3 Identification of Causes, Types and Locations of Traffic Congestion

3.1 Introduction

This section concerns primarily with identifying the causes, types and locations of road congestion in the GCMA. The strategic purpose of this task is to serve as input into phase 2 of the study which aims at determining and prioritizing congestion relief interventions. In addition, part of the information will be used in the calculation of economic costs of congestion (Chapter 4), in particular the information on average speeds in peak and off-peak periods.

In this section, we adopt a hybrid approach consisting of (1) a quantitative assessment of a limited number of principal corridors; and (2) a network-wide qualitative assessment. In the quantitative assessment, we identify the causes and locations of congestion along the study corridors, while in the network-wide assessment we focus on the causes of traffic congestion across the GCMA without reference to specific locations.

3.2 Principal corridor assessment

This section presents the analysis of the floating car survey data and discussion of results. The collected data were principally travel distances per time interval for each direction of each route, for multiple runs during the morning and afternoon peaks. Observations on some traffic influencing events were also recorded. The analysis also encapsulates information from other sources, namely traffic police monitoring center and road features visual inspections. The performed analysis is discussed at two levels; a collective assessment level and an individual one. The principal corridors collective assessment level aims at providing a bird's eye view on the traffic conditions along the study corridors. Route aggregate operational performance indicators serve as the backbone of the intended analysis. On the other hand, the principal corridor individual assessment level provides more insightful details pertaining to localized congestion conditions.

3.2.1 Principal Corridor Collective Assessment

The objective of this analysis phase is twofold, first to provide a wide scope network condition assessment and second to enable the comparative assessment of the different individual corridors. To achieve these objectives the following analysis dimensions are investigated:

- Speed and Reliability Analysis
- Traffic Influencing Events Analysis

Speed and Reliability Analysis

Segmented Speed Analysis

Identification of congestion patterns from a network perspective could be adequately represented through the analysis of speed patterns. Figures 3.1 and 3.2 display a sample of estimated travel speeds along surveyed routes for the morning and evening peak periods, respectively. Reduced travel speeds have been observed in the evening peak in comparison to the morning one, as shown in Figures 2.10 and 2.11. It is clear from the figures that congested conditions in the evening period are more widespread across the network relative to the morning peak period. In the following, some insights pertaining to the observed congestion patterns are highlighted.

Area Type (1)

City centre gateways on the radial corridors connecting the peripheral areas to the city center.

Description

Near City center portions of the radial corridors connecting the peripheral areas to the city center. Those portions represent the main gateways to the CBD. Several physical and operational bottlenecks have been observed on those gateways.

Example locations

Morning Peak

Within the Ring Road portion of the 26th of July corridor, Gesr ElSuez, Salah Salem near El-Abasseya, ElHaram Street near ElHaram Tunnel, and Cornish El-Nile.

Evening Peak

Extended segments on: Ahmed Helmy street in Shobra, El-Thawra Street in between Orouba/Salah Salem and El-Nasr/Autostrad, and within ring road portion of the 26th of July/15th of May corridor, Cairo/Ismailia Desert Road

Area Type (2)

Centre Business District (CBD) surface street network

Description

High density traffic network with several traffic conflicts and inefficient traffic controls. Frequent operational bottlenecks (such as random microbus stops) and traffic influencing event (such as random pedestrian crossing) are among the main causes of traffic congestion on this area type.

Example locations

Ramsis Street and El-Tahrir Square.

Area Type (3)

Segments of major East-West/North-South arterials

Description

East-West/North-South travel corridors are high volume arterials connecting the city ends. Several physical and operational bottlenecks have been observed along those arterials. In addition, intersections-related delays (mainly inefficient traffic controls, and u-turns delays) have been among the causes of observed congestion.

Example locations

Morning Peak

ELkablat Street, and Salah Salem from ElMokatam till Abbass Bridge

Evening Peak

Extended segments on Salah Salem in between ElAbasseya and Ein Elsira, El Nasr/Autostrad from Sheraton till 6th of October Bridge, 6th of October Bridge in between Cornish El-Nile and El-Orouba exit.

Area Type (4)

Ring Road segments in the vicinity of major interchanges
Description Congestion along the Ring Road is predominantly due to operational and physical bottlenecks. Operational bottlenecks are mostly observed near major interchanges; due to the high volume of traffic using those interchanges. The high traffic volume exceeds the exits/entrances capacities at most of the identified locations. In addition, frequent random microbus stops are observed at those locations. **Example locations** Morning Peak Limited segments near: 26th of July corridor interchange, Cairo/Alexandria road interchange, El-Maryoutya interchange, El-Khosous interchange, Cairo/Ismailia interchange, Cairo/Suez interchange, and Carrefour Shopping mall interchange Evening Peak Extended segments near: 26th of July corridor interchange, Cairo/Alexandria road interchange, ElMaryotaya interchange, Cairo/Ismailia interchange, Cairo/Suez interchange, and Carrefour Shopping mall interchange

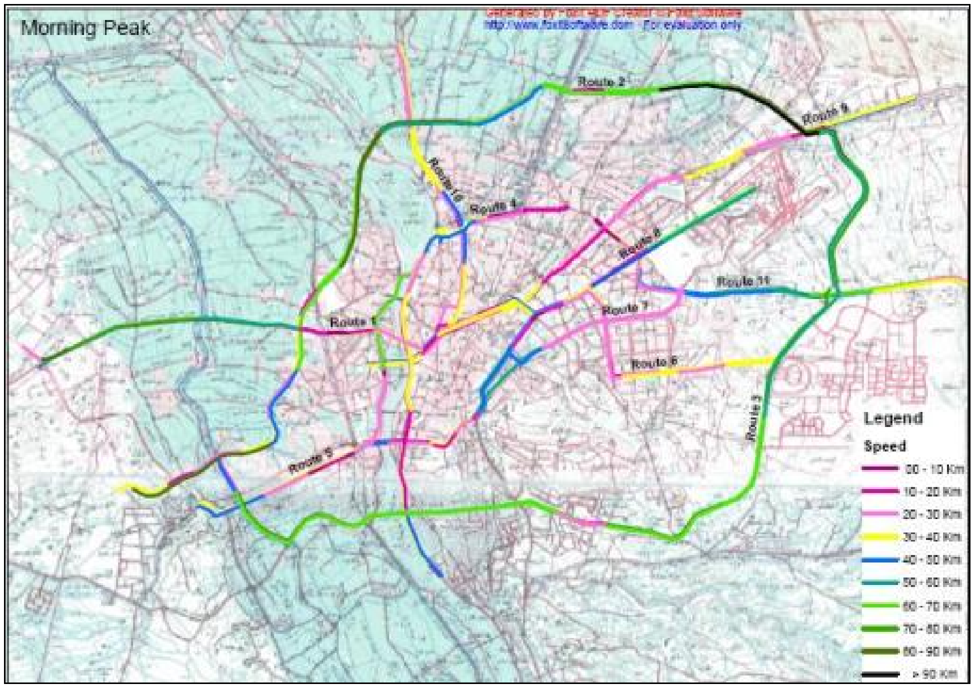

Figure 3.1: Morning Peak Sample Travel Speed

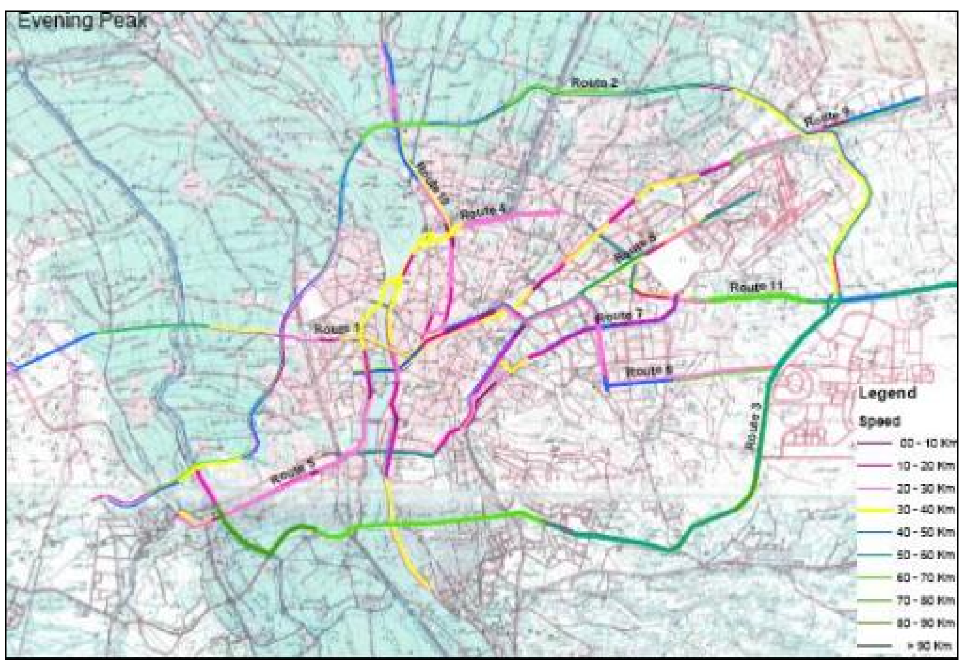

Figure 3.2: Evening Peak Sample Travel Speeds

Corridor Average Speed Analysis

From an aggregate corridor perspective, average travel speeds as well as speed indices (ratio of the average speed to the free flow speed) are estimated to enable the principal corridors comparative assessment. The detailed estimation procedure is provided in Annex 4.

As previously mentioned, the floating car survey data included travel distances that were recorded only every 5 minutes, together with the start and end times of each trip. Observations on some traffic influencing events were also recorded, yet not when the end of a queue was reached or at major intersections.

Figures 3.3 through 3.10 display the estimated average speeds for the different travel directions for both peak periods. It is noteworthy that direction 1, in the analysis results, represents the movement towards the Central Business District (to-CBD) and direction 2 represent the movement from the CBD (from-CBD). The only exception is the Ring Road, as direction 1 represents counter-clockwise for Route 2 and clockwise for Route 3.

