultural areas in Giza and Qalioubia, as well 54 km in residential and desert areas in Cairo). It has two directions, the width for both direction is 42 m, including four traffic lanes, and a traffic island, its width is 7m, allowing to pass a fast metro, but later it used to increase the width of the road lanes; to absorb the increasing numbers of cars. This road can be divided into two arches. The northern arc which is the subject of study extending 61 km from the desert Ismailia intersection to Al-Wahat Road.

This arc serves a huge number of areas in Cairo, Giza and Qalioubia, so it is characterized by increasing in traffic pressure, especially heavy trucks movement through "El-Marg direction" from 10th of Ramadan city, petroleum companies area in Mostorod and industrial zone in Shobra Al-Khaimah, or coming through "El-Mounib direction" from industrial zone in Abo-Rawash and sixth of October city. In addition, its contribution in traffic reduction and redistribution it from CBD to Qalioubia and Giza through number of intersections such as Moasst el-Zakah, El Marg, Alexandria Agricultural Road, Rood Al-Farj, 26th July, Saft El-laben and absorbing traffic flow from west Giza and south Cairo through El-Mansouriya and El-Marioutia axes. In addition the accessibility to Autostrad and Upper Egypt Governorates.

3.2. Description of the Data

The raw traffic data collected on two main points on the northern arc of the first ring road. The first point is Mansheat El-Bakari and the second is El-Khosos. Those points selected for several reasons, the most prominent reason is nearness of main axes, Alexandria Agricultural Road axis and 26th July axis received a huge traffic over the day. In addition, prevalence of unplanned lanes that have multiple uses as an entrance and exit of the road, like " El-Manshiya On-ramp" used as multiple entrance and exit to Kaabeesh, El-Tawabek in Faisal district and "El-Tarabeia Off-ramp" used as multiple entrance and exit to Mansheat El-Bakari. (Figure 5).

Figure 5. Unplanned ramps (on-off) on the north arc.

3.3. Size of the Analyzed Sample

Traffic has been monitored at two periods. Morning period from 7am to 10am, and evening period from 3pm to 7pm, in equal intervals (15 minutes) for 18 hours.

In Mansheat El Bakari: Traffic volume has reached in the morning 40196 vehicles (Table 1), while reached in the evening 48528 vehicles (Table 2).

Table 1 : Morningtraffic volume in Mansheat El Bakari.

Traffic volume (15 veh/ minutes)			Traffic volume (15 veh/ minutes)		
El Marg .Dir	.El Mounib Dir	Period	.El Marg Dir	.El Mounib Dir	Period
1423	1102	9- 9.15	1040	843	7- 7.15
1357	1151	9.15- 9.30	1011	954	7.15- 7.30
1516	1208	9.30- 9.45	1054	1089	7.30- 7.45
1350	1117	9.45- 10	1200	1250	7.45- 8
5646	**4578**	**(veh/ hr)**	**4305**	**4136**	**(veh/ hr)**
1168	1054	10- 10.15	1426	1445	8- 8.15
1353	1201	1.15-1.30	1441	1532	8.15- 8.30
1436	1174	10.30-10.45	1420	1488	8.30- 8.45
1384	1282	10.45-11	1468	1259	8.45- 9
5341	**4711**	**(veh/ hr)**	**5755**	**5724**	**(veh/ hr)**
Total for 4hr: 40196					

Table 2 : Eveningtraffic volume in Mansheat El Bakari.

Traffic volume (15 veh/ minutes)			(Traffic volume (15 veh/ minutes		
.El Marg Dir	.El Mounib Dir	Period	.El Marg Dir	.El Mounib Dir	Period
1382	1417	5- 5.15	2080	1997	3- 3.15
1029	1257	5.15- 5.30	1868	1855	3.15- 3.30
1406	1326	5.30- 5.45	1968	1792	3.30- 3.45
1346	1216	5.45- 5	1640	1220	3.45- 4
5163	**5216**	**(veh/ hr)**	**7556**	**6801**	**(veh/ hr)**
1446	1331	6- 6.15	1335	1321	4- 4.15
1420	1494	6.15- 6.30	1759	1767	4.15- 4.30
1519	1337	6.30- 6.45	1684	1953	4.30- 4.45
1388	1086	6.45- 7	1442	1510	4.45- 5
5773	**5248**	**(veh/ hr)**	**6220**	**6551**	**(veh/ hr)**
Total for 4hr: 48528					

In El Khosos: Traffic volume has reached in the morning 42946 vehicles (Table 3), while reached in the evening 49391 vehicles (Table 4).

Table 3 : Morningtraffic volume in El Khosos.

(Traffic volume (15 veh/ minutes			(Traffic volume (15 veh/ minutes		
.El Marg Dir	.El Mounib Dir	Period	.El Marg Dir	.El Mounib Dir	Period
1448	1217	9- 9.15	1065	958	7- 7.15
1382	1266	9.15- 9.30	1036	1069	7.15- 7.30
1541	1373	9.30- 9.45	1079	1254	7.30- 7.45
1380	1282	9.45- 10	1230	1415	7.45- 8
5751	**5138**	**(veh/ hr)**	**4410**	**4696**	**(veh/ hr)**
1193	1169	10- 10.15	1451	1560	8- 8.15
1378	1316	1.15-1.30	1466	1647	8.15- 8.30
1461	1339	10.30-10.45	1445	1653	8.30- 8.45
1501	1447	10.45-11	1501	1424	8.45- 9
5533	**5271**	**(veh/ hr)**	**5863**	**6284**	**(veh/ hr)**
Total for 4hr: 42946					

Table 4 : Eveningtraffic volume in El Khosos.

Traffic volume (15 veh/ minutes)			Traffic volume (15 veh/ minutes)		
.El Marg Dir	.El Mounib Dir	Period	.El Marg Dir	.El Mounib Dir	Period
1407	1442	5- 5.15	2105	2022	3- 3.15
1054	1282	5.15- 5.30	1893	1880	3.15- 3.30
1431	1351	5.30- 5.45	1993	1817	3.30- 3.45
1371	1241	5.45- 5	1665	1245	3.45- 4
5263	**5316**	**(veh/ hr)**	**7656**	**6964**	**(veh/ hr)**
1471	1356	6- 6.15	1360	1346	4- 4.15
1445	1519	6.15- 6.30	1784	1792	4.15- 4.30
1544	1362	6.30- 6.45	1709	1978	4.30- 4.45
1413	1111	6.45- 7	1467	1535	4.45- 5
5873	**5348**	**(veh/ hr)**	**6320**	**6651**	**(veh/ hr)**
Total for 4hr: 49391					

Upper El Manshiya on-ramp and El Tarabeia off-ramp: Traffic has been monitored during two peak hours in the morning and evening (Table 5).

