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Cairo Traffic Congestion Study

Phase 1

Final Report
November 2010

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Executive Summary

Study motivation

The urban agglomeration of Cairo, designated as the Greater Cairo Metropolitan Area (GCMA), is the largest urban area in Egypt, Africa and the Middle East and amongst the most populous metropolises of the world. In 2006, its population reached 17 million people spread across the governorates of Cairo, Giza and Qalyobiya and a number of new cities.

Despite the massive efforts by the Egyptian government to tackle traffic congestion and environmental deterioration, by introducing a metro system and a comprehensive bus network, traffic congestion remains a serious problem in the GCMA with substantial adverse effects on personal travel time, vehicle operating costs, air quality, public health, business environment and business operations. The causes of traffic congestion are complex, as are the range of possible policies and investments that could be arrayed to address the problem.

The study is conducted to assess the baseline economic cost of current road traffic congestion in the GCMA, based on which to prepare policy recommendations and an action plan to reduce traffic congestion. The first phase involves the review of traffic congestion in the GCMA, its causes, types and locations, with the final objective of assessing the overall economic costs and the associated energy inefficiencies.

Study area

The study area is referred to as the Greater Cairo Metropolitan Area (GCMA), which mainly includes the governorates of Cairo, Giza and Qalyobiya in addition to the new cities of New Cairo City, 6th of October City, 15th May City, 10th of Ramadan City, El-Obour City and Badr City, and is consistent with the study area defined by the JICA study[1]

Data collection

A comprehensive assessment of the data and information needs was first carried out. Under this task, several urban transport-related studies and development master plans of Greater Cairo were identified and reviewed, including the comprehensive transport plans proposed by JICA in the period 2002-2008. The lack of appropriate technical studies with

[1] Greater Cairo Urban Transport Master Plan - CREATS, 2003

clear methodologies to assess the economic costs of congestion was identified. Sources and samples of existing data were also listed such as traffic data, GIS maps, vehicle and accident statistics, public transport data and cost factors, etc.

Additional data were collected through various means. The study team conducted a *Floating Car Survey (FCS)* on 11 principal corridors including primary arterials and expressways within the Ring Road boundaries in the GCMA. The survey involved test drives along selected routes where travel distances as well as qualitative observations were recorded at specified time intervals. Additionally, the study team conducted a *Traffic Count Survey (TCS),* which included manual classified counts (MCC) at 15 observation locations, selected on the basis of consistency with the traffic counting efforts made by previous studies while maintaining an adequate overlap with the selected routes of the FCS. The FCS was conducted between 24/5/2010 and 1/6/2010, while the TCS was carried out between 05/07/2010 and 07/07/2010. Both surveys took place during the morning peak period (7:00 am to 11:00 am) and afternoon peak period (3:00 pm – 7:00 pm).

Observed Modal Split

The traffic composition in the study area was estimated based on the classified vehicle counts performed in the TCS. The analysis of the collected data shows that road traffic is still dominated by private cars with a share of 70%, followed by taxis with 15% share, then microbuses and minibuses with 7%, while large buses make up only 1% of the overall traffic. Small trucks and heavy trucks constitute 5% and 2% of road traffic, respectively.

Identification of Causes, Types and Locations of Traffic Congestion

The average traffic volumes were estimated for the morning and afternoon periods for each survey location. The highest volume during the morning peak (7,400 vehicles/hour) was recorded on the 6th October Bridge -between Zamalek and Agozah- in the direction of Al Mohandiseen and Al Doki; while the highest volume during the evening peak (9,605 vehicles/hour) was recorded on the Ring Road in the direction of Al Maadi. It also appears that the highest peak during the morning period occurs between 8 and 9 AM at most traffic count locations. On the other hand, volumes are comparable in the different afternoon hours and there does not seem to be any specific peaking pattern.

A trend analysis of the travel characteristics in the period 2005 – 2010 was performed, utilizing the traffic data collected in this study and a consistent dataset obtained from the JICA's Study. The analysis shows that traffic has generally increased on most traffic count locations such as the Ring Road, Gesr El Suez, Suez Desert Road, etc. while it decreased on fewer links such as Abbas Bridge, Ahmed Helmy Street, etc. These changes can be attributed to certain changes in transport demand and supply and land use characteristics in the GCMA, such as population growth in the new peripheral cities, the expansion of the Central Business District, the operation of the new Maryotiya corridor, the upgrade of El Khalafawy Corridor and the significant increase in the overall car ownership. The morning peak period has remained between 7:00 and 9:00 AM while the afternoon peak period has shifted from (13:00 – 16:00) to (15:00-18:00). The comparison of modal splits in 2010 and 2005 indicates that the share of passenger cars remains the highest and has generally increased since 2005, while the share of microbuses, minibuses and taxis has moderately increased. On the other hand, the large bus share has dropped and so has the share of trucks. The latter could be a result of banning trucks on most of the city roads during working hours.

The adopted approach to identify the causes, types and locations of road congestion in the GCMA involved a quantitative assessment which identified the causes and locations of congestion along the study corridors and a network-wide qualitative assessment that focused on the causes of traffic congestion across the GCMA without reference to specific locations.

Reduced travel speeds and more widespread congested conditions have been observed in the evening peak in comparison to the morning peak. Some insights into the observed congestion patterns are highlighted through the classification of the study area into four area types. The average speeds for all surveyed corridors within the area bounded by the Ring Road 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 to 30 km/hr. The average speed along the Ring Road is slightly higher, varying between 30 and 60 km/hr depending on the peak period and direction.

The analysis results reveal that the average speed indices, being the ratio between the route average speed to its free flow speed, for all surveyed routes range from 0.31 (PM peak period) to 0.63 (AM peak period). 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.

The reliability analysis is based on the estimated coefficients of variation of the corridors average speeds. The estimated Coefficients of Variation 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 is estimated for the evening peak compared to the morning peak for all surveyed corridors, with the exception of two locations. The highest variability in travel speeds is estimated for the 26th of July/15th of May travel corridor.

Among the numerous causes of travel time variability, traffic influencing events are major contributors. The most notable event type is vehicle breakdowns, which occur at a daily rate that is substantially higher than other traffic influencing events along all surveyed routes. It was also observed that higher frequencies of accidents, security checks and breakdowns occurred more on urban primary highways compared to the urban primary arterial routes. The analysis also reveals the substantial occurrence of both random microbus stops and random pedestrian crossings on most surveyed routes.

The quantitative analysis also involved an assessment of the individual principal corridors, in which the aggregate as well as localized congestion causes were identified. The analysis includes average speeds, coefficient of variation, frequencies of daily traffic influencing events, conclusions from space-time plots and a description of distinct congestion locations and causes along the route.

The network-wide qualitative assessment was performed through a consultative workshop involving a panel of experts. Through a structured approach known as Nominal Group Technique (NGT), a list of 35 causes of traffic congestion in the GCMA was compiled. The causes of traffic congestion in the GCMA were classified into "operational" and "strategic". Through the NGT, the panel of experts ranked the operational causes by degree of importance as follows: traffic management and control, design features of the road network, law observance and enforcement, awareness of road etiquette and manners, parking supply and behavior, traffic demand related factors, traffic influencing events and work zones.

The comparative assessment of qualitative and quantitative outcomes is summarized for each of the identified congestion cause categories, which include traffic management and control, design features of the road network, law observance and enforcement, awareness of road etiquette and manners, parking supply and behavior, traffic demand related factors, traffic influencing events, and work zones. For example, the "design features of the road network" was evaluated as one of the most salient causes of traffic congestion by both qualitative and qualitative assessments.

Estimation of Direct Economic Costs of Traffic Congestion in Cairo

The next step in the study was to estimate the direct economic costs of traffic congestion in the GCMA. A selection of suitable methods of measurement of congestion levels are described for this purpose. Then the adverse components of traffic congestion are identified. The adopted procedure consists of two parts: first a calculation of direct congestion costs on the 11 Principal Corridors and second an extension of the calculation to cover the complete GCMA. Two methods were used to estimate the cost, namely Speed Plot and Volume-to-Capacity Ratio.

Based on the literature review, the direct cost elements commonly used to calculate the direct costs of traffic congestion include: (a) cost of travel time delay imposed on users (passengers as well as freight); (b) cost of travel time unreliability in passenger transportation; (c) cost of excess fuel consumption in vehicular transportation (Diesel and Gasoline) and (d) the associated cost of Carbon Dioxide (CO_2) emissions due to excess fuel consumption.

The annual recurring and nonrecurring cost of travel time delay for the 11 corridors amounts to 2.6 billion LE using the speed plots approach and 2.4 billion LE using the volume to capacity ratio (V/C) approach. The share of recurrent delay costs is estimated to be approximately 40% leaving 60% for the non-recurrent delay (consistent in both approaches). The estimation is based on the methodology developed by the Texas Transportation Institute in which ratios have been determined for recurrent and non-recurrent delays.

In general, reliability is highly valued by travelers and commercial vehicle operators. Although a congested network is not necessarily unreliable, congestion increases the likelihood of unreliability. The total cost of passenger travel time unreliability for the 11 corridors is estimated approximately 1.7 billion LE. The total unreliability cost for freight transportation is roughly estimated around 13.5 Million LE per year for the 11 corridors based on the annual tonnage of cargo transported in the region.

The total excess fuel costs for the 11 corridors due to traffic congestion are estimated to be 2.85 billion LE using the speed plots approach and 2.38 billion LE using the volume to capacity ratio (V/C) approach. The share of the costs to the user is 45% with the remaining 55% of the total amount incurred by the Government.

The total costs of CO_2 emission due to traffic congestion for the 11 corridors is estimated approximately at 97 million LE per annum using the speed plots approach and 86 million LE per annum using the volume to capacity ratio (V/C) approach.

The total direct traffic congestion cost *for the 11 corridors* is therefore estimated to exceed **7.0 billion LE** according the first approach **and 6.6 billion LE** according to the second approach. The main cause of difference between results of these two approaches is the applied method to determine the congested part of the corridors.

In order to estimate congestion cost for the entire GCMA, and in the absence of complete information needed to calculate the volume to capacity ratios for the entire transport network, an alternative method was used to extend the estimated direct economic cost of traffic congestion from the 11 corridors to the GCMA. The applied methodology consisted of developing a traffic model using Emme/3 based on the trip generation and distribution tables of the JICA study and the 11 major corridors attributes and alignments. The percentage of the traffic in Greater Cairo carried by the 11 major corridors was calculated based on a comparison between the actual traffic counts and the traffic model volumes on these corridors, which entail the ratios of 50.4% in the morning peak period and 50.9% in the evening peak period.

Based on the traffic counts, the total number of vehicles in the peak hours (both AM and PM) in the 11 corridors is estimated around 605.000 PCU. Similarly, the total number of vehicles in peak hours in the entire GCMA is approximated to 1,210,000 PCU. Consequently, the total annual direct congestion costs *for the GCMA* is estimated in the range of **13 to 14 billion LE.** The highest shares of the total direct cost are those of the travel time delay cost (36%), consisting of recurrent and non-recurrent congestion costs, and excess fuel cost (37%), of which half is paid by users (retail price of fuel) and the other half is additional costs to the Government (fuel subsidies); followed by unreliability cost (25%); and finally, the CO_2 emissions cost has a fairly small share of less than 1% of total costs.

To determine direct economic cost at a disaggregate level for each zone of GCMA, several factors were considered such as geographic size, local road types, traffic network types, number of available lanes in the traffic network and land use. The factors used to determine the share of congestion costs by each traffic zone included the number of zonal trip origins and destinations from the adjusted 2010 OD matrix (based on JICA study) as a proxy for traffic flow, network type(s) as a proxy for design road capacity and free flow speed, number of trips per lane-kilometer as a proxy for actual road capacity and average speed, and land use as a proxy for level of congestion and the network length.

The congestion costs in the 11 corridors cover the following zones: Salam City, Nasr City, Khaleefa, Giza, Dokki, CBD, Masr El Gadida, Shoubra, Shoubra El Khima, Part of Imbaba Markaz and Ain Shams. The share of each zone is calculated based on the trip production/attraction, the network type and the network capacity. Nasr City is found to have the highest share of congestion (23.6%), followed by Masr El Gadida (19%) and Giza (14.7%). The congestion costs for traffic zones located in the suburbs are also estimated. The Qanater area had the highest share (24.5%), followed by Qalioub (22.8%), then Maadi (13.5%) and Imbaba Markaz (13.2%).

1 Introduction

1.1 Background

The total population of Egypt over the ten-year period between 1996 and 2006 increased from 59 million to 73 million, with an average annual growth rate at 2.04%. The Greater Cairo Metropolitan Area (GCMA) hosts the largest share of population, economy, industry, and human resources in Egypt. With a population that stood at 17 million in 2006 and fast rate of urbanization (expected to reach 24 million in 2027), GCMA is one of the largest mega cities in the World and is Egypt's largest agglomeration (22% of Egypt's population).

Traffic congestion is a serious problem in the Cairo metropolitan area with substantial adverse effects on personal travel time, vehicle operating costs, air quality, public health, business environment and business operations. The causes of traffic congestion are complex, as are the range of possible policies and investments that could be arrayed to address the problem. In CGMA, about 2/3 of all motorized trips are made by public transport (mostly taxis and minibuses), and there are therefore tremendous opportunities for improving traffic congestion through accelerated modal shift to mass transit systems. The government has committed itself to significantly support modal shift, improve fuel efficiency in the urban transport sector, and identify cost effective investments and measures.

The government's vision for transforming the urban transport sector in GCMA is reflected in the Greater Cairo Urban Transport Master Plan. The implementation of plans for GCMA has been slower than envisioned and traffic has increased more than originally expected. For instance, the previous JICA 2003 report projected a reduction of the travel speed from 19 km/h to 12 km/h by 2020 in the worst case scenario. The most recent estimates indicate that the travel speed had fallen to around 12 km/h in 2005, notably due an increased car ownership associated with higher income growth and urbanization.

Part of the problem for properly addressing urban congestion arises from the lack of appropriate technical studies, with clear methodologies, specifically aimed at assessing the economic costs of congestion. These studies would help assess the magnitude of the problem, its types, and locations, therefore providing a solid ground for making appropriate policies and investments recommendations.

1.2 Objective of the Study

The Objective of this study is at first to assess the baseline and economic cost of current congestion in GCMA, based on which to prepare policy recommendations and an action plan to reduce traffic congestion. In order to achieve this important objective, the study will be carried in two main phases:

- The **first phase** will at the outset involve the review of traffic congestion in GCMA, its causes, types and location, with the final objective of assessing the overall economic costs and the associated energy inefficiencies. This will permit depicting a clearer image of CGMA' complex traffic congestion problems and associated costs, and inform policy makers about their real magnitude.
- The **Second phase** will involve prioritizing and recommending a package of specific fiscal (congestion pricing schemes, fuel subsidies), regulatory (vehicle inspection norms and standards, regulation of public transport, public transport pricing), and investment (traffic management and public transportation investments) measures.

This assignment will cover the first phase of the study only. The first phase will involve the following activities:

- Task 1: Review literature, organize first consultative workshop, and prepare inception report
- Task 2: Assess information need, and collect additional data as necessary.
- Task 3: Identify the causes, types and locations of traffic congestion.
- Task 4: Quantify the direct economic costs of traffic congestion.

1.3 Structure of this report

Section 2 presents a comprehensive assessment of the data and information needs of this study, identifying sources and samples of existing data and describing additional data that were collected as part of Task 2.

Section 3 presents an analysis of the extent of traffic congestion in the GCMA, its main causes and key locations. Specifically, the section describes the detailed analysis performed on the Floating Car Survey (FCS) data and discusses the results. The section also presents the results of the consultative workshops we conducted with traffic experts from academia, industry and Ministry of Interior.

In section 4, we present the estimation of the direct economic cost of traffic congestion in Cairo. In this stage, economic costs of travel time delay, travel time unreliability, costs of excess fuel consumption, the associated cost of CO2 emission due to fuel consumption, and eventually total direct economic costs of traffic congestion in Cairo will be estimated.

2 Assessment of Information Needs and Collection of Additional Data

2.1 Introduction

Greater Cairo Area and Population

Cairo or rather the urban region of the Greater Cairo Metropolitan Area is the largest urban area in Egypt, Africa and the Middle East and amongst the most populous metropolises of the world. It occupies the 10th rank within mega cities across the world in the period between 2000 and 2015[2].

Greater Cairo has been the centre of gravity for many of Egypt's activities. It has grown mainly due to increased migration from rural areas, and high growth rates were witnessed during the second half of the 20th century vis-à-vis investments, economic activities, job opportunities and number of students.

At the turn of the 21st century, Greater Cairo started to get its contemporary structure as a "main dense urban area" with varied socioeconomic levels encircled by the Ring Road and an "outer belt" of 8 new satellite cities as shown in Figure 2.1.

In 2006, the population of Greater Cairo Area reached 17 million people spread across Cairo, Giza and Qaylobiya and the new cities listed in Table 2.1 below. The urbanization continues to progress, and the performance of the entire transport system is less than desirable, despite the massive efforts striven by the Egyptian government to tackle traffic congestion and environmental deterioration, by introducing a metro system and a comprehensive bus network.

Table 2.1: New Cities around Greater Cairo- Type and Population [3]

City	Type	Population in 2006
6 October	Industrial	500,000
Al Sheikh Zayed	Residential	48,000
15 May	Industrial	180,000
Al Oboor	Industrial	100,000
Badr	Industrial	60,000
Al Shorooq	Residential	62,000
New Cairo	Residential	302,000

[2] "World Urbanization Prospects, the 2001 Revision", Department of Economic and Social Affairs, Population Division, United Nations Publications, UN, 2002.

10 Ramadan	Industrial	500,000

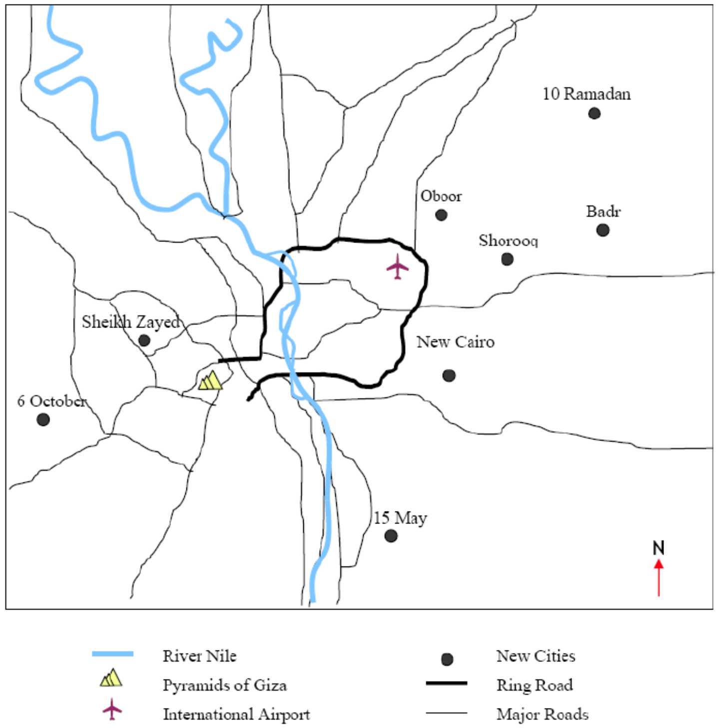


Figure 2.1: Location of the new cities around Greater Cairo[3]

Previous transport studies and relevance to this study

There exist several urban transport-related studies and development master plans for Greater Cairo to date. The most recent were reviewed by the Consultant and mainly include:

- "Transportation master Plan and feasibility Study of Urban Transport Project in Greater Cairo Region in the Arab Republic of Egypt" Greater Cairo Urban Transport Master Plan" (CREATS), JICA – 2002: was the first attempt to delineate a comprehensive transport master plan, covering the entire metropolitan areas of Greater Cairo Region. It adopts approaches designed to mitigate urban transport problems and contribute to the sustainable development of the Greater Cairo Region. Its key objectives are to formulate a master plan for the urban transport network in the Study Area to the year 2022; to conduct a feasibility study for the priority project(s) identified under the master plan (however, this object was to be undertaken as a follow-up effort to the master plan study); and to carry out technology transfer to the Egyptian counter personnel in the course of the study.
- "Public-Private Partnership Program for Cairo Urban Toll Expressway Network Development", JICA – 2006. The study's main objectives are to review and update the traffic demand, routing and development phasing plan of the Cairo urban expressway network proposed in the CREATS Master Plan of 2002; set up the toll

[3] Research Study on Urban Mobility in Greater Cairo, Trends and Prospects, Final Report, February 2009 – by the Development Research and Technological Planning Center, Cairo University

road system for the sustainable development of the proposed Expressway network; and formulate a comprehensive strategy for the introduction of a PPP program for the development of the Expressway network.

- "Strategic Urban Development Master Plan Study for Sustainable Development of the Greater Cairo Region in the Arab Republic of Egypt", JICA – 2008 (Updated in 2009). The objectives of the study include: formulating a strategic development master plan for the study area in the target year of 2027 to achieve the sustainable social-economical development through well-balanced urban development; formulating an implementation scheme for priority development corridor(s), considering the effective urban development being integrated with transportation development; and exchanging experience related to urban planning and urban development.
- "Research Study on Urban Mobility in Greater Cairo, Trends and Prospects", Development Research and Technological Planning Center, Cairo University – 2009. This study mainly covered evolution trends of urban development, transport and energy/environment in Greater Cairo area so as to call attention of decision-makers and other stakeholders to the related effects on sustainable development and sustainable transport.
- "Greater Cairo: A Proposed Urban Transport Strategy", Urban & Transport Unit, Middle East and North Africa Region, World Bank – 2006. The study provided an assessment of the urban transport system in Greater Cairo, identified the most pressing urban transport problems, and proposed a framework for urgent policy actions and investment priorities that would be the basis of a formal transport strategy to be adopted and implemented by the authorities of the metropolitan area of Cairo.
- "Proposed Cairo Urban Transport Strategy & Priority Program", Greater Cairo Development Project, Ministry of Housing and the World Bank – 2010. This study includes a short and medium term priority program, which depends on institutional strengthening, development of public transport system, traffic management and enforcement, toll roads facilities and sustainable funding.

In addition to the above-mentioned studies, the following attempts to develop a transport master plan for Greater Cairo were made:

- A study dating back to 1973 undertaken with French support under Transport Planning Authority (PTA), MOT, focusing on the Metro Line Development
- A study conducted in 1989 with the technical support of JICA under Cairo Governorate
- The "Public Transport Study" with French support in 1999 under NAT.

The Egyptian Government also issues Five Years Plans for the nation as a whole and for the Governorates, which include the projects and the programs to be implemented in the various sectors during the upcoming five years in consideration.

The World Bank has been assisting the Egyptian Government in elaborating its urban transport policy and prioritizing interventions and has committed financing to urban transport projects from IBRD, the Clean Technology Fund, and Carbon Finance sources to contribute to the cost of short-term investment needs based on the above government plans.

Nevertheless, part of the problem for properly addressing urban congestion, in most countries, arises from the lack of appropriate technical studies with clear methodologies, specifically aimed at assessing the economic costs of congestion. There is therefore a critical need to assess the magnitude of the problem, its types, and locations, therefore providing a solid ground for developing appropriate policies and investments recommendations.

Based on the above, the scope of the current study includes the following activities (amongst others):

- **Assessing information need, and collecting additional data as necessary (Task 2):** After review of the existing studies on urban transport in Greater Cairo, the consultant shall assess the data collection needs and methodologies to obtain the necessary information for carrying out this assignment and shall perform additional data collection where needed, including site surveys, to update and complement the existing information.
- **Identifying the causes, types and locations of traffic congestion (Task 3):** The consultant shall identify the locations, types and causes of traffic congestion in metropolitan Cairo.

2.2 Task Description/Objectives

Chapter 2 of this report presents a comprehensive assessment of the data and information needs of this study, in line with Task 2 of the study, identifying sources and samples of existing data and describing additional data that were collected. The chapter also provides a detailed description of the Floating Car Survey (FCS) which the study team conducted on 11 principal corridors in the Greater Cairo Metropolitan Area (GCMA).

In addition to the FCS, the study team conceived a detailed plan for collection of traffic counts; however this plan faced prolonged delays in obtaining the required security clearances for the field surveyors, despite persistent efforts to secure the clearances from the responsible authorities in a timely manner. The traffic counts were finally conducted in July, and are reported in Section 2.10 and Annexes 6 and 7.

2.3 Study area

Previous studies in Greater Cairo and local ministries have been using different study areas or planning boundaries, making it difficult to compare the study results on the same ground. In other words, there is no clearly defined boundary for the Greater Cairo Region or Greater Cairo Metropolitan Area.

For the purpose of this study, the scope will relate to the study area defined by the JICA study (Greater Cairo Urban Transport Master Plan - CREATS, 2003), as recommended in the project's Terms of Reference. The Study Area therefore consists of the Greater Cairo Region, including the new cities of New Cairo City, 6th of October City, 15th May City, 10th of Ramadan City, El-Obour City and Badr City, as shown in the Figure 2.2 below.

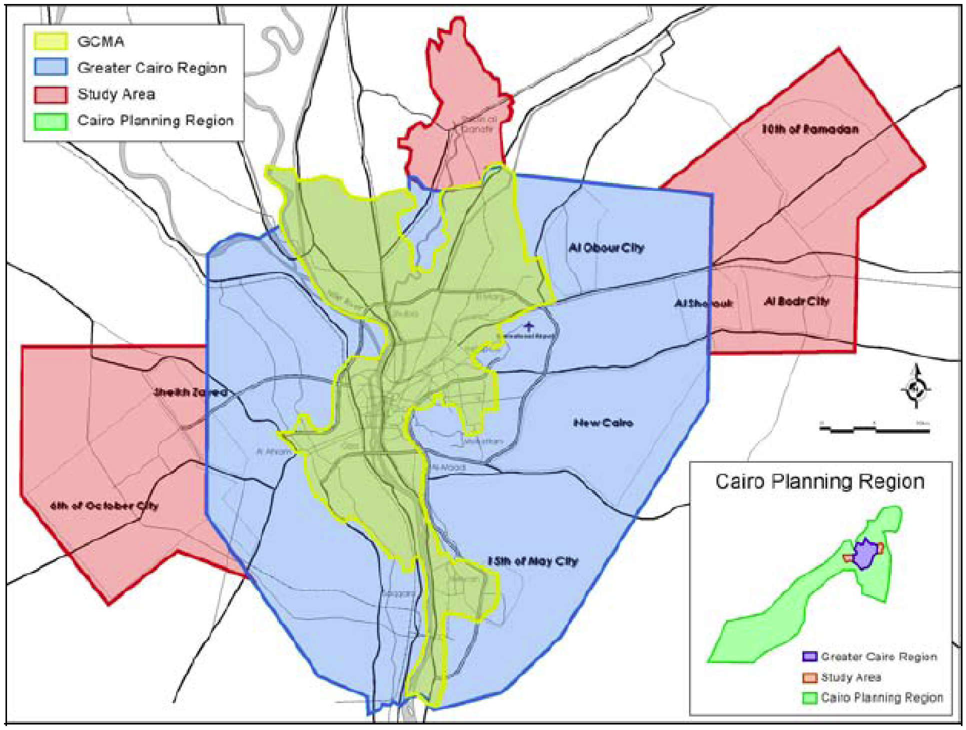


Figure 2.2: Administrative and Planning Boundaries in the Study Area (CREATS, 2003)

In administrative terms, the Study Area covers Cairo Governorate, Giza Governorate and part of Qalubia and Sharqia Governorates. Alternatively, the study area is identified as the envelope of the 11 major districts identified by the JICA study, as follows (Figure 2.3):

1- Central Cairo
2- Central Giza
3- Heliopolis/Nasr City
4- Shoubra/Shoubra El Kheima
5- Mataryia
6- Maadi/Qatamiya Road
7- Shibin El Qanater/ El Obour
8- 10^{th} of Ramadan/Badr/El Shorook
9- New Cairo
10- Helwan/15^{th} of May
11- 6^{th} of October/El Sheikh Zayed

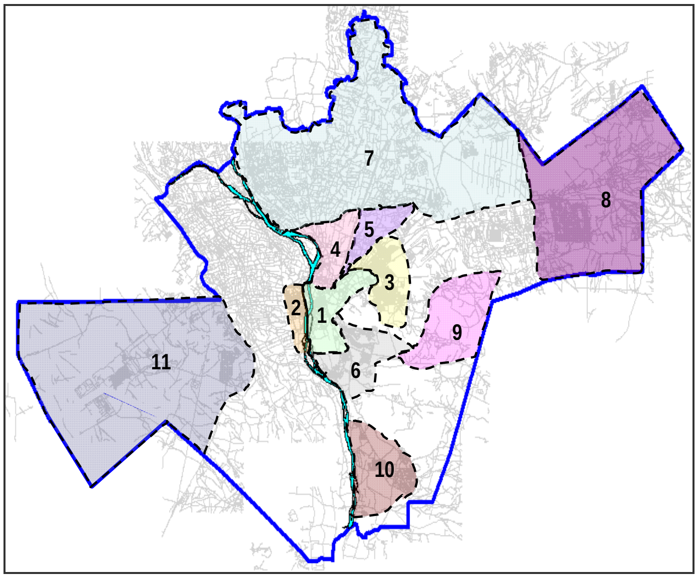


Figure 2.3: Greater Cairo Region Major Districts (CREATS, 2003)

2.4 Assessment of Data and Information Needs

The table below outlines the data and information needs. The table includes the potential sources of this data and their relevance to the assignment.

Table 2.2: Study Data and Information Needs

Data/ Information item	Source/ method
Origin/Destination (O/D) matrices by traffic mode	Derived from the results of the study of "Public Private Partnership Program for Cairo Urban Toll Expressway Network Development"
GIS maps of network characteristics	Ministry of Housing, Ministry of Transport
Current traffic volumes	Field traffic counts at selected corridors
Current traffic speeds	Floating car surveys at selected corridors
Difference between design capacity and actual capacity	Based on noted observations made by floating car survey personnel
Frequency of incidents (at an appropriate level of disaggregation)	Based on noted observations made by floating car survey personnel
Locations, types and causes of congestion	Analysis of collected data plus two workshops with MOI personnel and traffic experts
The total number of vehicles (by type)	Egypt Government, offered by the WB
Public transport capacity, fleet composition & age	Egypt Government, offered by the WB
Accident data and information	Egypt Government, offered by the WB
Unit vehicle operating cost	Based on an analysis of actual performance data collected from different transport operators, as well as automobile dealers
Fuel cost	Obtained by interviewing gasoline stations and some car dealers
Household income and value of time	Based on a household opinion poll survey that was carried

	out in the Cairo master plan in June and July 2007
Percentage of daily traffic in peak hour	Based on the Public Private Partnership Program for Cairo Urban Toll Expressway Network Development study
Passenger Car Unit (PCU)	Based on the strategic urban development master plan study for sustainable development of the greater Cairo region in the Arab republic of Egypt (March 2008)
Vehicle Occupancy Factor	Based on the strategic urban development master plan study for sustainable development of the greater Cairo region in the Arab republic of Egypt (March 2008)

2.5 Floating Car Survey and Traffic Counts

2.5.1 Data Collection Objectives

The floating car survey and collection of traffic counts were intended to:

- Fill major data gaps identified upon consolidation of traffic data from previous studies;
- Facilitate the development of growth factors that could be used to update traffic data from previous studies; and
- Enable the quantitative assessment of congestion levels, locations and causes along selected travel corridors.

2.5.2 Data Collection Techniques

- Floating Cars: test drives along selected routes where travel distances as well as qualitative observations are recorded at specified time intervals.
- Traffic Counts: manual classified traffic counts at selected locations.

2.5.3 Technical Plan Development Methodology

Study Area and Road Classification

The focus of this study is for the within ring road area. However the main corridors connecting all external cities to the within ring road area are included: 26th of July corridor carrying traffic from 6th of Oct city; Cairo/Suez Desert road carrying traffic from new Cairo, ElShorouq, and Badr; Cairo/ Ismailia Desert road carrying traffic from Obour, 10th of Ramadan, and Elshorouq; Cairo/Alex agriculture road carrying traffic from El-Qalyoubya; and Cornish El-Nile carrying traffic from 15th of May city.

According to the JICA study, the roadway network of the GCR is classified into 7 categories/levels as shown in Figure 2.4 and listed next.

1- Inter-Urban Primary Arterial Highway
2- Regional Primary Arterial Highway
3- Urban Expressway
4- Urban Primary Arterial Street
5- Urban Secondary Arterial
6- Collector/Distributor Street

7- Local Street

<u>Due to budget and time constraints, the scope of our data collection is limited to levels 1, 2, 3, and 4.</u>

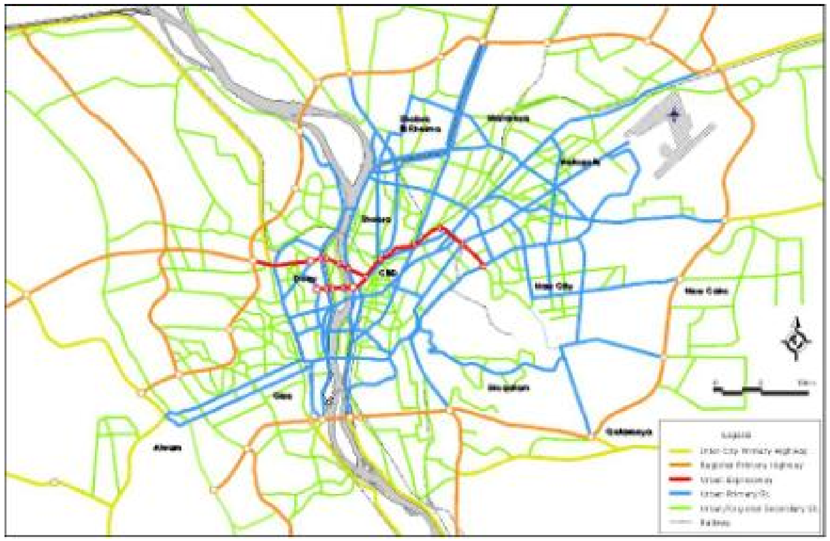


Figure 2.4: Greater Cairo Region Roadway classification (CREATS, 2003)

Consolidation of traffic data from previous studies

The JICA study of 2005 (Cairo Urban Toll Expressway Network Development) conducted traffic surveys at 28 locations within the GCR. Traffic counts as well as classification data were collected at the 28 locations, for both travel directions, for 16 hrs. The observation locations and peak hour traffic volumes are shown in Figure 2.5 and Figure 2.6, respectively.