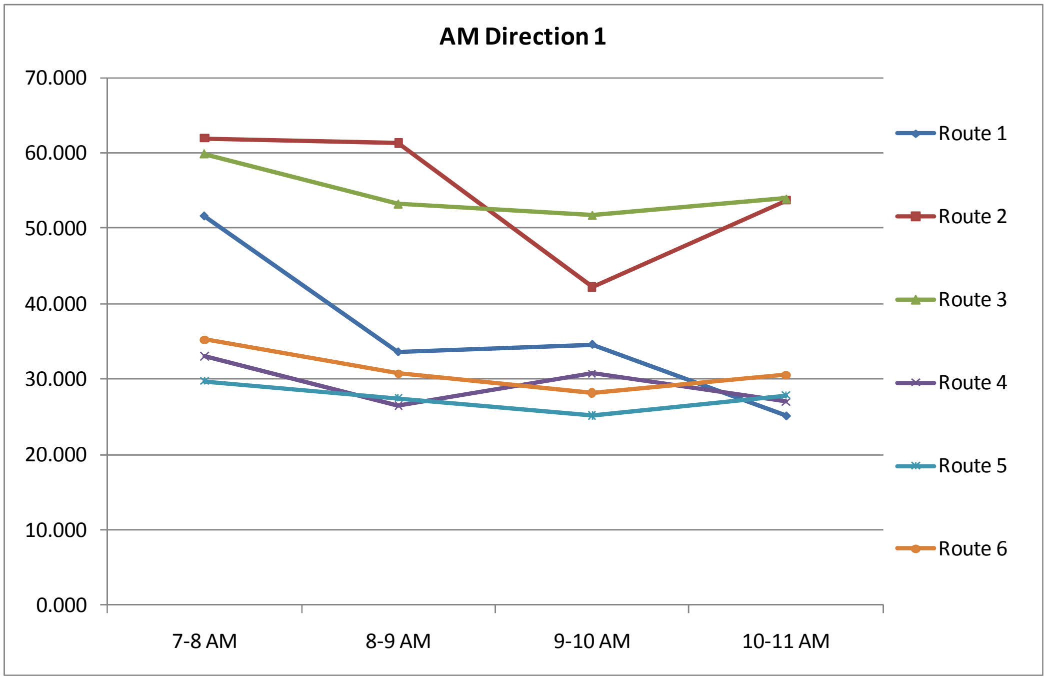

Figure 3.3: Principal Corridors Average Speeds- AM Direction 1- Routes 1 to 6

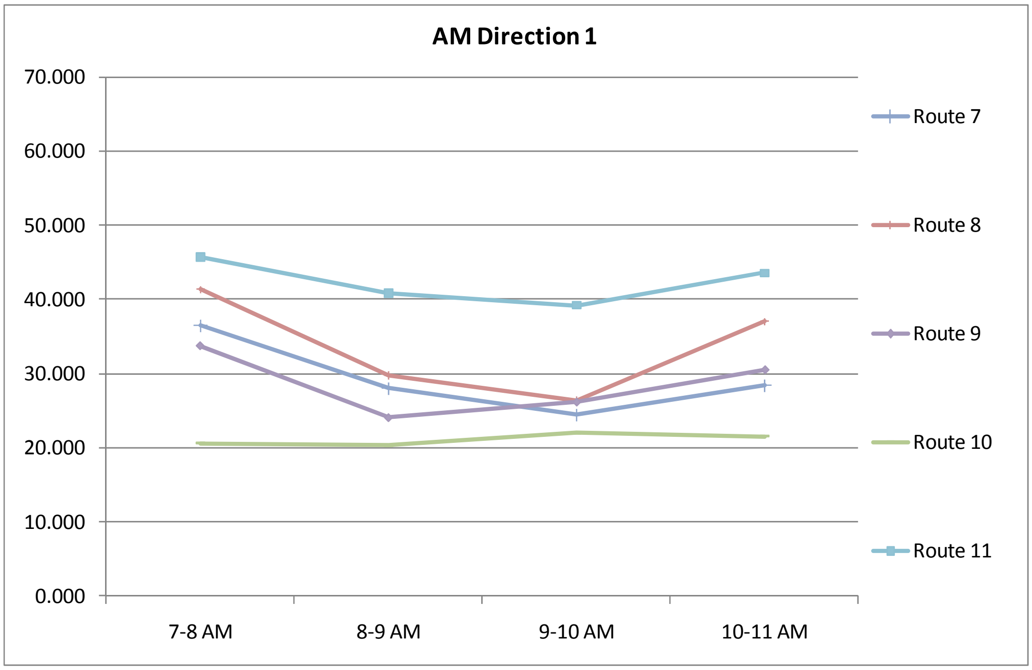

Figure 3.4: Principal Corridors Average Speeds- AM Direction 1- Routes 7 to 11

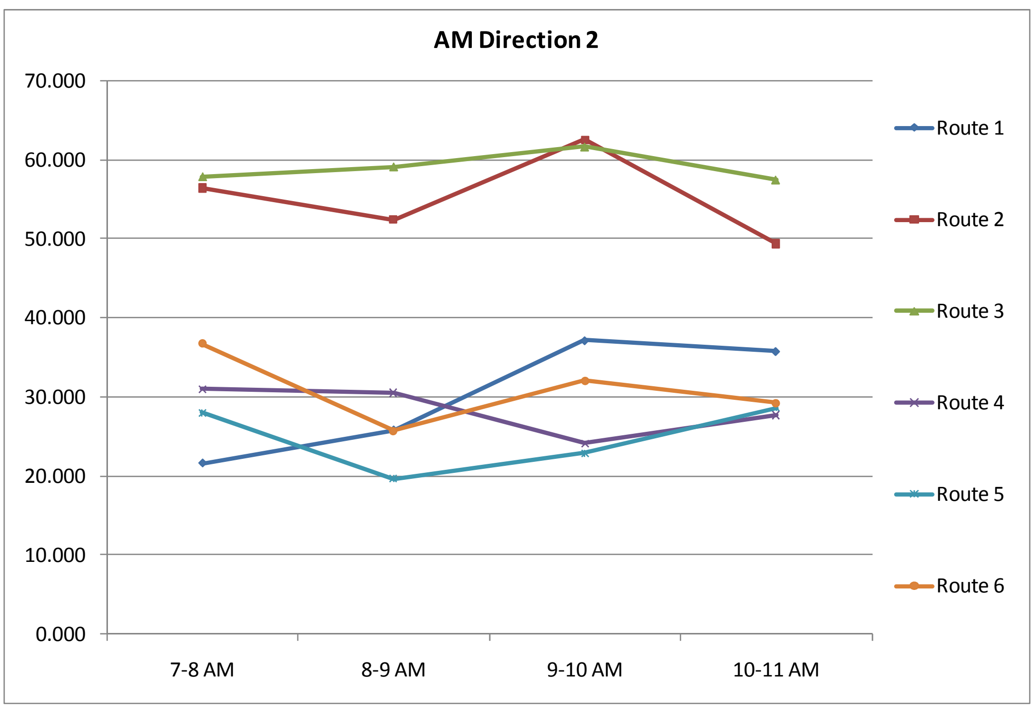

Figure 3.5: Principal Corridors Average Speeds- AM Direction 2- Routes 1 to 6

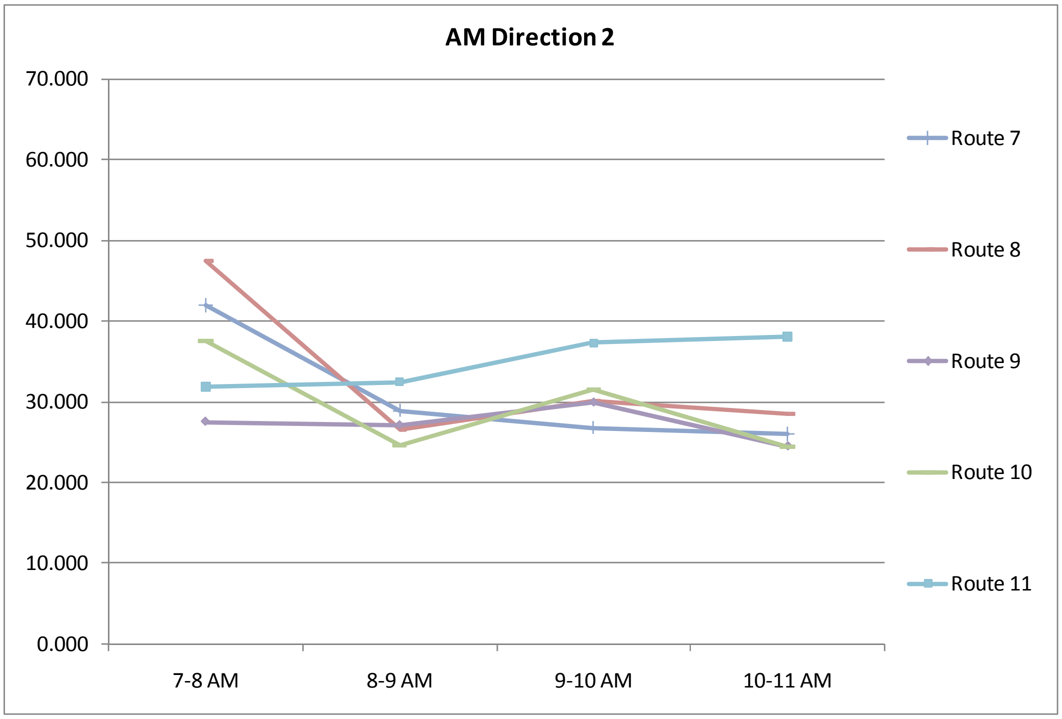

Figure 3.6: Principal Corridors Average Speeds- AM Direction 2- Routes 7 to 11

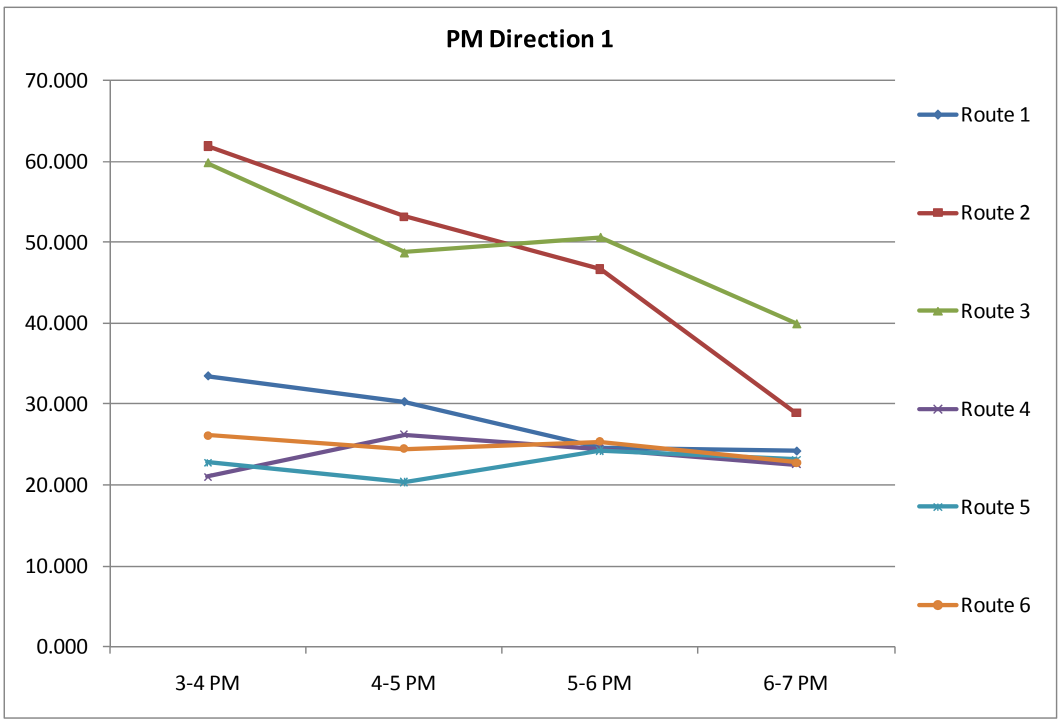

Figure 3.7: Principal Corridors Average Speeds- PM Direction 1- Routes 1 to 6

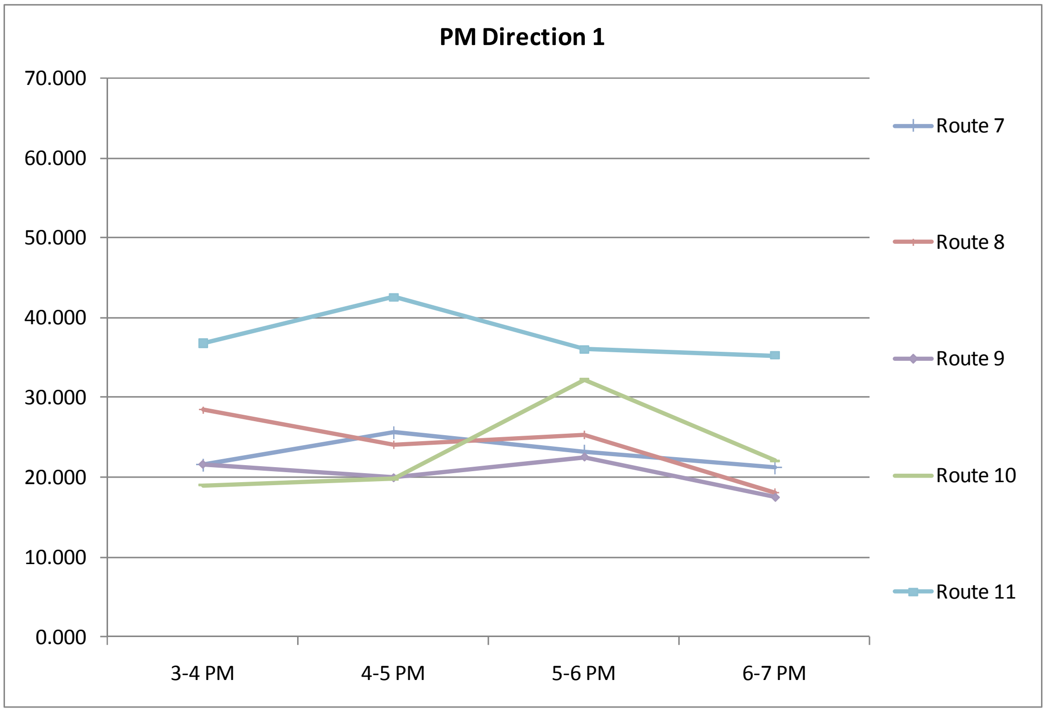

Figure 3.8: Principal Corridors Average Speeds- PM Direction 1- Routes 7 to 11

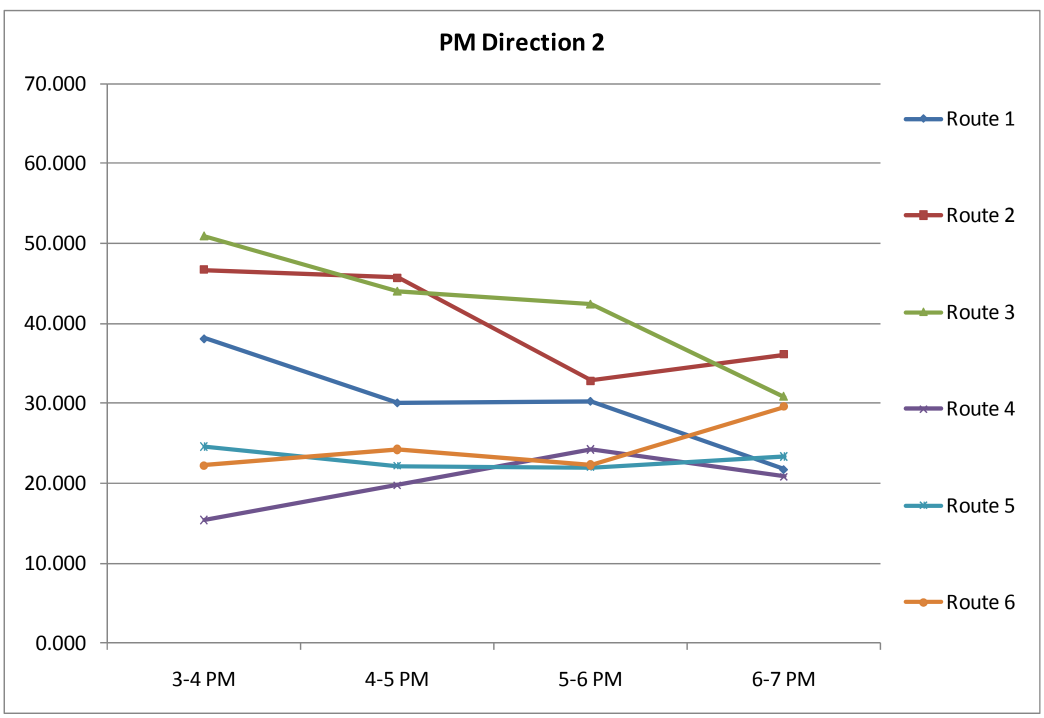

Figure 3.9: Principal Corridors Average Speeds- PM Direction 2- Routes 1 to 6

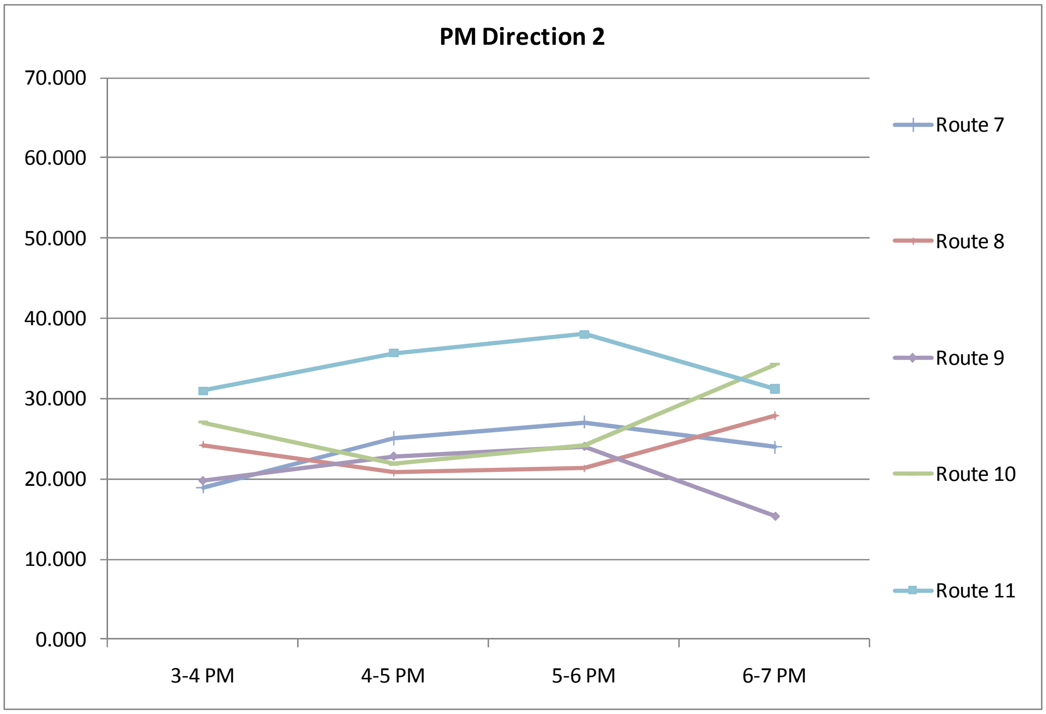

Figure 3.10: Principal Corridors Average Speeds- PM Direction 2- Routes 7 to 11

The graphs provide the following insights:

- Average speeds for all surveyed corridors within the area contained by the Ring Road but not including the Ring Road (routes 4 to 11) fall in the range of 20 - 45 km/hr for the entire morning peak duration, for both travel directions. Reduced travel speeds have been observed for the evening peak ranging from 15- 30 km/hr.
- The average speed along the Ring Road (routes 2 and 3) is in the range of 45 – 60 km/hr for the westbound (direction 1) during the morning peak. This range is further extended to 30 – 65 km/hr during the evening peak.
- The average speed along the Ring Road (routes 2 and 3) is in the range of 50 – 60 km/hr for the eastbound (direction 2) during the morning peak. Reduced average travel speeds have been observed for the evening peak ranging from 30 to 50 km/hr.
- The average speed along the 26th of July/15th May Travel Corridor (Route 1) is in the range of 30–50 km/hr for the morning peak of the "to-CBD" direction (direction 1). Reduced travel speeds have been observed for the evening peak ranging from 25 to 35 km/hr.
- The average speed along the 26th of July/15th of May Travel Corridor (Route 1) is in the range of 20–40 km/hr for the morning peak and evening peaks of the "from-CBD" direction (direction 2).
- A reduced morning peak period 8:00-10:00 am could be observed on most of the surveyed corridors. A reduced evening peak period of 5:00-7:00 pm for the "to-CBD" direction could also be observed for most surveyed corridors.

Similar to the corridor average speed analysis, a speed index has been estimated for each surveyed route. The speed index, representing a measure of congestion, is calculated as the ratio between the route average speed to its free flow speed. The free flow speed estimation procedure is outlined in Annex 4.

In many areas of the world, the speed index is close to 1 on inter-urban highways, where the average speed is almost equal to the free flow speed, and starts decreasing in urban areas where congestion starts to take effect. One example of time-dependent speed profiles on urban expressways is given for the Swedish road network by a White paper on Travel Time Measurements using GSM and GPS Probe Data. Although Sweden usually only suffers moderately from congestion compared to other European capitals, some of the bigger roads in the area of Stockholm also show rush hour behavior, including the Western stretch of the Essingeleden highway. On Monday morning, the average speed sharply drops to about half the free flow speed on a regular basis (resulting in a speed index of 0.5). Similarly, on Monday afternoon, there are significant speed drops on some of the city's highway stretches and on its major roads compared to free flow conditions.

The analysis results revealed that the average speed indices for all surveyed routes range from 0.31 (PM peak period) to 0.63 (AM peak period), as shown in Figure 3.11. In general, the speed indices of the afternoon peak period seem to be constantly lower than those recorded during the morning peak period, implying slower speeds and more congestion. Surveyed routes are ranked in descending order of the average speed index (considering AM and PM periods) as follows:

- Route 3 (0.57)
- Routes 2, 6 (0.55)
- Route 7 (0.49)
- Route 8 (0.48)
- Route 11 (0.47)
- Route 5 (0.46)
- Route 4 (0.44)
- Route 10 (0.41)
- Route 1 (0.38)
- Route 9 (0.36)

An average speed index of 0.5 implies that the speed experienced by the driver on a certain route under uncongested (free flow) conditions is reduced to half during actual, congested conditions. Routes 1, 4, 9 and 10 seem to be witnessing the most delays as their speed indices are below the 0.5 threshold. Motorists on routes 5, 7, 8 and 11 seem to be experiencing the situation where the free flow speed is reduced to half, while those on routes 2, 3 and 6 seem to be experience a fairly better situation.

Considering the effect on travel time, the lower speed index values are particularly onerous. For roads with similar free flow speeds, such as Routes 1 and 11 where free flow speed are near 80 Kph, the travel time on Route 1 would take around 1 more minute for every 2.65 Km travelled compared to Route 11, due to the drop in the speed index.

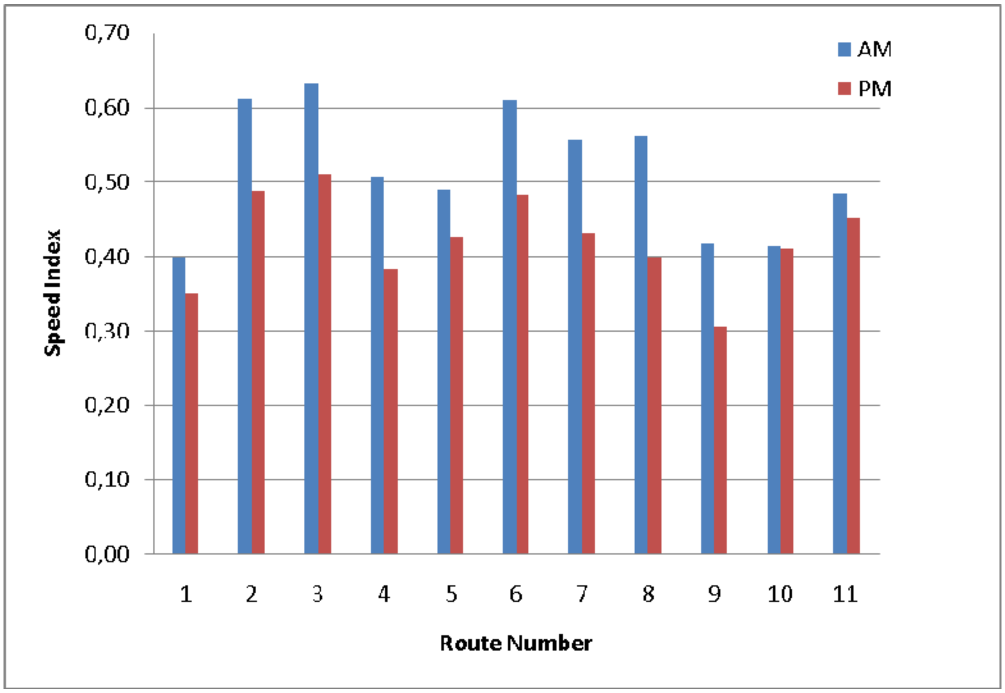

Figure 3.11: Principal Corridors Speed Indices

Reliability Analysis

Network reliability could be captured by measuring the variability in observed travel speeds from multiple floating car runs. On average 16 runs were recorded for each direction of each route for each peak period through the FC survey. Variations in trips' length caused some alterations. As such, the undertaken reliability analysis is based on the estimated coefficients of variation of the corridors average speeds. Figures 3.12 and 3.13 depict the analysis results. The following insights are made:

- Estimated COVs for all surveyed corridors, except for the 26th of July/15th of May travel corridor, fall in the range of 0.25 to 0.65.
- An increased variability in travel speeds has been estimated for the evening peak compared to the morning peak for all surveyed corridors, with the exception of direction 2 of routes 5 and 10.
- A significantly higher variability in travel speeds has been estimated for the 26th of July/15th of May travel corridor (route 1) with a COV ranging from 0.69 to 0.85.

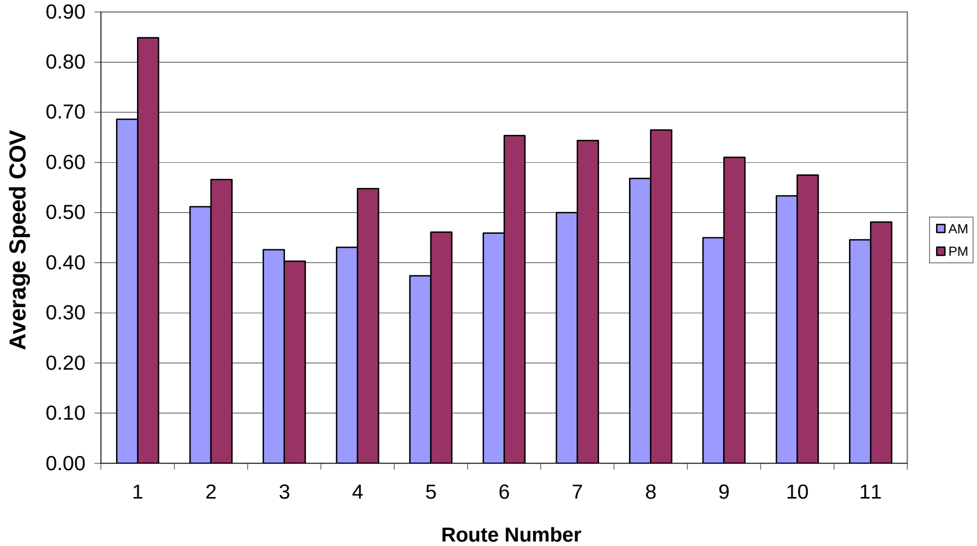

Figure 3.12: Principal Corridors Speed COVs, Direction 1

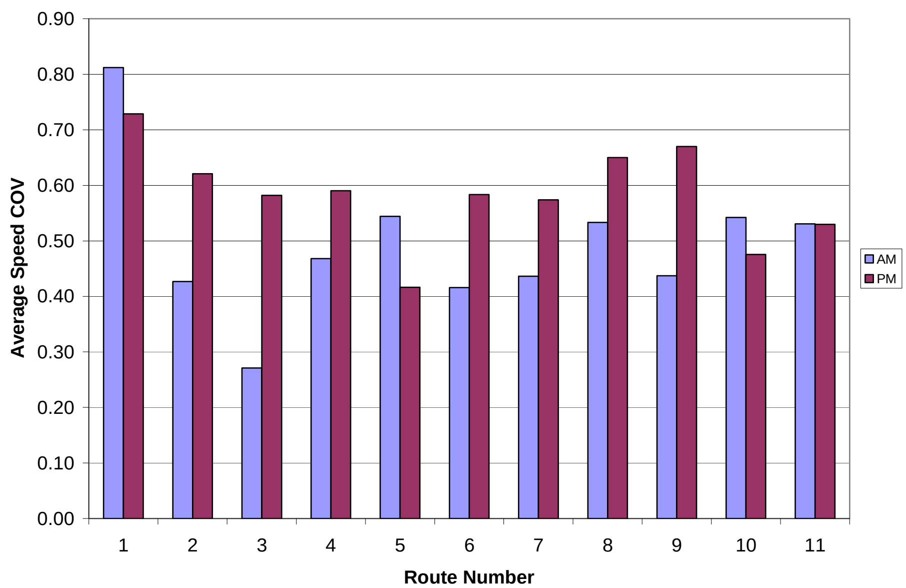

Figure 3.13: Principal Corridors Speed COV, Direction 2

The shown variability in traffic speeds is likely to encapsulate both day to day variability in traffic volumes as well as within-day variability due to situational differences (such as the random stop of a microbus) and personal differences (such as drivers' experiences and responsiveness).

Another measure for travel time reliability is the buffer index. The buffer index is estimated as the difference between the 95^{th} percentile speed and the average speed divided by the average speed. The buffer index represents the additional time travelers need to consider in the planning phase of their trip to ensure on-time arrival. As the buffer index increases the travel time reliability decreases. Figures 3.14 and 3.15 present the estimated buffer indices for the 11 surveyed corridors. Analysis results indicate the following:

- Estimated buffer indices range from 0.36 to 1.61.
- As revealed from the COV analysis, higher values for the buffer indices are estimated for the evening peak compared to the morning one. Exceptions are direction 2 of routes 5 and 10.
- Estimated buffer index for the 26th of July corridor ranges from 1.2 to 1.6, which means that the 95th percentile speed is more than double the average speed. This high buffer index value reflects the lack of reliability on this crucial travel corridor.
- Above unity value for the buffer indices are estimated for the evening periods of routes 6, 7, 8, and 9. This high value reflects the decreased travel time reliability on those routes, where the 95th percentile speed[5] exceeds double the average speed. While Routes 6, 7, 8 and 9 are not the most congested as observed in the average speed graphs presented earlier, the analysis of traffic performance along the corridors would benefit from considering both reliability and traffic congestion.