Table 5 : Traffic volume on El Manshiya on-ramp and El Tarabeia off-ramp.

Traffic volume (15 veh/ minutes)		
El Tarabeia off-ramp	**El Manshiya on-ramp**	Period
65	95	9- 9.15
80	106	9.15- 9.30
74	105	9.30- 9.45
70	101	9.45- 10
289	**407**	**Total morning peak hour**
120	234	3- 3.15
109	243	3.15- 3.30
117	172	3.30- 3.45
88	147	3.45- 4
434	**796**	**Total evening peak hour**

3.4 Traffic Composition and Modal Split

Traffic composition is defined as the vehicles types classification which form the traffic stream during collecting raw data. It is one of the most important characteristics which used in calculating the equivalent flow rate, thereby determination level of service on the road network. It is also useful in dividing traffic trips on different modes of vehicles that known in transportation engineering as a "Mode Split" or Modal split or Mode Choice which represents the ratio of different transport modes in the total journey from the origin (O) to the destination (D). The difference between modal split and vehicle counting must be acknowledged because vehicle counting provides only information about traffic volume in certain area [11], we can use it to estimate probabilities of travel by specific Mode, then predicting the demand on it [12]. Modal split also helps to Know Public transport contribution in persons Transfer and the effect of economic and social conditions on expanding of use specific modes, such as private cars or motorcycles..

The following tables (Table 6, 7, 8) shown the contribution of every mode in traffic trips on the northern arc in the study points.

Table 6 : Modal split for trips in Mansheat El Bakari.

Private Buses	Motorcycle	Mini/Micro Buses	Taxi	Light Trucks	Heavy Trucks	Private Car	Type	
0.2	**3.8**	**4.7**	**18.5**	**18.1**	**16**	**38.7**	**AM**	**El Mounib Dir.**
0.06	2.95	6.75	17.61	11.67	10.98	49.98	PM	
0.31	**2.5**	**3.8**	**19.89**	**9.9**	**8.9**	**54.7**	**AM**	**El Marg Dir.**
1.2	3.9	5.72	21.4	10.8	11.65	45.33	PM	

Table 7 : Modal split for trips in El Khosos

Private Buses	Motorcycle	Mini/Micro Buses	Taxi	Light Trucks	Heavy Trucks	Private Car	Type	
0.2	**9.8**	**12.1**	**2.6**	**18.2**	**18.4**	**38.7**	**AM**	**El Mounib Dir.**
0.06	5.95	8.75	4.61	19.17	17.98	43.48	PM	
0.3	**8.2**	**10.8**	**3.2**	**19.7**	**22.6**	**35.2**	**AM**	**El Marg Dir.**
0.33	7.7	5.63	5.4	20.5	19.8	40.64	PM	

Table 8 : Modal split for trips upper El Manshiya on-ramp and El Tarabeia off-ramp.

Others	Motorcycle	Mini/Micro Buses	Taxi	Light Trucks	Heavy Trucks	Private Car	Type	
1	**11**	**15**	**5**	**10**	**12**	**46**	**AM**	**El Manshiya**
1	8	18	6	11	9	47	PM	
2	**4**	**21**	**4**	**14**	**12**	**43**	**AM**	**El Tarabeia**
3	10	8	1	10	10	58	PM	

3.5 Estimation of PCU Values

According to the procedure described "Highway Capacity Manual" in 1965, the PCU value defined as a passenger car numbers which excluded from the traffic stream because of heavy vehicles passing under the prevailing traffic conditions [13]. Consequently, the PCU value is a conversion factor of non-homogeneous traffic flow into equivalent traffic flow as if it consisted of passenger cars, by giving each type of other vehicle values to equalize passenger cars in the case of homogeneous traffic flow, which is useful in analyzing the road capacity, determine the level of service and functional performance depending on the traffic volume that it receives.

There are many several mathematical and statistical methods to calculate PCU values for various modes of vehicles as lagging headway method and Equal density method, but this paper will based on typical values prepared by JICA in Cairo regional area transport study [14], as well as it used in the World bank study in 2010, as follows (Table 9):

Table 9 : Coefficients values of non-homogeneous traffic flow.

Medium Truck	Light Truck	Passenger car	Motorcycle	Type
2.5	2	1	0.33	**PCU value**
Bus	**Minibus**	**LargeTruck**	**Microbus**	**Type**
2.5	2	3	1.5	**PCU value**

3.5.1 Effect of Traffic Composition on PCU values

Since PCU values linked relatively with the physical dimension of each vehicle in the traffic stream and its average speeds, so the variation of PCU values on the northern arc depended on traffic composition and its vehicles category, which formed from large vehicles as Two-axle truck and Three-axle truck, as well as motorcycles and three-wheelers "Toktok", where have an influence on travel speed and equivalent flow rate.