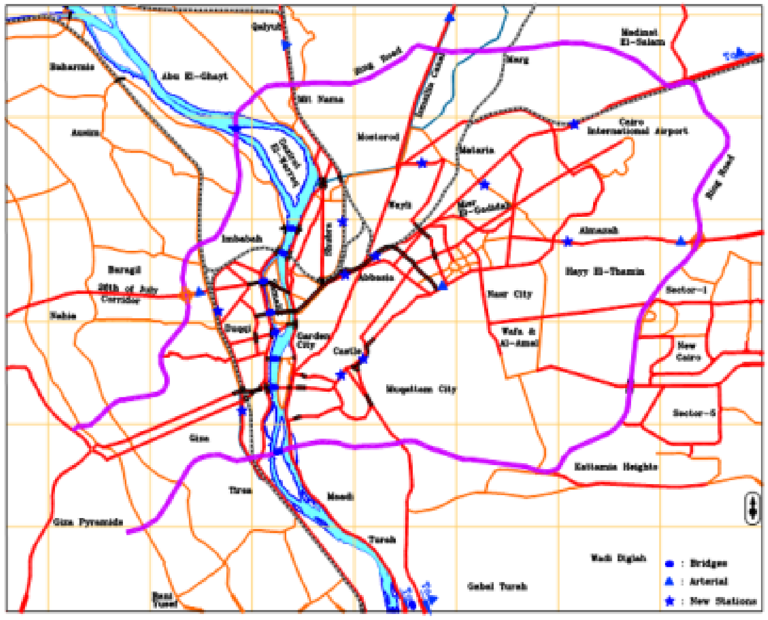


Figure 2.5: Traffic counts observation locations (JICA, 2005)

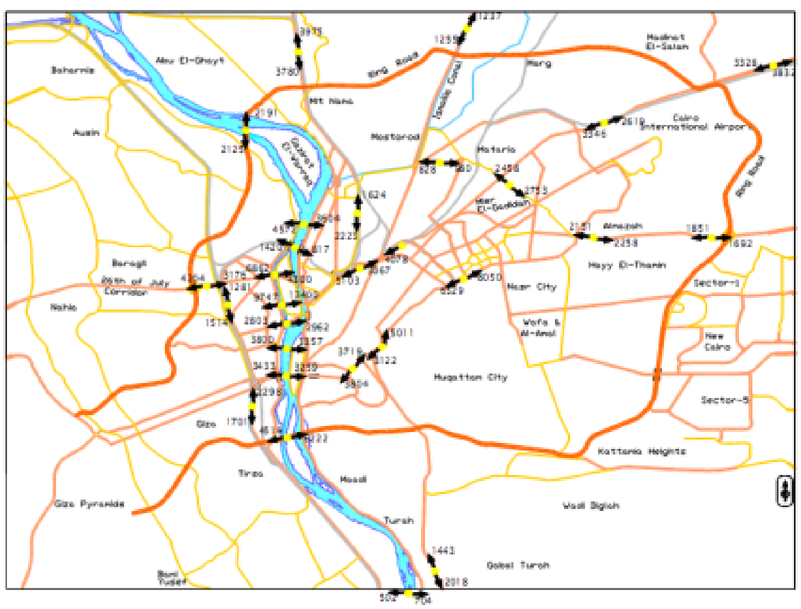


Figure 2.6: Peak hour traffic volumes (JICA, 2005)

The JICA study of 2007 (CUTE) conducted traffic count surveys at 8 locations as identified in Figure 2.7. Classified traffic volumes were manually observed for both directions of the 8 locations for 16 hrs.

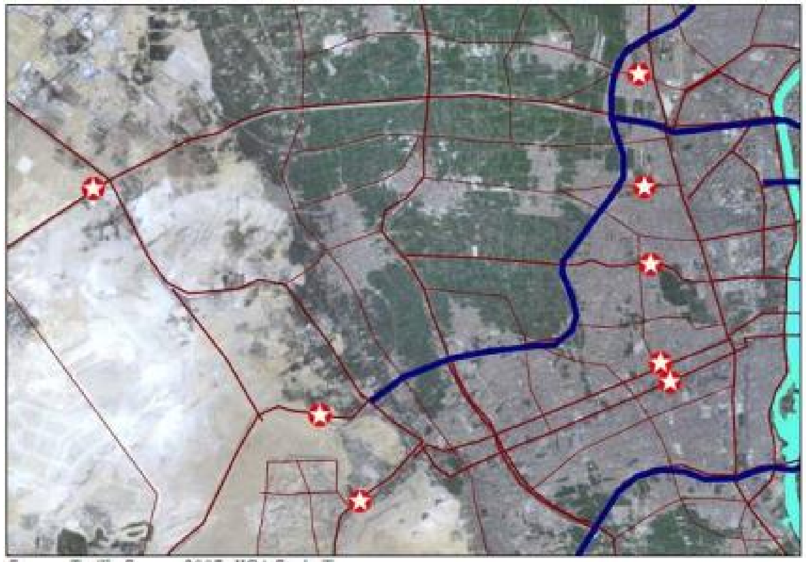


Figure 2.7: Traffic counts observation locations (JICA, 2007)

The Cairo Ring Road study of 2007 (Upgrading of Greater Cairo Regional Ring Road to an Integrated Transport Corridor) conducted traffic count surveys along the Ring Road. Continuous traffic counts ranging from 16-hr to 24-hr were performed at each approach of the 23 interchanges of the Ring Road as shown in Figure 2.8.

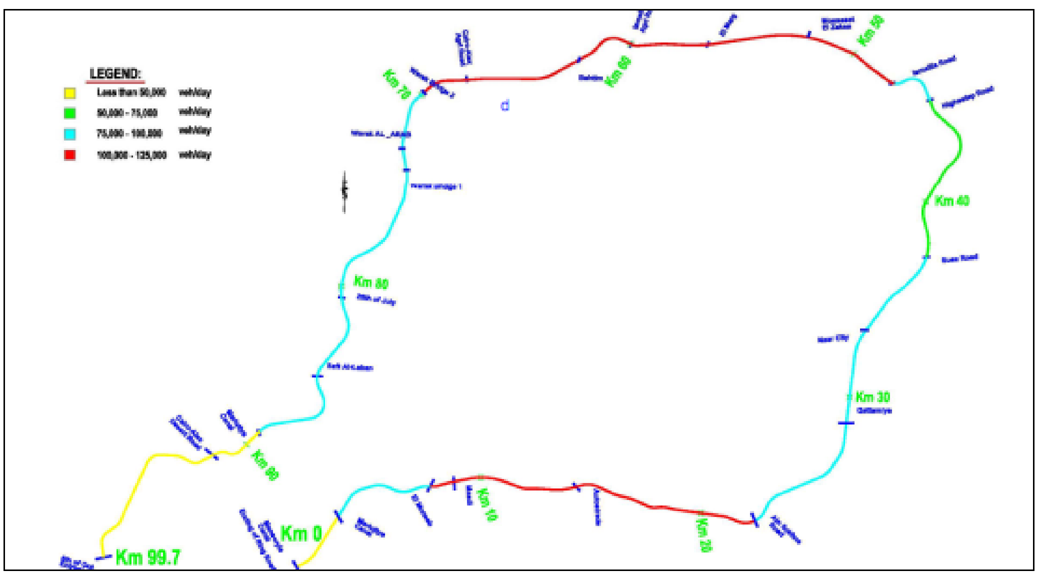


Figure 2.8: Cairo Ring Road Study, 2009

Selection criteria for additional data collection sites

Floating cars

- Maintaining an adequate representation of all identified districts within the GCR
- Maintaining an adequate representation of different road hierarchy levels (considering only the levels from 1 to 4, as defined previously).
- Capturing the impacts of the recent substantial growth in the new settlements on the periphery of the ring road. The main radial corridors carrying traffic demand from those areas, crossing the ring road, to the centre of the city are to be considered.
- Capturing critical corridors with excessive delays considering inputs from the traffic police, professionals, and results reported in previous studies.
- Capturing the severely congested segments of the ring road.
- Maintaining a round-trip travel time within 2 hours (on average) to be able to conduct more than one round trip during the peak period.

Traffic Counts

- Duplicating the traffic counting efforts made by previous studies at a few selected locations. This duplication will enable the estimation of realistic growth factors that could assist in updating the rest of the data.
- Maintaining an adequate representation of areas/corridors where major recent land use developments have been realized. A focus will be dedicated to major traffic corridors connecting GCR new settlements (including 6th of October, El Sheik Zayed, 10th of Ramadan, Obour, Badr, Elshorouk, New Cairo, 15th of May) with the city centre. At least one data collection location is to be defined along the main corridor connecting each of those areas with the ring road.
- Maintaining an adequate overlap with the selected routes of the floating car study. This overlap will allow for the consolidation of different data types which enable a more insightful assessment of traffic conditions.

2.5.4 Development of Data Collection Technical Plan

Floating Cars

Floating Car Routes

A preliminary plan was developed for the floating car routes based on the previously stated route selection criteria. The plan identifies 10 travel routes as candidates for the floating car surveys. The selection process was based on several brainstorming sessions with a number of transportation professionals. Figure 2.9 depicts the formulated preliminary plan.

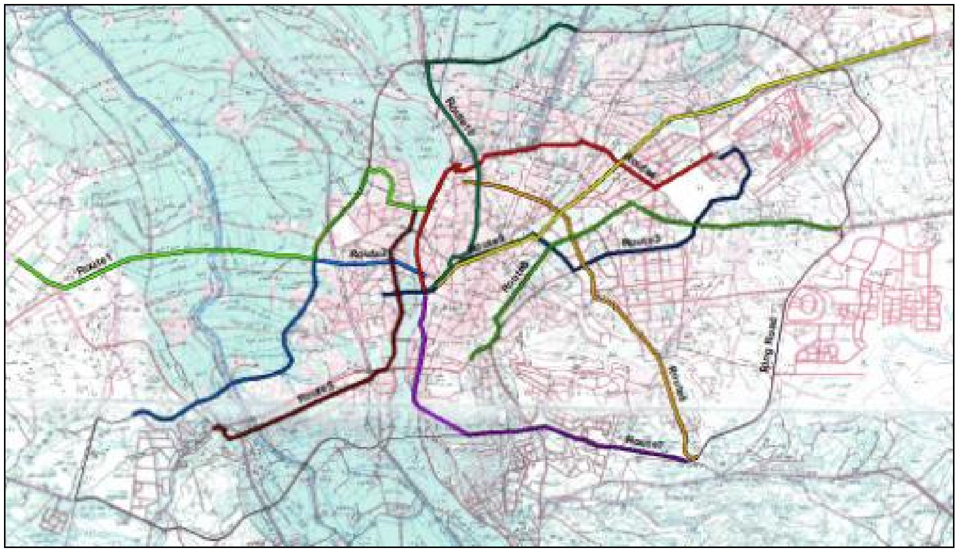


Figure 2.9: Preliminary Routes for the Floating Car Survey

The preliminary plan was subsequently updated based on brainstorming sessions with traffic police representatives and transportation experts. The objective of such sessions was to encapsulate different experiences into the data collection plan. The main feedback obtained was:

- The Ring Road is a crucial travel corridor needs to be entirely surveyed.
- Abass Bridge is a critical high volume flyover that mandates surveillance.
- The appropriateness of "Route 6" in the preliminary plan is not well established. Concerns pertaining to road segments functional hierarchy as well as congestion levels have been expressed.

The preliminary plan was modified in accordance to the above feedback. The entire Ring Road as well as Abass Bridge were included in the updated plan. The final plan constitutes 11 floating car routes, as depicted in Figure 2.10.

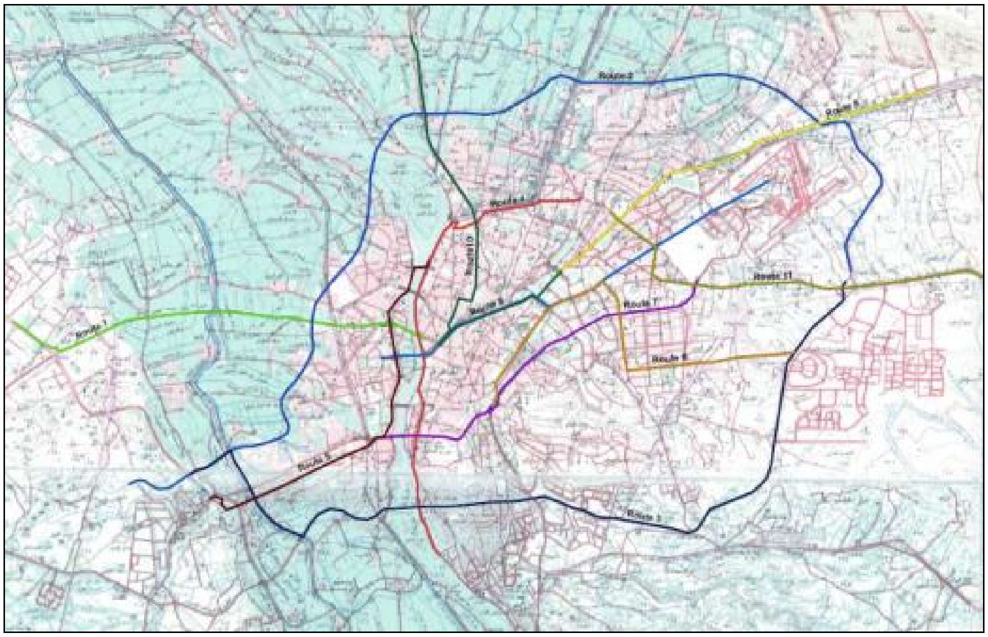


Figure 2.10: Final Routes for Floating Car Survey

Traffic Counts

Based on the previously outlined selection criteria, 15 observation locations were identified along the floating car routes for traffic counts. Figure 2.11 displays the selected observation locations.

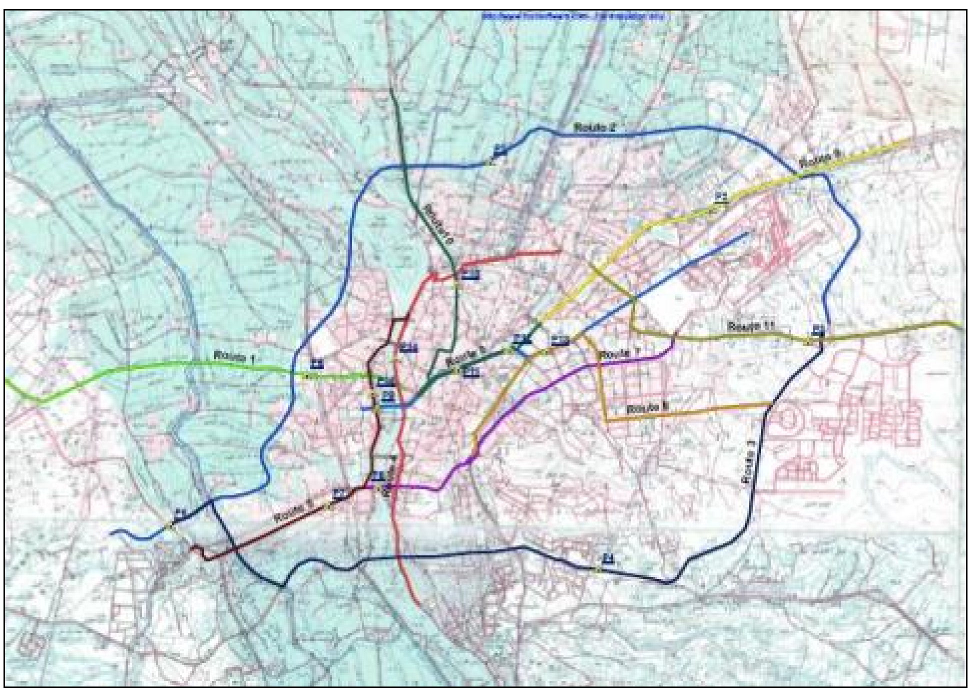


Figure 2.11: Traffic counts observation locations

2.5.5 Data Collection Operational Plan

Floating cars

- Reported Observations: Travel distance, actual number of lanes, judgmental congestion level, incidents, unpredictable pedestrian crossing (i.e. Jaywalking), microbus drop-offs/pickups, security checks, and intersections. A sample observation sheet is included in Annex 4.
- Surveyed Routes: (Table 2.3) presents the details of the identified 11 routes. Each route is to be covered by 2 floating cars traveling in opposite directions.
- Drivers/Observers: 22 drivers and 22 observers were recruited to perform the floating car survey. A training session was conducted to get drivers/observers familiar with their assignments.
- Date: the survey was conducted during the following days:
  - Monday 24/5/2010
  - Tuesday 25/5/2010
  - Monday 31/5/2010
  - Tuesday 1/6/2010
- Time: the survey took place during the following peak periods:
  - Morning peak period: 7:00 am to 11:00 am
  - Afternoon peak period: 3:00 pm – 7:00 pm

On each route and during each peak period of each day listed above, two cars were traveling in opposite directions and making two way trips (departure and return). The total number of runs (complete loops) made on the 4 days per route and peak period ranges between 10 (Route 9, PM peak period) and 22 (Route 8, AM and Route 11, PM), as indicated in Table 2.4 below, and the average number of runs for all routes is 16.

Table 2.3: Floating Car Survey Detailed Routes

Route	Name	O/D (Direction 1)	Main Streets	Road Class	% Length
1	26th of July/ 15th May Travel Corridor	Cairo-Alex Desert Road/ El-Esaaf	26th July Street 15th of May Bridge 26th of July corridor Cairo-Alex Desert Road	3 3 2 1	3 13 78 7
2	Ring Road North	Cairo-Suiz Desert Road Interchange/ El-Wahaat Road	Ring Road	2	100
3	Ring Road South	Cairo-Suez Desert Road Interchange/ Cairo Alex Desert Road	Ring Road	2	100
4	El Corniche-East/ El-Matareya Square	El-Matareya Sqr/ Maadi Corniche	El-Kablat Str. Terat Al-Ismaileya Road Said Salem Str. Kornish El-Nile Road(East)	4 4 4 4	9 16 7 69
5	Rod El Farag/ El-Remaya	Roud El-Farag-Bridge/ Remaya Sqr	Roud El-Farag Bridge Kornish El-Nile Road(West) Gamal Abdel Naser(El-Nile)Str. El-Giza (Sharl De Gol) str. Morad Str. El-Giza Bridge El-Ahram Str.	4 4 4 4 4 4 4	7 13 16 12 3 3 44
6	Cairo-Suez Desert Road/El-Qallaa	Mobarak Academy for Security (5th District)/ El-Qalaa	Ahmad El-Zomor Str. (El Methaq Str.) Zaker Hussein Str. El-Tayaran Str. El-tayaran Tunnel Salah Salem	4 4 4 4 4	30 5 20 5 40
7	Autostrad/ Giza Square	Autostrad-Thawra Intersection/Giza Sqr	El-Nasr Road/Autostrad Salah Salem Hassan El-Anwar Str. El Rawda Abbas Bridge Al-Ahram Str.	4 4 4 4 4 4	70 19 5 2 2 2
8	El-Orouba/ 6th of October Bridge	Cairo Int Airport/ ElBatal Ahmed AbdElaziz	El-Orouba Str. 6th of October Bridge	4 3	54 46
9	Cairo-Ismaillia Desert Road/El-Qubba	Obour City/ El-Qubba Bridge	Cairo-ismaileya Desert Road Gesr El-Suize Str.	1 4	30 70
10	Cario-Alex Agr Road El-Qubba	Upstream RingRoad Interchange/El-Qubba Bridge	Cairo-Alex Agricultural Road(Quesna-Qalyoub Road) Ahmed Helmy Str. Ahmed Badawy Str. Shoubra Str. El-Galaa Str. Ramsis Str. El-Khaleefa El-Ma'moon Str.	1 4 4 4 4 4 4	25 34 3 4 4 23 6
11	Cairo-Suez Desert Road/Ebn-ElHakam Square	Cairo-Suiz Desert Road (Rehab Entrance)/ Ibn El-Hakam Sqr.	Cairo-Suiz Desert Road El-Thawra Str. El-Nozha Str. Abo Bakr Al-Sedeeq Str. Ibn El-Hakam Str.	1 4 4 4 4	71 10 6 10 2

Table 2.4: Number of Runs on Each Route during the Floating Cars Survey

	No of Runs/Complete Loops (departure and return trips were completed)	Additional Number of Incomplete Loops (return trip could not be made in the specified period)
Route 1 (AM)	19	5
(PM)	20	4
Route 2 (AM)	13	6
(PM)	11	6
Route 3 (AM)	16	4
(PM)	16	0
Route 4 (AM)	16	3
(PM)	14	3
Route 5 (AM)	19	3
(PM)	19	2
Route 6 (AM)	17	2
(PM)	13	3
Route 7 (AM)	16	1
(PM)	13	5
Route 8 (AM)	22	1
(PM)	14	5
Route 9 (AM)	17	7
(PM)	10	6
Route 10 (AM)	12	3
(PM)	12	2
Route 11 (AM)	21	1
(PM)	22	1

Traffic Counts:

- Data Types: Traffic counts at all observation locations, traffic composition at selected observation locations
- Survey locations: defined in Table 2.5.
- Date: The schedule was determined based on clearances from the Ministry of Interior. The survey was conducted on Monday 05/07/2010, Tuesday 06/07/2010 and Wednesday 07/07/2010.
- Time: Morning peak (7:00 am to 11:00 am) and the afternoon peak period (3:00 pm – 7:00 pm).
- All traffic counts were conducted at normal days during which no local or regional special events were noted.

Table 2.5: Traffic Counts Detailed Observation locations

Code	Description	Date of survey
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	Tues - 06 July
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	Mon - 05 July
P3	Suez Desert Road / Between KM 4.5 and Ring Road	Tues - 06 July
P4	Ring Road / Carrefour El-Maadi	Wed - 07 July
P5	Ring Road / Above Cairo-Alex Desert Road	Wed - 07 July
P6	26th July / Between Railway and Ring Road	Tues - 06 July
P7	Al-Ahram Street / Electricity Station	Mon - 05 July
P8	Middle Abbas Bridge	Mon - 05 July
P9	6th October Bridge / Zamalek-Agouza	Wed - 07 July
P10	Ahmed Helmy Str./ Before Abou Wafya Bridge	Mon - 05 July
P11	Ramsis Str./Between Ghamra and Ramsis Srq	Mon - 05 July
P12	Lotfy El-Sayed/between Abaseya&Demerdash Metro stn	Mon - 05 July
P13	Salah Salem Str./Between Elfangary and Abbaseya	Wed - 07 July
P14	Kornish El-Nil /Between 15th May & El-Sahel Brdg	Tues - 06 July
P15	Gamal Abd El-Naser (El-Nile str)/Cornishe El- Agouza	Tues - 06 July

2.6 Peak Hours

According to the Public-Private Partnership Program for Cairo Urban Toll Expressway Network Development traffic count survey (May 2006), the morning peak (07:00 – 9:00) occurred in 29% of traffic count stations, followed by the afternoon peak (13:00 – 16:00), which accounts for 27%. Moreover, other peak periods exist during the day such as the evening peak (20:00 – 21:00). It is interesting to notice that even the period (10:00 – 12:00) was observed to have the peak traffic volume in some locations (e.g., 15th of May Bridge).

The table below classifies peak periods for Cairo based on the results of Public-Private Partnership Program for Cairo Urban Toll Expressway Network Development study (2006):

Table 2.6 Traffic peak periods in the Greater Cairo Metropolitan Area

Peak	Period	Percentage of occurrence in traffic count stations
Morning	07:00-09:00	29.1 %*
	10:00-12:00	21.8 %
Afternoon	13:00-16:00	27.3 %
	17:00-18:00	9.1 %
Evening	20:00-21:00	12.7 %
Total		100 %

*e.g. the morning peak (07:00 – 9:00) occurred in 29.1% of traffic count stations

Given table 2.6, hours between [9:01-9:59], [12:01-12:59], [16:01-16:59], [18:01- 19:59], and [21:01-6:59] won't be considered as peak hours.

2.7 Traffic Composition in the Corridors

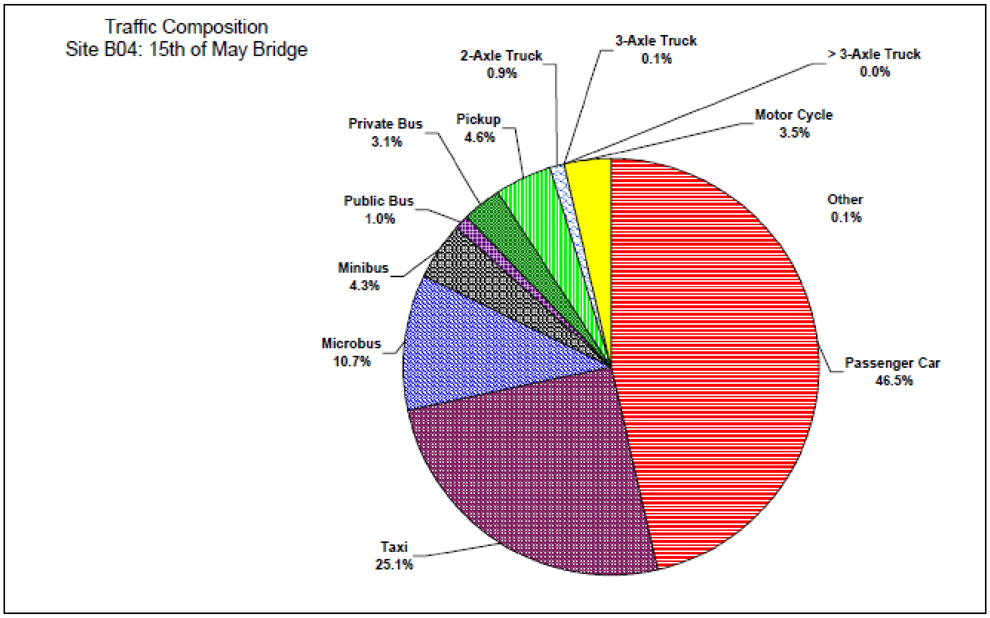
Traffic composition is one of the essential characteristics of traffic flow, especially when the need arises to convert the traffic flow from vehicles into passenger car unit (PCU). Fortunately, the manual classified count (MCC) procedure, which was followed in this study, provides the opportunity to identify the share of each vehicle type within the traffic flow per site per direction per hour. The traffic composition consists of twelve vehicle types which are listed below:

- Passenger Car
- Taxi (metered taxi and intercity taxi).
- Microbuses (shared taxi)
- Public Transport minibus
- Public Transport bus
- Private Bus (school bus, company bus, tourist bus, etc.)
- Light commodity vehicle (pickup and vans)
- 2-Axles truck
- 3-Axles truck
- Heavy truck (more than 3-axle, trailer, semi-trailer).
- 2-wheeler (bicycle and motorcycle)
- Others (military, police, ambulance, etc.)

2.8 Modal Split in the Corridors

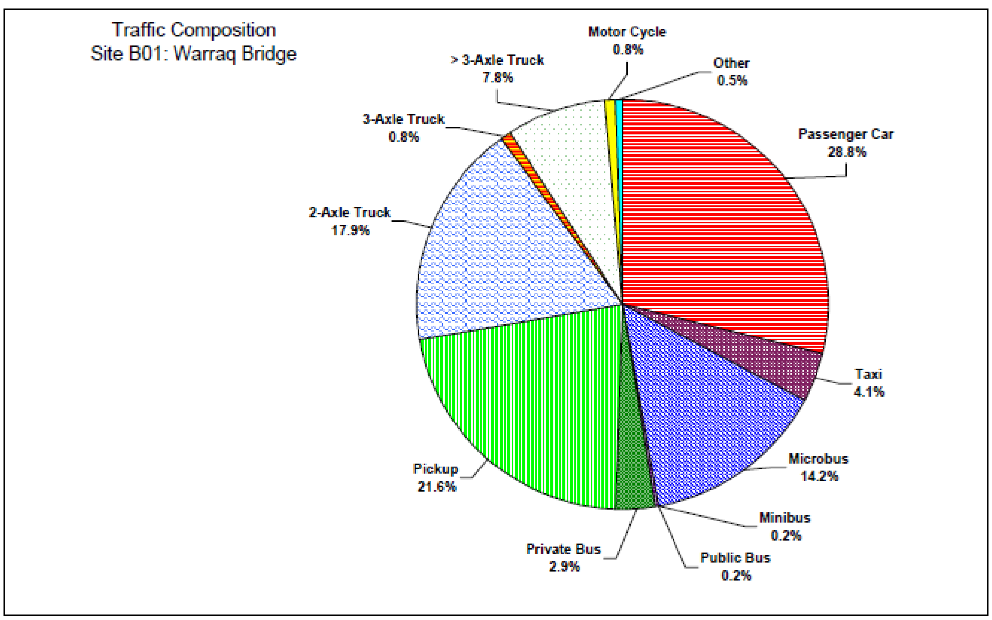
Based on the results of Public-Private Partnership Program For Cairo Urban Toll Expressway Network Development study (2006) and given the diverse mode composition in all eleven corridors, the following pie charts illustrate the modal split for each studied corridor:

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



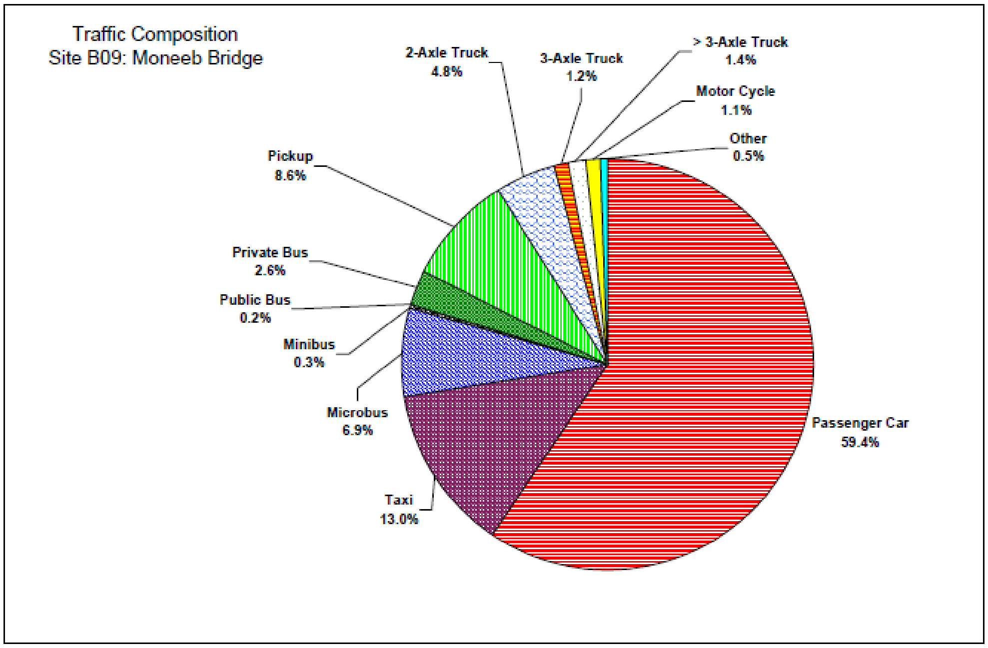
The share of passenger car is the highest in corridor 1.

Corridor 2: Ring Road (Northern segment)



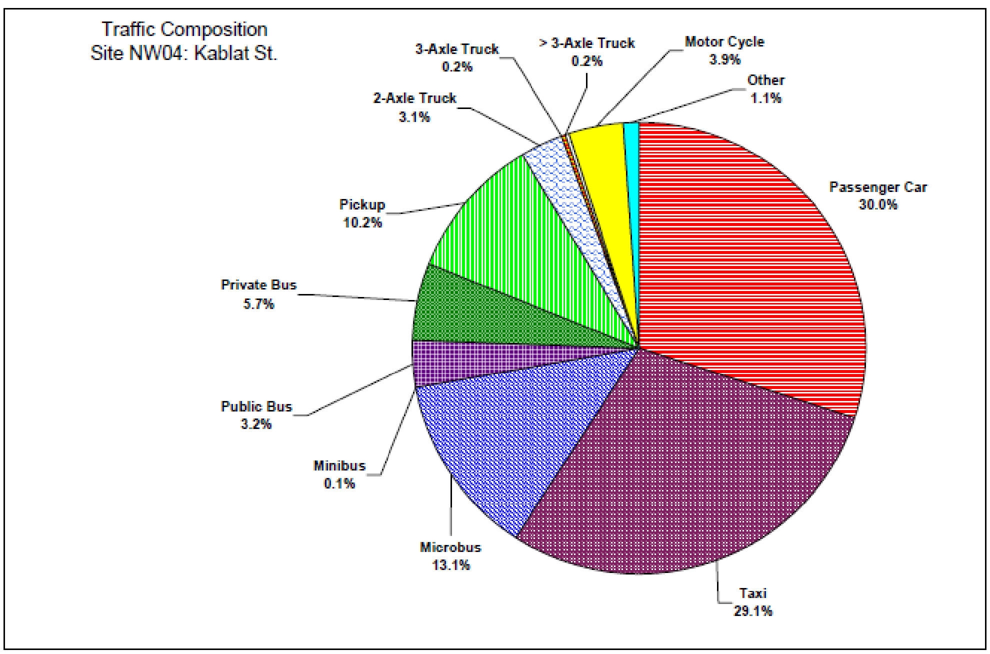
The share of public transportation is fairly low in corridor 2.

Corridor 3: Ring Road (Southern Segment):



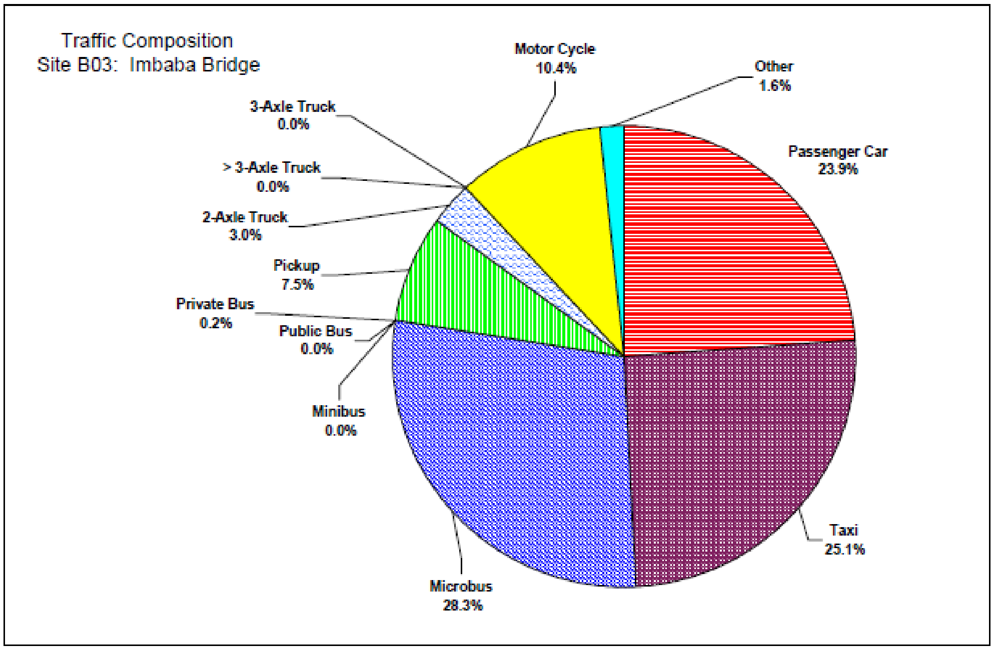
The share of passenger car is the highest and the share of public transportation is low in corridor 3.

Corridor 4: El Corniche-East/El-Matareya Square



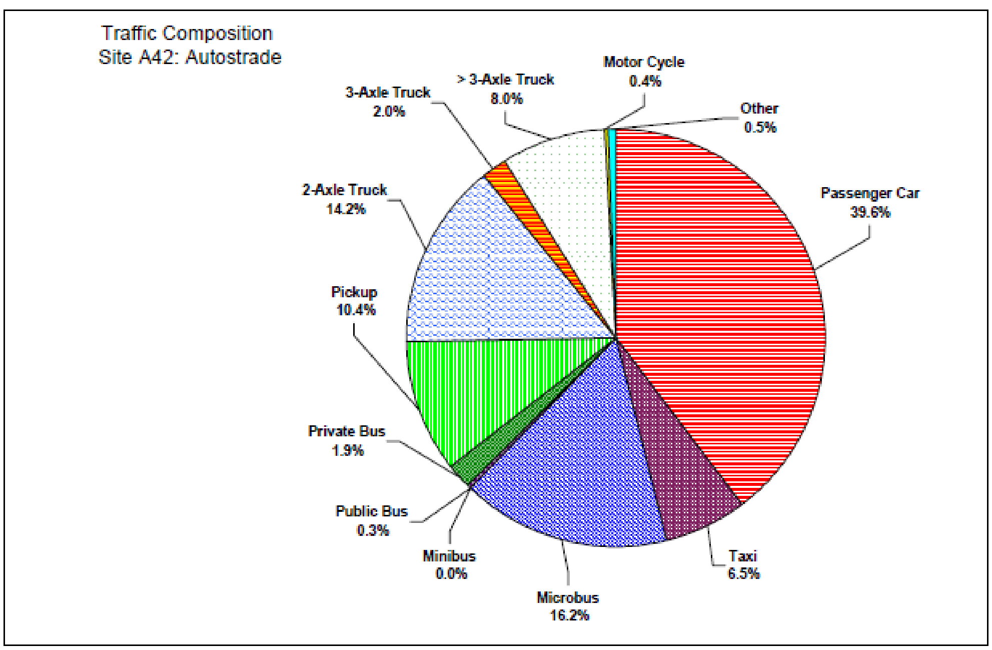
The share of passenger car and taxi is almost the same in corridor 4.