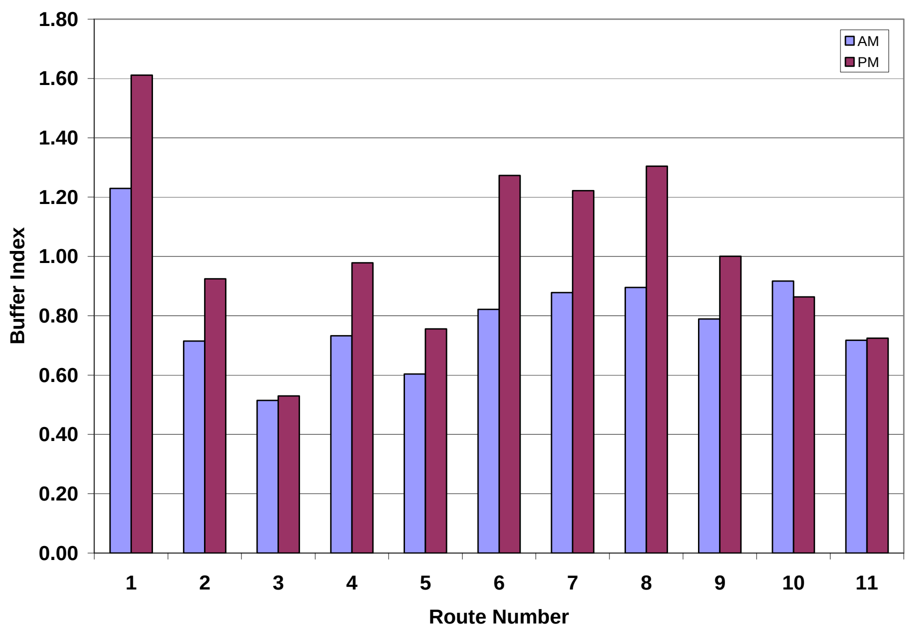

Figure 3.14: Principal Corridors Buffer Index, Direction 1

[5] It should be noted that with 16 runs recorded through the floating car survey the valid number would be at the 93.75th percentile

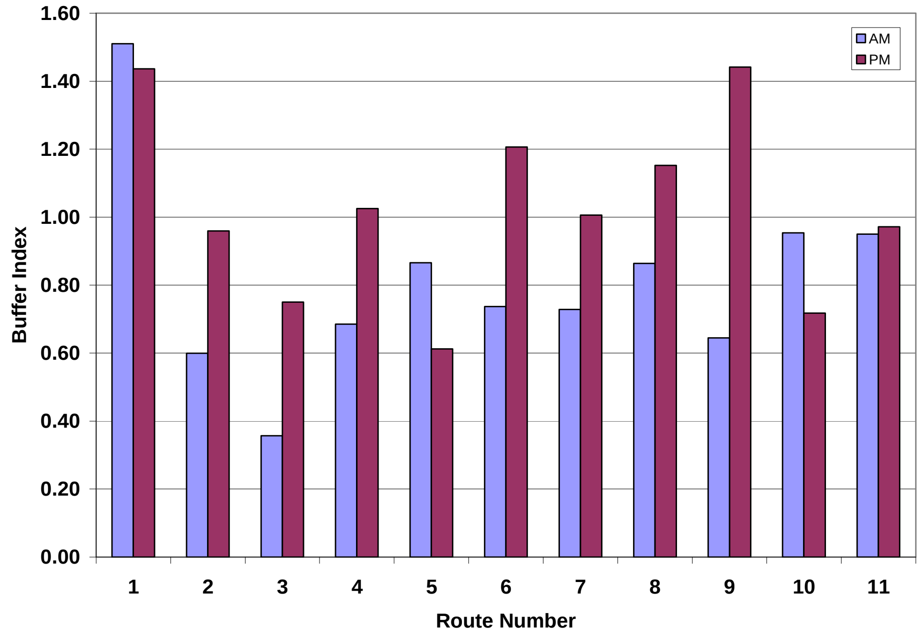

Figure 3.15: Principal Corridor Buffer Index, Direction 2

Traffic Influencing Events Analysis

Traffic influencing events are considered one of the main causes of travel time variability. Figure 3.16 depicts the average daily frequencies of three main traffic influencing events, namely; accidents, security check points, and vehicle breakdowns, along all surveyed routes over the four days of the FC survey. The reported daily frequencies encapsulate morning and evening peaks for both travel directions. The following insights could be made:

- The daily rates of vehicle breakdowns on all surveyed routes are significantly higher than the other traffic influencing events.
- Increased frequencies of accidents, security checks and breakdowns are observed on all urban primary highways (routes 1, 2, and 3) compared to the urban primary arterial routes (dominant portions of routes 4, 5,6,7,8,9,10, and 11).
- Route 3 (Southern portion of the Ring Road) witnesses the highest frequencies of all traffic influencing events.
- Route 1 (26^{th} of July/15^{th} of May corridor) witness high frequencies of vehicle breakdowns as well as security check points.
- Route 2 (Northern portion of the Ring Road) and Route 3 witness relatively high accidents rates.

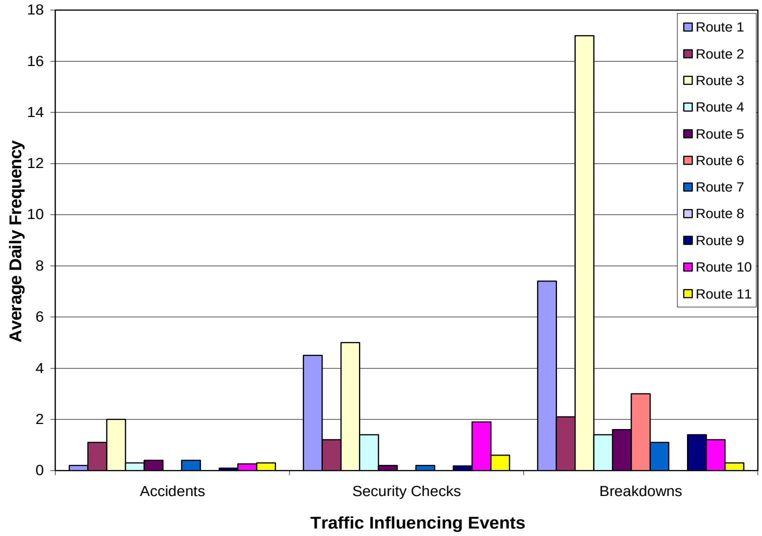

Figure 3.16: Traffic Influencing Events Frequencies

In addition to the quantitative analysis of the above listed traffic influencing events, a qualitative analysis is conducted with respect to two additional types of events, namely; random microbus stops and random pedestrians crossing. Table 3.1 summarizes the analysis results, where "H" denotes High rates, “M" for Medium and "L" for Low. The analysis reveals the substantial occurrence of both events on most surveyed routes.

Table 3.1: Aggregate Qualitative Observations on Traffic influencing Events

Routes	Random Microbus Stops	Random Pedestrian Crossings
1	H	M
2	M	L
3	H	M
4	H	H
5	H	H
6	M	M
7	H	H
8	NA	NA
9	H	L
10	H	H
11	L	H

3.2.2 Principal Corridor Individual Assessments

This section discusses in detail the analysis results of the collected data for each surveyed route independently. Aggregate as well as localized congestion causes are identified along each route. The key analysis results are included in this section, for conciseness purposes. More details on space-time plots and field photos are included in Annex 4.

Route 1: 26th of July/15th of May Travel Corridor

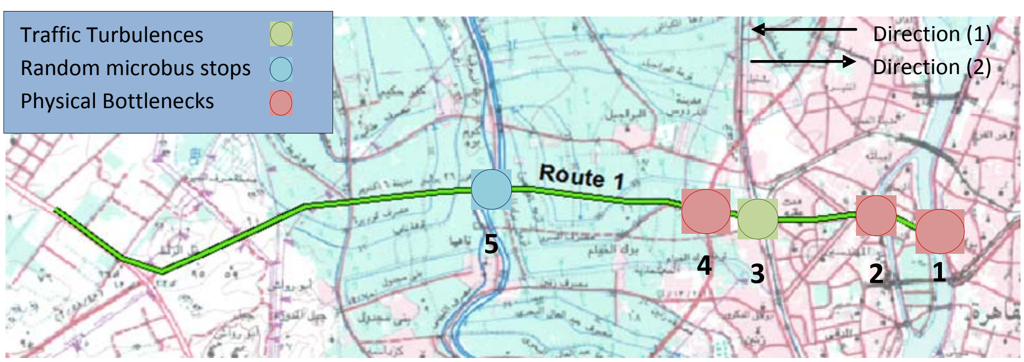

Figure 3.17: Route 1 Schematic

This route stretches from the Cairo - Alexandria desert road in the west and heads eastwards into downtown Cairo crossing the Ring Road, Lebanon Square, Zamalek and ending at Elesaaf (Figure 3.17). The total length of the route is approximately 20km. The route is considered a vital traffic corridor in Cairo as it is the main link connecting Cairo with 6th of October City and the Cairo-Alexandria Desert Road. Most of route 1 belongs to road class 2 (urban primary highway), with an 80 Km/hr speed limit. Less than 25% of that route belong to road class 3 (urban expressway), with a 60 km/hr speed limit.

The estimated average speed along the route is 31 km/hr with a speed index of 0.38. Significant variations of travel speeds have been experienced on that route, with an average speed COV of 0.77. In addition many traffic influencing events have been reported as depicted in Table 3.2.

Table 3.2: Daily Traffic Influencing Events, Route 1

Average Daily Frequency	Accidents	0.2
	Security Checks	4.5
	Vehicle Breakdowns	7.4
Qualitative observation	Random Microbus Stops	High
	Random Pedestrian Crossings	Medium

Analysis results from space-time plots of multiple runs along route 1 together with obtained information from the traffic police control centre indicate that causes of congestion are predominantly due to physical bottlenecks. The majority of these bottlenecks occur at the entrance and exit ramps along the route. The following is a description of distinct congestion location/causes along the route:

Location (1)
Cause: Physical Bottleneck
4 entrances to 15th of May bridge (2 lanes each with high demand) merge into a 4-lane 180 m segment crossing the Nile. The route then shrinks into a 2-lane overpass over Zamalek.
Location (2)
Cause: Physical Bottleneck
Direction-2: Three traffic streams from Abou El-Feda, Zamalek and through traffic from 15th of May Bridge all merge into a 3-lane overpass crossing the Nile. Direction-1: Three entrances to 15th of May bridge, located at a very short distances merge into 3 lanes across the River Nile. The distance along the segment crossing the river Nile is insuffecient for waeving for vehicles to reach El-Zamalek and El-Gabalaya exits.
Location (3)
Cause: Conflicts inducing traffic turbulences + Physical Bottleneck
Direction-2: Surface flow merges with the travel corridor at Tersana Club. This causes conflicts and turbulences to the through traffic. Three traffic streams (two lanes each) merge into two lanes. These lanes continue till the interchange of the Ring Road. After the interchange, the road widens into a 4-lane road till the end of the route.
Location (4)
Cause: Physical Bottleneck
Direction-1: Reduction in number of lanes; from 4 lanes to 2 lanes in addition to extra merging traffic from the Ring Road.
Location (5)
Cause: Operational Bottleneck
Passengers from surface roads board and un-board microbuses frequently at this location causing an induced reduction in road capacity

Route 2: Ring Road (Northern segment)

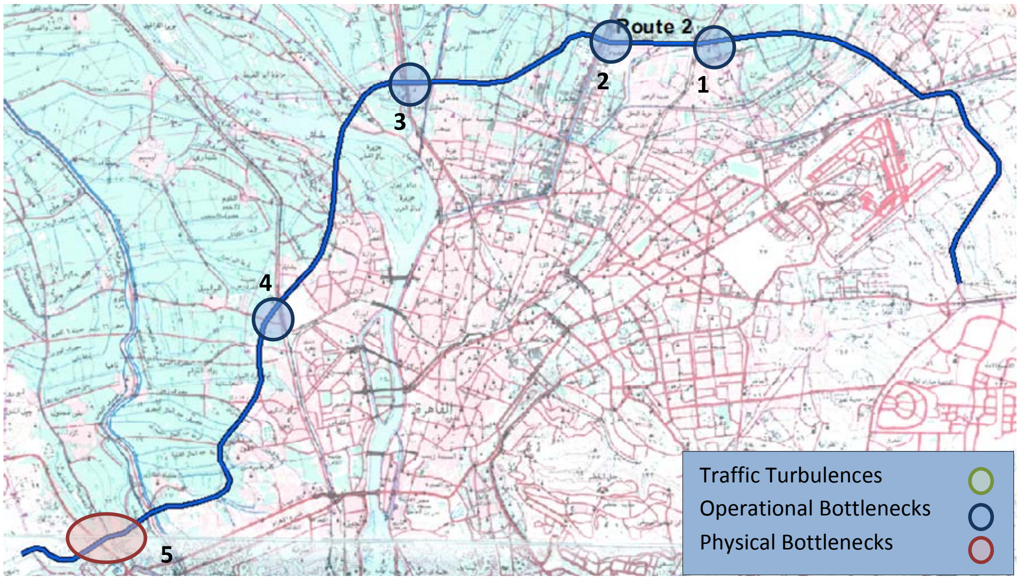

Figure 3.18: Route 2 Schematic

This route stretches from the east end of Cairo at the intersection of Suez Desert Road with the Ring Road along the northern and western segments of the Ring Road until the Wahat Desert Road (Figure 3.18). The total length of the route is approximately 60km. The route passes along some major interchanges of the Ring Road with regional highways like the Ismailia Desert Road, The Alexandria Agricultural Road, El-Khosous and the 26^{th} of July Corridor.

The estimated average speed along the route is 50 km/hr with a speed index of 0.55. An average COV of observed speeds is estimated to be 0.53. An observed day-to-day variability in travel speeds significantly contributes to the overall speed variability. This section of the Ring Road experiences some traffic influencing events on a daily basis, most notably, daily accidents. Table 3.3 provides a summary of observed traffic influencing events.

Table 3.3: Daily Traffic Influencing Events, Route 2

Average Daily Frequency	Accidents	1.1
	Security Checks	1.2
	Vehicle Breakdowns	2.1
Qualitative observation	Random Microbus Stops	Medium
	Random Pedestrian Crossings	Low

Analysis results indicate that causes of congestion along route 2 are predominantly due to operational and physical bottlenecks. Operational bottlenecks are mostly observed near major interchanges, most notably, the 26^{th} of July interchange. The following is a description of distinct congestion location/causes along route 2:

Locations (1, 2, 3, 4)
Cause: Operational Bottleneck
Observed operational bottlenecks are due to the volume of traffic using those major interchanges which exceeds the exits/entrances capacities at most of the identified locations. In addition, frequent random microbus stops are observed at those locations.
Location (5)
Cause: Physical Bottleneck
A reduction in the number of lanes from 4 lanes to 2 lanes in section of the Ring Road from El-Maryoutya interchange to El-Wahat Desert Road.