3.6 Quality/level of service and operational performance.

Traffic performance for the northern arc of the first ring road can be assessed by measuring "level of service (LOS)"which provided in the case of passing a certain number of vehicles through a specified period of time by calculation capacity ratio. It is ratio of vehicles passing through the road (operational capacity) to the design capacity [15]. Therefore, it can be said that LOS is a qualitative measure describing operational conditions within a traffic stream. It illustrates speed, travel time, how well the smooth traffic flow to maneuver and Finally traffic capacity [16]. It should be noted that the relationship between the values of the capacity ratio and the level of service is inversely related, it's differ between zero and one depend on the level of service [17]. The highway capacity manual has provided several procedures to determine the level of service that divided it

into six levels representing a range of operating conditions and the driver's perception of those conditions, graded from standard level (A) to lowest level (F). as follows (Table 10):

Table 10 : Road service levels

LOS	Capacity Ratio (v/c ratio)
A	0.35
B	0.54
C	0.77
D	0.93
E	(**full capacity**)1
F	**Traffic paralysis**

The American Association of State Highway and Transportation Officials has recommended that the service level of the ring roads shouldn't be less than (B), to preserve the free flow movement and the accessibility [18]. Accordingly, the road occupancy ratio was calculated for the points which traffic volumes were monitored during the morning and evening peak hours, as follows (Table 11):

Table 11 : The level of service on the northern arc of the ring road

Level		Capacity Ratio		Evening peak		Morning peak		Point
				.El Marg Dir		**.El Mounib Dir**		
Evening peak	Morning peak	Evening peak	Morning peak	**Time**	**.PCU Vol**	**Time**	**.PCU Vol**	
D	C	0.88	0.72	16.00	10568	8.00	8654	Mansheat El Bakari
F	D	1.1	0.82	16.00	11977	9.00	9758	El Khosos

III. RESULTS AND DISCUSSION

Traffic conditions are similar in both of El-Khosos and Mansheat El-Bakari, so the research results can be generalized along the northern arc of the first ring road. Accordingly it can be said that the northern arc is Characterized as follows:

- The highest traffic flow rate is recorded during the morning period (8-9 AM), where the lowest average of headway time reached (2 sec/ 3vehicle) with peak hour factor attained (0.93) on El-Mounib direction and (0.99) on El-Marg direction. (Figure 6) shows slight differences in traffic at morning in both directions, without a clear reduction of vehicular volume especially on El-Marg direction. This can be traced to vehicular trips which generated after the traffic modifications in El-Khalafawi Square and linked to the northern arc across El-waeily axis in 2010, add to the 26th of July axis extension to the Cairo/Alexandria Desert Road from central business district directly, as well as building Saft Al-laben axis up, minimized traffic time from the Pyramids district, sixth of October city and El-Sheikh Zayed city to Cairo University, Giza Square, and the 6th of October Bridge.

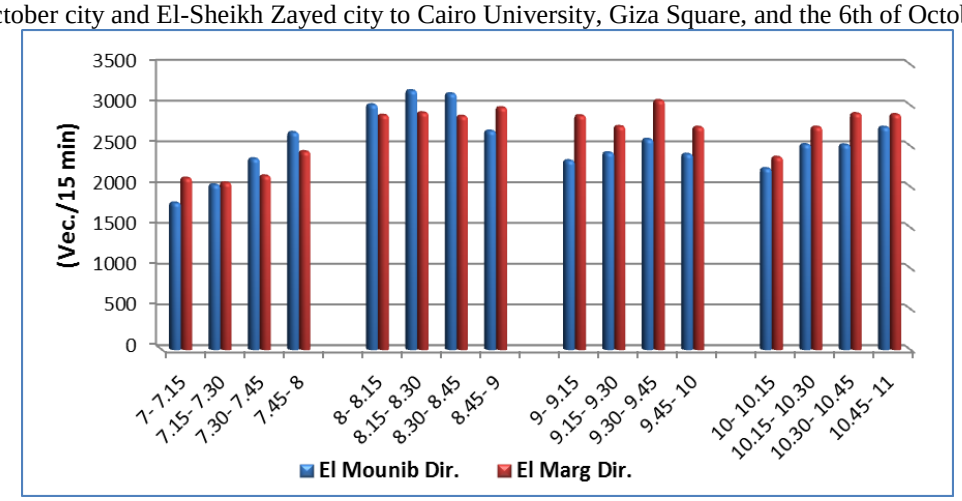


Figure 6. Morningtraffic volume on the northern arc.

It is noted from the following (Figure 7) that the highest traffic flow rate is recorded during the evening period (3-4 PM), with a lowest average of headway time reached (sec/ 2vehicle). Typically it rises during the

period (4.15- 4.45) significantly, where returning from various work trips and students of schools and universities, furthermore generation recreational, marketing and shopping trips.

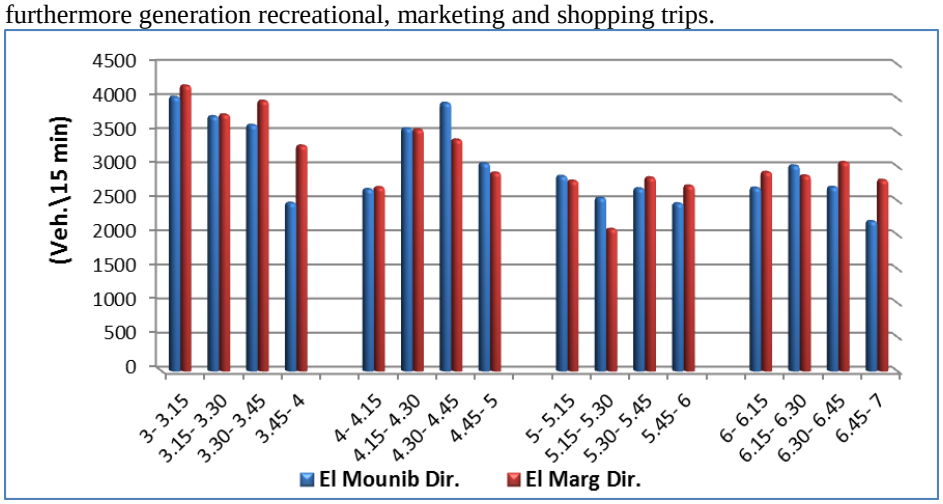


Figure 7. Eveningtraffic volume on the northern arc.

As for unplanned ramps (on/off), it is noted that El-Manshiya On-ramp higher than El-Tarabeia Off-ramp during the morning and evening periods, with average of headway time reached in the case of El-Manshiya On-ramp (17 seconds/ 2 vehicles) in the morning and (11 seconds/ 3 vehicles) in the evening, while El-Tarabeia Off-ramp reached (25 seconds/ 2 vehicles) in the morning and (15 seconds/ 2 vehicles) in the evening. This is due to that the first ramp serves a larger populous area, represented in El-Manshiya, El-Mazraa and Kaabeesh, whilst the second ramp serves agricultural area, exposed to urban sprawl recently.