Corridor 5: Rod El Farag/El-Remaya:



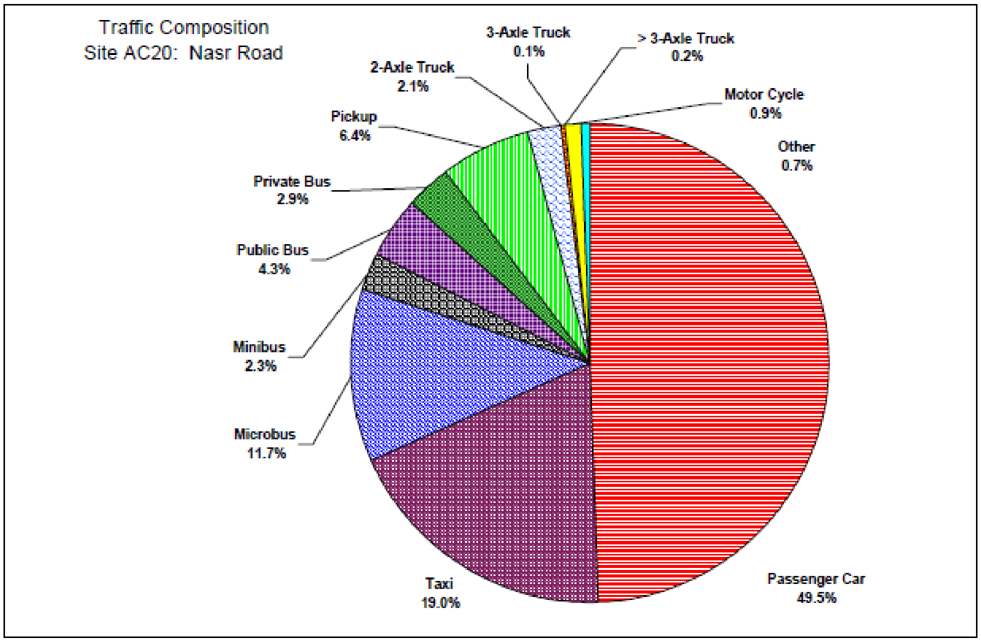
The share of microbus (Shared taxi) in quite high in corridor 5. The share of bus services is almost zero in this corridor.

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



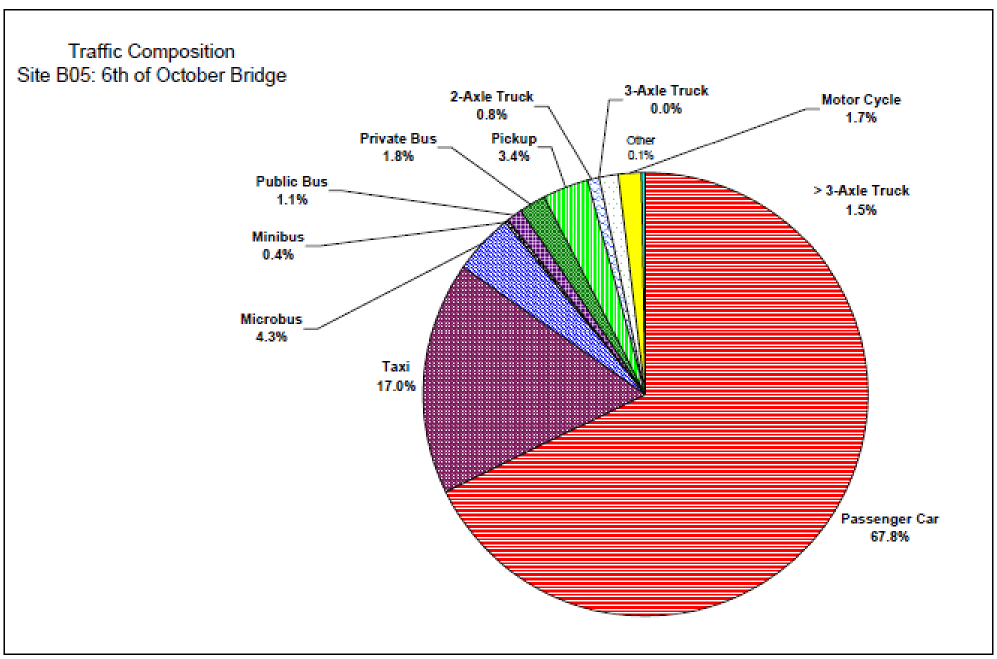
The share of passenger car is the highest in corridor 6.

Corridor 7: Autostrad/Giza Square:



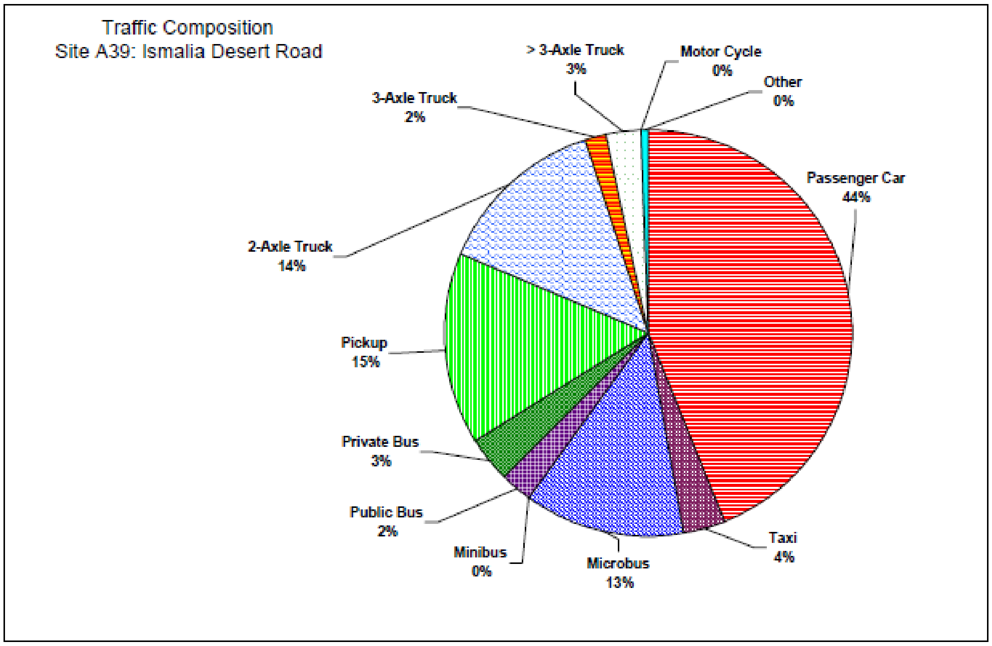
The share of passenger car is the highest in corridor 7.

Corridor 8: El-Orouba/6th of October Bridge



The share of passenger car is the highest in corridor 8. The share of freight transport is negligible in corridor 8. The roads between Cairo and 6th of October City and certainly the end of the Ring Road and 26th of July Corridor have small trucks in substantial volumes. These roads are used to transport industrial and agricultural products to the factories and the wholesale market respectively and later on to Cairo and other destinations for final consumption.

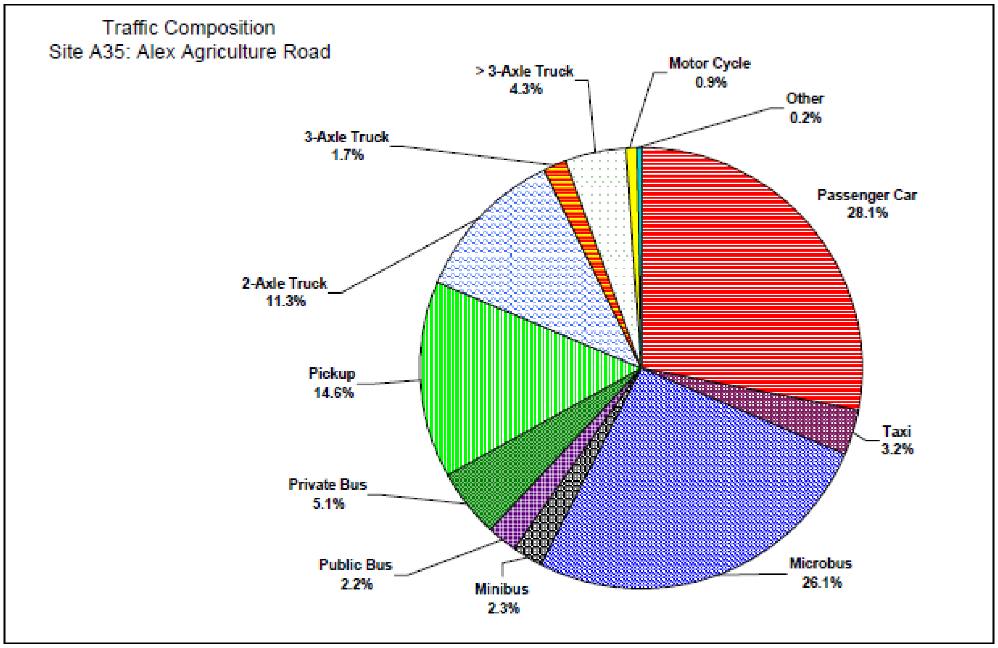
Corridor 9: Cairo-Ismaillia/El-Qubba:



The share of passenger car is the highest in corridor 9. Ismailya Desert Road is characterized by dense truck traffic (over 10,000 PCU per day per direction) that serves four specific areas, namely Oboor City (in particular the wholesale market), 10th of Ramadan City, Ismailya and the Ports of Port Said and Damietta. The effect of truck traffic on the extension inside the Ring Road remains limited, with only Gesr El Suez (extension of the Ismailya Desert road) showing a density above 5,000 PCU per day per direction.

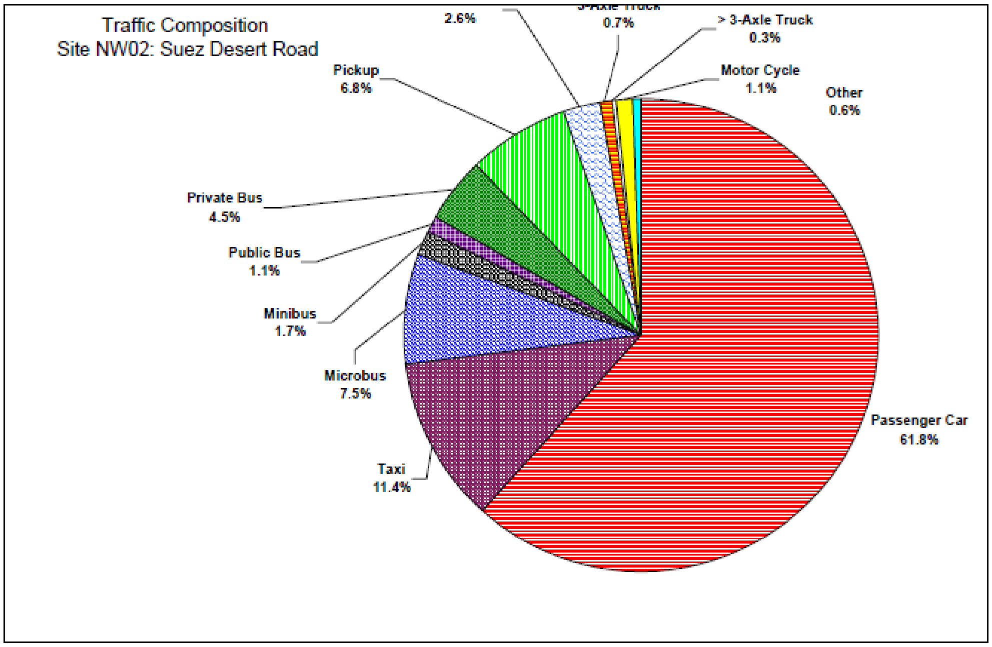
Truck density on Ismailya Agriculture Road is below 5,000 PCU per day per direction. Trucks on this road do not cause problems, not even at its extension inside the Ring Road. The effects of heavy trucks can therefore be ignored.

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



The share of passenger car and Microbus (Shared Taxi) is the same in corridor 10. The Alexandria Agricultural Road is at present the most important truck route. Pick Up trucks and two-axle trucks represent 79% of total trucks while the largest truck type is responsible for only 19% of total volume, going to / coming from Alexandria port and serving the factories (car assembly, glass, cement, etc…) that are located in that Lower Delta region. Up north on Alexandria Agricultural Road, there is a clear separation between heavy and light trucks. While light trucks continue on Alexandria Agricultural Road, heavy trucks predominantly divert to the west towards the road to Belqas, which over its entire length has a share of heavy trucks above 50%. This could indicate that this road is frequently used by heavy trucks as alternative for Alexandria Agricultural Road. But the total number of trucks remains low on this alternative road where capacity is sufficient to accommodate traffic.

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



The share of passenger car is the highest in corridor 11. The share of Trucks is negligible in corridor 11.

Truck traffic on this corridor is on average below 10,000 PCU per day per direction but is dominated by heavy trucks, predominantly entering the Ring Road via Suez Desert Road. In addition to trucks coming from Suez port, trucks serving the large number of cement factories along this road generate the high volume of heavy trucks.
Contrary to Suez Desert Road, Qatameya Road has a share of heavy trucks that remains below 50% while the density is also between 5,000 and 10,000 PCU per day per direction.

The high number of heavy trucks accessing the Ring Road via Suez Desert Road joins traffic of the northern section of the Ring Road, making the stretch between Ismailya Desert Road and Suez Desert Road in terms of heavy trucks the most dense road section of the entire road network. That particular section has a density of over 10,000 PCU per day per direction, of which more than 50% are heavy trucks.

Concluding figures above, in most of corridors the share of passenger cars is the highest (Table 2.6 summarizes the figures in the eleven corridors). The average share of passenger cars is approximately estimated 42% for the aforementioned corridors. Moreover, corridors in which the share of public buses is low are usually served by taxies and share taxies instead. The average share of taxies and share taxies is approximately 28% overall. Finally, in corridors 2 (ring road), 9 (Cairo-Ismaillia Desert Road/El-Qubba) and 10 (Cario-Alex Agr Road El-Qubba) the modal share of freight and public transportation (Diesel cars) are higher than that of other corridors. The modal share of freight and public transportation for corridors 2, 9, and 10 is around 60%, 47%, and 53.5% respectively.

Table 2.7: Modal split summary in the eleven corridors (by percentage)

Corridor	Car %	Taxi %	Microbus %	Minibus %	Public bus %	Private bus %	Pickup %	> 3- Axle Truck %	2 Axle Truck %	3 Axle Truck %	Motorcycle %	Other %
1	46.5	25.1	10.2	4.3	1.0	3.1	4.6	0.9	0.1	0.0	3.5	0.1
2	28.8	4.1	14.2	0.2	0.2	2.9	26.1	17.9	0.8	7.8	0.8	0.5
3	59.4	13.0	6.9	0.3	0.2	2.6	8.6	4.8	1.2	1.4	1.1	0.5
4	30.0	29.1	13.1	0.1	3.2	5.7	10.2	3.1	0.2	0.2	3.9	1.1
5	23.9	25.1	28.3	0.0	0.0	0.2	7.5	3.0	0.0	0.0	10.4	1.6
6	39.6	6.5	16.2	0.0	0.3	1.9	10.4	14.2	2.0	8.0	0.4	0.5
7	49.5	19.0	11.7	2.3	4.3	2.9	6.4	2.1	0.1	0.2	0.9	0.7
8	67.8	17.0	4.3	0.4	1.1	1.8	3.4	1.5	0.8	0.0	1.7	0.1
9	44.0	4.0	13.0	0.0	2.0	3.0	15.0	14.0	2.0	3.0	0.0	0.0
10	28.1	3.2	26.1	2.3	2.2	5.1	14.6	11.3	1.7	4.3	0.9	0.2
11	61.8	11.4	7.5	1.7	1.1	4.5	6.8	2.6	0.7	0.3	1.1	0.6

Table 2.8 summarizes the percentage of traffic volumes during peak period. As the table shows, the percentages range from 46% in corridor 4 to 72% in corridors 1.

Table 2.8: The percentage of traffic volumes in peak hours

Corridor	Count Site	Direction	% of traffic volumes in the peak period
1	15th of May Bridge	Cairo	68%
		Giza	68%
2	Warraq Bridge	Qalyobeya	55%
		Giza	50%
3	Moneeb Bridge	Cairo	60%
		Giza	60%
4	Kablat St.	Mataria Sq.	50%
		Ismailia Canal	46%
5	Imbaba Bridge	Cairo	50%
		Giza	50%
6	Autostrade	Cairo Airport	50%
		Helwan	50%
7	Nasr Road	Cairo Airport	69%
		Helwan	65%
8	6th of October Bridge	Cairo	60%
		Giza	65%
9	Ismailia Desert Road	Ismailia	51%
		Cairo	58%
10	Alex. Agriculture Road	Alexandria	72%
		Cairo	56%
11	Suez Desert Road	Suez	47%
		Cairo	51%

2.9 Daily Traffic Volume

Table 2.8 summarizes the traffic counts including 16 hours, 24 hours, and 24 hours PCU for the eleven corridors in 2005 according to the JICA study of (Cairo Urban Toll Expressway Network Development) conducted traffic surveys at 28 locations within the GCR. Traffic counts as well as classification data were collected at the 28 locations, for both travel directions, for 16 hrs. The JICA counts have been matched with the defined corridors by the consortium.

Table 2.9 summarizes the estimated traffic counts for 2010 using growth rate factors for the period 2005-2010 as provided in the JICA report. For the sake of comparison among different traffic volumes with different traffic compositions, it is preferable to convert the unit of traffic volume from vehicle to passenger car unit (PCU) by applying passenger car equivalencies. The gross-up factors of expanding the traffic volume from 16-hour count into 24-hour volume and passenger car equivalencies (PCE) are given in table 2.5 and are derived from the JICA study of (Cairo Urban Toll Expressway Network Development). These factors were applied to the total observed traffic counts in 2005 to estimate the traffic volume expressed in PCU per day.

Table 2.9: Traffic counts in the eleven corridors (2005)

Corridor	Count Site	Direction	16 Hour Count (2005)	Total	24- Hour vehicles (2005)	24-Hour PCU (2005)	ADT (2005)	Growth rate PCU (%)
1	15th of May Bridge	Cairo	47456	118548	141847	159359	63793	2.6
		Giza	71092				95566	
2	Warraq Bridge	Qalyobeya	24820	45992	56161	83198	44899	5.5
		Giza	21172				38299	
3	Moneeb Bridge	Cairo	43707	104066	125381	145532	61122	16.9
		Giza	60359				84410	
4	Kablat St.	Mataria Sq.	12214	22565	26991	31791	17208	2.4
		Ismailia Canal	10351				14583	
5	Imbaba Bridge	Cairo	8500	21574	25898	28619	11276	3.9
		Giza	13074				17343	
6	Autostrade	Cairo Airport	14445	32579	39984	58716	26034	2.9
		Helwan	18134				32682	
7	Nasr Road	Cairo Airport	92674	169714	202874	241226	131724	3.1
		Helwan	77040				109502	
8	6th of October Bridge	Cairo	144986	259798	311933	329331	183790	6.0
		Giza	114812				145541	
9	Ismailia Desert Road	Ismailia	38960	79534	95907	130693	64020	1.0
		Cairo	40574				66673	
10	Alex. Agriculture Road	Alexandria	43959	89080	107287	157960	77950	0.6
		Cairo	45121				80010	
11	Suez Desert Road	Suez	27525	51872	62032	71264	37815	2.4
		Cairo	24347				33449	

Table 2.10: Traffic counts in the eleven corridors (estimated for 2010)

Corridor	Count Site	Direction	24- Hour vehicles (NON PCU) (2010)	ADT (PCU) (2010)	Peak Periods ADT (PCU) 2010 (total peak hours)	Peak Periods ADT (NON PCU) 2010 (total peak hours)
1	15th of May Bridge	Cairo	64559	72529	49342	43920
		Giza	96713	108653	73884	65765
2	Warraq Bridge	Qalyobeya	39611	58681	32558	21978
		Giza	33789	50056	24822	16755
3	Moneeb Bridge	Cairo	114960	133436	80062	68976
		Giza	158759	184274	110564	95255
4	Kablat St.	Mataria Sq.	16449	19374	9723	8255
		Ismailia Canal	13940	16419	7539	6401
5	Imbaba Bridge	Cairo	12355	13653	6826	6177
		Giza	19003	21000	10500	9501
6	Autostrade	Cairo Airport	20452	30034	14872	10128
		Helwan	25676	37704	18852	12838
7	Nasr Road	Cairo Airport	129051	153447	105830	89004
		Helwan	107280	127560	82498	69382
8	6th of October Bridge	Cairo	232960	245953	148388	140548
		Giza	184477	194766	127295	120570
9	Ismailia Desert Road	Ismailia	49377	67286	34382	25231
		Cairo	51422	70074	40556	29762
10	Alex. Agriculture Road	Alexandria	54551	80316	57964	39369
		Cairo	55993	82440	46325	31464
11	Suez Desert Road	Suez	37060	42576	20139	17530
		Cairo	32781	37660	19134	16655

2.10 Traffic Survey Results

Summary sheets for the non-classified and classified vehicle counts conducted on the 5th, 6th and 7th of July 2010 are included in Annex 6 and Annex 7 respectively. Counts were taken at 15 minute intervals during the following times and periods:

- 7:00 to 11:00 - AM
- 3:00 to 7:00 - PM

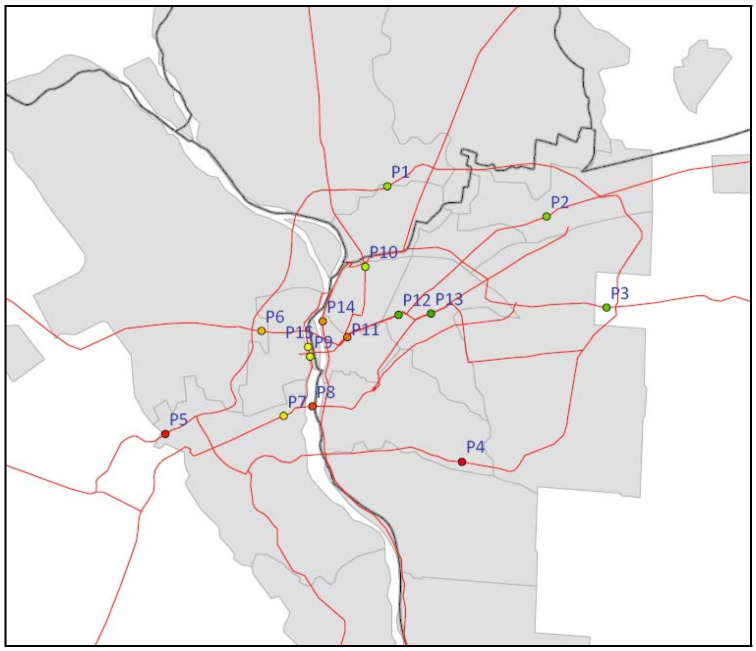


Figure 2.12: Traffic counts observation locations

Tables 2.9 and 2.10 indicate the <u>average traffic volumes</u> recorded on each location in the AM and PM periods respectively, while Figures 2.13 through 2.27 indicate the traffic volumes recorded for each 15 minute interval during the AM and PM survey periods.

It appears that the highest peak during the morning period occurs from 8 to 9 at most traffic counts locations. On the other hand, volumes are comparable in the different afternoon hours and there does not seem to be any specific peaking pattern.

Table 2.11: Traffic Survey Results- AM

Traffic Count Number & Road Name		Traffic Count Direction 1 (veh/hr)	Traffic Count Direction 2 (veh/hr)
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	3299	3212
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	5708	2766
P3	Suez Desert Road / Between KM 4.5 and Ring Road	3051	1890
P4	Ring Road / Carfour Al Maadi	6969	6716
P5	Ring Road / Above Cairo-Alex Desert Road	3418	2981
P6	26th July / Between Railway and Ring Road	4389	2398
P7	Al-Ahram Street / Electricity Station	2242	2813
P8	Middle of Abbas Bridge	1512	2022
P9	6 October Bridge between Zamalk and Agozah	7400	7154
P10	Ahmed Helmy Str./ Before Abo Wafya Bridge	651	497
P11	Ramses St. between Ghmara and Ahmed Said St. (One Way to Abasia)	4244	
P12	Lotifi Al Said St. between Abasia and Ghamrah (One Way to Ramses Square)	4093	
P13	Salah Salem Str./Between Elfangary and Abbasey	3873	3600
P14	Cornish El-Nil /Between 15th May & El-Sahel Bridge	2535	4016
P15	Gamal Abd El-Naser (El-Nile St.)/Kornish al Agouza	4058	3000

Table 2.12: Traffic Survey Results-PM

Traffic Count Number & Road Name		Traffic Count Direction 1 (veh/hr)	Traffic Count Direction 2 (veh/hr)
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	2968	2985
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	5532	2821
P3	Suez Desert Road / Between KM 4.5 and Ring Road	3996	2009
P4	Ring Road / Carfour Al Maadi	7821	9605
P5	Ring Road / Above Cairo-Alex Desert Road	2765	2958
P6	26th July / Between Railway and Ring Road	3323	2499
P7	Al-Ahram Street / Electricity Station	3267	2318
P8	Middle of Abbas Bridge	1765	2464
P9	6 October Bridge between Zamalk and Agozah	5695	3197
P10	Ahmed Helmy Str./ Before Abo Wafya Bridge	606	726
P11	Ramses St. between Ghmara and Ahmed Said St. (One Way to Abasia)	4448	
P12	Lotifi Al Said St. between Abasia and Ghamrah (One Way to Ramses Square)	4111	
P13	Salah Salem Str./Between Elfangary and Abbasey	3773	5454
P14	Cornish El-Nil /Between 15th May & El-Sahel Bridge	3460	3249
P15	Gamal Abd El-Naser (El-Nile St.)/Kornish al Agouza	3513	4192