Route 3: Ring Road (Southern Segement)

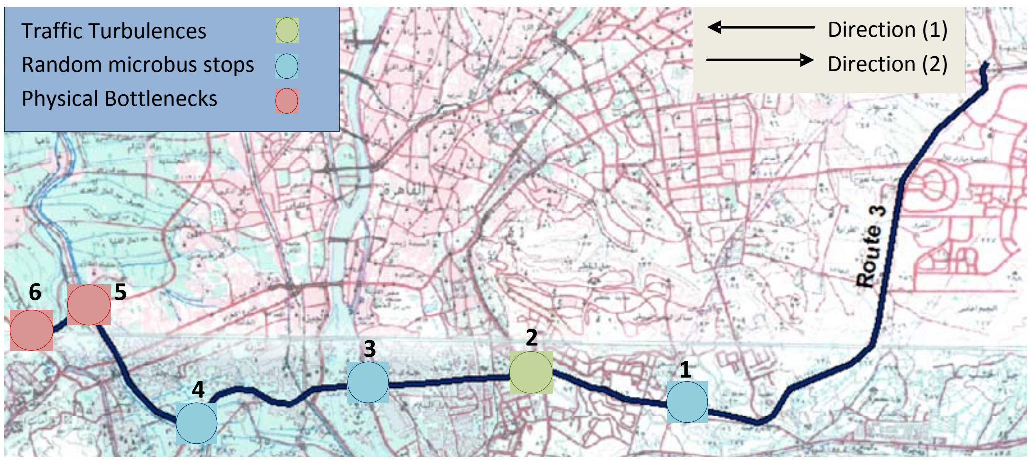

Figure 3.19: Route 3 Schematic

This route stretches from the east end of Cairo at the intersection of Suez Desert Road with the Ring Road along the southern segments of the Ring Road until the Alexandria Desert Road (Figure 3.19). The total length of this route is approximately 40km. The route passes along some major interchanges that include the Autostrad, and Maryouteya interchanges.

The estimated average speed along the route is 51 km/hr with a speed index of 0.57. An average COV of observed speeds of 0.42 has been estimated. Observed day-to-day variability in travel speeds are rather limited for this section of the Ring Road. This section of the Ring Road experiences many traffic influencing events on a daily basis (Table 3.4). In addition, pedestrian flows across the Ring Road reflect a crucial hazard phenomenon.

Table 3.4: Daily Traffic Influencing Events, Route 3

Average Daily Frequency	Accidents	2
	Security Checks	5
	Vehicle Breakdowns	17
Qualitative observation	Random Microbus Stops	High
	Random Pedestrian Crossings	Medium

Analysis results indicate that causes of congestion along route 3 are predominantly due to operational and physical bottlenecks. The following is a description of distinct congestion location/causes along route 3:

Location (1)

Cause: Operational Bottleneck

Both directions of the route are impacted by frequent Microbus stops alongside the Carrefour shopping complex. This was further substantiated by the floating car survey and is shown in the time-space plots.

Location (2)

Cause: Operational Bottleneck + Traffic Turbulences

This occurs at both directions of the route at the Autostrad interchange. This was caused by the following:

- High traffic demand at entrances with high percentage of trucks.
- Frequent microbus stops
- Pedestrian Crossing
- Turbulences induced by conflicting traffic movements near the exit ramp

Location (3, 4)

Cause: Operational Bottleneck

Frequent random microbus stops and a security checkpoint cause congestion in direction 2.

Location (5)

Cause: Operational Bottlenecks

Direction (1):

Alexandria desert road exits: High traffic volume exiting the Ring Road to Cairo/Alex Desert road. Peak hour exiting traffic volume exceeds the exiting ramp capacity causing accumulation of traffic queues on the Ring Road.

Location (6)

Cause: Physical bottlenecks

A Physical bottleneck occurs from the Maryouteya interchange to El-Wahat Desert Road The number of lanes is reduced from 4 lanes to 2 lanes.

Route (4): El Corniche-East/El-Matareya Square

This route stretches from the north end of Cairo in Materya square, along Kablat street westwards till it meets Corniche ElNile-East-bank street near Roud El Farg Bridge (Figure 3.20). The route then runs south along Corniche El-Nile-Eastbank street till Maadi. This route is quite different from the first three routes as it is mostly an Urban Primary Arterial Street and has several signalized and un-signalized intersections, with a dominant speed limit of 60 km/hr. Corniche ElNile-Eastbank Street is a critical travel corridor in the City as it is considered one of the main North-South corridors near the centre of the City.

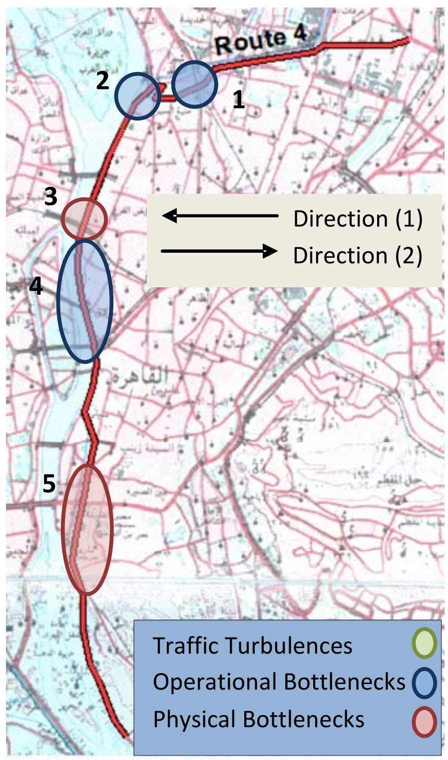

Figure 3.20: Route 4 Schematic

The estimated average speed along the route is 25 km/hr with a speed index of 0.44. An average COV of observed speeds of 0.5 has been estimated. Most of the observed speed variability is attributed to inconsistencies in intersection-related delays and random microbus stops. Table 3.5 summarizes the observed daily traffic influencing events on route 4.

Table 3.5: Daily Traffic Influencing Events, Route 4

Average Daily Frequency	Accidents	0.3
	Security Checks	1.4
	Vehicle Breakdowns	1.4
Qualitative observation	Random Microbus Stops	High
	Random Pedestrian Crossings	High

Analysis results revealed widespread traffic disturbances along this route compared to the more localized problems that were encountered along the first three routes. Physical/operational bottlenecks and intersections-related delays are the main causes of traffic congestion on this route. The following is a description of distinct congestion location/causes along route 4.

Location (1)
Cause: Operational Bottleneck
The Aboud location is a well-known microbus stop for travellers heading to the Delta Governorates. The space time plots show a noticed impact on travel times in this vicinity especially in Direction-2.
Location (2)
Cause: U-turns inducing traffic turbulences
This occurs along Corniche ElNile-East-bank Street till Arkadia Mall. The primary reason for these turbulences is a series of U-Turns carrying high traffic volumes and lacking acceleration and deceleration lanes.
Location (3)
Cause: Physical bottlenecks
The entrance ramp to the 15^{th} of May Bridge that occupies a portion of main corridor physical capacity causing a physical bottleneck along direction-1.
Location (4)
Cause: Traffic Turbulences
Various traffic turbulences due to conflicting traffic movements from exits of both 15th of May and 6^{th} of October bridges. In addition, inadequate traffic controls have been observed in this location.
Location (5)
Cause: Physical bottlenecks
Successive fluctuations in the number of lanes have been observed along this section of Cornish ElNile-East-bank Street.

Route (5): Rod El Farag/El-Remaya

This route stretches from Rod El-Farag bridge in Cairo, across the bridge to the Corniche ElNile-West-bank street (Figure 3.21). The route continues southward along Corniche El-Nile street, Morad steet, Giza Square, westwards on El-Haram street, past the Pyramids ending in the Remaya Square. This route mainly belongs to the urban primary arterial class with a dominant speed limit of 60 km/hr. The route has several signalized intersections. Corniche ELNile-East-bank street is a one of the main North/South Corridors in Giza city.

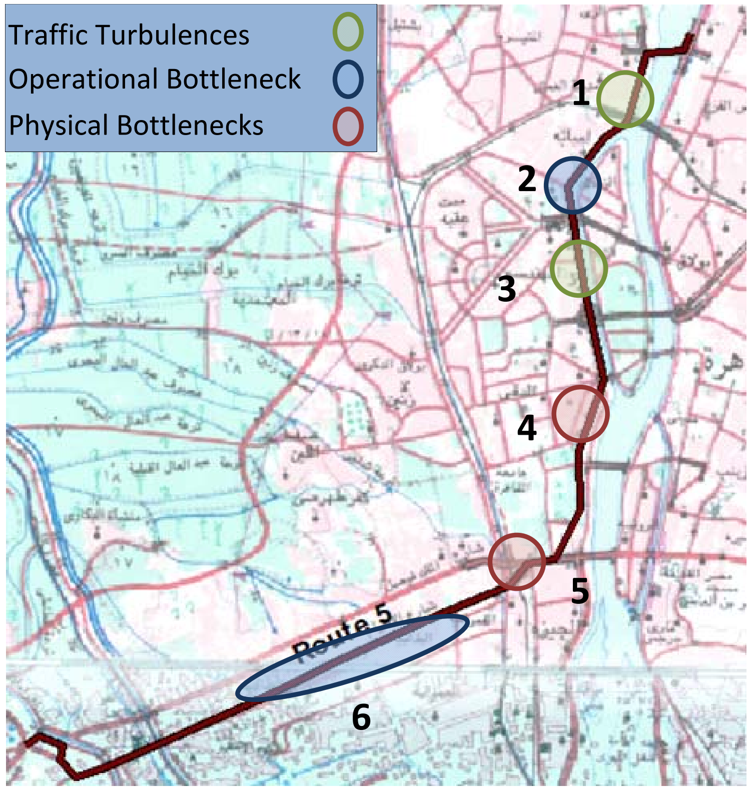

Figure 3.21: Route 5 Schematic

The estimated average speed along the route is 24 km/hr with a speed index of 0.46. An average COV of observed speeds of 0.4 has been estimated. Observed variability in travel speeds is rather limited. Most of the observed variability is attributed to random pedestrian crossings and random microbus stops. Table 3.6 summarizes the observed daily traffic influencing events on route 5.

Table 3.6: Daily Traffic Influencing Events, Route 5

Average Daily Frequency	Accidents	0.4
	Security Checks	0.2
	Vehicle Breakdowns	1.6
Qualitative observation	Random Microbus Stops	High
	Random Pedestrian Crossings	High

Analysis results revealed widespread traffic disturbances along this route. Physical/operational bottlenecks, geometric design and access management inefficiencies are main causes of traffic congestion on this route. In addition, unique observations that contribute to a reduction in the route capacity (such as animal-driven carts and on-street trash boxes) have been reported for this route. The following is a description of distinct congestion location/causes along Route 5.

Location (1)
Cause: Road Geometry/Access management inefficiencies
Direction-2: Traffic conflicts due to merging traffic from minor connectors to the main arterial on a horizontal curve segment.
Location (2)
Cause: Operational Bottleneck + Access management inefficiencies
Operational bottleneck at KitKat square due to several random microbuses. In addition the failure of the roundabout to handle existing traffic flows.
Location (3)
Cause : Access management inefficiencies
Direction-1, near the exit ramp from 6th of October bridge (Agouza exit). High exiting traffic volumes (in 2 lanes) merges with the through traffic from the main road (2 lanes) on a 3 lane road segment.
Location (4)
Cause: Physical bottlenecks
A lane reduction from 4 lanes to 3 lanes occurs in front of the Giza Police Headquarters.
Location (5)
Cause: Physical bottlenecks
Direction-1: Before El-Giza Bridge a reduction in the number of lanes coming from El-Giza tunnel (4 lanes) into 2 lanes heading to El-Giza Bridge
Location (6)
Cause: Operational Bottleneck
Several operational bottlenecks on El-Harm street due to; a series of successive u-turns, tourists' buses heading towards the pyramids area, and illegal on-street parking

Route 6: Cairo-Suez Desert Road/El-Qalaa

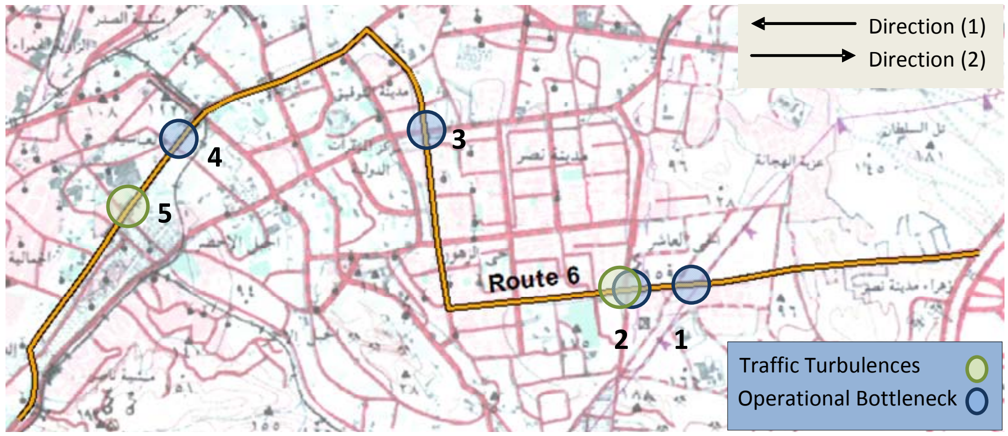

Figure 3.22: Route 6 Schematic

This route stretches from the 5th District in New Cairo in front of the Mubarak Police Academy making its way westwards along Ahmed El-Zomor street towards Nasr City. At Nasr City the route continues north along Tayaran street and then west along Salah Salem via the Tayaran street tunnel (Figure 3.22). The route is approximately 22 km in length. It is entirely an Urban Primary Arterial with several signalized intersections.

The estimated average speed along the route is 30 km/hr with a speed index of 0.55. An average COV of observed speeds of 0.53 has been estimated. Day-to-day variability in travel speed has been observed for route 6 which indicates a possible variation in daily traffic volumes. Random pedestrian crossings and random microbus stops also contribute to the observed variability in travel speeds. Table 3.7 summarizes the observed daily traffic influencing events on route 6.