Average daily traffic volume on the northern arc in 2016 increased almost tenfold comparing with it in 2005 and 2010 according to the world bank study (Figure 8); as a result of the deterioration of public transportation, which became unsuitable to cover the whole metropolitan area that grows fast. Besides that the licensed vehicular numbers in the region during this period increased about one million vehicle, added to commercial, recreational and educational uses extended on both sides of the northern arc and opening Marioutia axis for traffic, linked the northern and southern arc of the ring road to each other, leading to acceleration of daily traffic volume.

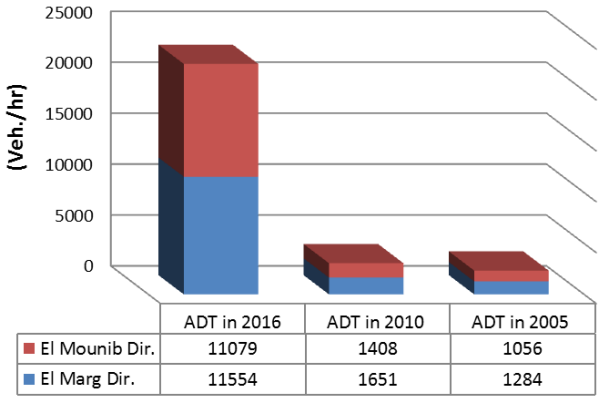


Figure 8. Average daily traffic volume on the northern arc

- Wilcoxon / Kruskal-Wallis Tests (One-way Test, Chi-Square Approximation) is performed on traffic volume data to examine the average of the vehicles distributions over the morning and evening hours (Figure 9).

$$H_o : \mu_m = \mu_e$$

$$H_1 : \mu_m \neq \mu_e \text{ for some } m \neq e$$

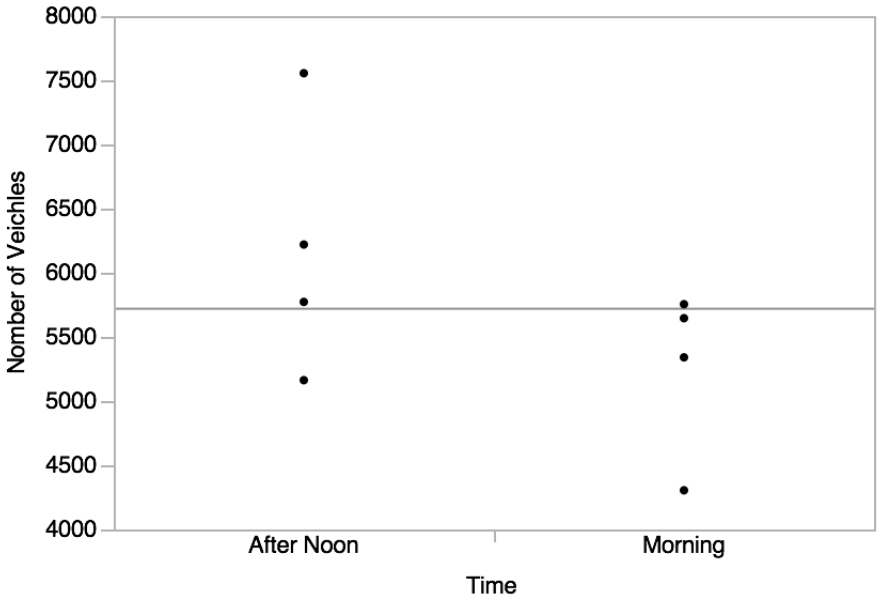


Figure 9. Comparing the average cars per hour for the two time zones

The chi-square test results indicate that there is not enough evidence to conclude that the average of the vehicles distributions over the morning and evening hours are equal, its p-value = 0.0404 (Table 12), Which is less than the significance level (0.05). Wherefore the null hypothesis is rejected and accepted the alternative hypothesis that the average of hourly mixed traffic volume in the evening hours (5750 vehicles/hour/direction) is greater than its counterpart in the morning hours (3250 vehicles/hour/direction).

(Table 12) : The chi-square test results

One-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
4.2001	1	0.0404*

- The traffic composition on the northern arc is mixed so, contingency analysis of time by vehicle types was performed to examine the relationship between the monitoring time whether morning or afternoon and the vehicle types in the traffic composition (Figure 10). From the mosaic plot and legend, notice the following:
- The Pearson's chi-square test results indicate that the variables are not independent (p-value < .0001) (Table 13).
- Negligible effect on two types of vehicle (passenger car - min/microbus) by the monitoring time, the two periods have the same distribution approximately.
- -Slight increase in frequency of vehicles in the afternoon period counter to the morning period mostly heavy trucks, taxi, motorcycle and “other” which include tractors, private buses, tokyok and police vehicles.

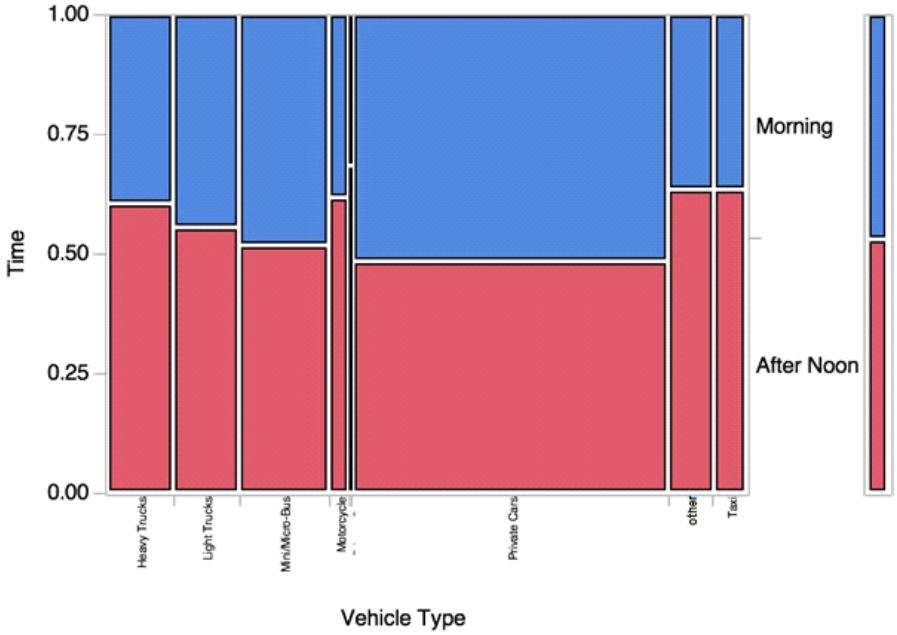


Figure 10. Contingency analysis mosaic plot

(Table 13) : The Pearson's chi-square test results

Tests

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	619.422	<.0001*
Pearson	613.870	<.0001*