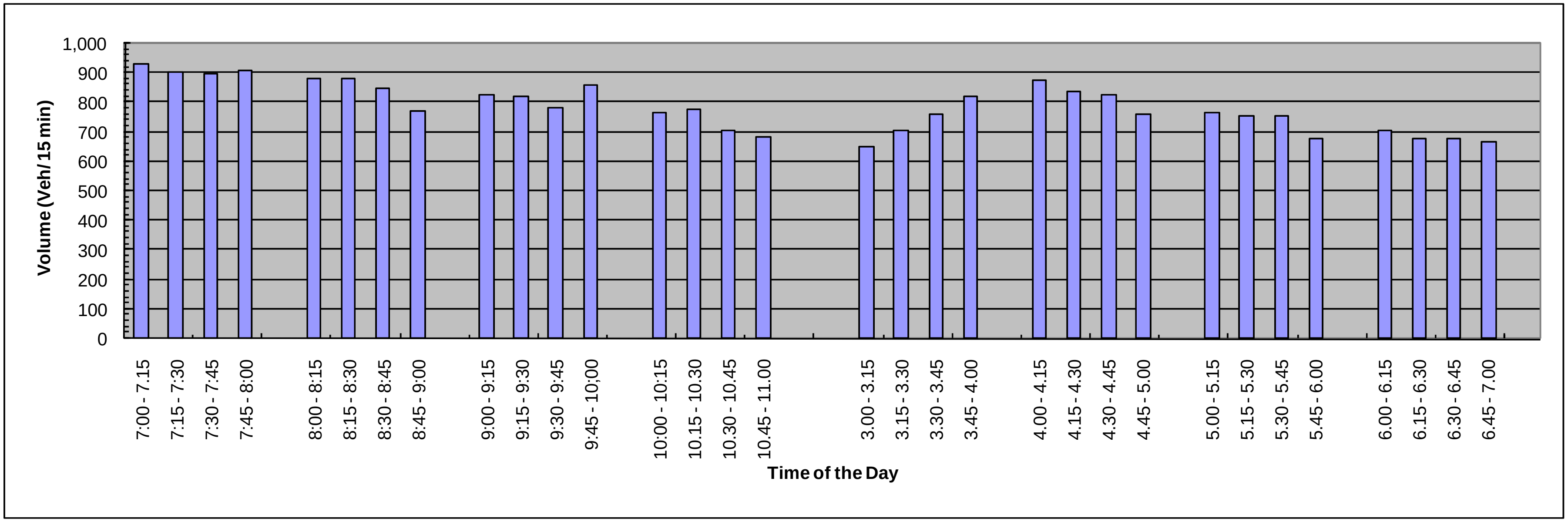


Figure 2.13: P1 - Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd

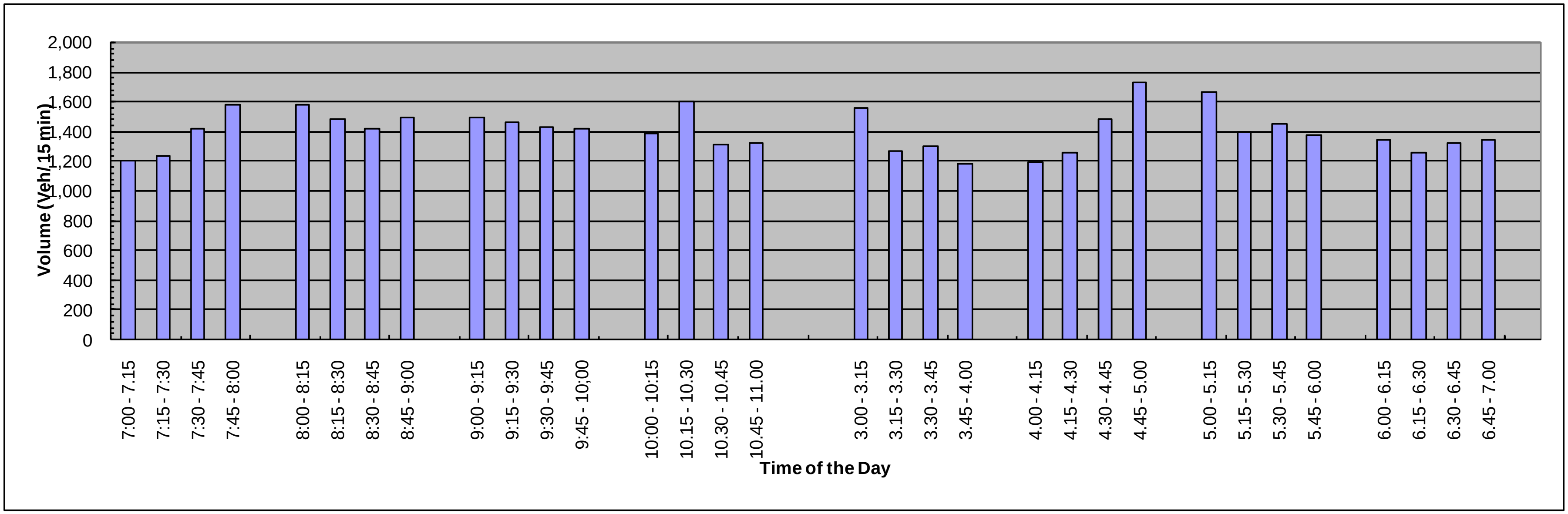


Figure 2.14: P2 – Gesr El-Suez/between Ring Road and Ainshams Street

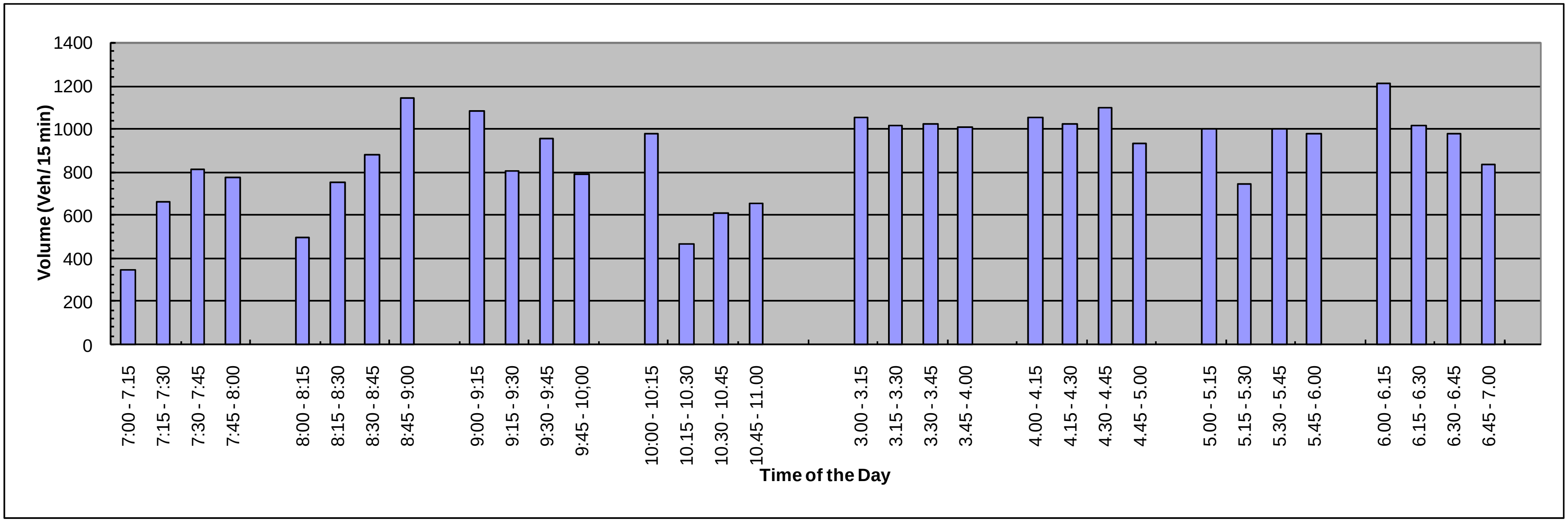


Figure 2.15: P3 – Suez Desert Road / Between KM 4.5 and Ring

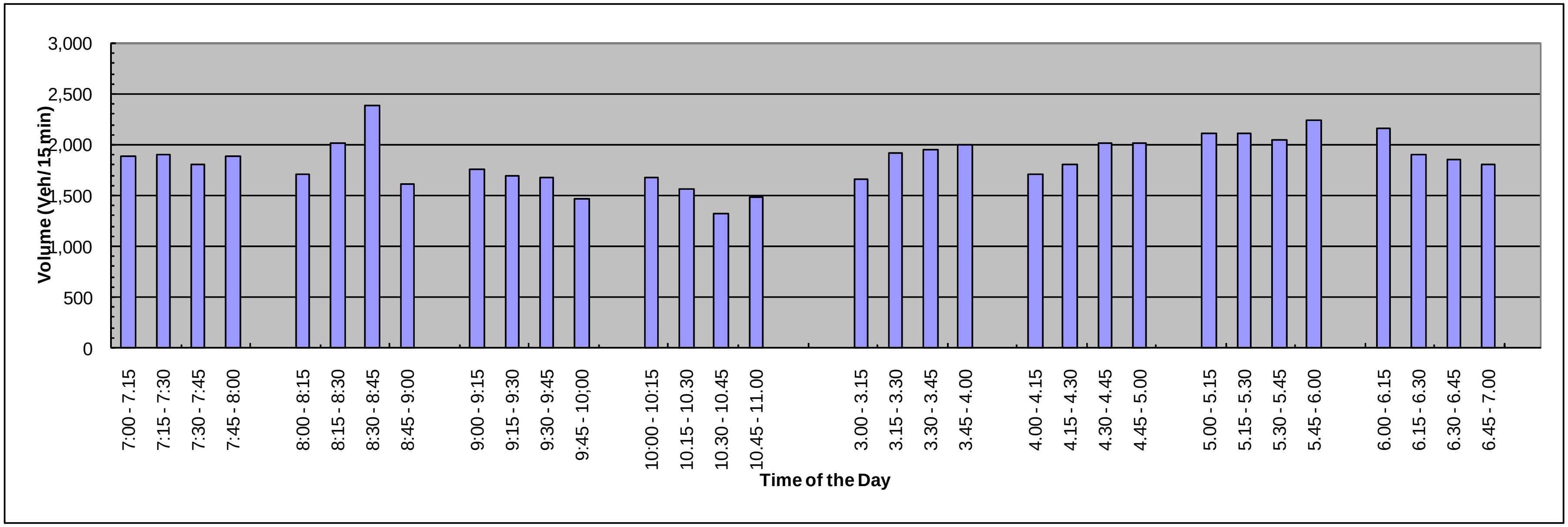


Figure 2.16: P4 – Suez Desert Road / Between KM 4.5 and Ring Road

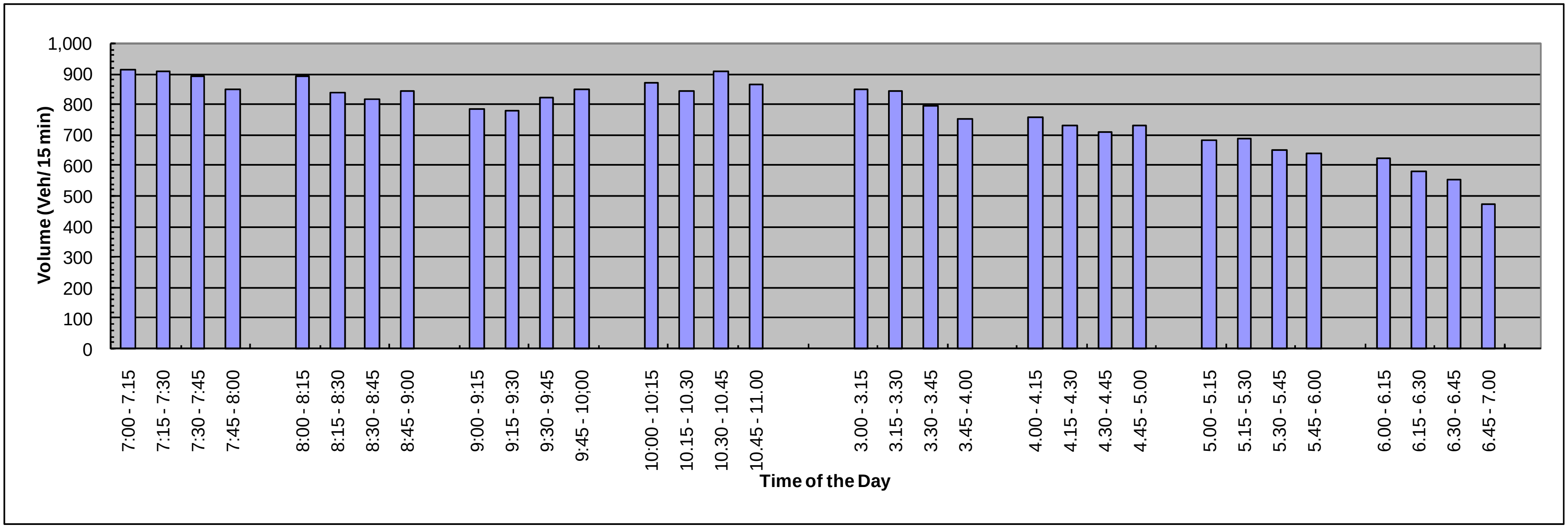


Figure 2.17: P5 – Ring Road / Above Cairo-Alex Desert Road

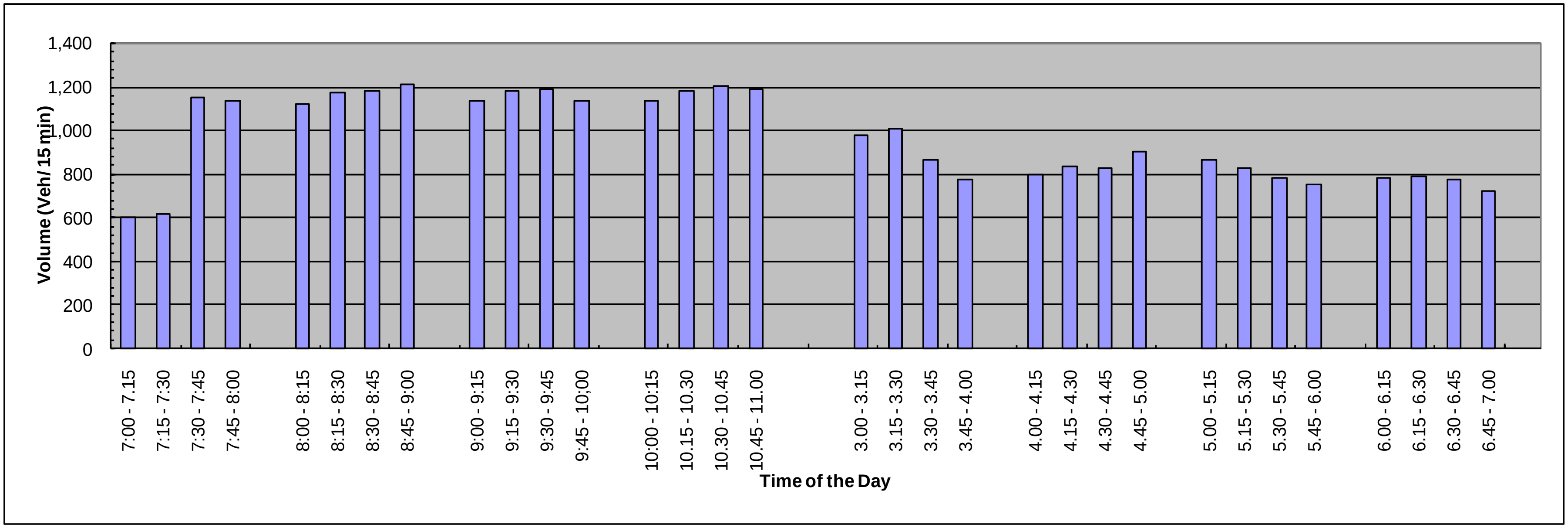


Figure 2.18: P6 – 26th July / Between Railway and Ring Road

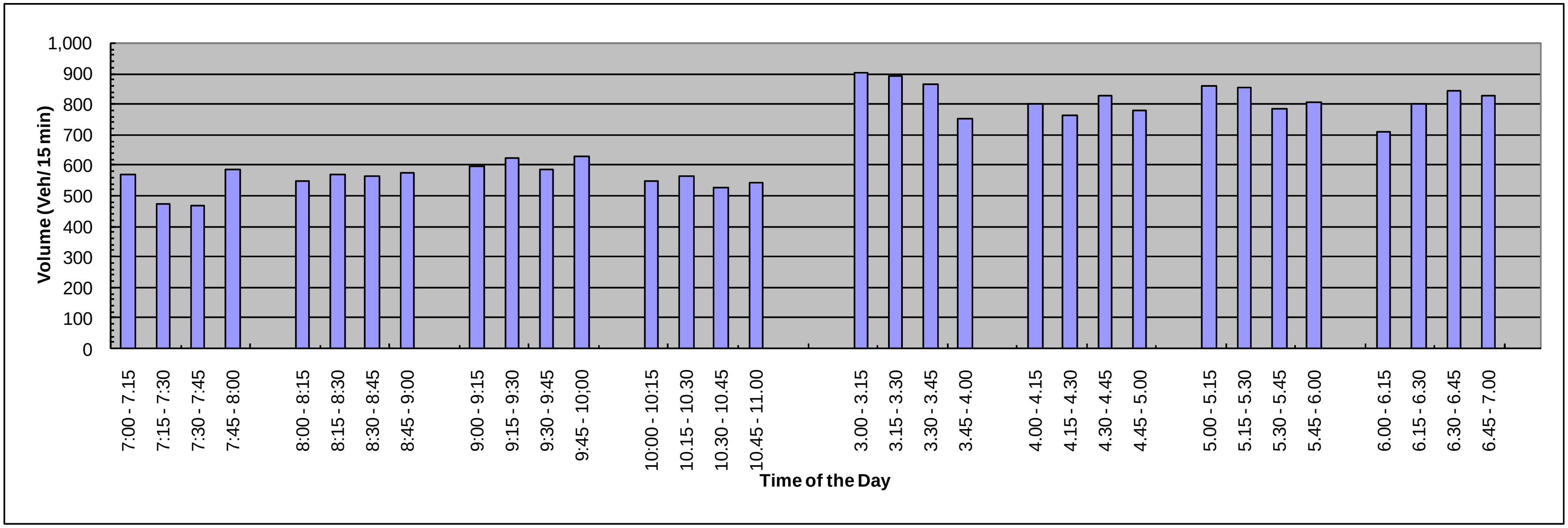


Figure 2.19: P7 – Al-Ahram Street / Electricity Station

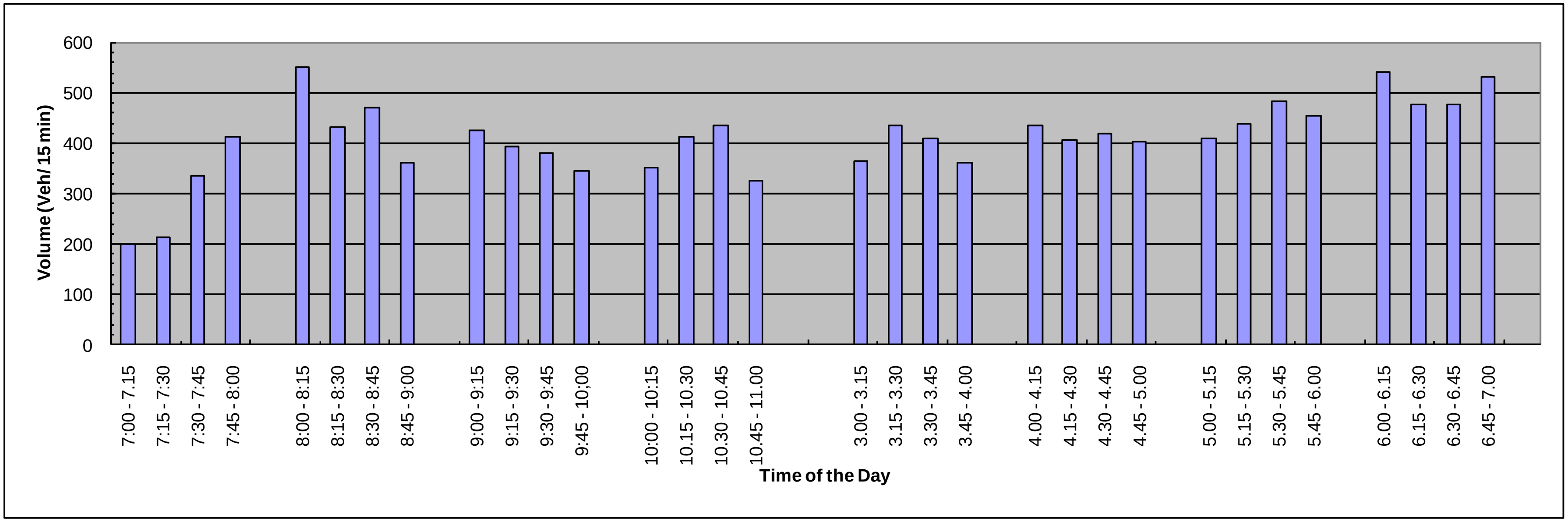


Figure 2.20: P8 - Middle of Abbas Bridge

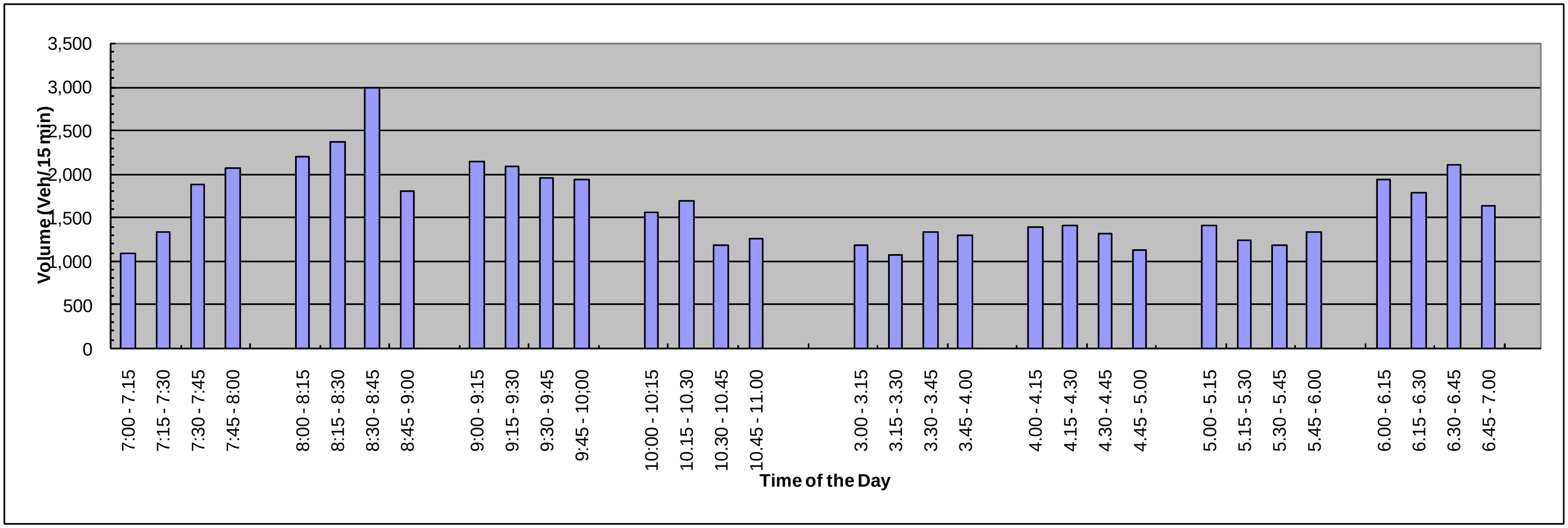


Figure 2.21: P9 - 6 October Bridge between Zamalk and Agozah

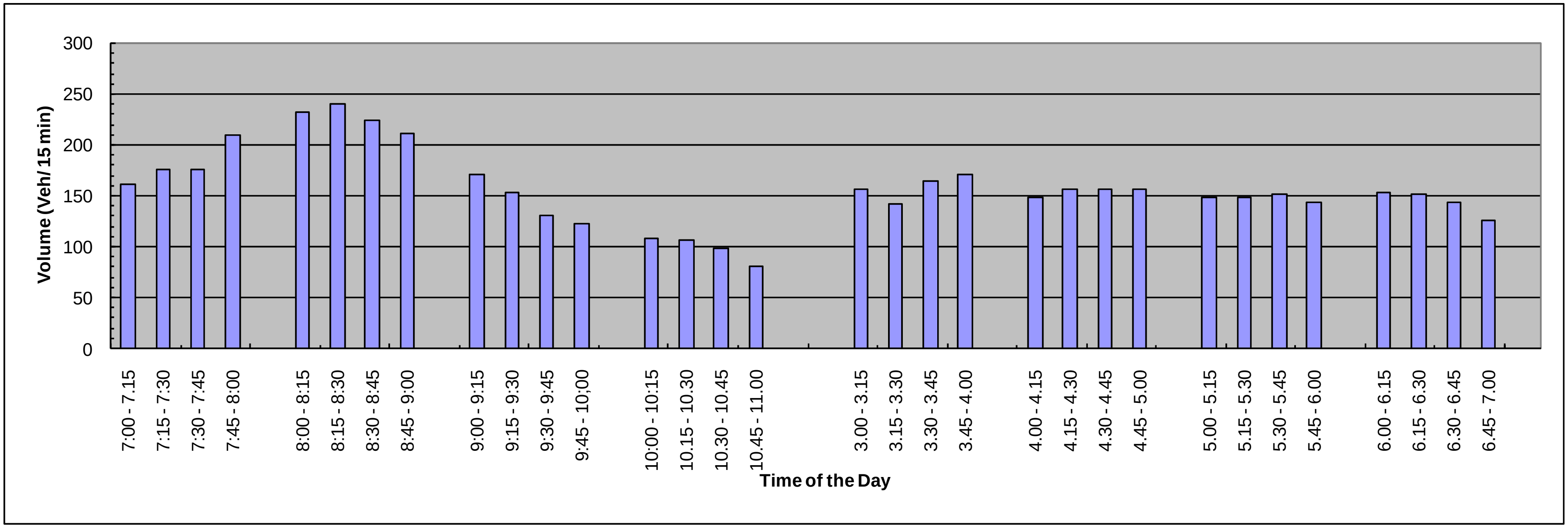


Figure 2.22: P10 - Ahmed Helmy Str./ Before Abou Wafya Bridge

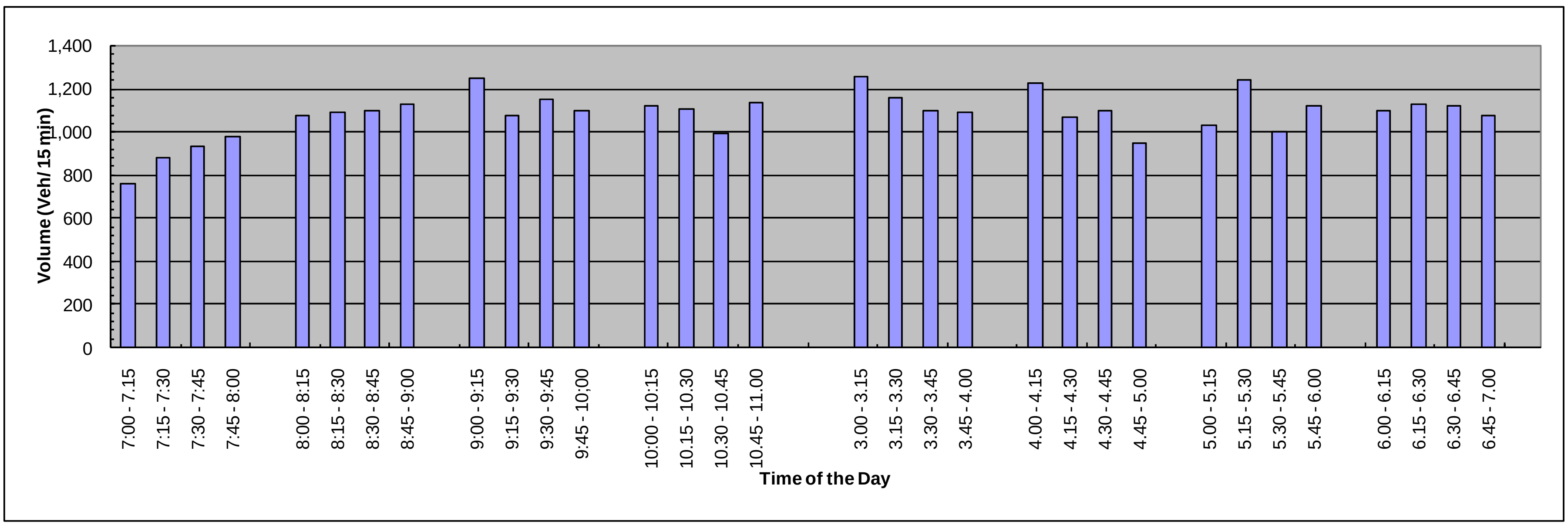


Figure 2.23: P11 – Ramses St. between Ghmara and Ahmed Said St. (One Way to Abasia)

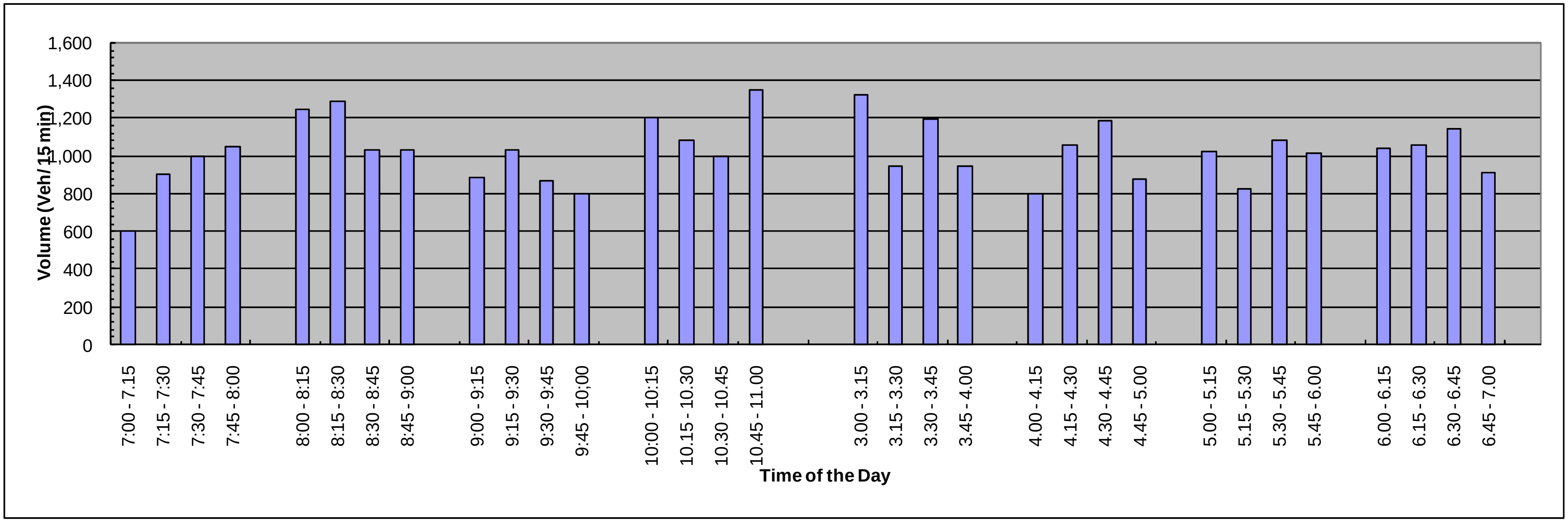


Figure 2.24: P12 - Lotifi Al Said St. between Abasia and Ghamrah (One Way to Ramses Square)

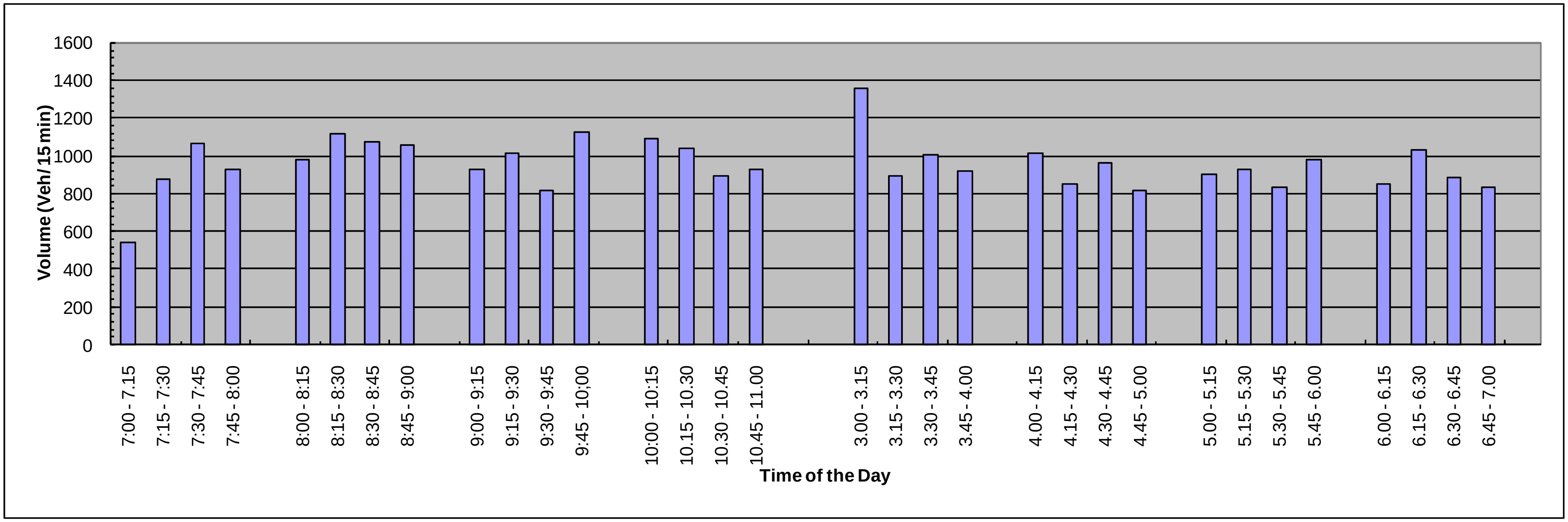


Figure 2.25: P13 - Salah Salem Str./Between Elfangary and Abbasey

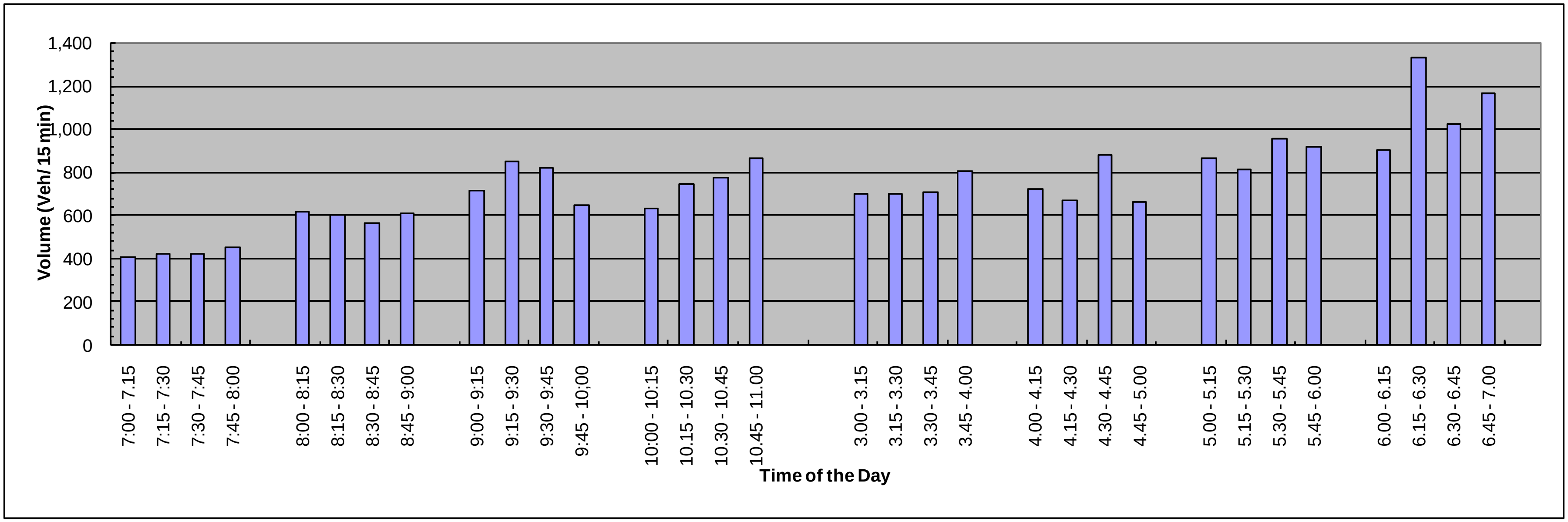


Figure 2.26: P14 – Kornish El-Nil /Between 15th May & El-Sahel Brdg

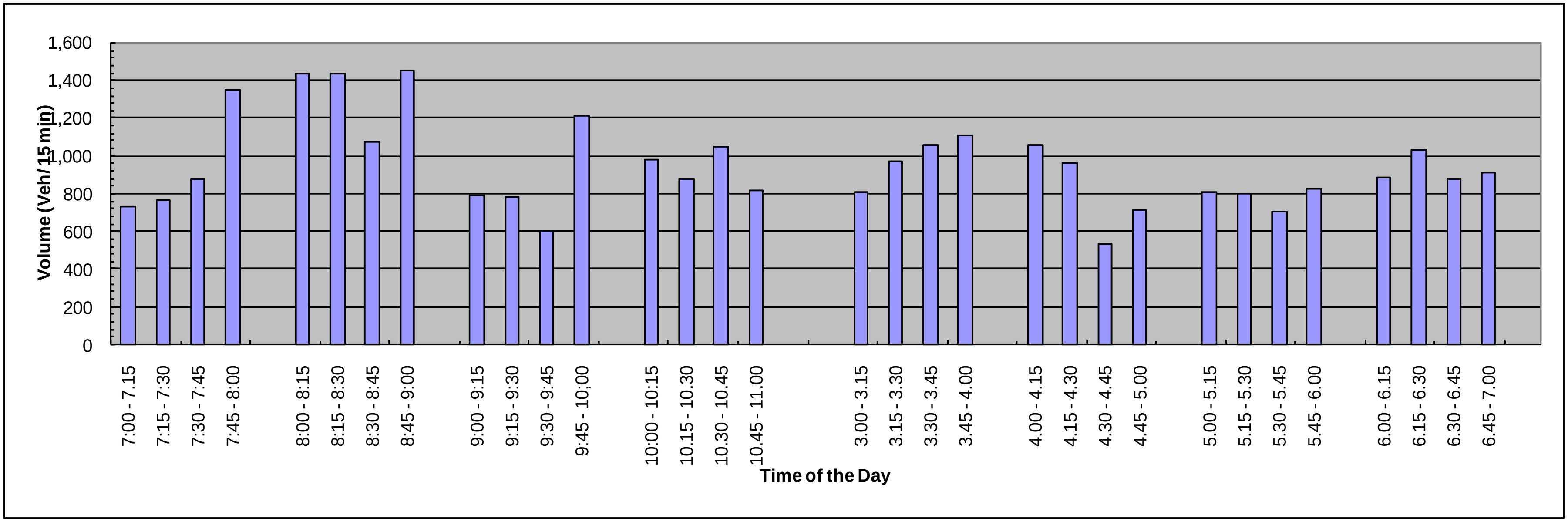
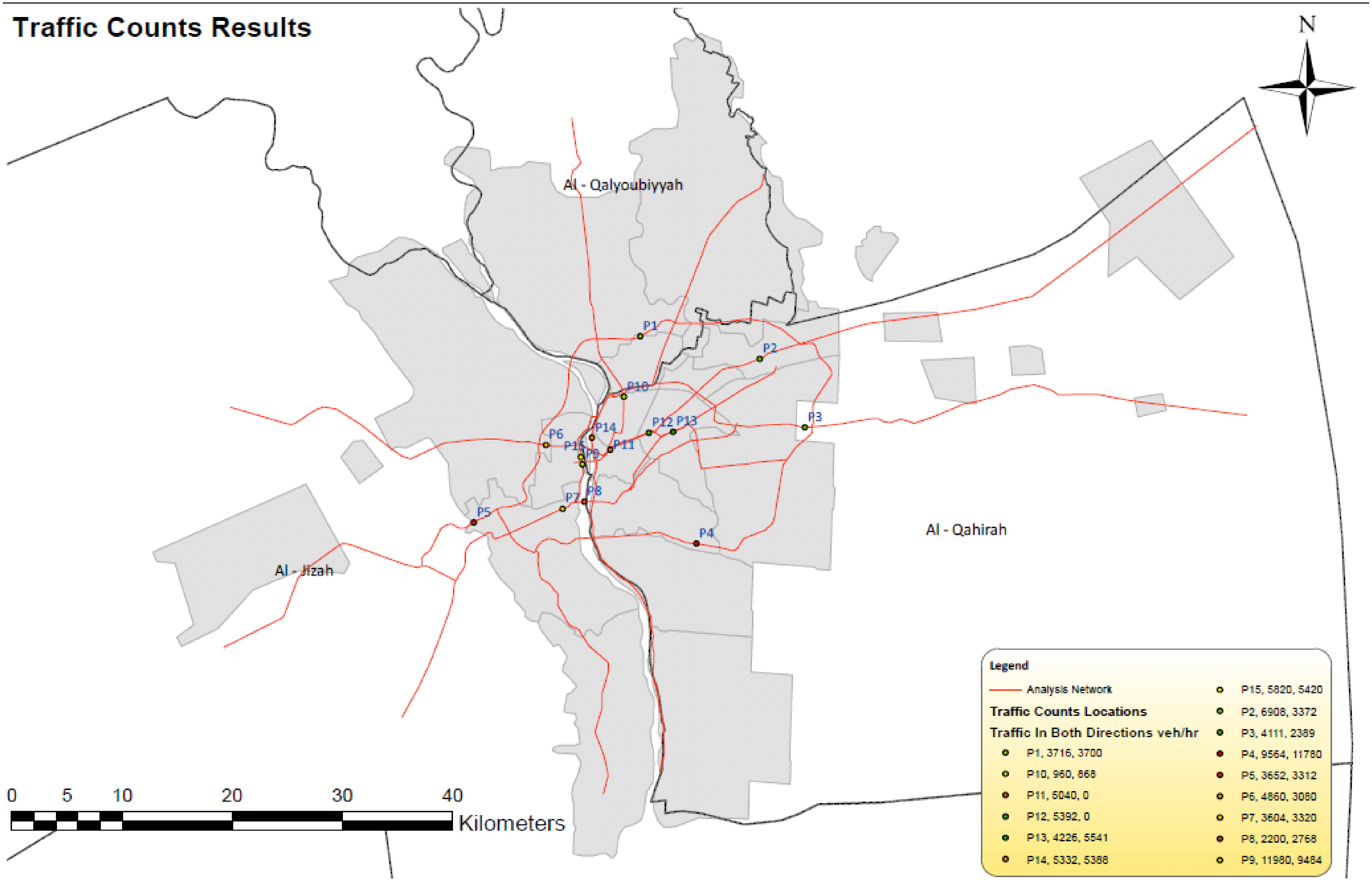


Figure 2.27: P15 – Gamal Abd El-Naser (El-Nile str)/Cornishe El- Agouza



Traffic Counts Results
N
Al - Qalyoubiyyah
Al - Qahirah
Al - Jizah
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
P15
0
5
10
20
30
40
Kilometers
Legend
Analysis Network
Traffic Counts Locations
Traffic In Both Directions veh/hr
P1, 3716, 3700
P10, 960, 868
P11, 5040, 0
P12, 5392, 0
P13, 4226, 5541
P14, 5332, 5388
P15, 5820, 5420
P2, 6908, 3372
P3, 4111, 2389
P4, 9564, 11780
P5, 3652, 3312
P6, 4860, 3080
P7, 3604, 3320
P8, 2200, 2768
P9, 11980, 9484

Classified vehicle counts were performed on locations of P3 (Suez Desert Road / Between KM 4.5 and Ring Road) and P13 (Salah Salem Str./Between Elfangary and Abbaseya), while vehicle counts on the remaining locations were non-classified.

Figure 2.28 below gives some indication about the modal split on the roads in Greater Cairo based on the classified vehicle counts performed on locations P3 and P13. It appears that road traffic is dominated by private cars with a share of 70%, followed by taxis with 15% share, then the microbuses and minibuses with 7%, while the big buses make up only 1% of the traffic. Small trucks and heavy trucks constitute 5% and 2% of road traffic respectively.