Table 3.7: Daily Traffic Influencing Events, Route 6

Average Daily Frequency	Accidents	0
	Security Checks	0
	Vehicle Breakdowns	3
Qualitative observation	Random Microbus Stops	High
	Random Pedestrian Crossings	High

Analysis results highlight the impact of illegal parking on the operational efficiency of a number of segments along route 6. In addition operational concerns arising from the excessive use of u-turns as a dominant access management strategy are perceived. The following is a description of distinct congestion location/causes along route 6.

Location (1)
Cause: Occasional Operational Bottleneck
Friday's open air car market at Ahmad El-Zomor Street induces excessive traffic volumes on this location. Random car stops and illegal parking outside the specified parking area are main causes of congestion.
Location (2)
Cause: Occasional Operational Bottleneck + Access management inefficiencies
In the vicinity of El-Salam Mosque; frequent illegal parking in front of the mosque causes severe traffic congestion. In addition, a series of inefficiently designed U-turns along this segment, with inadequate weaving lengths, contribute to observed congestion.
Location (3)
Cause : Operational Bottleneck
<u>Direction (1):</u> At Rabaa El-Adaweya Intersection, Public buses stop upstream of the traffic signal causing reduction in the actual capacity.
Location (4)
Cause : Occasional Operational Bottleneck
In the vicinity of El-Salam Mosque; frequent illegal parking in front of the mosque.
Location (5)
Cause : Traffic Turbulences
<u>Direction (1):</u> Conflicting traffic movements near the entrance of ElAzhar tunnel. Occasional spillbacks due to tunnel congestion.

Route (7): Autostrad/Giza Square

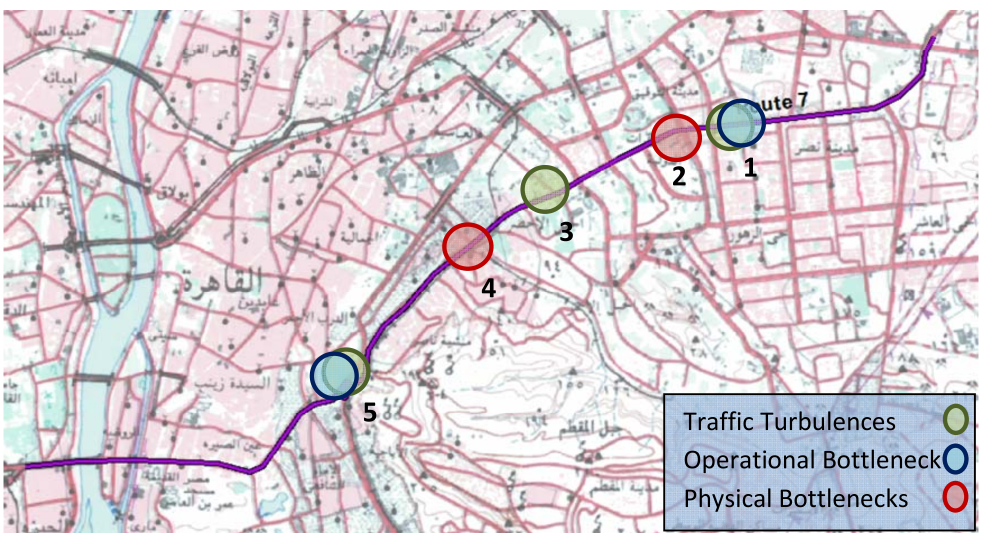

Figure 3.23: Route 7 Schematic

This route stretches from ELNasr/Autostrad and ElThawra intersection in the east side of the city heading west along ElNasr/Autostrad Street till Salah Salem Interchange at ElMokatem. At ElMokatem, the route continues west along Salah Salem to ElGiza square via Abbass Bridge (Figure 3.23). The route is approximately 18 km in length. It is entirely an Urban Primary Arterial with several high volume crossing streets. Most of those major intersections are manipulated through u-turns along route 7.

The estimated average speed along the route is 27 km/hr with a speed index of 0.49. An average COV of observed speeds of 0.54 has been estimated. Observed variability in travel speeds is more vivid in the evening peak compared to the mourning one. Frequent random microbus stops, random pedestrian crossing and inconsistencies in intersection-related delays contribute to the observed variability in traffic speeds. Table 3.8 summarizes the observed daily traffic influencing events on route 7.

Table 3.8: Daily Traffic Influencing Events, Route 7

Average Daily Frequency	Accidents	0.4
	Security Checks	0.2
	Vehicle Breakdowns	1.1
Qualitative observation	Random Microbus Stops	High
	Random Pedestrian Crossings	High

Analysis results highlight the negative impacts of the series of implemented u-turns along the corridor. The high traffic volume using those u-turns significantly contributes observed delays on this route. The following is a description of distinct congestion location/causes along Route 7.

Location (1)
Cause :Operational Bottleneck + Traffic Turbulences
A series of successive u-turns on both directions along the segment from Ahmed Fakhry street to Abbas El-Akkad street. Minimal weaving lengths are provided which contributes to frequent localized grid-locks. In addition, on-street parking and frequent random microbus stops (including within u-turn stops) significantly contributes to observed operational bottlenecks.
Location (2)
Cause: Physical Bottlenecks
Near Yousef Abbas intersection there is a reduction in the number of lanes from 6 lanes to 4 lanes.
Location (3)
Cause : Traffic Turbulences
Direction-2: In front of the Arab Contractors Hospital, traffic turbulences due to U-Turn
Location (4)
Cause : Physical Bottlenecks + Traffic Turbulences
Direction -2: Near the Deweqa entrance reduction in the number of lanes from 4 lanes to 3 lanes. In addition, u-turn-induced traffic turbulences were observed.
Location (5)
Cause : Operational + Traffic Turbulences
Near ElMokataam entrance, traffic turbulences due to conflicting traffic movements. In addition frequent random microbus stops.

Route (8): El-Orouba/6th of October Bridge

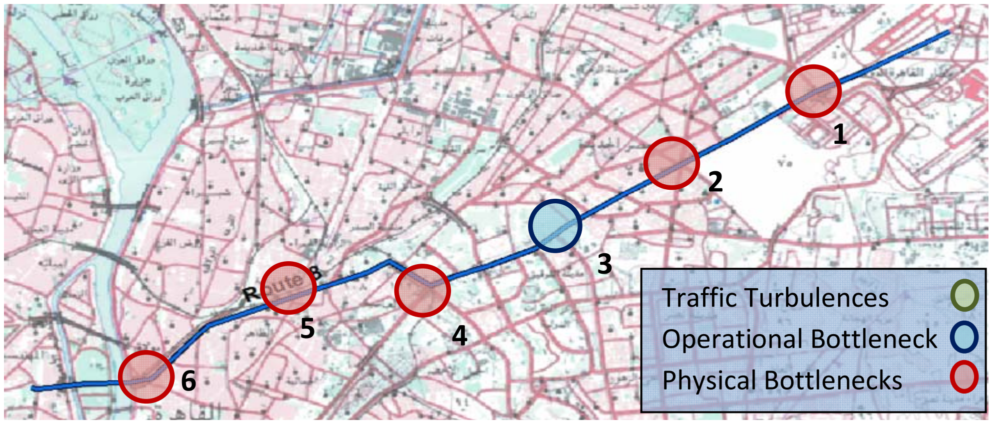

Figure 3.24: Route 8 Schematic

This route stretches from El-Orouba/Salah Salem Street near Cairo International airport to ElDoKki (at ElBatal Ahmed AbdElaziz) via 6th of October Bridge (Figure 3.24). The route is approximately 22 km in length. El-Ourouba/Salah Salem is a major east/west arterial street with several grade-separated intersections. On the other hand, 6th of October Bridge is a crucial urban expressway that crosses the river Nile and flies over the CBD.

The estimated average speed along the route is 29 km/hr with a speed index of 0.48. An average COV of observed speeds of 0.6 has been estimated. Day-to-day variability in travel speeds has been observed, in the evening peak. Limited traffic influencing events have been recorded on that route, except for daily vehicle breakdowns.

Analysis results indicate that causes of congestion along route 8 are predominantly due to physical and operational bottlenecks mostly along 6th of October bridge and sections of El-Orouba street. The following is a description of distinct congestion location/causes along route 8.

Location (1)
Cause :Physical Bottleneck
El-Galaa Bridge; reduction in the number of lanes from 4 on the main corridor to 2 lanes on the bridge
Location (2)
Cause: Physical Bottlenecks
El-Orouba Tunnel; reduction of number of lanes from 4 on the main corridor to 2 lanes entering the tunnel.
Location (3)
Cause : Operational Bottleneck
Direction-2: In front of the Central Agency for Public Mobilization And Statistics (CAPMAS), employees' busses inducing excessive delays.
Location (4)
Cause : Physical Bottlenecks
Direction -1: El-Orouba Entrance to 6th October Bridge; traffic from El-Orouba (2 lanes) and traffic from 6th October Bridge (2 lanes) merges together into a 2 lane segment of 6th of October Bridge.

Location (5)
Cause : Physical Bottlenecks
Direction -1: Ghamra Bridge entrance; merging traffic (2 lanes) from Ghamra Bridge into 2 lanes of through traffic without additional lanes.
Location (6)
Cause : Physical Bottlenecks
Direction -1: In between Ramsis Exit and El-Tahrir Entrance; two physical lanes are dedicated for the merging traffic from El-Tahrir square causing a bottleneck for the through traffic. This bottleneck (at high traffic volumes) causes queues to spill backward blocking Ramsis Exit.

Route 9: Cairo-Ismaillia/El-Qubba

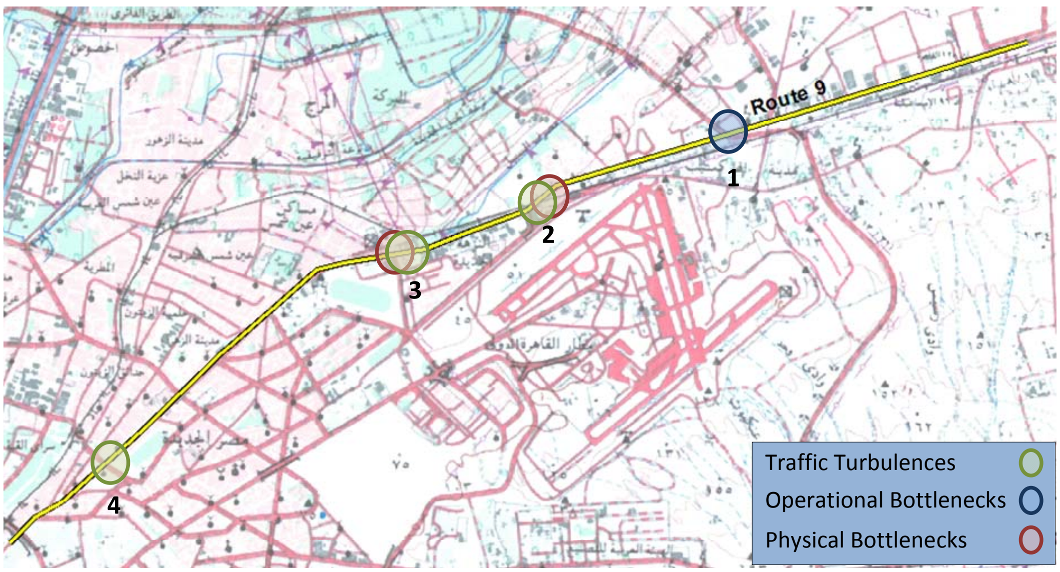

Figure 3.25: Route 9 Schematic

This route stretches from El-Obour on Cairo/Ismaillia Desert Road crossing the Ring Road towards El-Qubba Bridge via Gesr El-Suez (Figure 3.25). The length of this route is approximately 20 km. Gesr El-Suez area is a high density population area with mixed residential/commercial land use patterns. While, the larger portion of this route belongs to the urban primary arterial class, the rest of the route is an inter-urban highway that connects the cities of Cairo and Ismaillia.

The estimated average speed along the route is 24 km/hr with a speed index of 0.36. The low value of the estimated average speed index reflects the deteriorated level of service of that route. An average COV of observed speeds of 0.54 has been estimated. Day-to-day variability in travel speeds, in the evening peaks, has been observed at Gesr El-Suez area. Frequent random microbus stops also contribute to the observed variability. Table 3.9 summarizes the observed daily traffic influencing events on route 9.

Table 3.9: Daily Traffic Influencing Events, Route 9

Average	Accidents	0.09

Daily Frequency	Security Checks	0.18
	Vehicle Breakdowns	1.4
Qualitative observation	Random Microbus Stops	High
	Random Pedestrian Crossings	Low

Analysis results indicate that this route is one of severely congested arterials. Observed causes of congestion are predominantly due to high traffic volumes and inadequate traffic management strategies. A unique feature of Gesr El-Suez Street is the on-street shopping activities. Mobile sellers are distributed at several locations along Gesr El-Suez selling various products and severely impacting traffic operations. The following is a description of distinct congestion location/causes along route 9.

Location (1)
Cause :Operational Bottleneck
In the vicinity of El-Asher public bus station; frequent random microbus stops outside the station. In addition the high traffic volume using the Ring Road interchange contributes to perceived congestion.
Location (2)
Cause: Physical Bottlenecks + Traffic Turbulences
Direction (1): Under the Hikesteb Bridge; reduction in number of lanes from 3 lanes to 2 lanes. In addition, observed u-turn-related delays.
Location (3)
Cause : Physical Bottleneck + Traffic Turbulences
In the vicinity of At Abd el Aziz Fahmy intersection, the following contribute to observed congestion: • Railway at-grade crossing • Physical bottleneck • Inappropriate u-turn location
Location (4)
Cause : Traffic Turbulences
Direction (2): Upstream of El-Qubba Intersection; multiple access points to Gesr ElSuez Street (El-Sheikh Abo-Elnour and El-Kanadi streets) inducing extremely high traffic volume at El-Qubba intersection. Both Directions: At El-Qubba Intersection; access management and geometric design inefficiencies.