H0: "Time" and "vehcile type" are independent.
H1: "Time" and "vehcile type" are associated (not independent).
Reject H_o

- By computation the modal split of the traffic composition during the morning, it noticed that the private cars contributed about two-thirds of the traffic stream volume on El-Marg direction and one-third on El-mounib direction, as a result of increasing demand on private transport cause of inadequate public transport, followed by the other types with convergent ratios on the two direction. It observed the high proportion of motorcycles (dual-and triple-cycle) in both directions, possibly because of its suitability for current economic situation (Figure 11).

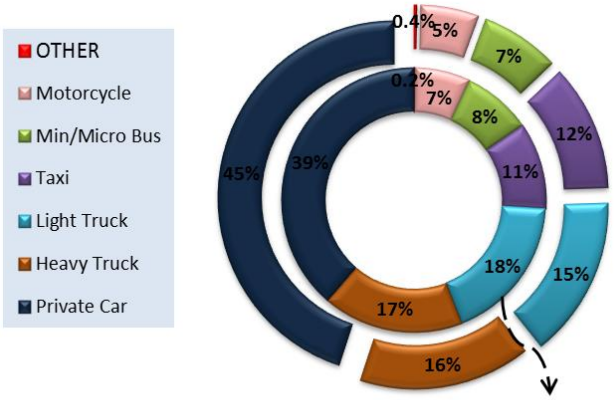


Figure 11. The modal split of the morning traffic composition

Continuation of the high contribution for the private cars in the traffic stream during the evening. It is almost half of the traffic stream volume. As well it noticed the convergent ratios for the other vehicle types in both directions because the return trip of the morning traffic (Figure 12).

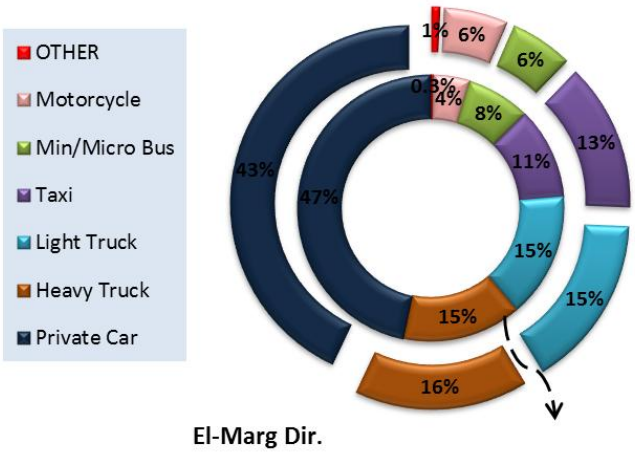


Figure 12. The modal split of the evening traffic composition

Concerning to the modal split of the traffic composition upper El-Manshiya On-ramp and El-Tarabeia Off-ramp during peak hour, it noticed that the private cars contributed about half the traffic stream volume, followed by the different types have convergent ratios. During the field study, it observed that majority of heavy vehicles are coming from behind El-Tarabeia, where livestock farms, poultry Farms and agricultural markets, which took El-Tarabeia Off-ramp if it directed to El-Mounib or took El-Manshiya On-ramp (in the opposite direction) if directed to El-Marg through by passing a tunnel under the ring road. The "Other" category includes three main types, represented in motorcycle, toktok and Tractor (Figure 13).

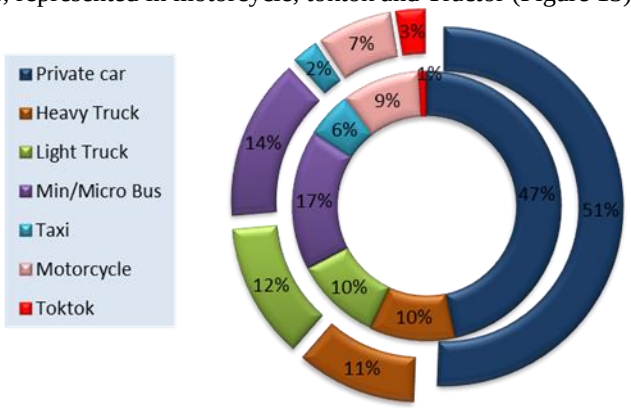


Figure 13. The modal split of the traffic composition at the peak hour

- HCM developed estimates for highway capacity ''ideal conditions", which required homogeneous mix of vehicles in a traffic stream. All highways have a mixed nature and the ratio of heavy vehicles in a traffic stream varies from one highway to the other depending on the location within the transportation network. According to HCM this proportion ranges from as low as 2% to as high as 25% of total traffic during the daytime, the higher its ratio, the more affected on the operational characteristics (acceleration, deceleration, maneuverability, etc.).

It turns out from the traffic composition and calculated its modal split that the proportion of total vehicles differed in its physical dimensions and the average space taken up by its from the passenger cars as heavy vehicles in all their forms and motorcycle are ranged between (45- 50%). So it is besides their effect on the operational characteristics upper the northern arc, they are believed to have a psychological impact on the drivers of these vehicles.

Using the typical values for those types of vehicles developed by Jaica, Found that the hourly flow volume upper the arc in 2016 attained (16633 pcu/hr/4lane) increased by 28.1% over the design capacity, which reached (11960 pcu/hr/4lane) (Figure 14) .