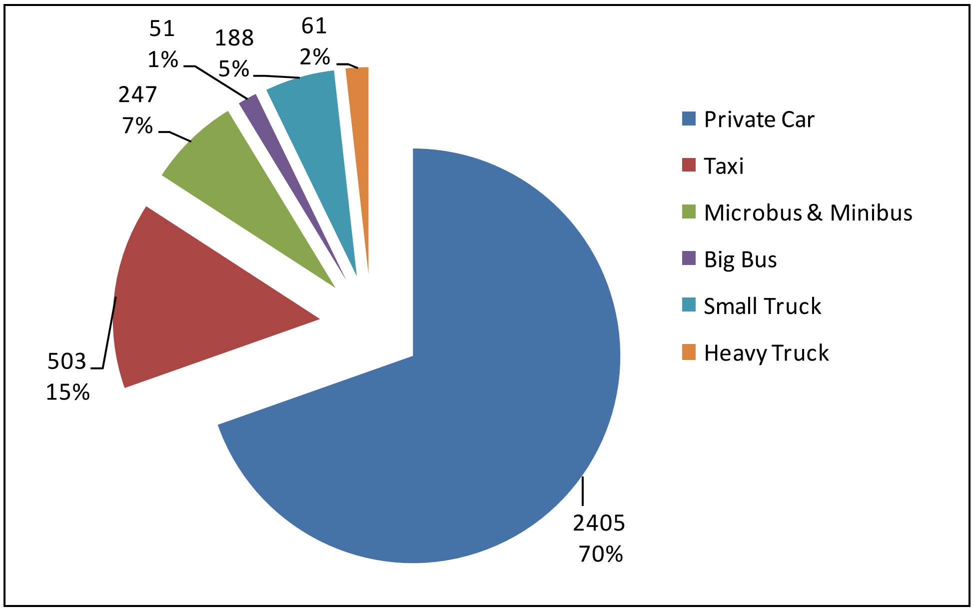


Figure 2.28: Modal Split according to the Classified Vehicle Counts

2.11 Trend Analysis of Travel Characteristics (2005-2010)

2.11.1 Changes in Modal Split

As mentioned in Section 2.10 of this Report classified vehicle counts at the following two locations have been carried out:

- P3: Suez Desert Road / Between KM 4.5 and Ring Road
- P13: Salah Salem Street/Between Elfangary and Abbasia

The resulting modal distributions are compared with those of the "Public-Private Partnership Program for Cairo Urban Toll Expressway Network Development" study at the same locations, based on a survey conducted in 2005.

For the sake of comparison, the compositions related to the following modes were considered equivalent:

2005	Private Car	Taxi	Microbus	Minibus	Public bus	Private bus	Pickup	2 Axle Truck	3 Axle Truck	> 3 Axle Truck
2010	Private Car	Taxi	Microbus and Minibus		Big Bus		Small Truck		Heavy Truck	

The modal splits at Suez Desert Road are illustrated in the following pie charts:

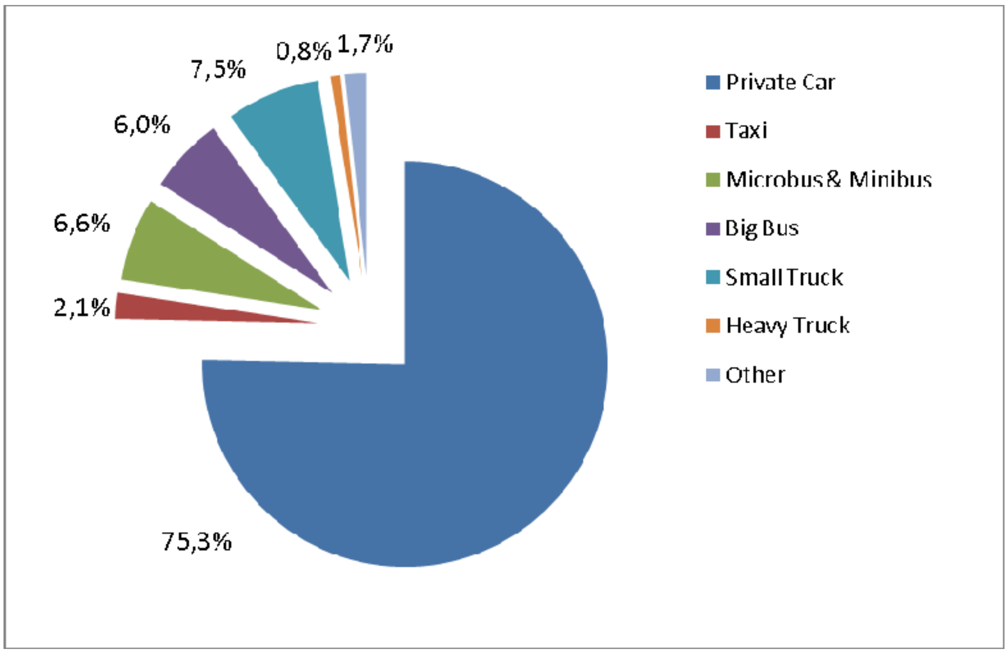


Figure 2.29: Modal Split according to 2005 Survey on Suez Desert Road

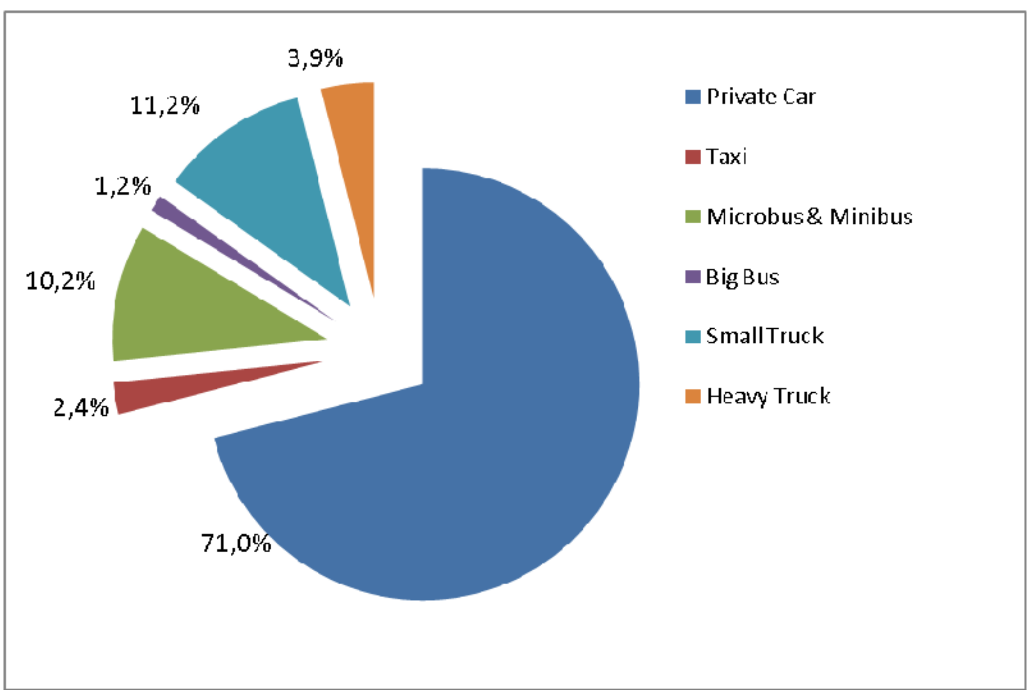


Figure 2.30: Modal Split according to 2010 Survey on Suez Desert Road (P3)

A moderate decrease is observed in the share of passenger cars (around 4%), which continues to be the highest among other transport modes share in 2010. The taxi use seems to have slightly increased by 0.3% while the use of microbuses and minibuses has increased by 3.6%. The big bus share however has decreased from 6% to 1.2%, which could be due to some shift to taxi, microbus and minibus throughout the past 5 years. The shares of small and heavy trucks have increased by 3.7% and 3.1% respectively.

The modal splits at Salah Salem Street are illustrated in the following pie charts:

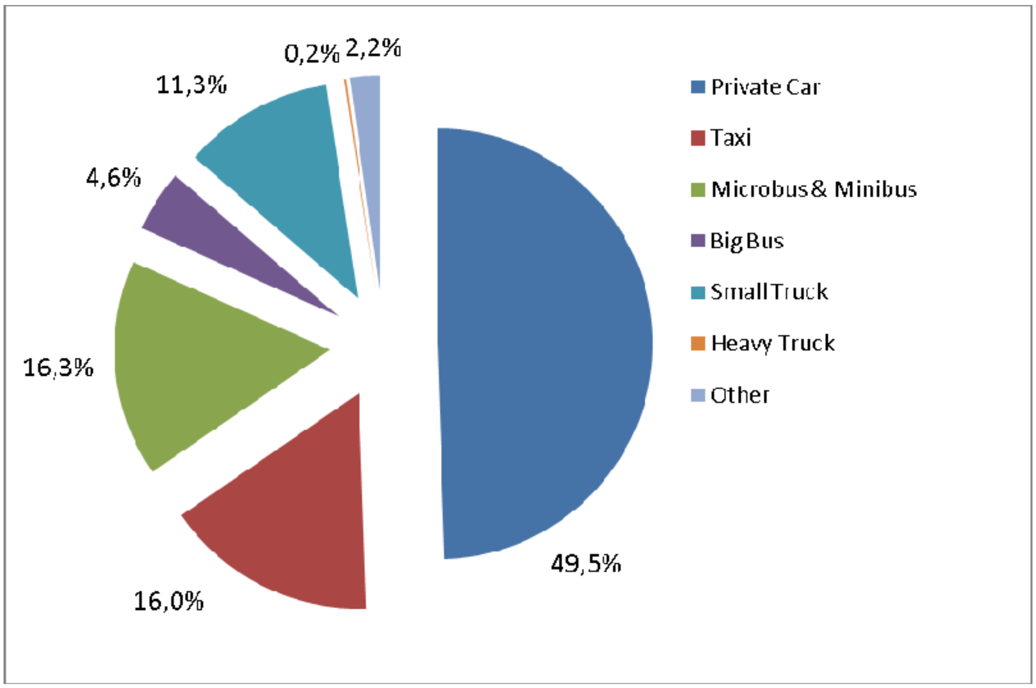


Figure 2.31: Modal Split according to 2005 Survey on Salah Salem Street

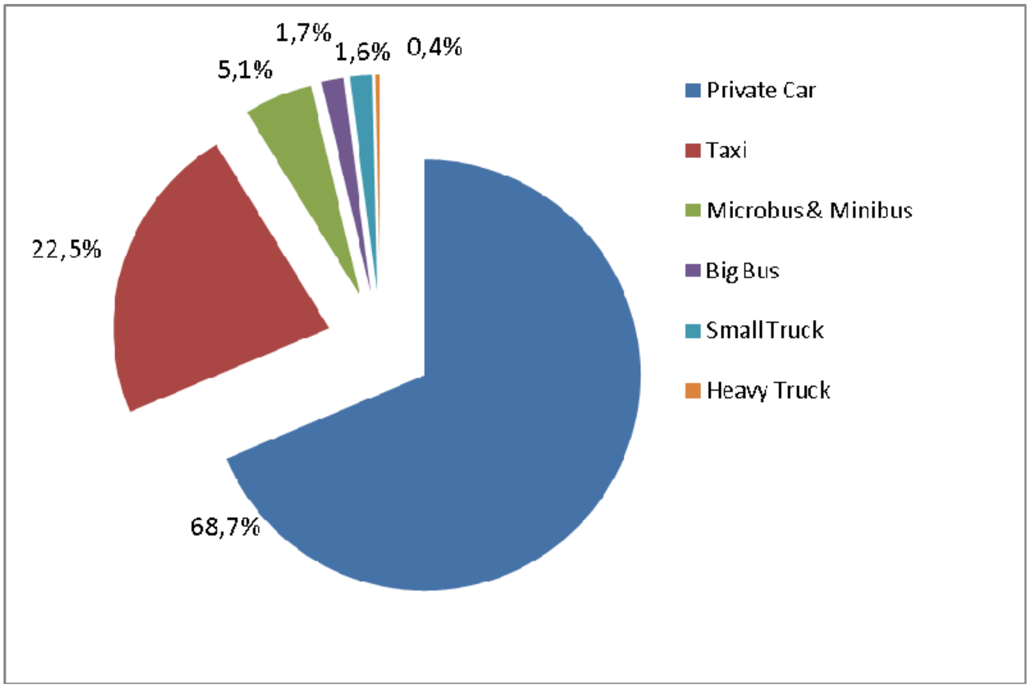


Figure 2.32: Modal Split according to 2010 Survey on Salah Salem Street (P13)

Differently from the results shown on the above-mentioned location, the private car share on Salah Salem Street was originally around 50% in 2005, compared to 75% on Suez Desert Road. Yet this share increased to 69% in 2010, implying the persistence of the undesirable situation of car dominance. The taxi share increased notably from 16% in 2005 to 23% in 2010. However, the overall bus utilization including microbus, minibus and the big bus, has dropped significantly by around 11% at this location. The construction of a new metro station is taking place in this area, which could have caused a temporary change in bus routes. While the share of small trucks decreased unaccountably by some 10%, the number of heavy trucks almost doubled.

Finally, if we compare the overall modal split charts, on one hand the average modal composition based a survey of 11 corridors in 2005[4] and on the other hand the one based on the classified vehicle counts performed in 2010, it may be concluded that:

- The share of passenger cars is not only the highest but in a continuous increase
- The taxi share increased by less than 1.5%
- The overall microbus and minibus share almost doubled
- The big bus share dropped by more than 3%
- The number of small trucks decreased by around 6%,
- The number of heavy trucks decreased by around 7%

The decrease in the number of trucks could be a result of banning them from using most of the city roads during working hours.

[4] Public-Private Partnership Program For Cairo Urban Toll Expressway Network Development study

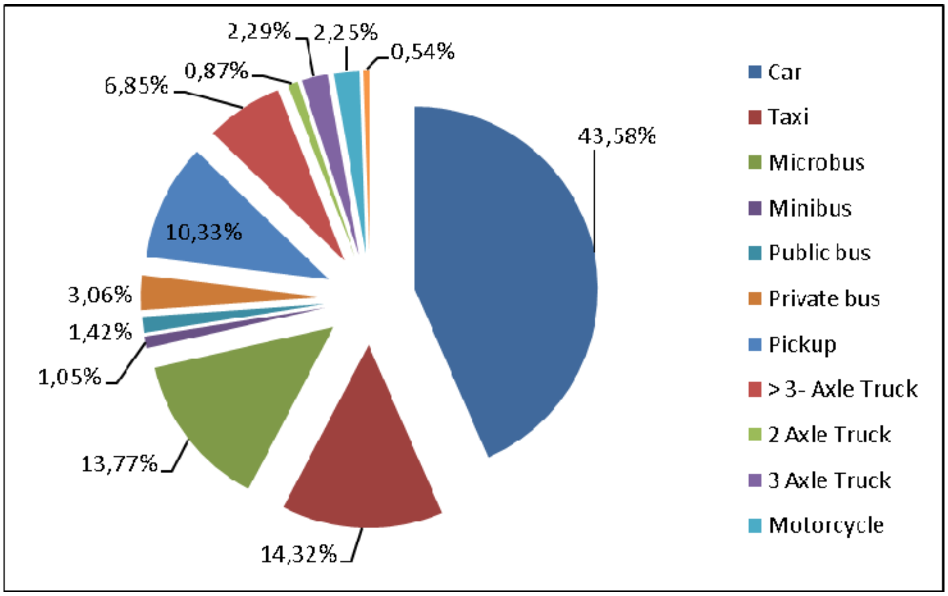


Figure 2.33: Average Modal Split – 2005

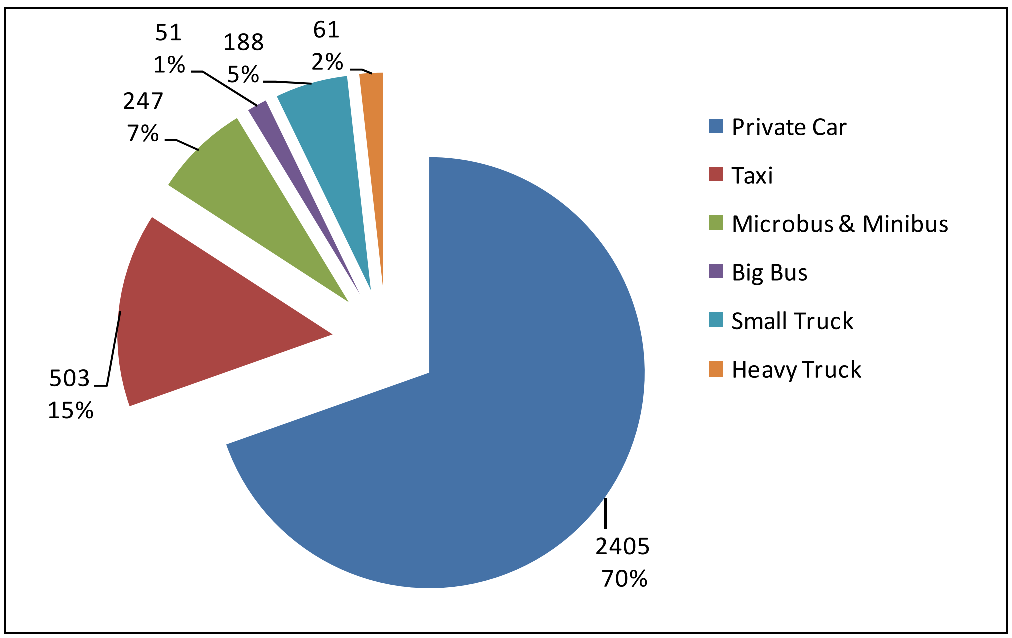


Figure 2.34: Modal Split - 2010

2.11.2 Changes in Traffic Patterns

To develop an idea about the changes in traffic patterns in the past 5 years, the following two data sources were compared:

a. 2005 data, as per the survey in the JICA Study (Cairo Urban Toll Expressway Network Development), presented in Table 2.9

b. 2010 data obtained from the survey of Cairo Congestion Study, and presented in Tables 2.11 and 2.12.

In order to compare the results of 2005 and 2010 surveys, the following common traffic counts locations were identified:

Table 2.13: Comparable Traffic Count Locations

Code	Traffic Count Location (WB Study-2010)	Traffic Count Location (JICA Study-2005)
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	Warraq Bridge (TC no.1)*
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	Gesr El Suez St (TC no.18)
P3	Suez Desert Road / Between KM 4.5 and Ring Road	Suez Desert Road (TC no.12)
P6	26th July / Between Railway and Ring Road	26th of July Corridor (TC no.11)
P8	Middle Abbas Bridge	Giza Bridge (TC no.8)
P9	6th October Bridge / Zamalek-Agouza	6th October Bridge (TC no.5)
P10	Ahmed Helmy Str./ Before Abou Wafya Bridge	Ahmed Helmy (TC no.24)
P11	Ramsis Str./Between Ghamra and Ramsis Srq	Ramsis St (TC no.25)
P12	Lotfy El-Sayed/between Abaseya&Demerdash Metro stn	Lotfy El sayed (TC no.22)
P13	Salah Salem Str./Between Elfangary and Abbaseya	Salah Salem Road (TC no.26)

*** locations are not exactly similar but volumes maybe comparable**

Based on the above, the average traffic volumes per direction were compared at each location for the same peak periods (7:00 to 11:00 AM and 3:00 to 7:00 PM) as shown in the following tables.

Table 2.14: Comparison between 2005 and 2010 Traffic Count Surveys Data: Average Traffic Volumes per Direction for the AM Peak Period (7:00 to 11:00)

Traffic Count Number & Road Name		Direction	2010 (veh/hr)	2005 (veh/hr)	Percent Difference
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	To East Cairo	3,299	1,674	97%
		To West Cairo	3,212	1,271	153%
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	To CBD	5,708	1,576	262%
		To Ismailia	2,766	1,952	42%
P3	Suez Desert Road / Between KM 4.5 and Ring Road	To Cairo	3,051	1,204	154%
		To Suez	1,890	1,314	44%
P6	26th July / Between Railway and Ring Road	To Cairo	4,389	3,562	23%
		To 6th Oct City	2,398	2,812	-15%
P8	Middle of Abbas Bridge	To Cairo	1,512	2,328	-35%
		To Giza	2,022	2,452	-18%
P9	6 October Bridge between Zamalk and Agozah	To Al Mohandeseen &Al Doki	7,400	6,346	17%
		To Cairo-Alx Agr Rd	7,154	11,823	-39%
P10	Ahmed Helmy Str./ Before Abo Wafya Bridge	To Shobra	651	733	-11%
		To Ramsis	497	1,616	-69%
P11	Ramses St. between Ghmara and Ahmed Said St. (One Way to	To Abasiah (1 way)	4,244	1,772	139%

	Abasia)				
P12	Lotifi Al Said St. between Abasia and Ghamrah (One Way to Ramses Square)	To Ramses Sq (1 way)	4,093	3,696	11%
P13	Salah Salem Str./Between Elfangary and Abbasey	To Abasiah	3,873	3,367	15%
		To Cairo Airport	3,600	2,399	50%

Table 2.15: Comparison between 2005 and 2010 Traffic Count Surveys Data: Average Traffic Volumes per Direction for the PM Peak Period (3:00 to 7:00)

Traffic Count Number & Road Name		Direction	2010 (veh/hr)	2005 (veh/hr)	Percent Difference
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	To East Cairo	2,968	1,381	115%
		To West Cairo	2,985	2,049	46%
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	To CBD	5,532	2,566	116%
		To Ismailia	2,821	2,455	15%
P3	Suez Desert Road / Between KM 4.5 and Ring Road	To Cairo	3,996	1,250	220%
		To Suez	2,009	1,270	58%
P6	26th July / Between Railway and Ring Road	To Cairo	3,323	3,177	5%
		To 6th Oct City	2,499	2,252	11%
P8	Middle of Abbas Bridge	To Cairo	1,765	2,723	-35%
		To Giza	2,464	2,977	-17%
P9	6 October Bridge between Zamalk and Agozah	To Al Mohandeseen and Al Doki	5,695	6,860	-17%
		To Cairo-Alx Agr Rd	3,197	8,426	-62%
P10	Ahmed Helmy Str./ Before Abo Wafya Bridge	To Shobra	606	1,143	-47%
		To Ramsis	726	1,055	-31%
P11	Ramses St. between Ghmara and Ahmed Said St. (One Way to Abasia)	To Abasiah (1 way)	4,448	2,562	74%
P12	Lotifi Al Said St. between Abasia and Ghamrah (One Way to Ramses Square)	To Ramses Sq (1 way)	4,111	2,937	40%
P13	Salah Salem Str./Between Elfangary and Abbasey	To Abasiah	3,773	2,484	52%
		To Cairo Airport	5,454	3,416	60%

Most of the changes in traffic patterns can be attributed to variants in terms of transport demand and supply and land use characteristics within the last 5 years. The following major changes were identified in the GCMA:

1. Population growth in new cities on the peripheral areas of the Ring Road (6th of October, El Obour, El Rehab, etc). However, many of the new settlers still work in the CBD, implying the central area surrounded by the Ring Road.

2. With many residents leaving the central area to the GCMA periphery, an expansion in commercial and business activities is observed in certain areas such

as El-Mohandeseen and El Doki. The use of many residential facilities has been transformed into commercial and/or business, resulting in an extended CBD.

The changes in demand and land use mentioned in points 1 and 2 explain some of the observed increase in traffic volumes during the AM peak (to work trips) on the corridors leading to the extended CBD such as (26th of July in the direction to Lebanon square). Consequently there is an increase in the PM peak going out form the extended CBD.

3. A major change in supply has been perceived with the opening of the new Maryottya corridor that connects El Moneeb Bridge and the Ring Road. The new corridor has attracted a large portion of traffic going from/to the south (El Maadi and Helwan) and east areas (Nasr city) to/from the west area (6th of October City and Cairo/Alexandria Desert Road). This major supply change caused the reduction in traffic volumes along major routing alternatives such as (Abbas Bridge, 6th of October Bridge, etc).

4. Upgrading El Khalafaway corridor (north of Shobra and Ein Shams areas) into a limited access travel corridor. This corridor currently attracts traffic from surrounding areas; reducing their traffic load. The corridor also facilitates access to the north/west sections of the Ring Road in the vicinity of Cairo/Alexandria Agricultural Road.

5. A remarkable increase in car ownership in GCMA.

With reference to Table 2.14, it is clear that traffic in the AM period has increased remarkably on most traffic count locations including:

- The Ring Road, Between El Khosoos and Cairo Alex Agricultural Road in both directions. Such increase may have resulted from the changes identified in points 1, 4 and 5 described above.Gesr El Suez, between Ring Road and Ain Shams Street in both directions (points 1, 4, 5)
- Suez Desert Road, between KM 4.5 and Ring Road in both directions (points 1 and 5)
- 26th July Corridor, between Railway and Ring Road in the direction of Central Cairo (points 1, 2 and 5)
- 6th October Bridge in the direction of Al Mohandeseen and Al Doki (points 2 and 5)
- Ramses St. between Ghmara and Ahmed Said Street, in the direction to Abasia (points 2 and 5)
- Lotifi Al Said Street between Abasia and Ghamrah, in the direction to Ramses Square (points 2 and 5)
- Salah Salem Street, between Elfangary and Abbasey in both directions (points 2 and 5)

On the other hand, traffic has decreased on the following links:

- Abbas Bridge in both directions (attributed to the change identified in point 3)
- 6th October Bridge in the direction of Cairo-Alexandria Agricultural Road (points 3 and 4)

- Ahmed Helmy Street in both directions (attributed to the change identified in point 4, in addition that only one-way movement of traffic is currently allowed one a large segment of Ahmed Helmy street)
- 26th July Corridor in the direction of 6th October City (points 1, 2 and 3)

As seen in Table 2.15 above, the differences in traffic volumes in the PM period are generally consistent with those in the AM Period, in other words, traffic has increased or decreased at almost the same count locations, but the magnitude of the difference has sometimes switched directions. The exceptions are:

- 26th July Corridor in the direction of 6th October City: traffic decreased in the AM period by 15%, but increased at the same location by 11% during the PM peak period
- 6th October Bridge in the direction of Al Mohandeseen and Al Doki: traffic increased in the AM period by 17%, but then decreased at the same location by 17% during the PM peak period

The highest increase (220%) is observed at Suez Desert Road in the direction of Cairo. The highest decrease (-62%) is however seen at the 6th of October Bridge in the direction to Cairo-Alexandria Road.

Peak Hour Factor

The peak hour factors (PHF) calculated on the selected corridors based on the latest survey results generally range between 0.85 and 0.95, which is typical for urban peak hour conditions.

In comparison with JICA study, the PHF increased on five out of eight locations as shown in the table below, from an average of 0.81 (2005) to 0.91 (2010), implying more variation of the traffic volumes within the peak hours at these locations. On the other hand, the PHF decreased at the three remaining locations from an average of 0.94 (2005) to 0.90 (2010), but this drop can be considered as minor since the factors are still within the same range.

Table 2.16: Comparison of Peak Hour Factors at Traffic Count Locations

Code	Traffic Count Location	PHF (WB Study-2010)	PHF (JICA Study-2005)
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	0.93	0.72
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	0.92	0.87
P6	26th July / Between Railway and Ring Road	0.91	0.84
P8	Middle Abbas Bridge	0.89	0.93
P9	6th October Bridge / Zamalek-Agouza	0.86	0.78
P10	Ahmed Helmy Str./ Before Abou Wafya Bridge	0.92	0.86
P11	Ramsis Str./Between Ghamra and Ramsis Srq	0.93	0.94
P12	Lotfy El-Sayed/between Abaseya&Demerdash Metro Stn	0.87	0.95

2.11.3 Changes in Peak Hours

According to the Public-Private Partnership Program for Cairo Urban Toll Expressway Network Development traffic count survey (May 2006), and as shown in Section 2.6, traffic peak periods in GCMA are as follows:

- The morning peak (07:00 – 9:00)
- The afternoon peak (13:00 – 16:00)
- The evening peak (20:00 – 21:00)
- The period (10:00 – 12:00) was observed to have the peak traffic volume in some locations (e.g., 15th of May Bridge)

The current study's survey took place during the following peak periods:

- Morning peak period: 7:00 am to 11:00 am
- Afternoon peak period: 3:00 pm – 7:00 pm

The following observations could be made:

- The highest peak during the morning period occurs from 8 to 9 at most traffic counts locations, which is consistent with the highest peak identified in 2005 as 7:00 to 9:00 AM.
- According to 2010 data, volumes are comparable in the different afternoon hours and there does not seem to be any specific peaking pattern.
- Additionally, as per 2010 data, congested conditions in the afternoon peak period are more widespread across the network relative to the morning peak period.
- What has notably changed from 2005 till 2010 is that the afternoon peak period has shifted from (13:00 – 16:00) to (15:00-18:00 pm)

2.12 Overview of additional existing data

The following remaining data items listed in Table 2.have not yet been addressed:

A) The total number of vehicles (by type)
B) Public transport capacity, fleet composition and age
C) Accident data and information
D) Unit vehicle operating cost
E) Fuel cost
F) Household income and value of time
G) Car ownership
H) Percentage of daily traffic in peak hour
I) Passenger Car Unit (PCU)
J) Vehicle Occupancy Factor
K) OD Matrix (by Mode)

It is noted that only a few of these data items are actually needed to calculate the economic costs of congestion (Chapter 4), namely E) Fuel cost, F) value of time, H) Percentage of daily traffic in peak hour, I) Passenger car units and J) Vehicle Occupancy

Factor. The other data items are interesting to present to get a comprehensive overview of the urban transport situation in Cairo; however these are not crucial for the calculation.

In Annex 3 the detailed information on all data items is presented.

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

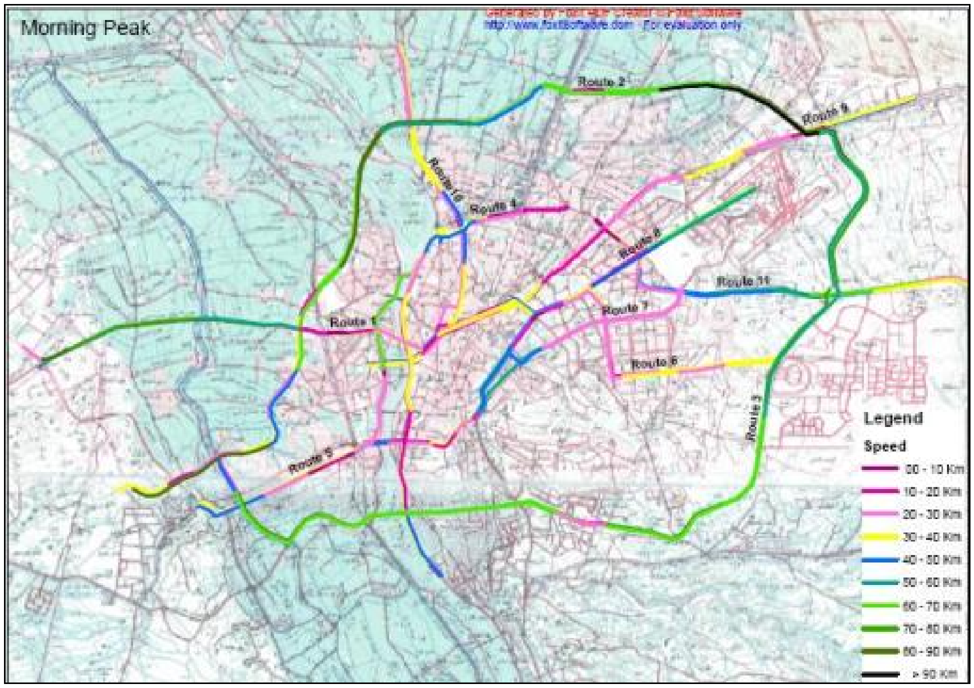


Figure 3.1: Morning Peak Sample Travel Speed

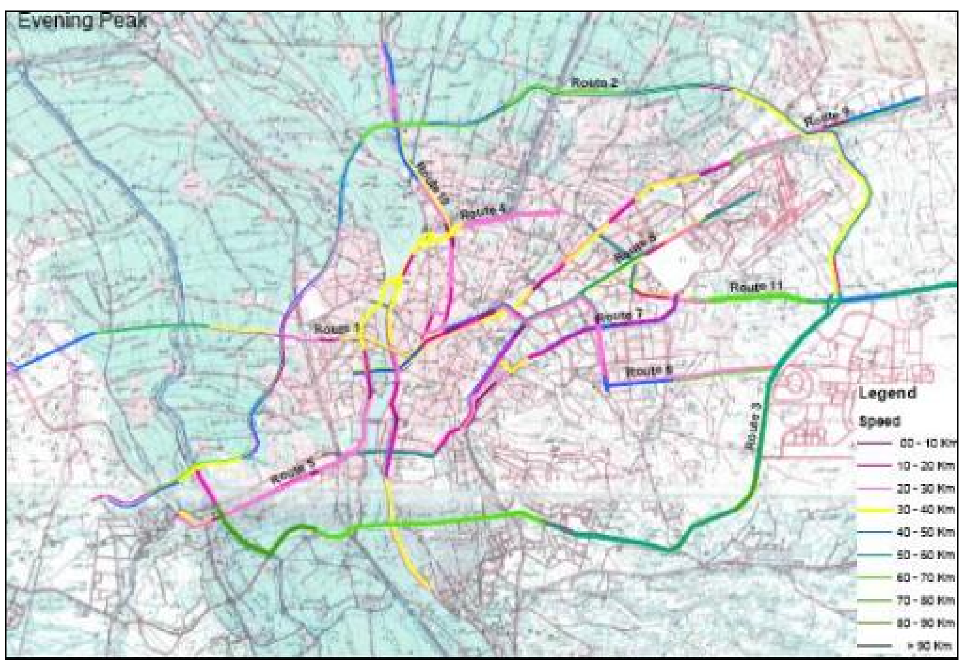


Figure 3.2: Evening Peak Sample Travel Speeds

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.