Route 10: Cario-Alex Agr Road/ El-Qubba Bridge

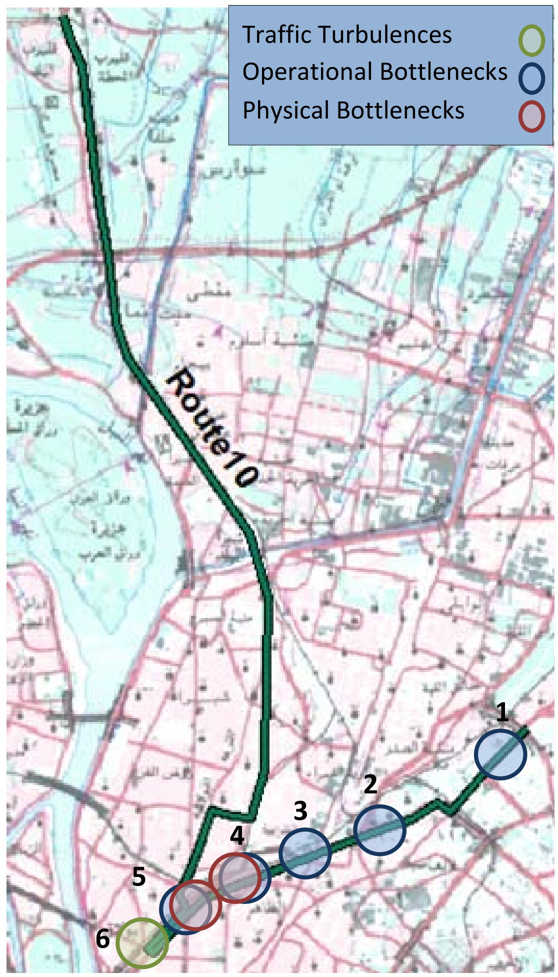

Figure 3.26: Route 10 Schematic

This route stretches south along the Cairo Alexandria Agricultural Road from Qwesna-Qalyub Road, then along Ahmed Helmy street and then east along Ramsis street, Ain Shams University ending in El-Khalifa El-Mamoun (Figure 3.26). The first 6 km of the route are along an inter-urban Highway while the remainder of the route is along an arterial street.

The estimated average speed along the route is 25 km/hr with a speed index of 0.41. The relatively low value of the estimated average speed index highlights congestion conditions. An average COV of observed speeds of 0.53 has been estimated. Space-time plots for this route indicates the presence of day-to-day variability in observed speeds. In additions within-day variability is also perceived. Several traffic influencing events have been observed on this route, most notably; security checks, random microbus stops, and random pedestrian crossings. Table 3.10 summarizes the observed daily traffic influencing events on route 10.

Table 3.10: Daily Traffic Influencing Events, Route 10

Average Daily Frequency	Accidents	0.26
	Security Checks	1.9
	Vehicle Breakdowns	1.2
Qualitative observation	Random Microbus Stops	High
	Random Pedestrian Crossings	High

Analysis results indicate that congestion along this route is predominantly due to operational and physical bottlenecks. In addition u-turns related delays have also been perceived. The following is a description of distinct congestion location/causes along route 10.

Location (1)

Cause: Operational Bottleneck

Both directions of the route in front of Ain Shams University due to several random pedestrian crossings between both sides of the campus

Location (2)

Cause: Operational Bottleneck

Direction (1): At El-Demerdash Metro Station (Loutfi El-Sayed Street), random microbus stops to load/unload passengers from the Metro station cause a bottleneck. Also many random pedestrian crossings impact traffic flows.

Location (3)

Cause : Operational Bottleneck

Both Directions :Under Ghamra bridge. Random Microbus and Bus stops

Location (4)

Cause : Physical Bottlenecks + Operational Bottleneck

Direction (1): Under pedestrian crossover near 6^{th} of October-Ghamra Exit; work zone causing a reduction in the number of lanes from 4 lanes to 3 lanes.

Direction (1): In front of Ramsis light rail station, several random Bus and microbus stops causing congestion that spills back until the previous physical bottleneck location.

Location (5)

Cause : Operational Bottleneck + Traffic Turbulences + Physical Bottleneck

Direction (1): Under 6^{th} of October bridge (El-Galaa Street); frequent random microbus stops in front of El-Azbakeya police station.

Direction (1:) At the beginning of Shoubra tunnel; U-Turn-related delays.

Direction (2): Reduction in number of lanes from 5 lanes (coming from Shoubra tunnel) into 3 lanes. In addition to U-Turn-related traffic conflicts.

Location (6)

Cause : Traffic Turbulences

Direction (2): Traffic conflicts due to insufficient weaving distance (~100 m) for traffic coming from Gamaaiet El-Shabab El-Muslimin street to Abd El-Khaleq Sarwat street, given a high traffic volume in Ramsis Street.

Route 11: Cairo-Suez Desert Road/Ebn-ElHakam Square

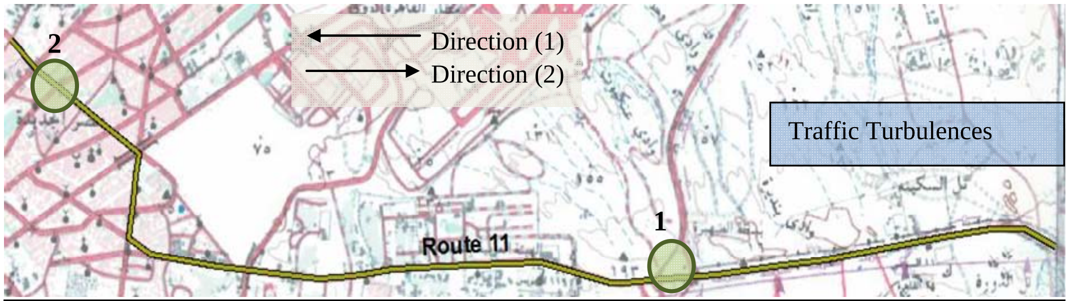

Figure 3.27: Route 11 Schematic

The route stretches from El-Rehab along Cairo/Suez Desert Road heading east to El-Thawra Street and then north via El-Nozha Street till Abou-Bakr EL-Sedik Street. East on Abou-Bakr EL-Sedik and Ebn ElHakam Street till Ebn El-Hakam square (Figure 3.27). This route mostly belongs to the urban primary arterial class, except for the Cairo/Suez Desert Road portion. The route length is approximately 21 km.

The estimated average speed along the route is 37 km/hr with a speed index of 0.47. An average COV of observed speeds of 0.5 has been estimated. Observed variations in travel speeds are mainly attributed to some traffic influencing events, as summarized in Table 3.11.

Table 3.11: Daily Traffic Influencing Events, Route 11

Average Daily Frequency	Accidents	0.3
	Security Checks	0.6
	Vehicle Breakdowns	0.3
Qualitative observation	Random Microbus Stops	Low
	Random Pedestrian Crossings	High

Analysis results indicate an impact of traffic influencing events on the performance of this route. In addition the high traffic volume in the vicinity of the Ring Road interchange induces extra delays. The following is a description of distinct congestion location/causes along route 11.

Location (1)

Cause : Traffic Turbulences

In the vicinity of the interchange with the Ring Road; conflicting traffic manoeuvres as well as high traffic volume using this interchange.

Location (2)

Cause : Traffic Turbulences

Both Directions: El-Mahkama Intersection; congestion spilling over upstream of the intersection due to inadequate traffic signal control.

3.3 Network-wide qualitative assessment

The network-wide assessment was performed to supplement the quantitative corridor-based assessment which has a relatively limited scope, both spatially (due to the relatively small number of corridors surveyed) and content-wise (due to the difficulty of capturing all key causes through a quantitative analysis). The network-wide assessment was performed through a consultative workshop involving a panel of experts.

3.3.1 Workshop Design and Process

The primary objective of the workshop was to identify and prioritize the causes of traffic congestion in the GCMA. It was recognized initially that the causes listed in Task 2 of the TOR under the three categories of “physical infrastructure features”, “traffic demand patterns” and “traffic influencing events” have to do mainly with the road network characteristics and its operational performance. Therefore, we labelled all such causes as “operational causes”, and we hypothesized that traffic congestion in Cairo could have more operational causes than those listed in the TOR (one example being the wide-spread phenomenon of jaywalking). We also recognized at the outset of the study that additional factors, of a strategic and systemic nature, contribute to traffic congestion in Cairo. These include characteristics of the multi-modal transport system, land use, population, etc. We labelled such characteristics as “strategic causes”, and we intended to address them in the study, since they lend themselves to a different set of congestion relief strategies than operational causes. Therefore, the workshop was designed to address the two following questions:

- What are the operational causes of traffic congestion in the GCMA?
- What are the strategic causes of traffic congestion in the GCMA?

In order to address the above questions adequately in the workshop, the study team identified a set of characteristics and criteria to select the workshop participants. Specifically, we sought a group of participants that:

- Possess in-depth technical knowledge of traffic congestion and causes across Greater Cairo;
- Have long, first-hand experience in managing traffic congestion in Cairo; and
- Have long experience in traffic congestion assessment and related policies and interventions.

In addition, it was deemed desirable to have the workshop participants come from different parts of Cairo in order to ensure a fair and uniform treatment of traffic congestion across the GCMA. Finally, the number of participants was desired to be moderate, not too small to ensure varied and rich input but not too large to ensure effective management of the workshop.

Based on the above criteria, we identified and invited 10 experts as follows[6]:

- Two professors of highway and traffic engineering from Cairo University;
- Two professors of transport and traffic engineering from Ain Shams University;
- One transportation engineering professor from Al-Azhar University who has also been a longstanding consultant on the JICA transport study;
- Three senior consultants;
- Head of the Road Department, Cairo Governorate; and
- Head of the Research and Planning Unit, Cairo Traffic Administration, Ministry of Interior.

We sent to each expert an invitation letter and information sheet[7] describing the background, objective, approach, program and venue of the workshop. The invitation package was delivered by various means (e-mail, fax, and hand) and followed up with a phone call by a study team member. All experts accepted the invitation and turned up at the workshop venue on June 6th in due time.

3.3.2 Workshop Approach and Results

The conventional approach of brainstorming and open group discussion, although widely employed in consultative workshops, was deemed risky to use in our workshop due to the following reasons:

- The panel may spend a disproportionate time discussing a limited set of causes, while leaving out other important ones. This is particularly a problem in our case, because there could be many more causes of traffic congestion in Cairo beyond the obvious ones. Therefore, it was deemed desirable to use a method that generates as many causes of traffic congestion as possible.
- Some participants may over-emphasize some causes and steer the discussion towards those causes. This may happen if some participants are vocal and have strong opinions, potentially suppressing potentially useful contributions of others. Therefore, it was deemed desirable to use a method that ensures even contribution by all participants, the passive ones as well as the more vocal.
- The open discussion approach does not usually allow for ranking the various causes in terms of importance (i.e. relative contribution to congestion). It was deemed desirable for the used method to produce a prioritized list of traffic congestion causes.

The above concerns led to the adoption of an alternative approach, known as the Nominal Group Technique (NGT), in our workshop. The approach, first developed in 1971[8], has seen wide application in various disciplines[9]. In transportation, it was used recently to identify and prioritize the problems and issues of the bus network in Melbourne[10]. The NGT has several reported advantages over alternative approaches to decision making and information gathering such as brainstorming. Specifically, the NGT helps generate many

6 The list of participants is included in Annex C.

7 Both are included in Annex C.

8 Delbecq, A and A. VandeVen, 1971. "A Group Process Model for Problem Identification and Program Planning," Journal of Applied Behavioral Science VII, pp. 466 -91.

9 A simple search on Google will return a large number of case study examples.

10 Currie, G. and K. Tivendale, 2010. “An Inclusive Process for City Wide Bus Network Restructuring: Experience and Impacts”, CD Proceedings of the 89th Annual Transportation Research Board Meeting, Washington D.C.

ideas beyond the obvious ones, balance the opinions and inputs of participants (i.e. avoids the domination of one idea or one vocal person), prioritize/rank the different ideas, build consensus among the participants, and provide a sense of closure on the addressed question. Those advantages are all relevant to the context of our study and to the qualitative assessment intended for the workshop.

Our initial plan was to use the NGT to answer the two questions of the workshop in two separate sessions (see the workshop program in Annex 8). In each session, we planned to follow the standard NGT four-step process as follows:

- Generate causes: each participant brainstorms silently and writes down on a piece of paper as many causes as possible.
- Record causes: In a round-robin format, participants share one cause at a time which is recorded on a flip chart seen by the entire group. In this step, all causes are exhaustively recorded and similar ones are grouped.
- Discuss causes: Each cause is discussed by all participants to establish clarity of definition and degree of importance. Further grouping is possible in this step.
- Rank causes: participants vote privately to rank the causes.

The June 6th workshop started according to plan with a presentation of the study objective, workshop objective and approach. In the discussion that followed the presentation, the participants agreed to the importance of treating not only operational but also strategic causes of traffic congestion, yet there was some disagreement as to where to draw the line between the two classes of causes. In order to the keep the workshop on track and avoid un-necessary delays, we made a slight modification to the plan of the workshop which proceeded as follows:

- Generate causes: In a silent brainstorming session of about 10 minutes, each participant generated a list of causes without specifying the type (operational or strategic). Each participant wrote down his/her list on a paper supplied by the study team.
- Record and discuss causes: Over a period of about two hours, each participant around the table shared with the group 2-3 causes which were recorded promptly on a flipchart by a workshop assistant. Upon recording of each cause, a moderated discussion took place, which was intended to establish a common understanding of the cause and its extent of influence. Initial grouping of similar causes were implemented by the group as the list of causes unfolded. At the end of this session, the list consisted of 35 causes of traffic congestion in the GCMA. Table 3.12 displays the entire list.
- Extract and group operational causes: Following a short break, the panel of experts together with the study team extracted the operational causes from the long list and combined them into 8 groups of causes. The discussion in the previous step helped build consensus among the experts on the final list of operational causes. Table 3.13 presents the list.
- Rank operational causes: Each participant ranked the 8 causes according to the relative contribution to traffic congestion in the GCMA. Each participant was given an index card, and was asked to rank the 8 causes by assigning a score of 8 to the most important cause, 7 to the second, etc. A total of 12 completed cards were collected and the results were tallied on a flipchart. Figure 3.28 depicts the final results.

Due to the constrained time of the workshop and the desire of several participants to depart, the "strategic" causes were not grouped and ranked similar to the operational causes.