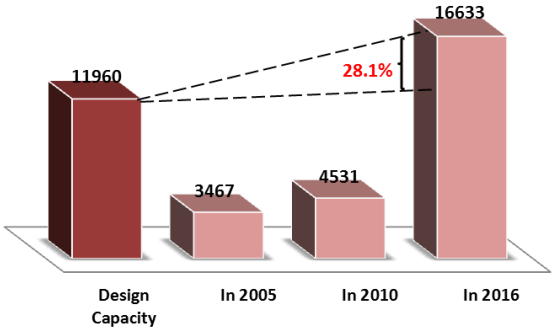


Figure 14. The hourly flow volume after calculation PCU

- Wilcoxon/ Kruskal-Wallis Tests (One-way Test, Chi-Square Approximation) is performed to examine the average of the vehicles distributions over the morning and evening hours after calculation PCU values (Figure 15).

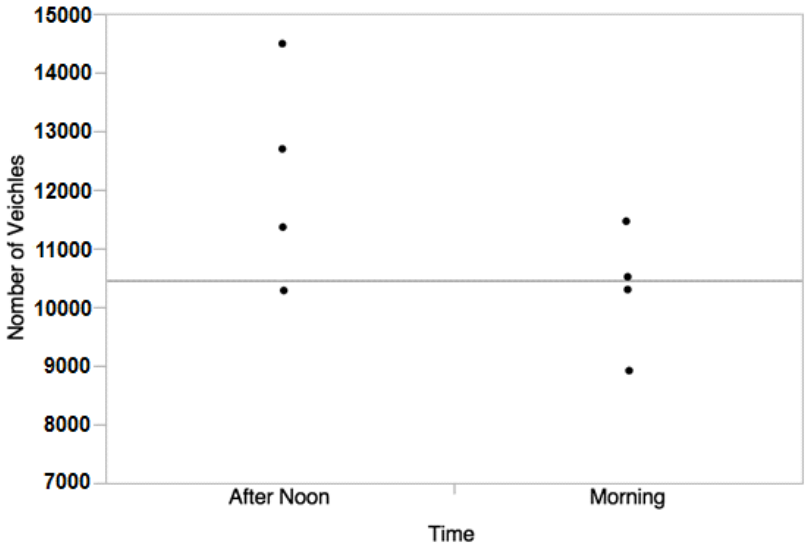


Figure 15. Comparing the average PCU per hour for the two time zones

The chi-square value (p-value > 0.0237) is less than the significance level (0.05) (Table 14). Hence it proved that the average of hourly "homogeneous" traffic volume in the evening hours (12240 Pcu/hour/direction) is greater than its counterpart in the morning hours (10393 Pcu/hour/direction).

(Table 14) : The chi-square test results for PCU values.

One-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
5.1136	1	0.0237*

- Mixed traffic and increased heavy vehicle contribution in its composition have affected on the traffic flow rate that doubled and exceeded the design capacity, Which was reflected on the average travel speed. Comparing between the typical values of average travel speed, provided by HCM and the actual values which recorded, it noticed that the average travel speed in the case of the best operational conditions is no more than 104 Km/hr with service frequency (10135 veh/hr/lane). While the service flow rate recorded (2534 veh/hr/lane) during the morning vs. (6120 veh/hr/lane) during the evening. Sometimes the average of travel speed is up to 16 km /hr in the case of accidents, repairs or ambushes.

(Table 15) : LOS for a basic freeway segment

LOS	Average Travel Speed (Km/ hr)		
	Current Situation	**HCM values**	
A	104+	120+	Free Flow
B	90	120	Stable Flow (slight delays)
C	75	114	Stable flow (acceptable delays)
D	60	99	Approaching unstable flow (tolerable delay, occasionally wait)
E	45	85	Unstable flow (intolerable delay)
F	> 45	> 85	Forced flow (Crowded)

The travel speed varies upper the northern arc from segment to the other, for example between El-Marg and Basos, ranging from 72 km/hr to 38 km/hr, it may down to 29 Km/hr, as a result of the existence of ambushes in El-Marg and close to El-Khosos besides the large number of heavy vehicles (trucks, tractor and buses), as well the traffic and parking infringements (Figure 16).

Figure 16. Examples of traffic and parking infringements upper the northern arc.

The average of travel speed between 26th July intersection and Rood Al-Farj intersection is up to 68Km/hr and sometimes down to 38Km/hr. On the remaining segment even El-Marioutia axis reached to 82Km/hr and down to 53Km/hr occasionally or less depending on operational conditions.

In Mansheat El-Bakari, the service level recorded level (C) during the morning peak with service flow rate (2163 pcu/hr/lane) on El-Mounib direction, where an acceptable traffic flow doesn't allow for maneuverability and less absorption of traffic accidents and sudden breakdowns of vehicles on the road. A service level (D) recorded during the evening peak with service flow rate (2642 pcu/hour/lane), where increased flow and low speed, not allowed maneuvering between vehicles. Arranged on this Queue discharge.

Arrange for the above Increased traffic volume upper the northern arc of the ring road. As well, retreat the level of service has led to the generation of traffic bottlenecks along the arc in specific locations, which are often related to operational reasons as the vehicles flow rate and pedestrian movement, sometimes for operational reasons related to road lanes and intersections. The most prominent operational bottlenecks, as following (Figure 17):