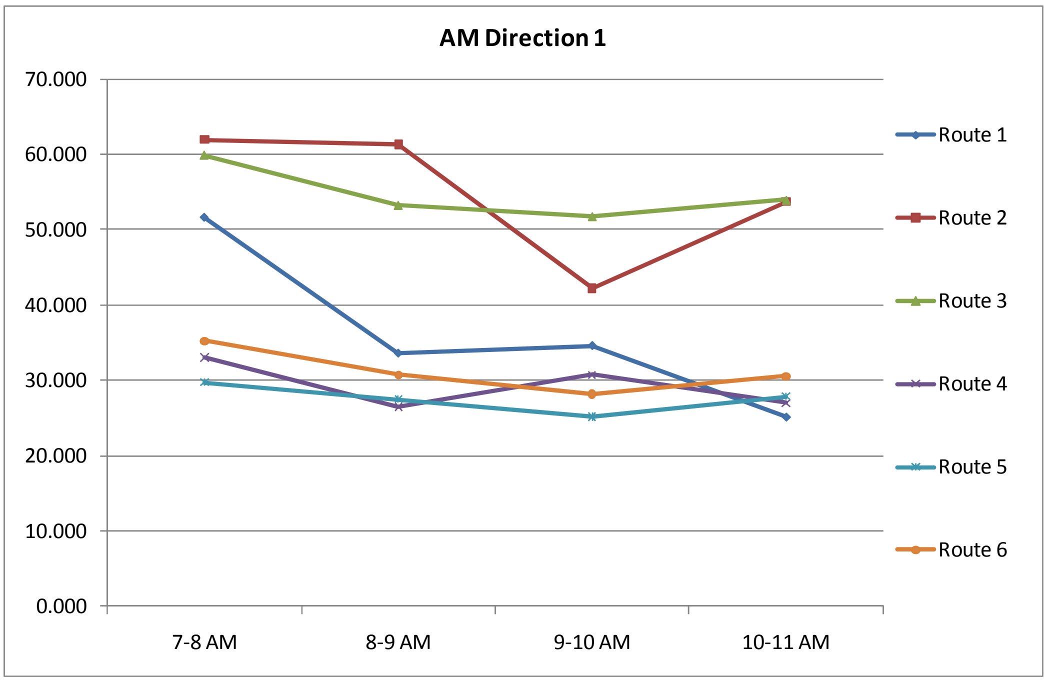


Figure 3.3: Principal Corridors Average Speeds- AM Direction 1- Routes 1 to 6

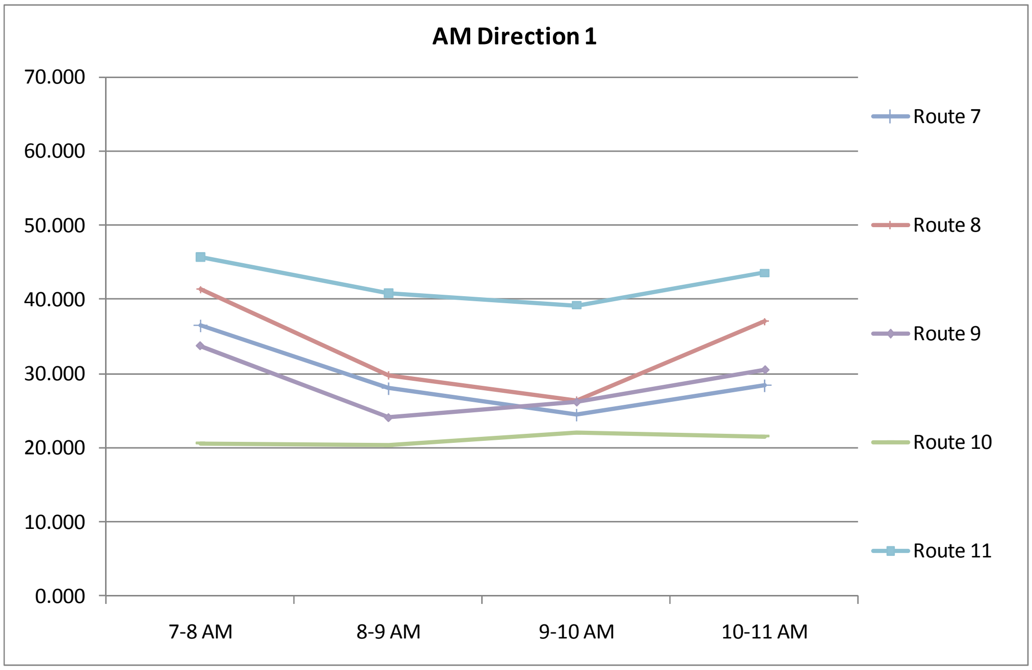


Figure 3.4: Principal Corridors Average Speeds- AM Direction 1- Routes 7 to 11

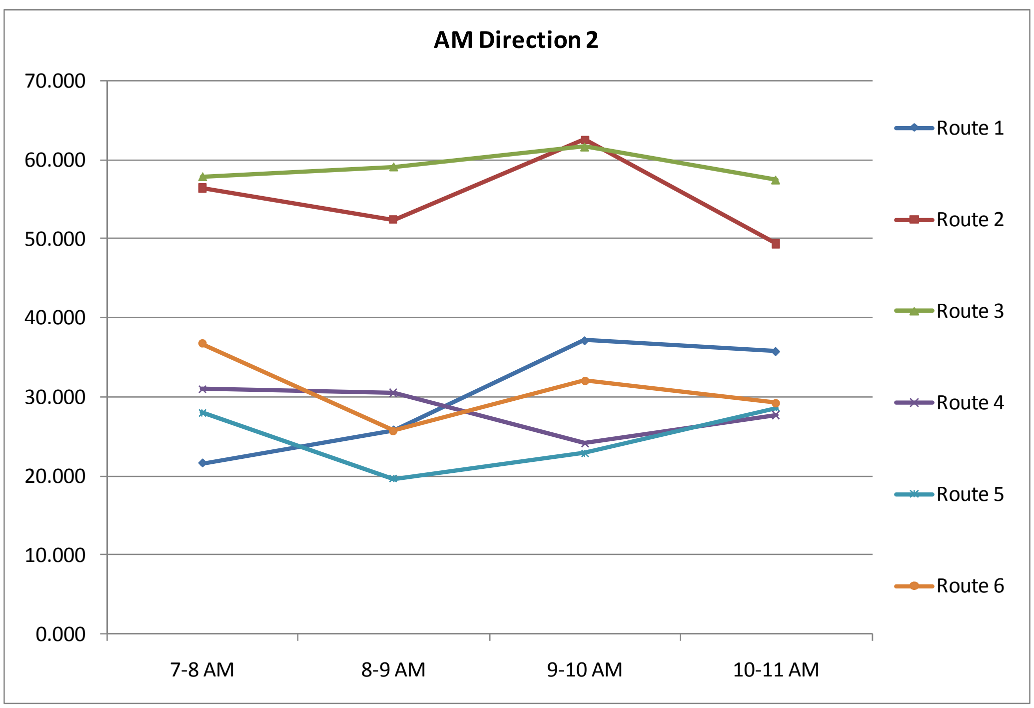


Figure 3.5: Principal Corridors Average Speeds- AM Direction 2- Routes 1 to 6

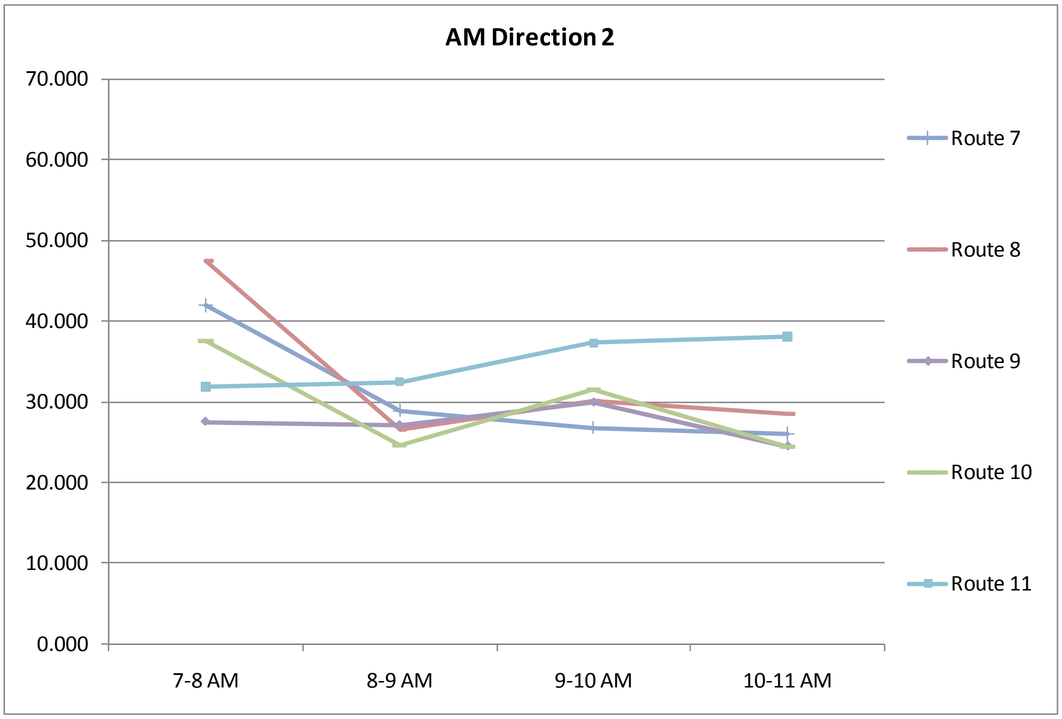


Figure 3.6: Principal Corridors Average Speeds- AM Direction 2- Routes 7 to 11

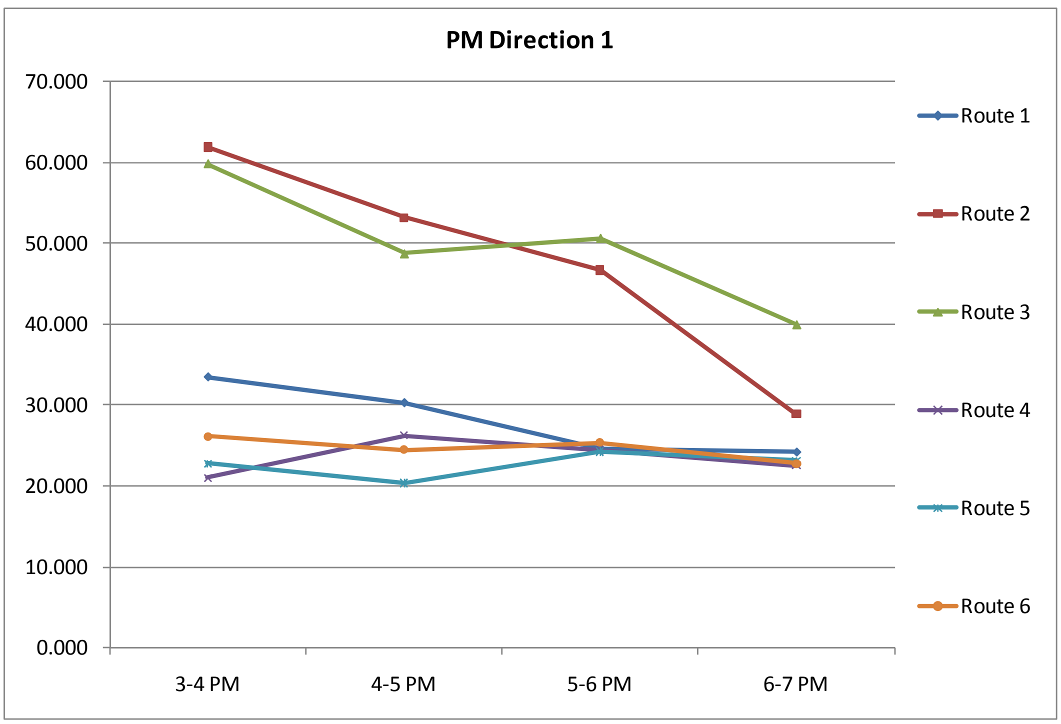


Figure 3.7: Principal Corridors Average Speeds- PM Direction 1- Routes 1 to 6

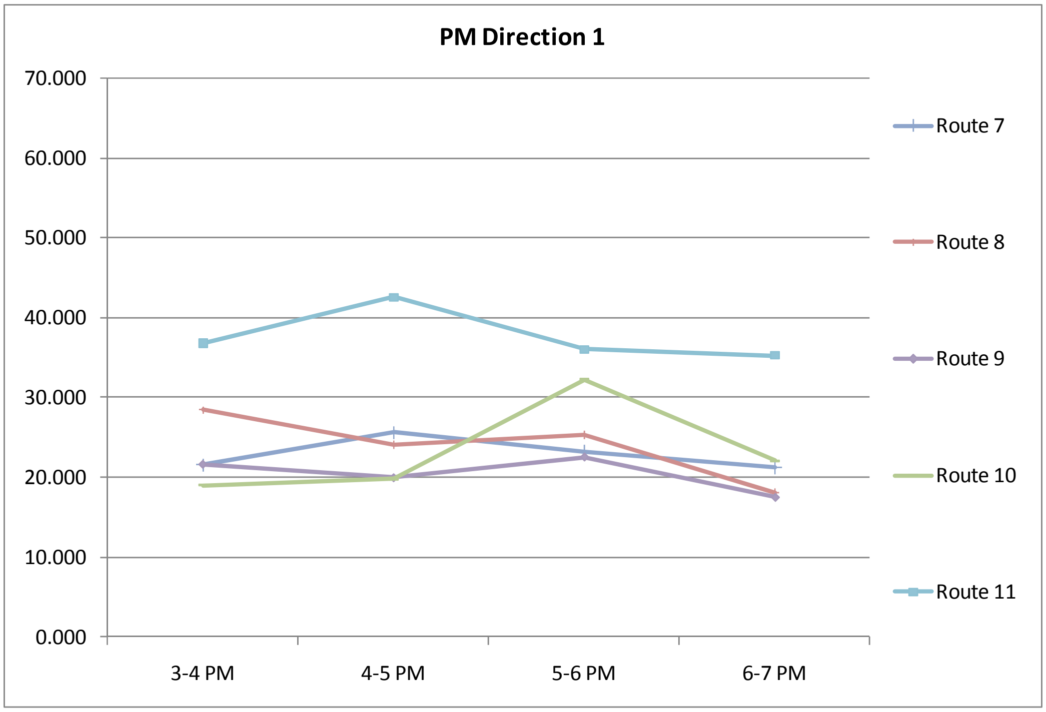


Figure 3.8: Principal Corridors Average Speeds- PM Direction 1- Routes 7 to 11

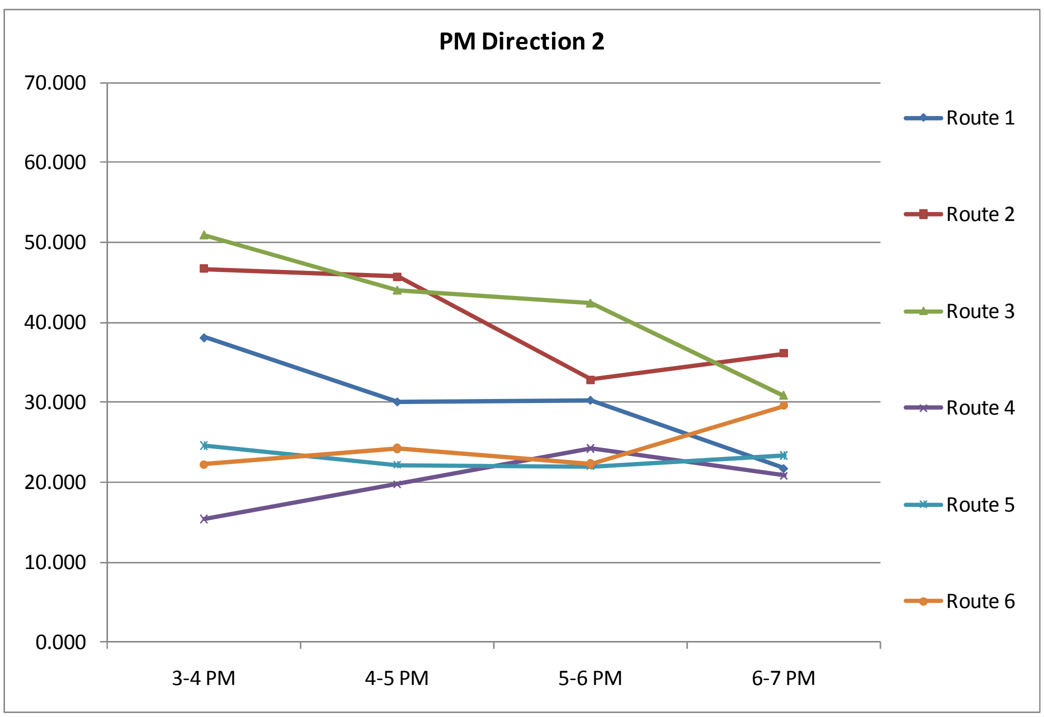


Figure 3.9: Principal Corridors Average Speeds- PM Direction 2- Routes 1 to 6

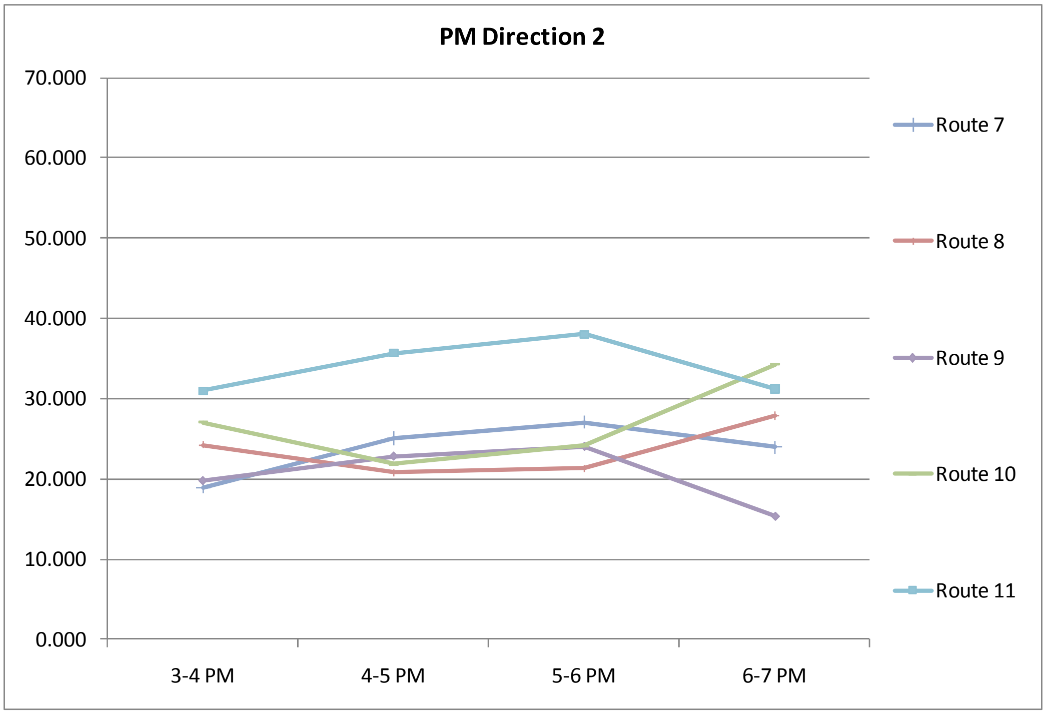


Figure 3.10: Principal Corridors Average Speeds- PM Direction 2- Routes 7 to 11

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.

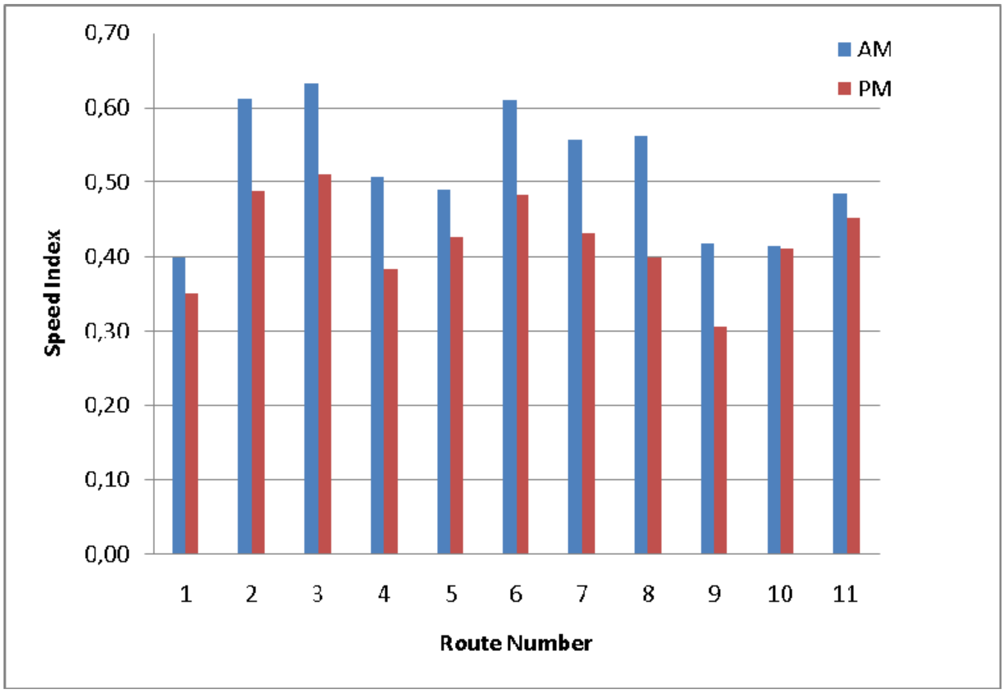


Figure 3.11: Principal Corridors Speed Indices

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.

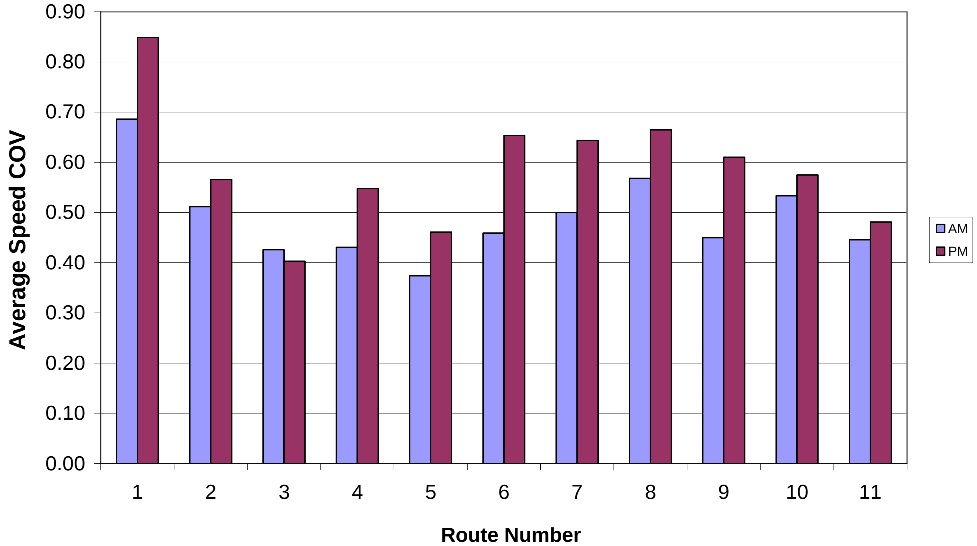


Figure 3.12: Principal Corridors Speed COVs, Direction 1

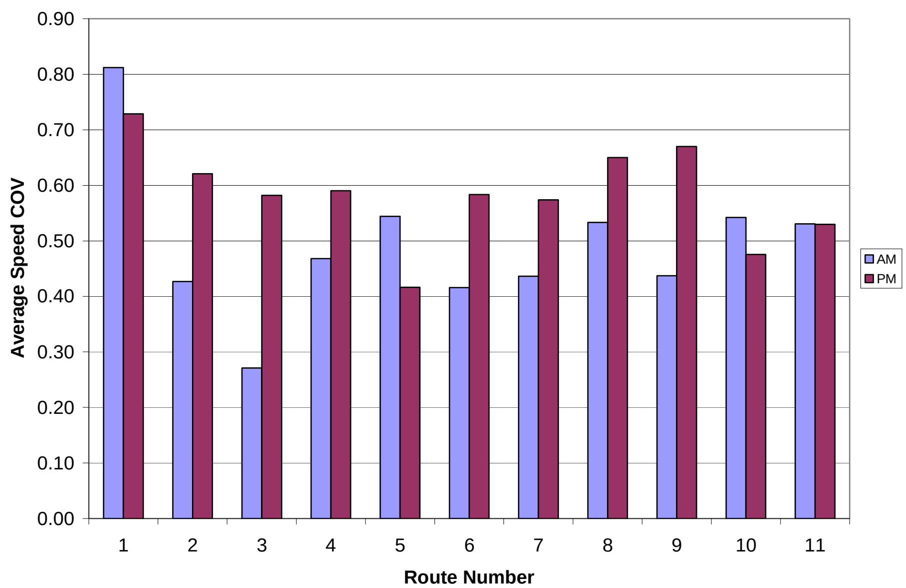


Figure 3.13: Principal Corridors Speed COV, Direction 2

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 95th 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.

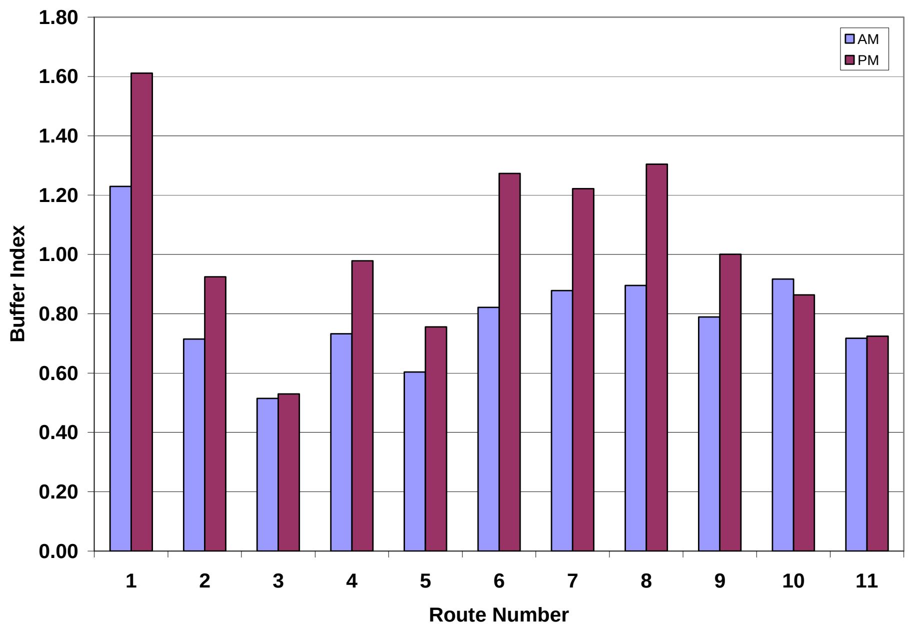


Figure 3.14: Principal Corridors Buffer Index, Direction 1

[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

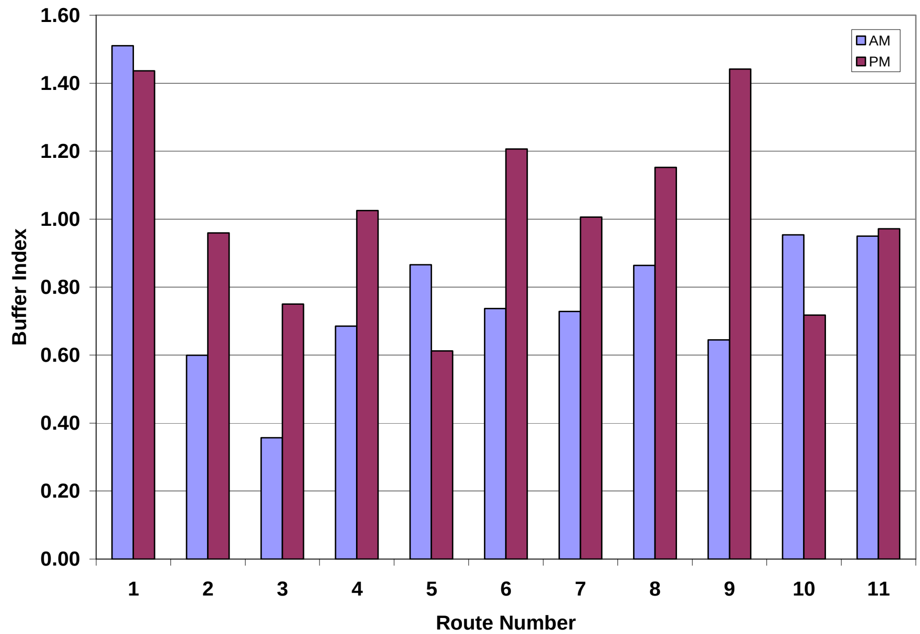


Figure 3.15: Principal Corridor Buffer Index, Direction 2

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 (26th of July/15th 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.

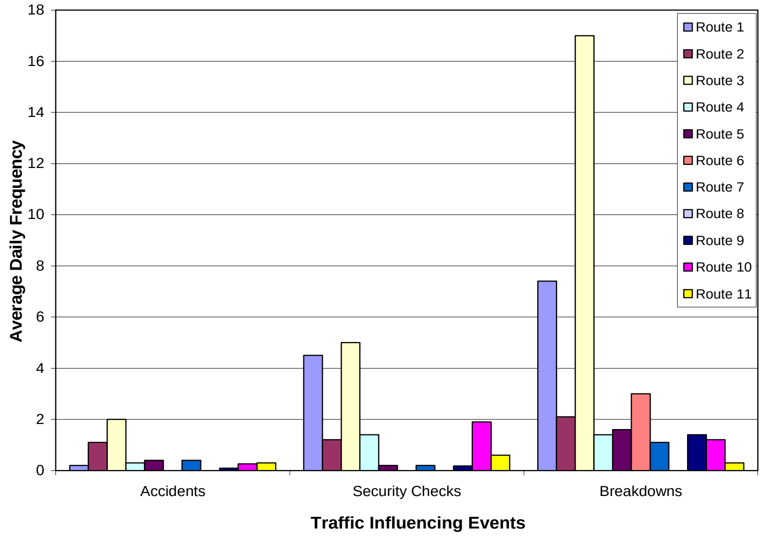


Figure 3.16: Traffic Influencing Events Frequencies

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

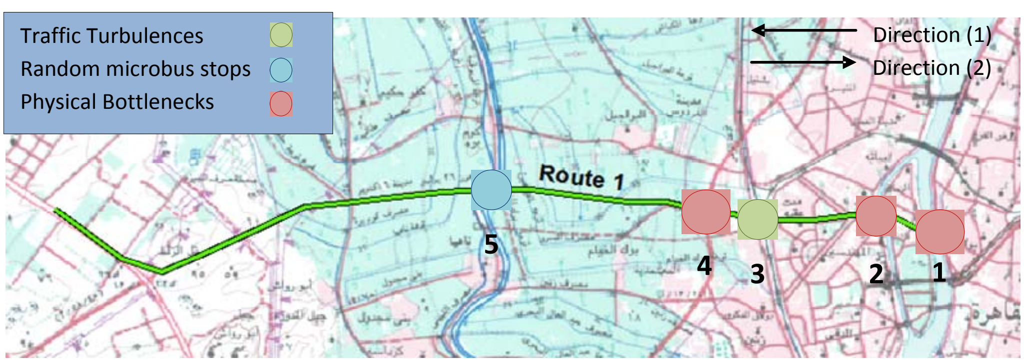


Figure 3.17: Route 1 Schematic

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
<u>Direction-2:</u> 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. <u>Direction-1:</u> 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
<u>Direction-2:</u> 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
<u>Direction-1:</u> 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)

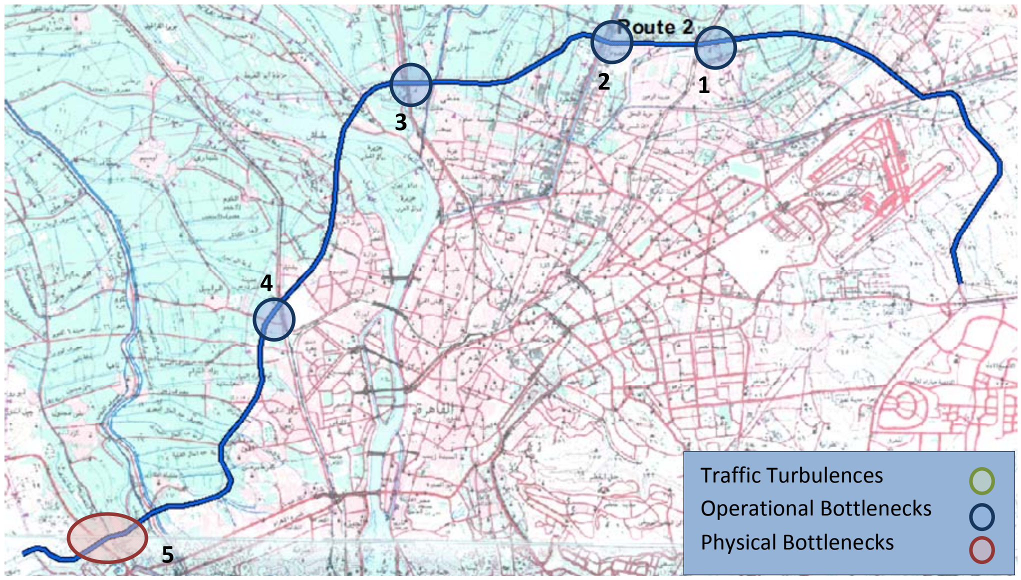


Figure 3.18: Route 2 Schematic

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 26th 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 26th 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)

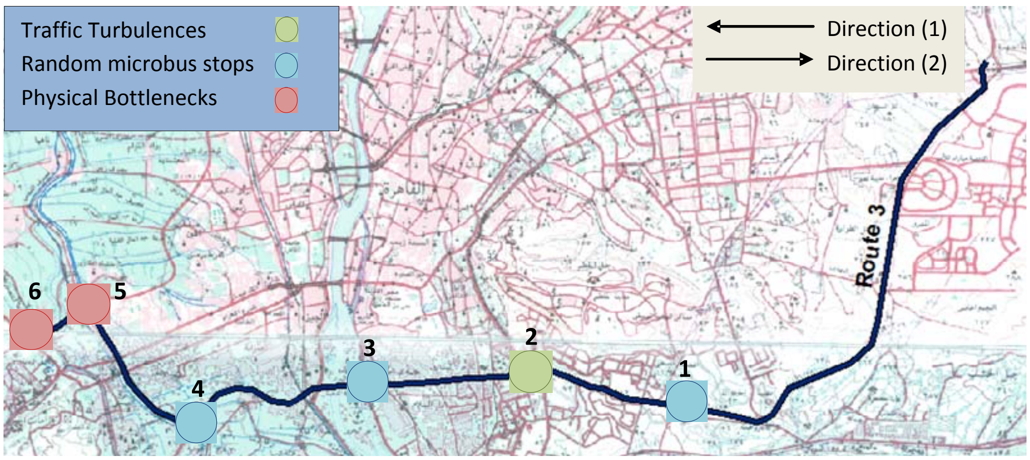


Figure 3.19: Route 3 Schematic

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.

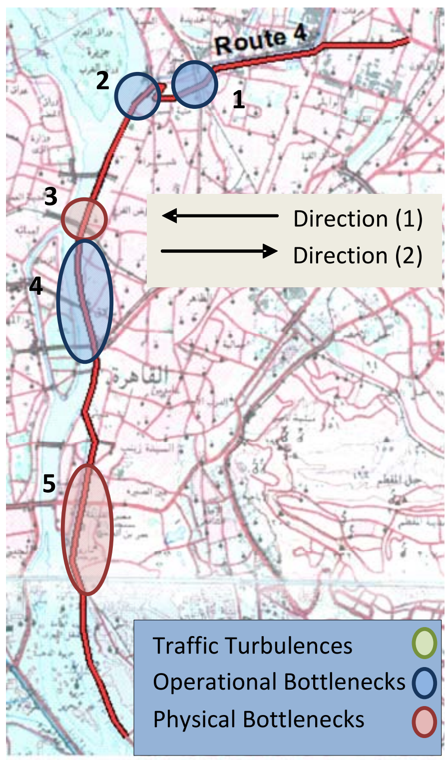


Figure 3.20: Route 4 Schematic

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.