Table 3.12: List of traffic congestion causes

	Cause	Effect on Traffic Congestion
1	Inadequate public transport system • Limited capacity and coverage • Poor quality of service • Scarce human and financial resources	Offers limited ability to attract auto users, thus keeping traffic volumes at high levels.
2	Lax procedures and practices of issuing driver's licenses	Result in majority of drivers lacking proper training and sufficient knowledge of traffic laws
3	Poor driver's observance of traffic lanes	Causes turbulence to traffic flow which contributes to congestion
4	Lack of coordination among the multiple agencies responsible for traffic management and planning	Results in localized, ad-hoc approach to traffic management and congestion relief
5	Dearth of qualified personnel	Results in sub-standard traffic engineering, planning and management practices
6	Deficient traffic management • Lack of traffic control at sensitive locations • Manual traffic control at key intersections during peak periods • Sub-optimal timings of traffic signals where they exist • Lack of modern technologies for traffic management	Results in poor utilization of the existing road capacity and high accident frequency
7	Traffic measures inconsistent with the road class hierarchy • Many speed bumps at key arteries	Cause un-necessary interruption to major traffic flows
8	Inadequate traffic and transport laws	
9	Lack of road etiquette and manners by various entities	Results in illegal and random usage of the existing road capacity, and gives rise to road accidents
10	Lax and inconsistent enforcement of traffic laws • Many road users elude consequences of traffic violations or secure exemptions	Causes frequent occurrence of traffic violations and accidents on the road, contributing to congestion
11	Poor control at locations of traffic conflicts (e.g. intersections, approaches to flyovers/underpasses, etc.)	Results in inefficient use of road capacity and increased frequency of road accidents
12	Wide transformation of intersections into U-turn strips for the purpose of autonomous/self control of conflicting traffic streams	Result in extensive weaving sections and bottlenecks
13	Insufficient parking capacity	Leads to illegal on-street parking (reducing effective road capacity) and to roaming traffic looking for parking space
14	Sudden vehicle breakdowns • Due to poor vehicle inspection and hot weather	Create incidents that reduce road capacity, and often result in bottlenecks
15	Random stopping behaviour of microbuses and regular buses	Causes interruption to traffic flow and in many cases to bottlenecks

16	Absence of transport demand management	Results in high traffic demand at peak times
17	Fuel subsidy policy	Contributes to low vehicle operating cost, thus increasing auto use
18	High auto ownership and usage rates	Increases traffic volumes
19	Absence of a "comprehensive security" concept • General security personnel are not utilized to improve traffic safety and security	Contributes to the limited scope of traffic enforcement across the road network, leading to high rates of violations and incidents
20	Confined presence of traffic police staff to a small set of locations (mainly intersections) • Lack of ubiquitous monitoring of traffic across the network	Contributes to the limited scope of traffic enforcement across the road network, leading to high rates of violations and incidents
21	Major changes to land use without conducting traffic impact studies	Creates an imbalance between travel demand and road supply
22	Lack of compliance with road occupancy policies by individuals, private companies and agencies.	Reduces effective road capacity
23	Poor urban planning and lack of coordination with transportation	Creates an imbalance between travel demand and road supply
24	Public services centralized at a few government agencies	Creates locations of very high traffic demand
25	Limited financial resources available for transport improvements	Results in transport supply expansion lagging behind growth in traffic demand
26	Lack of intermodal integration • E.g. inadequate park and ride facilities	Offers auto users limited ability to transfer to transit
27	Interference of higher authorities in transport decision making	Results in decisions that impact adversely the road capacity and usage
28	Disorderly use of the road network by vehicles, pedestrians, truck, etc.	Causes inefficient use of road capacity
29	Wide-spread jaywalking phenomenon	Deteriorates road safety and interrupts traffic flow
30	Ubiquitous bottlenecks due to road design irregularities	Result in congestion as demand approach the bottleneck capacity
31	Poor connectivity of the road network	Results in poor distribution of traffic demand across the network
32	Poor road surface conditions • Poor quality of pavement, speed bumps, etc.	Affects speed and flow of traffic
33	Special events and VIP motorcades	Disrupts base traffic flow and creates traffic jams
34	Absence of a single agency responsible for collection of traffic related data	Offers limited ability to analyze traffic patterns and prioritize measures to curb traffic congestion
35	Inefficient traffic network	Results in poor utilization of the existing road capacity

Table 3.13: List of grouped "operational" causes

	Operational Cause
1	Design features of the road network • physical bottlenecks, poor network connectivity, U-turns, poor road surface quality, speed bumps, etc. Several physical bottlenecks examples were perceived from the principal corridor analysis such as route 1 location 1 and route 5 location 4. Examples of U-turns include route 4 locations 2 and route 5 location 6.
2	Parking supply and behaviour • limited parking capacity, illegal on-road parking, etc.
3	Traffic influencing events • road accidents, vehicle breakdowns, security checkpoints, VIP motorcades, etc. Examples include route 3 locations 3 and 4.
4	Traffic management and control route 11 location 2 • poor control at intersections (such as route 11 location 2) and approaches to flyovers/underpasses (such as route 6, location 5) • lack of modern technologies for traffic management
5	Awareness of road etiquette and manners by various entities • no lane discipline, ubiquitous jaywalking, illegal stops by transit and other vehicles, etc.
6	Traffic demand related factors • special events (such as route 6 locations 1 and 2), inflexible work hours, etc.
7	Work zones (such as route 10 location 4)
8	Law observance and enforcement • poor observance and enforcement of traffic laws and road occupancy policies (e.g. on-street vendors, animal drawn carts as observed on route 6).

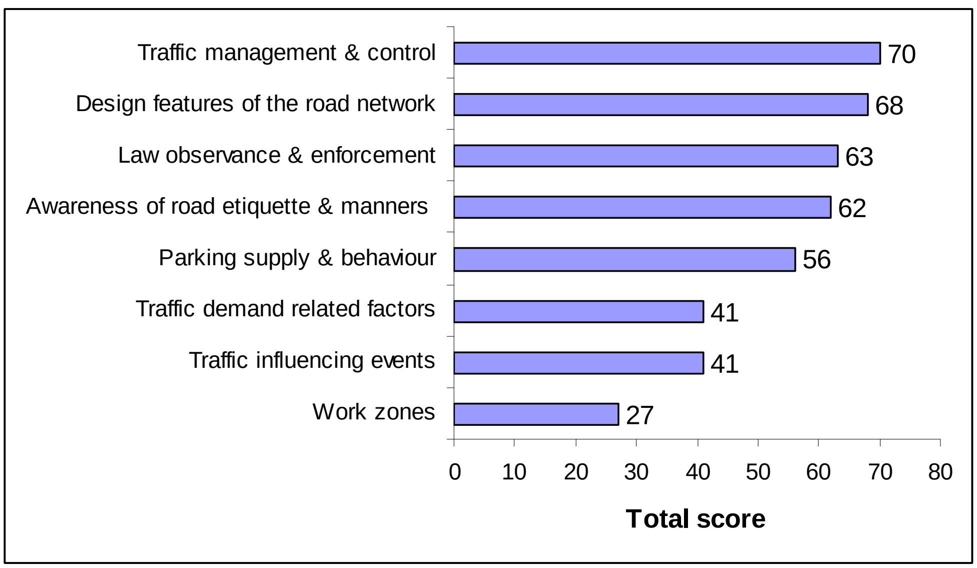

Figure 3.28: Ranking of the Operational Causes

3.4 Integration / Comparison of the Floating Car Survey and Workshop Outcomes

To gain further insights into the main causes of traffic congestion in GCR, the outcomes of the FC survey were mapped into the network-wide assessment framework. In the qualitative assessment (section 3.3), congestion causes were grouped into 8 different categories. In the quantitative assessment (section 3.2), localized congestion causes were identified from the FC survey. Mapping is realized through the re-arrangement of localized congestion causes to fit within the identified 8 main categories. Table 3.14 presents congestion locations and causes based on the network-wide categorization schema. For clarity purposes, the same results are displayed in a frequency diagram (Figure 3.29).

Table 3.14:Localized congestion causes mapped into congestion categories

Route #	Location	Category #	Operational Cause
1 2 3 4 5 6 7 8 9 10	1, 2, 3, 4 1,2,3,4,5 5,6 2,3,5 1,3,4,5,6 1 1,2,3,4 1,2,4,5,6 2,3,4 4,5,6	1	Design features of the road network • physical bottlenecks, poor network connectivity, U-turns, poor road surface quality, speed bumps, etc.
5 6 7	6 1,2, 4 1	2	Parking supply and behaviour • limited parking capacity, illegal on-road parking, etc.
3	3,4	3	Traffic influencing events • road accidents, vehicle breakdowns, security checkpoints, VIP motorcades, etc.
1 3 4 5 6 7 9 11	3 2 3 2 5 5 3,4 1,2	4	Traffic management and control • poor control at intersections and approaches to flyovers/underpasses • lack of modern technologies for traffic management
1 2 3 4 5 6 7 8 9	5 1,2,3,4 1,2,3,4 1 2,6 3 1,5 3 1	5	Awareness of road etiquette and manners by various entities • no lane discipline, ubiquitous jaywalking, illegal stops by transit and other vehicles, etc.

10	1,2,3,4,5		
5 6	6 1,2	6	Traffic demand related factors • special events, inflexible work hours, etc.
10	4	7	Work zones
		8	Law observance and enforcement • Poor observance and enforcement of traffic laws and road occupancy policies (e.g. on-street vendors, animal drawn carts as observed on route 6).

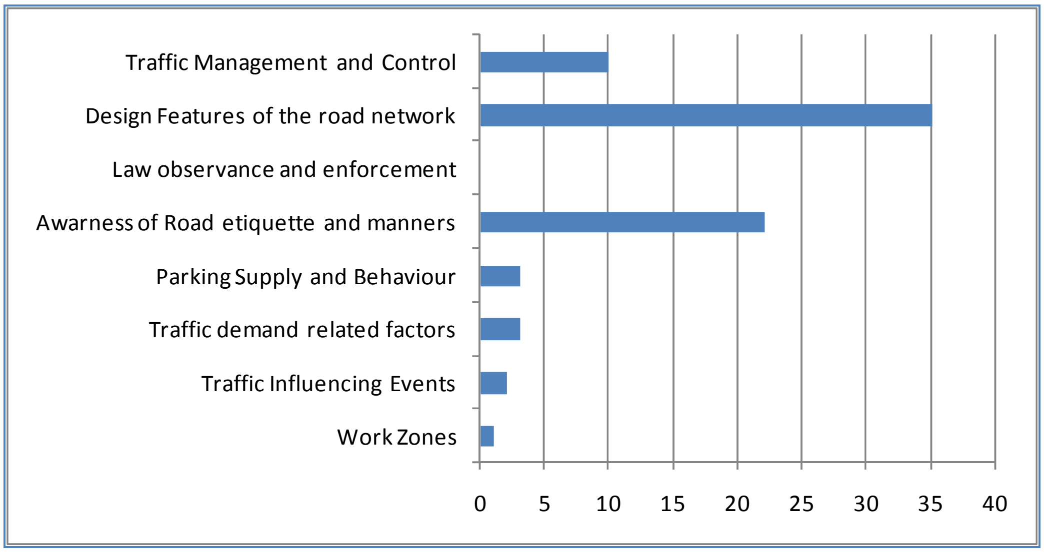

Figure 3.29: Congestion causes frequencies of occurrences

The comparative assessment of qualitative and quantitative outcomes could be summarized for each congestion cause category as follows:

1- <u>Traffic Management and control:</u> this category was identified in the qualitative assessment as the most salient congestion cause in GCR. A relatively high frequency of occurrence of localized congestion resulting from the lack of proper traffic management and controls has been reported. However, this category ranks third in the quantitative assessment compared to first in the qualitative one. Examples of prominent cases could be recognized along route 11 where congestion is mostly attributed to the failure of traffic signal controls such at El-Mahkama intersection; causing extensive upstream spillbacks.
2- <u>Design features of the road network</u>: both qualitative and qualitative assessments recognized this cause as one of the most salient causes of traffic congestion in GCR. Results of the quantitative analysis revealed that the highest frequency of occurrences of localized congestion causes from the FC survey was attributed to this category. Two main observations were repeatedly encountered in most surveyed corridors; 1) the inconsistency in the number of lanes assigned to a given corridor along its entire length, 2) the extensive deployment of improperly

designed u-turns. Examples of prominent cases of inconsistency in number of lanes include the section of the 26th of July corridor (route 1) in between the Ring Road and Lebanon square. Another example of an inadequate u-turns is the series of successive u-turns along El-Haram Street (route 5, location 6). It is noteworthy that the number of buses using El-Haram Street to access the pyramids area is substantial, which adds to the magnitude of congestion induced by u-turns.

3- Law observance and enforcement: while this category ranked 3rd in the qualitative assessment, it was not captured through the FC survey due to the nature of the surveying method.
4- Awareness of road etiquette and manners: high frequency of occurrence was observed for this cause in the quantitative assessment (ranking 2nd among all 8 categories). Most of the field observations of congestion causes under this category attributed congestion to frequent random microbus stops. The extensive random micro-bus stops along each of the surveyed corridor have been recognized as system wide phenomena that significantly impact traffic operations by reducing the operational capacity of all corridors. Examples include locations along all surveyed corridors, most notably near major intersections/interchanges.
5- Parking supply and behavior: the scope of the FC survey was limited to road levels 1, 2, 3, and 4 (section 2.5.3), where level 4 represents primary arterials. On-street parking was generally restricted on most of the surveyed corridors. Apparently, most of the parking-related issues are more pronounced along local streets. Nonetheless, some illegal parking observations were reported on routes 5, 6, and 7.
6- Traffic demand related factors: It has been observed that some special events induced congestion in the vicinity of their locations. Examples included Friday's open air car market at Ahmad El-Zomor and the vicinity of El-Salam Mosque.
7- Traffic influencing events: several traffic influencing events have been reported through the FC survey. However their contribution to perceived congestion has been rather limited. Examples of prominent cases include the security check points on route 3 (Ring Road) locations 3 and 4.
8- Work Zones: due to the seasonal nature of such a cause only a single work zone has been encountered during the FC survey (route 10 location 4).