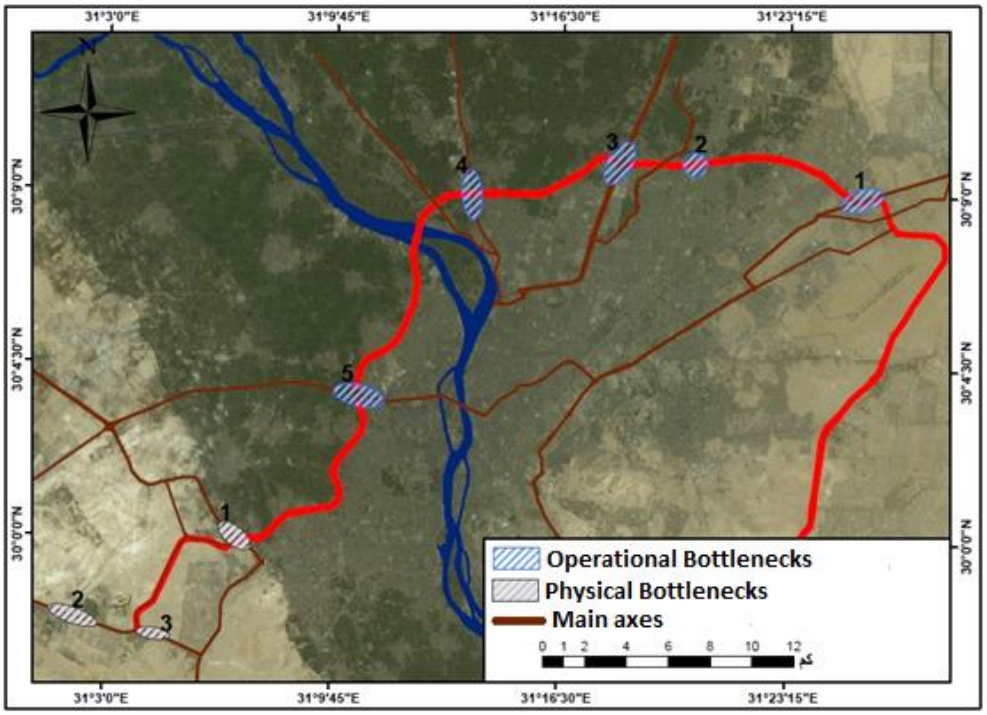


Figure 17. Traffic bottlenecks along the northern arc
[Source: Esri, Digital Globe with spatial resolution 1m. 2014]

- Cairo / Ismailia Desert Road intersection :As a result of the increasing of traffic flow over the design capacity of the intersection, passing the heavy vehicles which directed to the area of factories and companies in Gesr El Suez Street, El-Opor market and livestock farms, in addition to traffic accidents .itis appear clearlyon Google Earth images) Finger1:(8

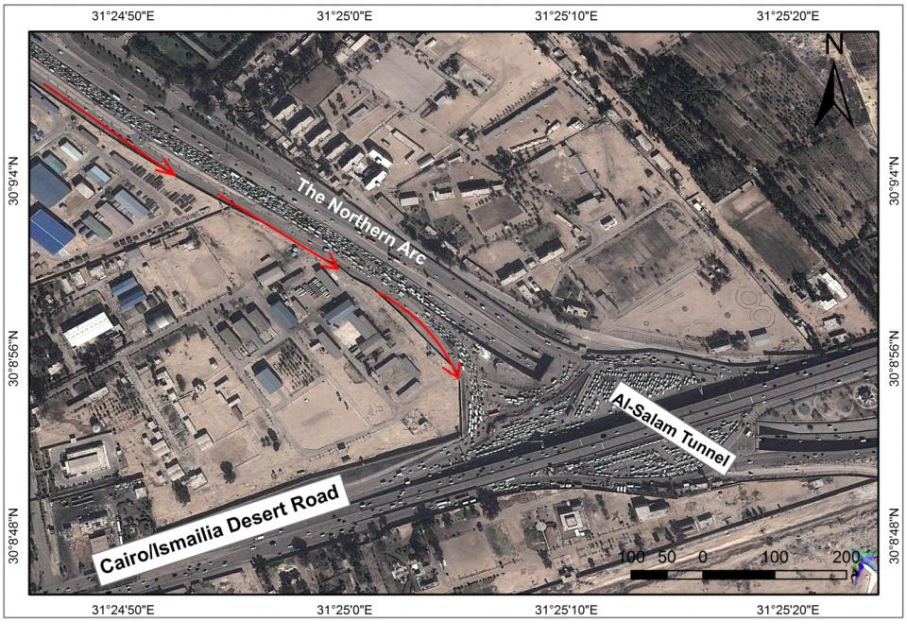


Figure 18 .Thebottleneck on Cairo / Ismailia Desert Road intersection
[Source: IKONOS Image loaded from Google Earth Pro with spatial resolution 1m, jun 2016]

- Cairo / Ismailia agricultural road Intersection (Al-Khosos intersection): Due to traffic coming from delta governorates towards El-Opor market, as well as the dense movement of heavy vehicles which going in between Mostorod and Shubra Al-Khaimah.

- El-Marg Intersection: There is a checkpoint, as well the density of traffic which directed to the Cairo / Alexandria agricultural road. Besides the movement of pedestrian and unsafe vehicles such as tricycles, motorcycles that cause a lot of traffic accidents (Finger19).

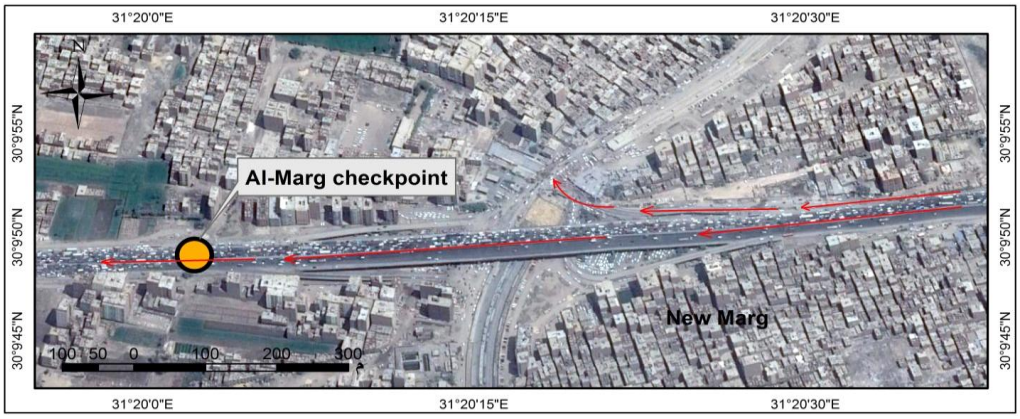
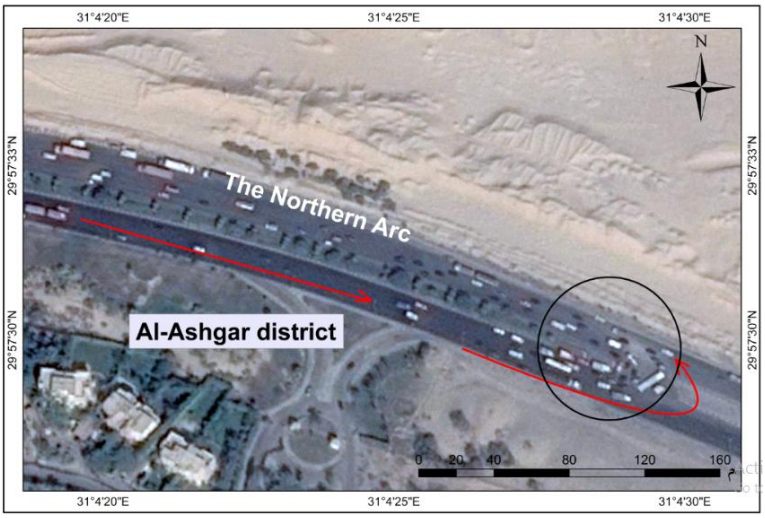