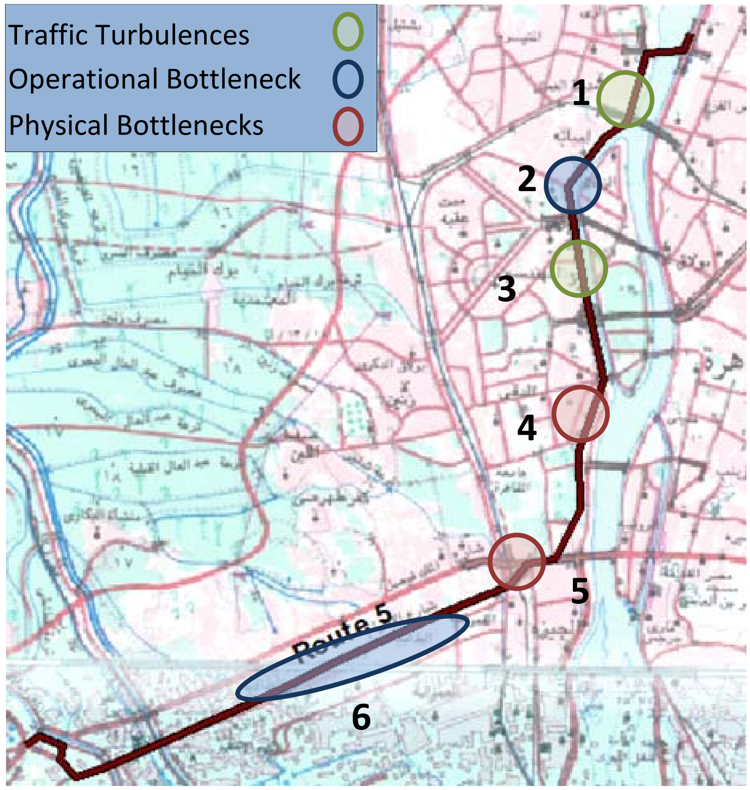


Figure 3.21: Route 5 Schematic

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

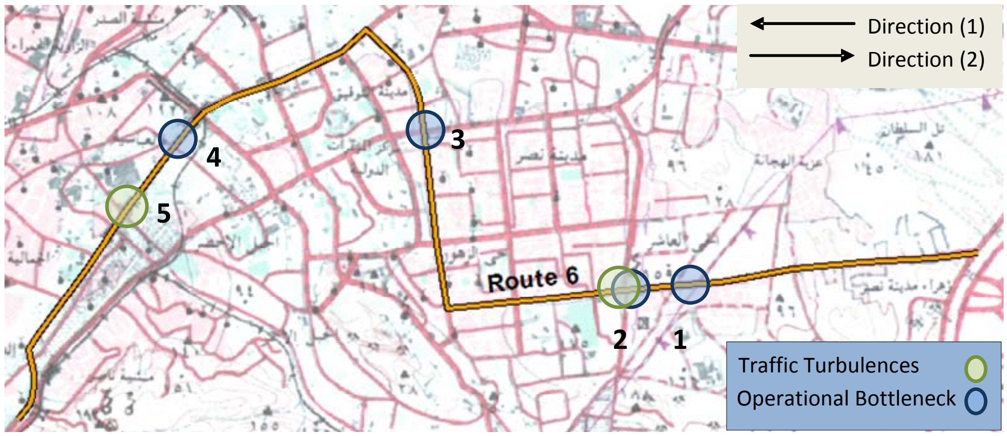


Figure 3.22: Route 6 Schematic

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
Direction (1): 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
Direction (1): Conflicting traffic movements near the entrance of ElAzhar tunnel. Occasional spillbacks due to tunnel congestion.

Route (7): Autostrad/Giza Square

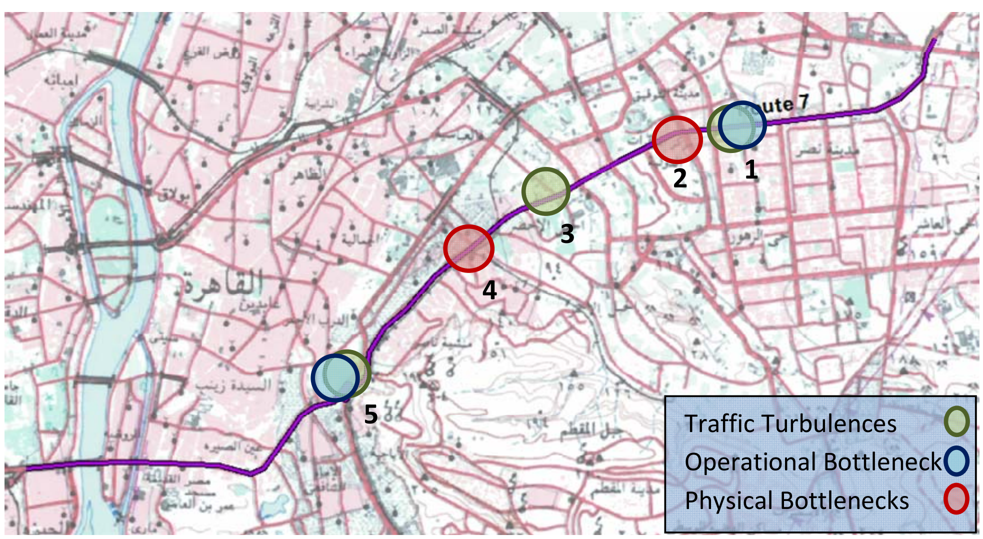


Figure 3.23: Route 7 Schematic

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

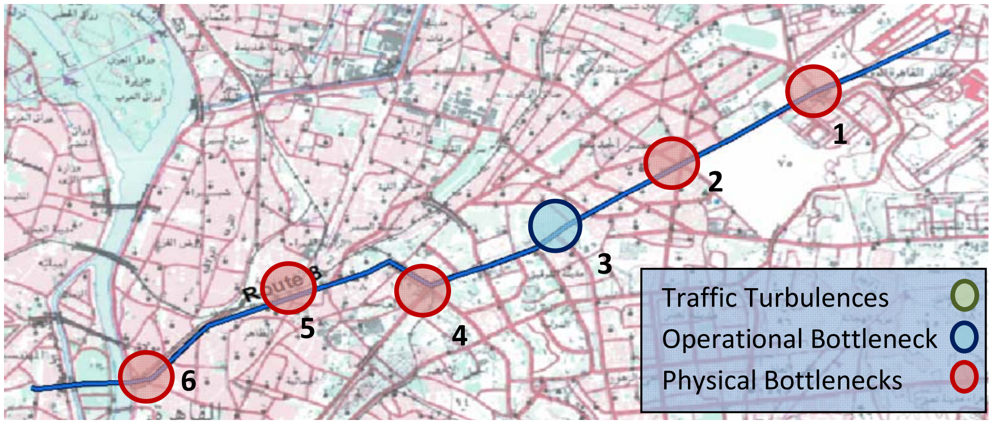


Figure 3.24: Route 8 Schematic

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

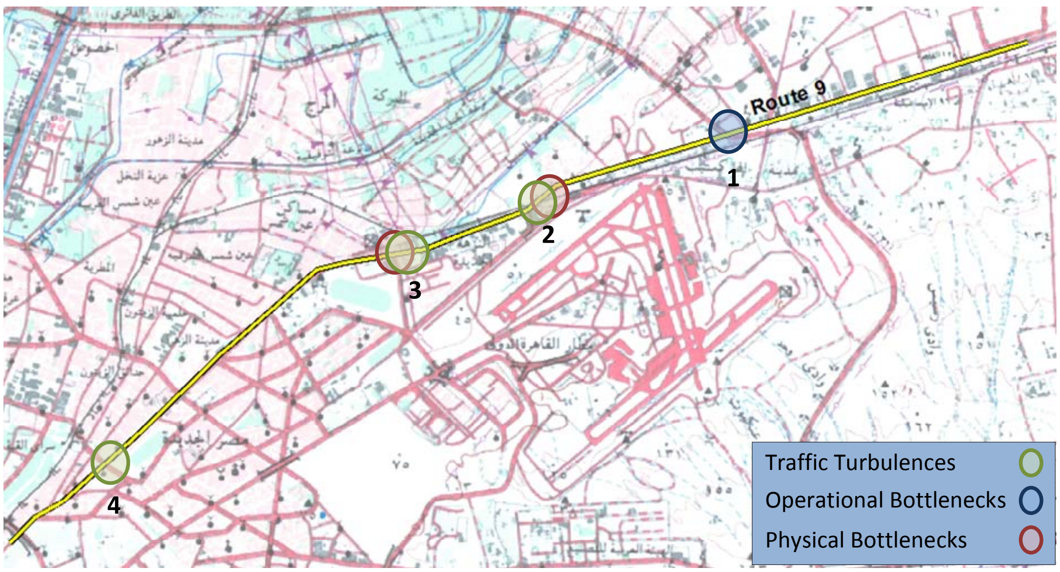


Figure 3.25: Route 9 Schematic

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
<u>Direction (1):</u> 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
<u>Direction (2):</u> 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. <u>Both Directions:</u> At El-Qubba Intersection; access management and geometric design inefficiencies.

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

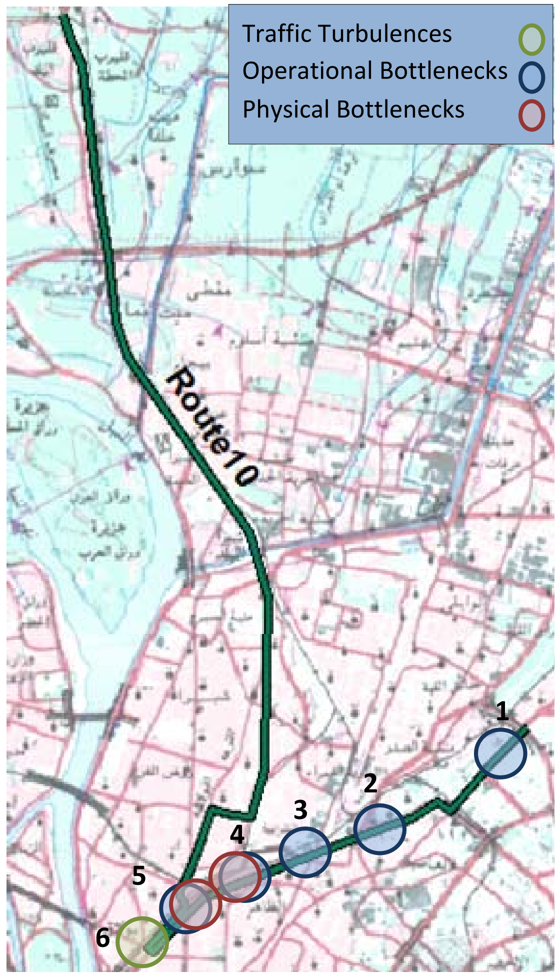


Figure 3.26: Route 10 Schematic

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 6th 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 6th 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

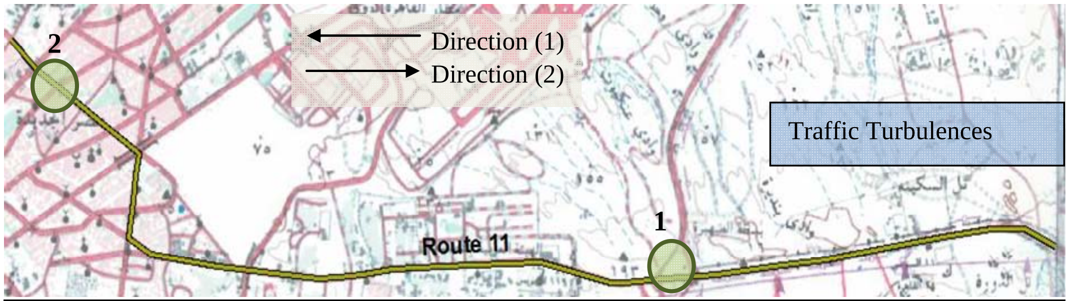


Figure 3.27: Route 11 Schematic

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

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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).

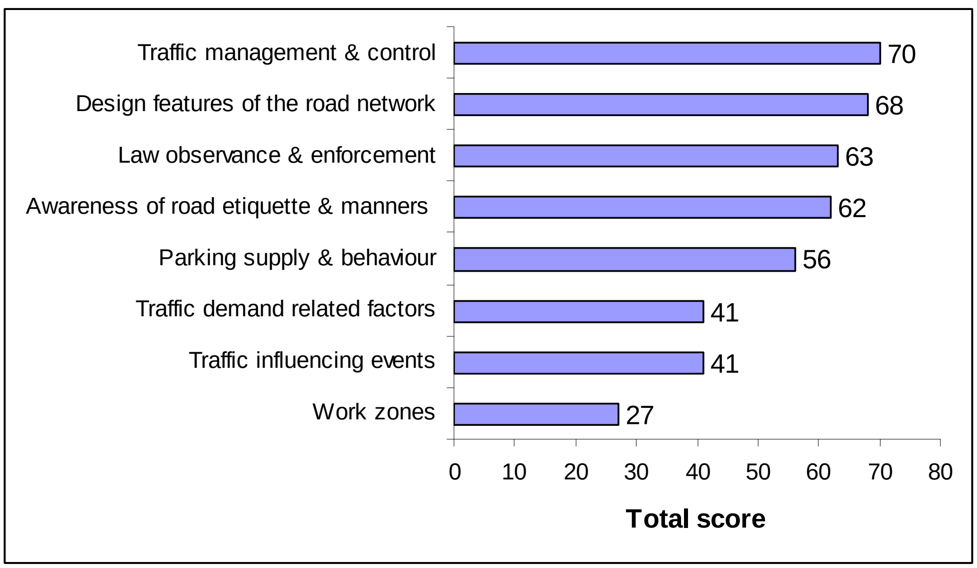


Figure 3.28: Ranking of the Operational Causes

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).

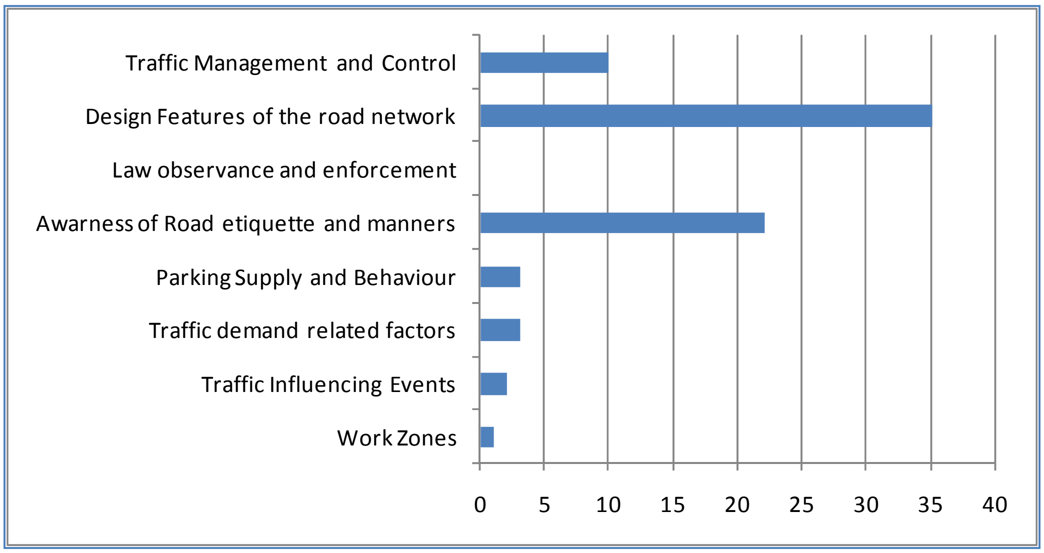


Figure 3.29: Congestion causes frequencies of occurrences

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).

4 Estimation of Direct Economic Costs of Traffic Congestion in Cairo

4.1 Introduction

This section provides the calculation of estimated direct economic costs of traffic congestion in the Greater Cairo Metropolitan Area (GCMA). In order to estimate costs of congestion, first a definition of congestion is presented. Then, based on a literature review a selection of suitable methods of measurement of congestion levels is described.

The next step is to identify the adverse components of traffic congestion. For each element a calculation method is explained and proposed, based on literature review. This resulted into two main approaches to calculate in particular the delay costs for the GCMA (one of the components). The approaches are divided into two parts: first a calculation on direct congestion costs on the 11 Principal Corridors (sections 4.3-4.7) and secondly an extension of the calculation to cover the complete GCMA (section 4.8)

Moreover, a zonal based distribution of congestion cost is conducted by applying an engineering judgment based on available information. Finally, this chapter presents a reflection of the calculation method in view of the data used.

4.2 Methods to Measure Direct Economic Costs of Congestion

4.2.1 Definition of congestion

To the traveler, congestion comprises motionless or slowly moving lines of vehicles on a freeway or urban street, a lane closure because of road construction or an accident, or some sort of traffic backup. The transportation professional, on the other hand, thinks of congestion in terms of flow rates, capacities, volumes, speeds, and delay.

Congestion occurs when the road capacity does not meet traffic demand at an adequate speed, traffic controls are improperly used, or there is an incident on the road such as an accident or disabled vehicle. Congestion can occur during any time of the day and along any type of roadway.

Congestion can take various forms, such as *recurring* or *nonrecurring*, and can be located across a network or at isolated points. Recurring congestion exists when the traffic volume on roadway exceeds its capacity at a particular location during a predictable and repeated time of day. Nonrecurring congestion is caused by random or unpredictable events that temporarily increase, demand, or reduce capacity on a roadway. Such events include accidents, disabled vehicles, road construction, and inclement weather.

4.2.2 How to measure congestion?

Measuring congestion is a necessary step in order to deliver better congestion outcomes. However, congestion should not be described using a *single* metric for policy purposes. Such an approach is sure to obscure either the quantitative aspects of congestion or its relative and qualitative aspects. These two aspects can not be disassociated and progress in managing congestion should be based on sets of indicators that capture both of these aspects.

Good indicators can be based on a wide network of roadway sensors but simple indicators based on less elaborate monitoring can sometimes adequately guide policy. What is important is to select metrics that are relevant to both road managers (e.g. speed and flow, queue length and duration, etc.) and road users (e.g. predictability of travel times, system reliability, etc).

Congestion has an impact on both the speed of travel and on the *reliability* of travel conditions. It is the latter that may be of greatest concern to individuals and businesses. Thus congestion management policies should keep track of travel reliability indicators. These may capture the variance in travel times or, alternatively, communicate the amount of time buffers road users have to include in their travel plans to make their trips "on time". Insofar as these reliability indicators give an understanding of the quality of travel conditions, they are important to policymakers seeking to address the qualitative aspects of congestion.

The manner in which *congestion is measured* has a fundamental impact on the manner in which *congestion is defined and managed*. Measures of congestion based alternately on speed, access, user costs, delay, reliability, etc. will give rise to different problem statements regarding congestion and will motivate sometimes radically different policy interventions.

There is no "simple" measure of congestion that is good for all purposes and all situations. The rating of a specific roadway segment's performance as translated by hourly vehicle counts against rated capacity will mean little to a user even if they travel over that link every day. Conversely, knowing the amount of time one must plan for to get from one suburb to another at peak hours in order to arrive before 09:30 will not necessarily help an engineer better time traffic signals in the central business district. There are not necessarily "better" indicators of congestion than others, but there may exist a *better fit* between those indicators selected and specific outcomes desired. In this respect, it is important not to simply use a specific congestion indicator because it is available (others might be as well), but because it allows one to measure progress towards a specific goal (e.g. link performance, system operation, user experience, etc…).

Based on an analysis of the commonly used performance measure(s) that reflects congestion levels on roads (see literature review Annex 9) it is concluded that both travel speed characteristics (differences between peak and off-peak) as well as the number of vehicles divided by the capacity (V/C[11]) are suitable for this study to calculate direct economic costs of congestion.

4.2.3 Economic Costs Elements and Calculation Method

Based on the literature review (see Annex 9) the following direct cost elements are commonly used to calculate the direct costs of traffic congestion:

- Costs of travel time delay imposes to users (passengers as well as freight)
- Costs of travel time unreliability in passenger transportation
- Cost of excess fuel consumption in vehicular transportation (Diesel and Gasoline)
- The associated cost of CO_2 emissions due to excess fuel consumption

The method used to estimate cost of time delay and the cost of excess fuel consumption is primarily based on the methodology developed by the Texas Transportation Institute[12].This methodology focuses on the calculation of delay costs and the costs of excess fuel consumption. The remaining cost items, namely the costs of travel time unreliability and associated costs of CO_2 emissions due to excess fuel consumption are estimated using other sources. These sources represent research on monetizing travel time uncertainty and the valuation of external costs of transport and are listed in the sections 4.4 and 4.6 in which the calculation of these costs is described.

It is noted that the detailed methodology used for the calculation of each direct cost item, including formulas used, is presented in Annex 10. The main report presents the main steps in the calculation, and focuses on the results.

4.3 Costs of Travel Time Delay

The methodology is outlined as follows and is performed on individual roadway segments. The three aforementioned peak period times (morning, afternoon, and evening) were used as the time for the beginning of congestion.

Most of the basic performance measures are developed as part of calculating travel delay (the amount of extra time spent traveling due to congestion).

An overview of the process is followed by more detailed descriptions of the individual steps. Travel delay calculations are performed in two steps: recurring (or usual) delay and secondly nonrecurring delay (due to crashes, vehicle breakdowns, etc.).

Recurring delay estimates are developed using a process designed to identify peak period congestion due to 1) differences in peak and off-peak speeds and 2) traffic volume and useable capacity.

[11] Congestion occurs if the number of vehicles is close to the capacity, the ratio of 0.77 V/C as provided in the Highway Capacity Manual is often used as a threshold.

[12] (http://mobility.tamu.edu/ums/report/Annex_a.pdf

Delay caused by stochastic events is included in the non recurring delay estimate. Generally, these events can be categorized as one of the eleven sources of unreliability:

- Traffic Incidents
- Work Zones
- Weather
- Fluctuation in Demand
- Special Events
- Traffic Control Devices
- Inadequate Base Capacity
- Vehicle breakdown
- Random Pedestrian Crossing
- Random Minibus Stops
- Security Checks

Given the available information from the Floating Car Survey (see Chapter 2) only estimates of nonrecurring travel delay from incidents, security checks, vehicle breakdowns, random minibus stops, and finally random pedestrian crossings have been taking into account in this assignment.

4.3.1 Estimation of Delay from Recurrent Traffic Congestion

In order to estimate delay from recurrent traffic congestion, determining the congestion threshold is essential. In order to determine the congestion threshold two different approaches have been applied as follows:

- Approach 1: Applying Principal Corridors Collective Assessment for corridors' speed plot
- Approach 2: Applying V/C based on traffic counts and useable road capacity

Approach 1: Applying Principal Corridors Collective Assessment for corridors' speed plot

The consultant uses the speed indices plots (see Chapter 2 and Annex 4) to determine the corridors' level of service and thus the congestion level. The hours that the speed indices show the average speed below 0.6 is considered as congested hours.

Travel delay from recurrent traffic congestion is estimated by equations relating vehicle traffic volume per lane and traffic speed. The calculation proceeds through the following simplified steps based on the method proposed by Texas Transportation Institute (TTI Method):

1. Estimate the daily volume of vehicles per lane corresponding to the congested peak hours
2. Calculate daily vehicle kilometers traveled (DVKT) for each roadway section as the average daily traffic (ADT) of a section of roadway multiplied by the length of that section of roadway
3. Calculate peak period volume
4. Determine average freeway speeds during the peak period based on data collected from travel time and speed surveys in corridors

5. Estimate travel delay. The difference between the amount of time it takes to travel the peak-period vehicle-Kilometers at the average speed and at free-flow speeds is termed delay.
6. Calculate daily recurring vehicle-hour delay

The amount of delay incurred in the peak period is the difference between the time to travel at the average speed and the travel time at the free-flow speed, multiplied by the distance traveled in the peak period.

The daily vehicle-kilometers of travel (DVKT) is the average daily traffic (ADT) of a section of roadway multiplied by the length (in kilometers) of that section of roadway. This allows the daily volume of all urban facilities to be presented in terms that can be utilized in cost calculations. The DVKT was estimated for the freeways and principal arterial streets located in each urbanized study area.

Approach 2: Applying V/C based on traffic counts and useable road capacity

By this approach the consultant applied the following multistep method to identify congested peak hours and segments for the corridors:

1. Divide each corridor into segments based on the useable segment's capacity
2. Calculate V/C for each segment during peak hours
3. Identify congested segments when V/C >0.77.

The FHWA model used 0.77 V/C ratio as threshold markers for traffic congestion. In fact, in 1991, the FHWA completed additional research in the area of quantifying congestion. The focus of this work was on recurring congestion on urban area freeways and the development of a congestion indicator combining both the duration and extent of congestion in a single measure (Cottrell, 1991), (Texas Transportation Institute, 1992), and (Epps et al. 1993). The only impact of congestion considered in this work was recurring congestion-induced delay expressed in terms of both its duration and physical extent by a newly developed indicator called the lane-mile duration index.

Given description above, the consultant applied the following steps to estimate the delay from recurrent congestion:

1. Calculate capacity based on number of lanes, an adjustment factor for lane width, lateral clearance, the presence of trucks, and type of terrain, and a value of 2,200 vehicles per lane per hour for the basic lane capacity assuming a roadway design speed of at least 60 Km per hour (kph)
2. Calculate volume-to-capacity ratio (V/C) for each hour of a typical day based on new counts
3. Determine which hours of the day are to be classified as congested. A V/C ratio of 0.77 was used to indicate the onset of congested travel conditions (boundary between LOS C and LOS D).
4. Calculate total annual congested vehicle Kms of travel (DVKT) based on AADT, roadway section length, and percentage of daily traffic experiencing congested conditions, which is the sum of the percentages of traffic occurring during those hours of the day with a V/C ratio greater than or equal to 0.77.

5. Estimate Travel Delay*:* The difference between the amount of time it takes to travel the peak-period vehicle-Kilometers at the average speed and at free-flow speeds is termed delay.
6. Calculate daily recurring vehicle-hour delay by the following formula:

4.3.2 Estimation of Delay from Nonrecurring Traffic Congestion

Another type of delay encountered by travelers is the delay that results from incidents, Security Checks, Vehicle Breakdowns, Random Minibus Stops, and finally Random Pedestrian Crossings. Incident delay is related to the frequency of crashes or vehicle breakdowns, how easily those incidents are removed from the traffic lanes and shoulders and the "normal" amount of recurring congestion. The basic procedure used to estimate incident delay in this study is to multiply the recurring delay by a ratio.

The process used to develop the delay factor ratio is a detailed examination of the freeway characteristics and volumes. In addition, a methodology developed by the Texas Transportation Institute is used to model the effect of incidents based on the design characteristics and estimated volume patterns.

The road incident delay factor is calculated based on TTI method. The process used to develop the delay factor ratio is a detailed examination of the road characteristics and volumes. The consultant uses daily traffic influencing events in the car floating survey to estimate the incident delay factor.
Incident delay occurs in different ways on streets than freeways. While there are driveways that can be used to remove incidents, the crash rate is higher and the recurring delay is lower on streets. Arterial street designs are more consistent from city to city than freeway designs. For the purpose of this study, the road incident delay factor for arterial streets is estimated between 110 to 160 percent of arterial street recurring delay depending on:

- No. of accidents
- Security checks
- Vehicle breakdowns
- Random Microbus stops
- Random pedestrian crossings

Based on engineering judgment most of the corridors are allocated the value of 1.1 as the incident delay ratio.

For corridor 1 with the following nonrecurring events, the value of 1.3 is considered as the incident delay ratio.

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

For corridor 3 with the following nonrecurring events, the value of 1.6 is considered as the incident delay ratio

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

For corridor 4 with the following nonrecurring events, the value of 1.2 is considered as the incident delay ratio

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

Inputs and assumptions

It should be noted that estimating recurrent as well as nonrecurring delay costs needs update data for the value of time, and vehicle occupancy factor. The vehicle occupancy factor for diverse vehicular modes is assumed as follows:

Passenger Transportation:

Table 4.1: Vehicle occupancy factor for diverse vehicular modes (passenger)

Passenger car	Pickup	Motorcycle	Taxi	Microbus	Minibus	Bus
1.5	1.3	1.0	2.5	13	21	49

Freight Transportation:

Table 4.2: Truck Load capacity (Ton)

Light Truck	Medium Truck	Large Truck
5	9	15

Source:
The strategic Development Master Plan Study for Sustainable Development of the Greater Cairo region in the Arab Republic of Egypt March 2008

In order to monetize the delays to costs, the following value of time classified for passenger car users, taxi users, and transit riders have been applied. The value of time for motorcyclists is assumed to be equal to that for transit riders.

Table 4.3: Value of time for diverse transport user classes (adjusted for 2010)

Passenger car users (LE/hr)	Taxi users (LE/hr)	Transit riders (LE/hr)	Freight transporters (LE/ton)
13,8	5,4	3.5	4.2

Sources:
For passenger transport: *Transportation Master Plan and Feasibility Study of Urban Transport Projects in Greater Cairo Region in the Arab Republic of Egypt, November 2002*

For freight transport: Developing Harmonized European Approaches for Transport Costing and Project Assessment (HEATCO), May 2006

Working Days
Cost calculations were based on 250 working days per year.

4.3.3 Total Delay Cost for 11 Corridors

The annual recurring and nonrecurring cost for the 11 corridors amount to **2.6 billion LE** using approach 1 (speed plots) and **2.4 billion LE** using approach 2(V/C ratios).

The share of recurrent delay costs is estimated to be approximately 40% leaving 60% for the non-recurrent delay (valid for both approaches). The estimation is based on the TTI methodology in which ratios have been determined on recurrent and non-recurrent delays. The information in the Floating Car Survey on the level of incidents in the corridors is used in this estimation; it is noted that the duration of the incidents is not known. Nevertheless, the non-recurrent delays are a substantial part of the delay costs, indicating that avoiding vehicle breakdowns and incidents provides substantial benefits.

Further information and a series of detailed analyses on delay costs for individual corridors can be found in Annex 11.

4.4 Costs of Travel Time Unreliability

Basically, average travel time between two destinations includes both expected and unexpected delays. It is assumed that network users accommodate expected delays into their travel time through, say, the inclusion of buffer time. However, it is more difficult and costly to incorporate the unpredictable the unexpected delays that lead to variation from planned or anticipated travel time.

The terms unreliability and congestion are often used synonymously. However, a congested network does not necessarily have to be unreliable. Unreliability refers to unanticipated delays, and therefore a congested network is not necessarily unreliable because journey time along a congested road can be fairly predictable. However, congestion increases the likelihood of unreliability: as traffic levels increase the time delays due to slight perturbations tend to increase more than proportionality.

4.4.1 Observed Travel Time Unreliability

A wide variety of temporal indicators (e.g. STD, COV, 95th Percentile, Buffer time index) can be used to provide a range of perspectives of the reliability issue. The consultant applied the *Coefficient of Variation of Travel time (COV)* in observed travel speeds from multiple floating car runs in the corridors as the travel time reliability measure. This approach is chosen since it directly uses the outcomes of the Floating Car Survey. 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)
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).

The coefficient of variation of travel times is defined as standard deviation divided by mean travel time:

$$COV_i = \frac{STD_i}{\bar{T}_i}$$

Where:
i: corridor number
STD: The standard deviation of travel time
$\bar{T}$: The mean travel time

$$STD_v = standard\ deviation\ of\ speeds$$

$$STD_T = standard\ deviation\ of\ travel\ times = \frac{L}{STD_v}$$

$$T = \frac{L}{V}$$

4.4.2 Cost of Unreliability for 11 Corridors

In general, reliability is highly valued by travelers and commercial vehicle operators reflecting the fact that a reliable transport network is a net benefit for society and that an unreliable network represents a net cost to society. A lot of work has been carried out in among others the Netherlands to monetize unreliability of travel time. Based on the research's outcomes (OECD 2010) and the local conditions, the consultant assumed the following rates for monetizing travel time unreliability:

Passenger cars and motorcycle:	1.0 minute travel time variation is equivalent to 0.9 minute travel time
Public Transport including taxi:	1.0 minute travel time variation is equivalent to 1.1 minute in vehicle travel time

It should be noted that reliability perception is a controversial issue and may range from 0.9 to 2.5 in different countries *(Senna 1991; Copley et al 2002)*. Also, due to lack of reliable source for economic valuation of buffer time index, the consultant uses the standard deviation of travel time derived from COV in economic analyses.

In order to estimate the accurate value of reliability, a SP survey seems to be essential. Given the aforementioned values, the consultant estimates monetary value of travel time unreliability for the 11 corridors as well as for all road users. The freight users have been excluded since no rates for monetizing travel time unreliability are available.

The total unreliability associated cost for the 11 corridors is estimated approximately **1.7 billion LE**. The level of unreliability costs is close to the delay costs, which is mainly caused by the assumed ratio of minutes travel time variation equivalent to minutes travel time.

Further information and a series of detailed analyses on unreliability associated costs for individual corridors can be found in Annex 11.

4.4.3 Unreliability in freight transport

Given the lack of sufficient information on annual cargo shipment volume and type in the Cairo region, the consultant is incapable to estimate the cost of unreliability in freight transportation. However, a rough estimation based on the annual tonnage of cargo transported in the region could be made to give a clue on impacts of unreliability on freight transport cost. The consultant applies the criterion of Willingness To Pay (WTP) which is derived from cargo transport companies in Nigeria. The case study has been done by Ogwude in (1990-1993) and reported in National Cooperative Highway Research Program (NCHRP 431). The Nigerian firms were willing to pay for 1.6 and 0.6 Naira per ton of consumer and capital goods respectively to reduce the standard deviation of travel time by an hour. Given the aforementioned value and inflation rate in the country, the consultant estimate the Willingness to Pay for Egypt approximately 0.70 LE and 0.26 LE per ton of consumer and capital goods respectively to reduce the standard deviation of travel time by an hour.

Thus, the total unreliability cost for freight transportation is estimated around **13.5 Million LE per year.**

4.5 Cost of Excess Fuel Consumption

The average fuel economy calculation is used to estimate the fuel consumption of the vehicles running in the congested condition. The formula used is derived from the TTI methodology, a metric conversion has been applied to the equation since it is originally formulated based on non metric units (Miles per Gallon).

In order to estimate excess fuel consumption due to traffic congestion the following steps are applied:

- Calculate average speed
- Calculate average fuel efficiency

- Calculate total excess fuel (liters) used as a result of recurring and nonrecurring delay, based on the mix of traffic and fuel used (diesel and gasoline)

The total annual gasoline consumption for the 11 corridors due to congestion is estimated around **608 million liters** (2.4 million liters per morning and evening peak hours – approach 1) and **552 million liters** (2.2 million liters per morning and evening peak hours – approach 2).

Similarly, the total annual diesel consumption for the 11 corridors due to congestion is estimated around **102 million liters** (410 thousands liter per morning and evening peak hours) by using approach 1 and **81 million liters** (326 thousand liters per morning and evening peak hours) by using approach 2.

Based on an interview with a petroleum company in Cairo, the following tariffs have been applied to estimate the total excess Gasoline and Diesel costs in Cairo:

- Gasoline (grade 80): 0.90 LE
- Gasoline (grade 90): 1.75 LE
- Gasoline (grade 92): 1.85 LE
- Gasoline (grade 95): 2.75 LE
- Diesel: 1.10 LE

Furthermore, it should be noted that a fuel subsidy has been assumed being 2.2 LE/Ltr for gasoline, and 1.1 LE/Ltr for Diesel according to GTZ Transport Policy Advisory reported in International Fuel Prices (2009). Both the costs for the users of excess fuel and the costs for the Government (subsidy provided) have been calculated:

Table 4.4: Excess fuel cost in the Greater Cairo because of traffic congestion

Approach 1			Approach 2		
Excess fuel cost imposed to transport users	Excess Fuel Subsidy	Excess total Fuel Cost	Excess fuel cost imposed to transport users	Excess Fuel Subsidy	Excess total Fuel Cost
1.20	1.46	2.85	1.08	1.30	2.38

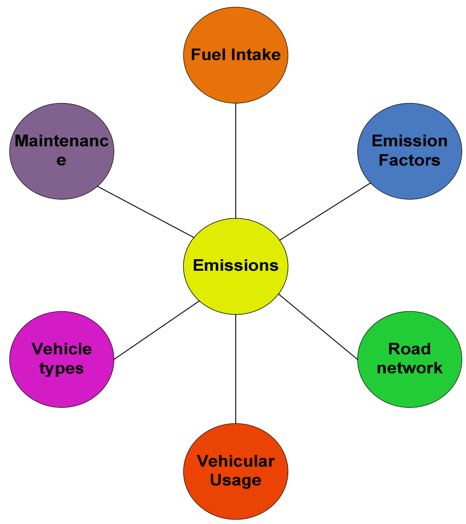
The total excess fuel costs for the 11 corridors are estimated to be **2.85 billion LE** using approach 1 (speed plots) and **2.38 billion LE** using approach 2(V/C ratios). The share of the costs to the user is 45% and the costs for the Government represent 55% of the total amount.