Figure 19 .Thebottleneck on El-Marg Intersection
[Source: IKONOS Image loaded from Google Earth Pro with spatial resolution 1m, jun 2016]

- Cairo / Alexandria agricultural road intersection (Met-Nama intersection): Due to the density of heavy vehicles traffic, the existing of a checkpoint in Basos and a random car park on the agricultural road off-ramp, causing the Queue of vehicles.
- July 26 axis intersection: As a result of the increasing traffic volume flow, which coming to and from the central business district of greater Cairo, especially during the peak periods.
- Exit of the Ring Road (9D) on Cairo / Alexandria Desert Road: To increase traffic flow up over its capacity, Leading to queue of the vehicles.

The most prominent physical bottlenecks, as following (Figure 16)**:**

- Upper Ring Road (9d) on Cairo / Alexandria Desert Road in the direction from 6 October city to 26 July axis and vice versa because it is a repair area for the joints of bridge.
- The ring road link by El-wahat Road: Because of the narrow of width (The width of two lanes in each direction is10.5 m) which doesn't suitable with the volume of heavy vehicles coming through Sahary El-Ahram axis and Cairo/ Fayoum Desert Road.
- There is a U-turn on El-wahat road in front of Al-Ashgar district, where the width of rotation is not suitable for the heavy vehicles which coming from the 6th of October industrial zone, as well the residents movement by their private cars.



(**Figure 20).** The bottleneck in front of Al-Ashgar district U-turn

REFERENCES

[1]. Ministry Of Housing, Utilities & Urban Development. (2008). ***Development strategy for the governorates of the Republic: Cairo Region (Cairo - Giza - Qalioubia)***. Cairo. P15.

[2]. Sharaby, Mahapat. (1990). ***Population Growth and Transportation Network in the Greater Cairo Region***. Cairo: Dar Alfeker Alarabi. P23.

[3]. Rodrigue, J& Comtois,C. (2006). ***The Geography of Transport Systems***. New York. Routledge. P179.

[4]. Ahmad, Ashraf saied. (2005). ***The Ring Road and the Third Millennium***. First Edition. Cairo: Dar Tapa. P17.

[5]. Alzoka, Mohmed khamies. (1997). ***Geography of Transportation***. Alexandria: Dar Almarefa. P94.

[6]. World Bank (2014). ***Egypt - Cairo Traffic Congestion Study: Final Report***. Arab Republic of Egypt. Vol No 2.P1-2. Available on: http://documents.albankaldawli.org/curated/ar/2013/05/19657784/egypt-arab-republic-cairo-traffic-congestion-study-vol-2-2-final-report

[7]. - Salem, Mahmoud Hassan. (1991). ***Traffic engineering***. Beirut: Dar Alrateb Algameaya. P155.

[8]. Rahka, H & Trani,A & Ahn, K. (2004) Development of Passenger Car Equivalents for Basic Freeway Segments. (M.Sc In Civil Engineering). the Virginia Polytechnic Institute. Virginia State University. P1-2.

[9]. Parvathy R& Sreelatha T& Reebu Z Koshy (2013) ***Development of new pcu values and effect of length of passenger cars on Pcu***. International Journal of Innovative Research in Science, Engineering and Technology. Vol 2. Special Issue 1. December 2013. P344-346.

[10]. Al-Obaedi, Jalal. (2016) ***Estimation of Passenger Car Equivalents for Basic Freeway Sections at Different Traffic Conditions***. World Journal of Engineering and Technology. Vol 4. P155.

[11]. Matulin, ect. 2009. ***Different Approaches to The Modal Split Calculation in URBAN AREAS.*** University of Zagreb: Faculty of Transport and Traffic Sciences. Department of Intelligent Transportation Systems. P2. Available on : https://bib.irb.hr/datoteka/414598.Matulin20Bosnjak20Simunovic.pdf

[12]. Trani, A. (November 2011) ***Transportation Systems Analysis Modeling***. the Virginia Polytechnic Institute. Virginia State University. P42.

[13]. Shalini, K & Kumar, B (June 2014) ***Estimation of the Passenger Car Equivalent: A Review***. International Journal of Emerging Technology and Advanced Engineering. Volume 4, Issue 6. P97.

[14]. Rahka, H & Trani,A & Ahn, K. (2004) ***Development of Passenger Car Equivalents for Basic Freeway Segments***. (M.Sc In Civil Engineering). the Virginia Polytechnic Institute. Virginia State University. P 344-346.

[15]. Jayaratne, D.& Jayasinghe, P.&H. R. Pasindu. (2016) ***Evaluation of Level of Service for two-lane roads in Sri Lanka***. Colombo: IESL Annual Sessions. P1. Available on: https://www.researchgate.net/publication/309285341

[16]. the National Academy of Sciences. (2000). ***Highway Capacity Manual***. Washington DC. P 4-5.

[17]. Mathew, V &Krishna, K (2007) ***Transportation Systems Engineering***. India: National Programme on Technology Enhanced Learning. P35.4. Available at: http://nptel.ac.in/courses/105101087/downloads/Lec-35.pdf

[18]. O'Flaherty, CA (2006) Transport Planning and Traffic Engineering. Elsevier Ltd. Netherlands. Sixth Edition. P283-284.

Abd-Elaziz, Asmaa"The Effect of Traffic Composition on PCU Values and Traffic Characteristics on The Northern Arc of The first Ring Road around Greater Cairo..” IOSR Journal Of Humanities And Social Science (IOSR-JHSS). vol. 22 no. 12, 2017, pp. 01-17.