Further information and a series of detailed analyses on excess fuel consumption and costs for individual corridors can be found in Annex 11.

4.6 Associated Cost of CO_2 Emissions due to Excess Fuel Consumption

This section outlines the method of estimating emissions from vehicular activity using available data from car floating survey.

A number of studies, in developed and developing countries, apportioning the sources of air pollution put the transport sector atop – both from direct exhaust and indirect road dust. Increasing fuel consumption on the road mean emissions increase, air quality will only get worse. The following figure provides the framework for the emissions from road traffic. The fuel intake is one of the elements determining the level of emissions.



Given the following standard emission rates for diverse vehicular modes, the CO_2 emission caused by excess fuel consumption due to congestion is estimated per year.

Table 4.5: The emission rate for diverse vehicular modes

Emission rate	CO2
Vehicular Mode	**kg/L**
Cars (diesel and gasoline)	2,40
Motorcycle	2,42
Taxi	2,40
Bus	2,41
BRT	2,24

Source: *Guttikunda, S., 2008, Simple Interactive Models for Better Air Quality, Vehicular Air Pollution Information System VAPIS. www.sim-air.org*

Likewise other cost components, the consultant applied both approaches to estimate emission weight and consequent cost for the region.

The total CO2 emission weight is estimated 1.7 million ton per annum for the 11 corridors using approach 1 (speed plots).The emission cost for each corridor is estimated by converting emission weights to costs. The consultant applied the conversion factor 57 (LE/Ton) based on the World Bank estimation. The total emission costs due to traffic congestion for the 11 corridors is estimated approximately **97 million LE** per annum.

When applying approach 2 (V/C ratios), the total CO2 emission weight is estimated 1.5 million ton per annum for 11 corridors and the emission cost due to traffic congestion is estimated approximately **86 million LE** per annum.

Further information and a series of detailed analyses on emission costs for 11 corridors can be found in Annex 11.

4.7 Total Direct Costs of Traffic Congestion for 11 Corridors

Summarizing the aforementioned traffic congestion cost components, the total direct traffic congestion cost for the 11 corridors is estimated as follows by:

Table 4.6: Direct cost components of traffic congestion (approach 1)

Delay cost	Unreliability cost	Excess fuel cost	Excess fuel subsidy	Emission Cost	Total cost
2.625.668.148	1.712.392.281	1.207.697.012	1.451.004.736	97.299.441	**7.094.061.618**

Table 4.7: Direct cost components of traffic congestion (approach 2)

Delay cost	Unreliability cost	Excess fuel cost	Excess fuel subsidy	Emission Cost	Total cost
2.375.181.344	1.712.392.281	1.084.507.106	1.305.544.977	86.813.921	**6.564.439.628**

The data that has been used for all calculations is presented in Annex 12.

Figure 4.1 and 4.2 illustrates the total direct economic cost of traffic congestion for 11 corridors given the approach 1 and 2. The main cause of difference between results of these two approaches is the applied method to determine the congested part of the corridors. Due to lack of sufficient information on legal and illegal onsite parking status on the corridors, police checks, random pedestrian crossings and microbus stops, the actual corridor's capacity in approach 2 might be overestimated and thus results in lower traffic congestion cost compared to approach 1. This is especially the case for corridors 2, and 10 which is the estimated length of congested segments in approach 2 is shorter than that in approach 1.

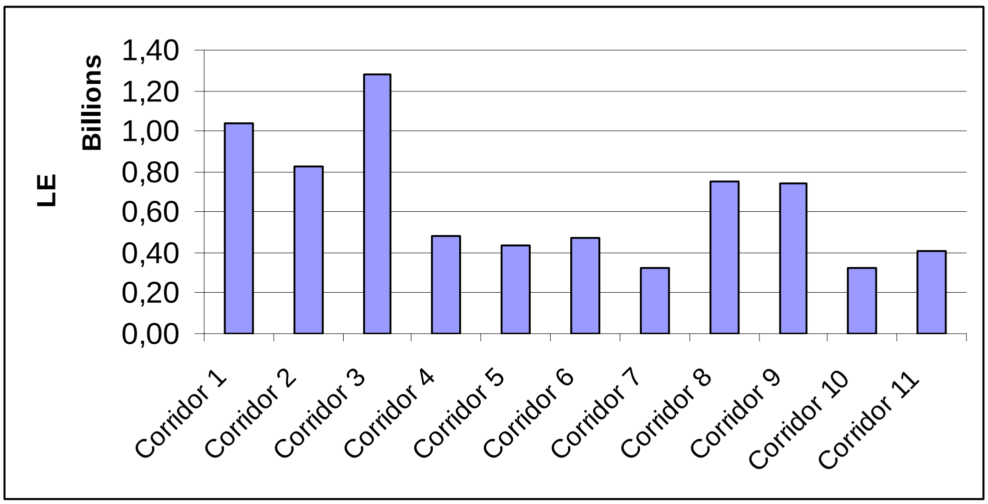


Figure 4.1 Total annual direct cost due to traffic congestion in 11 corridors (approach 1)

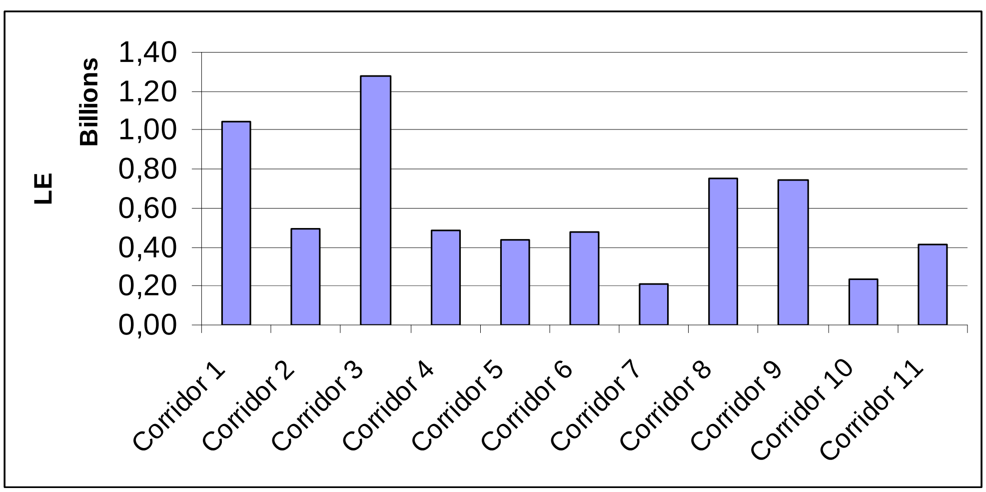


Figure 4.2 Total annual direct cost due to traffic congestion in 11 corridors (approach 2)

The figure shows that transportation in corridor 1 (26th of July/15th of May Travel Corridor) and corridor 3 (Ring Road Southern segment) faces the highest excess cost due to traffic congestion in Cairo compared to other corridors. For corridor 3, total excess cost exceeds 1.28 billion LE annually. This amount decreases for corridor 1 and approximately reaches to 1.1 billion LE per annum.

4.8 Sensitivity analysis

As indicated before, in the 2nd approach the congestion threshold is determined by using the V/C index. The road capacity in the GCMA is affected by onsite parking. In the lack of a comprehensive parking inventory analysis the consultant assumed that one lane of the corridors is occupied during peak hours by legally and/or illegally parked vehicles. By restricting onsite parking to 50% of corridors' length (instead of no restriction), the congestion level in the corridors decreases accordingly. In this case the total traffic congestion cost can be reduced down to 20%. In other words, an onsite parking inventory analysis on the GCMA network seems to be essential and would lead to more precise estimation of congestion cost in the region.

The second sensitivity analysis was performed based on the value of time for all road users (passenger car users, taxi users, transit users, and freight transporters). The analysis demonstrates that ± 1 LB change in the VoT results in approximately ± 8% alteration in the total congestion cost.

The third sensitivity analysis focused on fuel economy formulation. The consultant used the original fuel efficiency formula calibrated in 80th decade base on the US car fleet composition. In other words, the average fuel consumption is estimated around 10 litres/100 km (24 MPG) in the city based on speed of 60 Km/hr. The actual fuel consumption in Cairo depends on the fleet composition and the age of the fleet. This information is not yet available. In absence of fleet data, a sensitivity analysis has been conducted. The analysis results show that 20% reduction in fuel efficiency (12 liters/ 100 km), increases the excess fuel cost, the excess emission cost, and the total congestion cost around 25 %, 25% , and 10% respectively.

4.9 Total Direct Cost of Traffic Congestion for GCMA

The 11 corridors have been selected to represent the vast majority of traffic congestion locations in GCMA and have been done together with traffic police representatives. Clearly, the direct congestion costs of the entire GCMA will be higher compared to the amount calculated for the 11 corridors.

In order to estimate congestion cost for the entire GCMA, crucial information is needed to be able to calculate vehicle capacity ratios. The calculation of V/C ratios can only be done through assigning the total traffic to the total network. The following information is needed:

- Transit route(s) between OD pairs
- Taxi and shared taxi (microbus) route(s) between OD pairs
- Freight transportation routes between OD pairs
- Actual peak hour capacity of the routes
- Free flow speed, peak hour speed, and average speed of in the entire network

- The standard deviation of travel time in the route(s)

This listed information is not available, and therefore it is not possible to assign traffic to the network using transport modeling software.

The consultant used an alternative method to extend the direct economic cost of traffic congestion from 11 corridors to the GCMA and provide a framework for further research on the issue. The applied methodology can be outlined as a two step procedure as follows:

The consultant developed a Traffic Model in Emme3 based on the trip generation and distribution tables and the 11 major corridors attributes and alignments. By running this model we came out with traffic volumes in Greater Cairo distributed only on the 11 major corridors. Therefore, to calculate the percentage of the traffic in Greater Cairo carried by the 11 major corridors, we compared the actual traffic counts results to the Emme Traffic volumes on these corridors.

The method used is as follows:

- Summing up the traffic counts results on the 11 corridors in each direction and the total Emme traffic volume in one direction;
- Dividing the total traffic count in each direction by the total Emme traffic volume in one direction;
- Taking the average of the ratios in both directions.

This procedure was applied on the PM and AM traffic counts and the ratios turned out to be: 50.4% (AM) and 50.9% (PM). The average of these ratios has been used to extrapolate the congestion cost of the 11 corridors to the entire GCMA. The results are shown in the following tables:

Table 4.8: Direct cost components of traffic congestion for the entire GCMA (approach 1)

Delay cost	Unreliability cost	Excess fuel cost	Excess fuel subsidy	Emission Cost	Total cost
5.251.336.295	3.424.784.562	2.415.394.024	2.902.009.472	194.598.882	**14.188.123.236**

Table 4.9: Direct cost components of traffic congestion for the entire GCMA (approach 2)

Delay cost	Unreliability cost	Excess fuel cost	Excess fuel subsidy	Emission Cost	Total cost
4.750.362.688	3.424.784.562	2.169.014.212	2.611.089.953	173.627.841	**13.128.879.256**

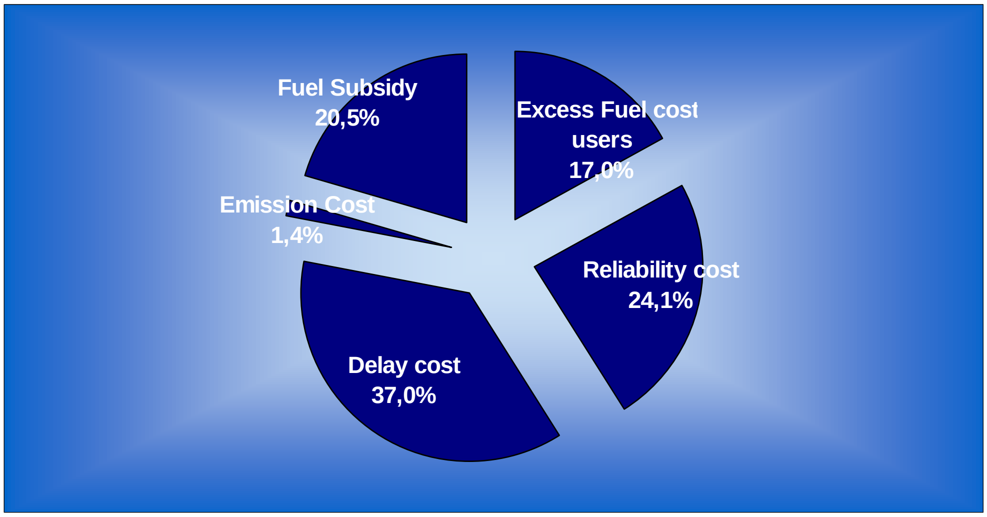


Figure 4.3 Distribution of total annual direct cost due to traffic congestion in GCMA (approach 1)

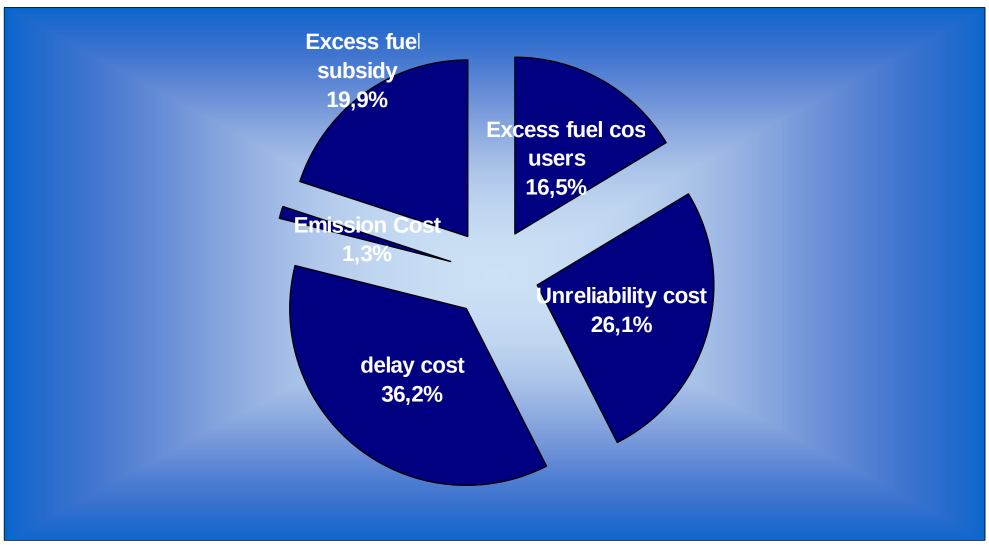


Figure 4.4 Distribution of total annual direct cost due to traffic congestion in GCMA (approach 2)

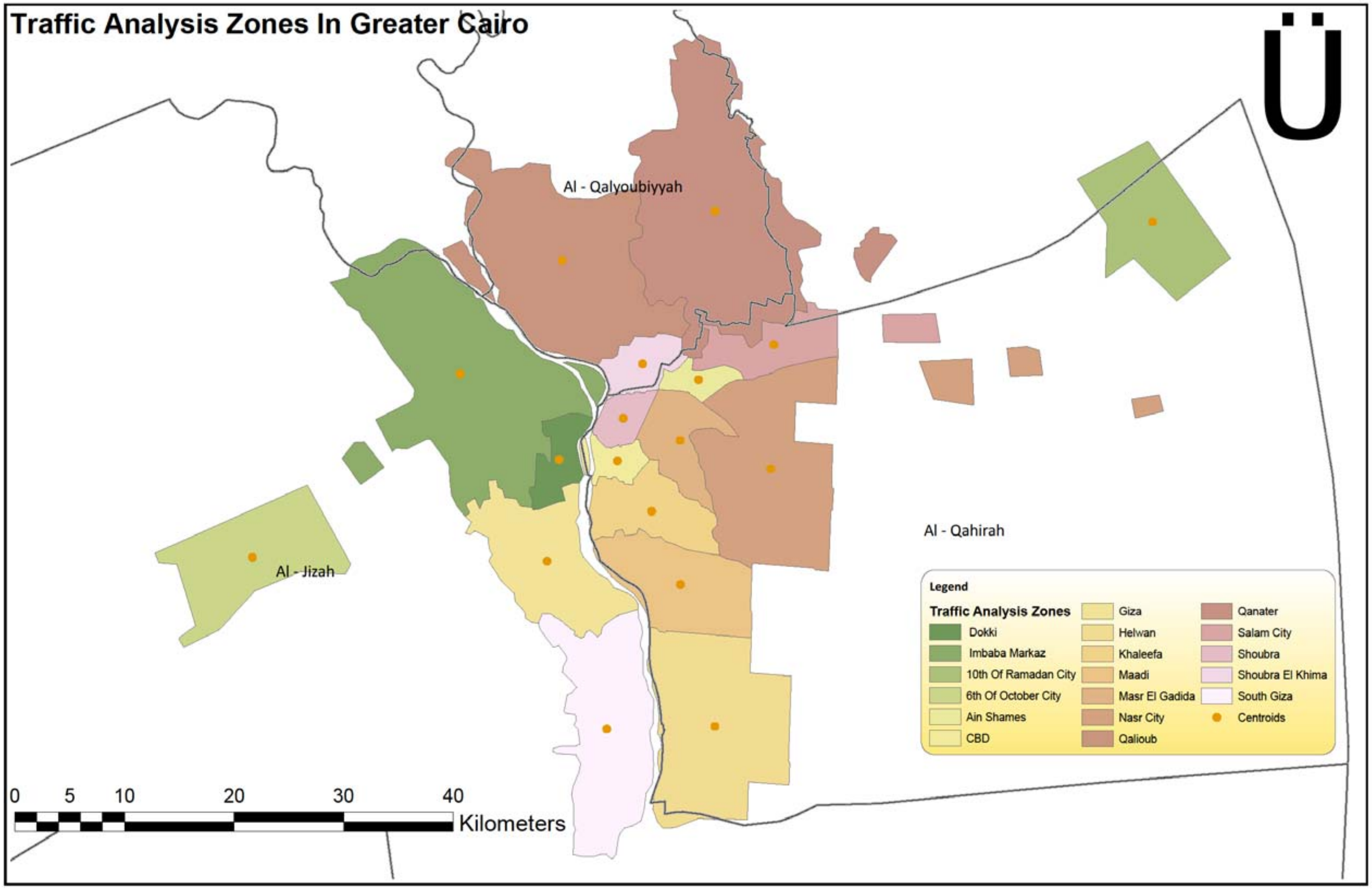
Based on the estimated figures the following conclusions are drawn:

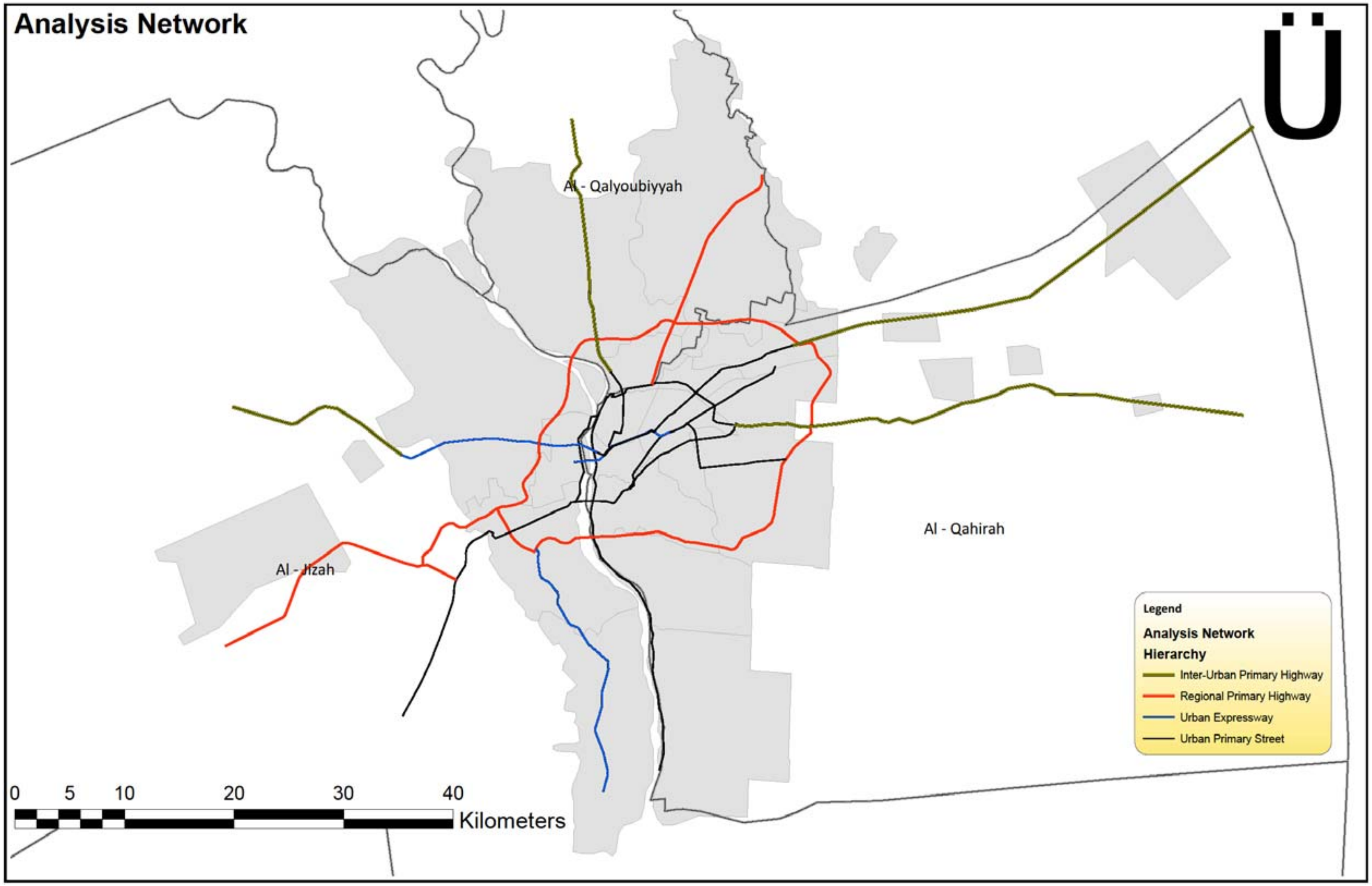
- The total annual direct congestion costs for GCMA is in the range from **13 to 14 billion LE.** This range is based on two approaches used: actual speed flow characteristics and calculated vehicle capacity ratios. The latter approach show higher values.
- The main contributor to the total direct cost is the delay costs (36%), which consist of recurrent and non-recurrent congestion costs. The non-recurrent delay costs represent approximately more than half of the total delay costs.
- The unreliability costs also represent a major part of total congestion costs (25%); though these costs are not as high as the total delay costs.
- The total share of the costs for excess fuel is 37% of total costs, of which half is paid by users (retail price of fuel) and the other half is additional costs to the Government (fuel subsidies).

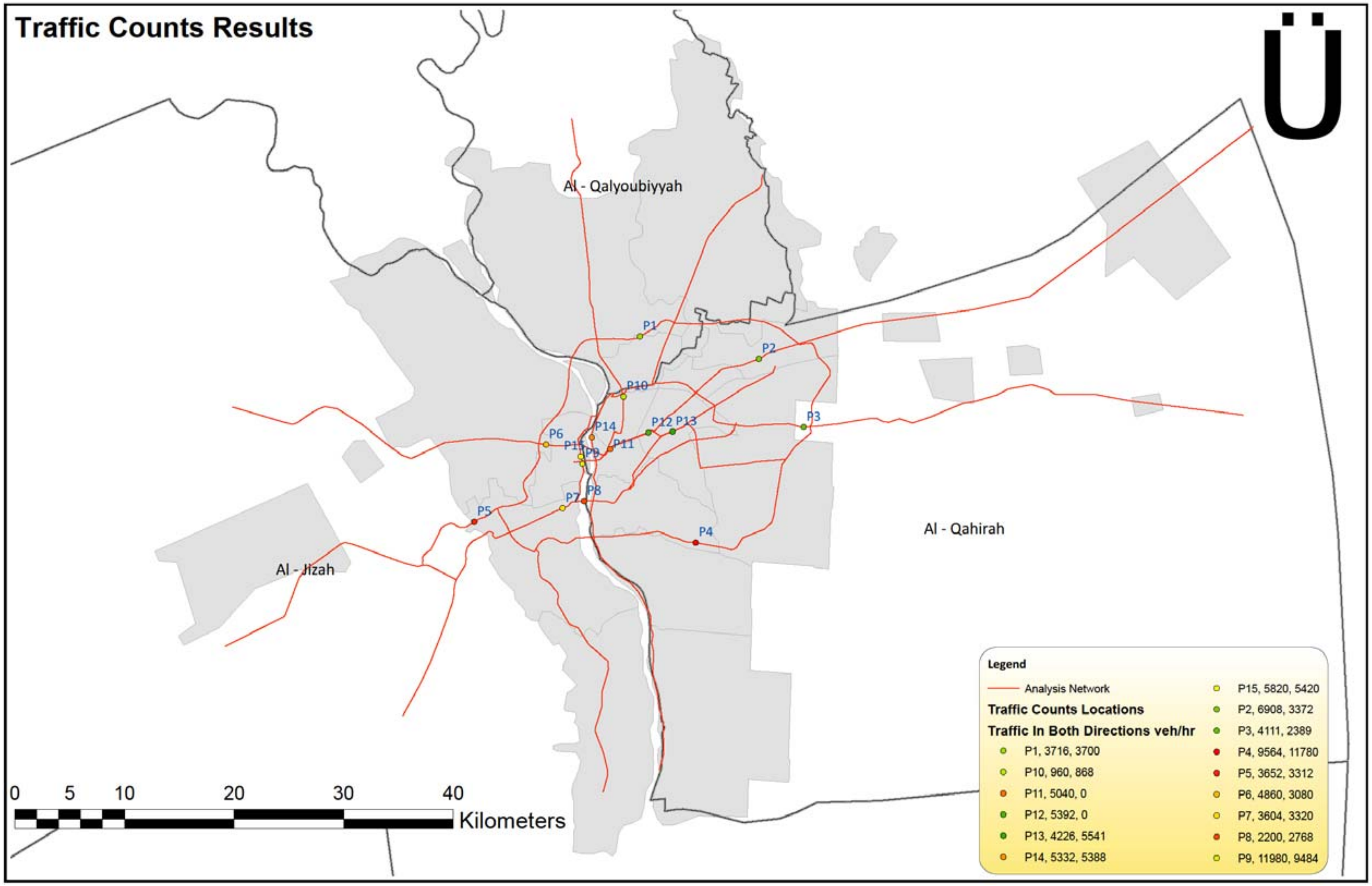
- The emission cost, which only consists of CO_2 emissions, is modest with a share of less than 1% of total costs.

An additional analysis has been carried comparing the traffic counts (2010 figures) and the Emme assigned traffic in

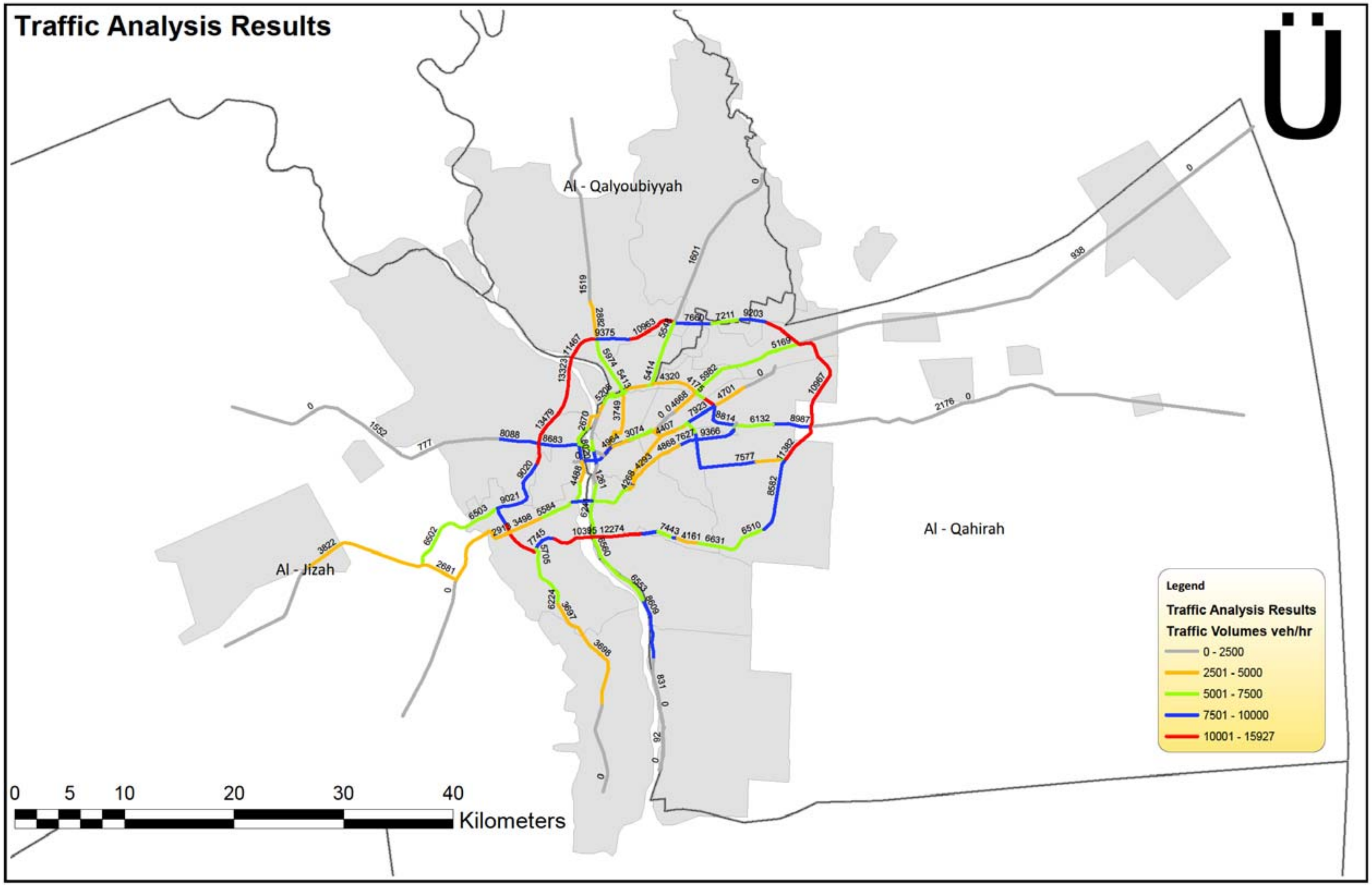
Tables 4.10, 4.11 4.12, and 4.13 summarize a comparison between traffic counts and EMME assignment results.


Traffic Analysis Zones In Greater Cairo
Al - Qalyoubiyyah
Al - Qahirah
Al - Jizah
Legend
Traffic Analysis Zones
Dokki
Imbaba Markaz
10th Of Ramadan City
6th Of October City
Ain Shames
CBD
Giza
Helwan
Khaleefa
Maadi
Masr El Gadida
Nasr City
Qalioub
Qanater
Salam City
Shoubra
Shoubra El Khima
South Giza
Centroids
0 5 10 20 30 40
Kilometers


Analysis Network
Al - Qalyoubiyyah
Al - Qahirah
Al - Jizah
0 5 10 20 30 40
Kilometers
Legend
Analysis Network Hierarchy
Inter-Urban Primary Highway
Regional Primary Highway
Urban Expressway
Urban Primary Street



Traffic Counts Results
Al - Qalyoubiyyah
Al - Qahirah
Al - Jizah
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
P15
0
5
10
20
30
40
Kilometers
Legend
Analysis Network
Traffic Counts Locations
Traffic In Both Directions veh/hr
P1, 3716, 3700
P10, 960, 868
P11, 5040, 0
P12, 5392, 0
P13, 4226, 5541
P14, 5332, 5388
P15, 5820, 5420
P2, 6908, 3372
P3, 4111, 2389
P4, 9564, 11780
P5, 3652, 3312
P6, 4860, 3080
P7, 3604, 3320
P8, 2200, 2768
P9, 11980, 9484



Traffic Analysis Results
Al - Qalyoubiyyah
Al - Qahirah
Al - Jizah
Legend
Traffic Analysis Results
Traffic Volumes veh/hr
0 - 2500
2501 - 5000
5001 - 7500
7501 - 10000
10001 - 15927
0 5 10 20 30 40
Kilometers

Table 4.10: Comparison Traffic Counts and Emme Assigned Traffic (vehicles/hour) (AM)

No	Road name	Traffic Count Direction 1 (v/h)	Traffic Count Direction 2 (v/h)	EMME Each direction
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	3299	3212	8879
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	5708	2766	5169
P3	Suez Desert Road / Between KM 4.5 and Ring Road	3051	1890	8988
P4	Ring Road / Carfour Al Maadi	6969	6716	7543
P5	Ring Road / Above Cairo-Alex Desert Road	3418	2981	6502
P6	26th July / Between Railway and Ring Road	4389	2398	7587
P7	Al-Ahram Street / Electricity Station	2242	2813	5584
P8	Middle of Abbas Bridge	1512	2022	7800
P9	6 October Bridge between Zamalk and Agozah	7400	7154	9685
P10	Ahmed Helmy Str./ Before Abo Wafya Bridge	651	497	3749
P11	Ramses St. between Ghmara and Ahmed Said St. (One Way to Abasia)	4244		4964
P12	Lotifi Al Said St. between Abasia and Ghamrah (One Way to Ramses Square)	4093		4648
P13	Salah Salem Str./Between Elfangary and Abbasey	3873	3600	4575
P14	Cornish El-Nil /Between 15th May & El-Sahel Bridge	2535	4016	5982
P15	Gamal Abd El-Naser (El-Nile St.)/Kornish al Agouza	4058	3000	8020
		57.4	43.1	99.7

Table 4.11: Comparison Traffic Counts and Emme Assigned Traffic (ratio count/model) (AM)

No	Road name	Direction 1	Direction 2
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	0,37	0,36
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	1,10	0,54
P3	Suez Desert Road / Between KM 4.5 and Ring Road	0,34	0,21
P4	Ring Road / Carfour Al Maadi	0,92	0,89
P5	Ring Road / Above Cairo-Alex Desert Road	0,53	0,46
P6	26th July / Between Railway and Ring Road	0,58	0,32
P7	Al-Ahram Street / Electricity Station	0,40	0,50
P8	Middle of Abbas Bridge	0,19	0,26
P9	6 October Bridge between Zamalk and Agozah	0,76	0,74
P10	Ahmed Helmy Str./ Before Abo Wafya Bridge	0,17	0,13
P11	Ramses St. between Ghmara and Ahmed Said St. (One Way to Abasia)	0,85	
P12	Lotifi Al Said St. between Abasia and Ghamrah (One Way to Ramses Square)	0,88	
P13	Salah Salem Str./Between Elfangary and Abbasey	0,85	0,79
P14	Cornish El-Nil /Between 15th May & El-Sahel Bridge	0,42	0,67
P15	Gamal Abd El-Naser (El-Nile St.)/Kornish al Agouza	0,51	0,37

Table 4.12: Comparison Traffic Counts and Emme Assigned Traffic (vehicles/hour) (PM)

No	Road name	Traffic Count Direction 1 (v/h)	Traffic Count Direction 2 (v/h)	EMME Each direction
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	2968	2985	8879
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	5532	2821	5169
P3	Suez Desert Road / Between KM 4.5 and Ring Road	3996	2009	8988
P4	Ring Road / Carfour Al Maadi	7821	9605	7543
P5	Ring Road / Above Cairo-Alex Desert Road	2765	2958	6502
P6	26th July / Between Railway and Ring Road	3323	2499	7587
P7	Al-Ahram Street / Electricity Station	3267	2318	5584
P8	Middle of Abbas Bridge	1765	2464	7800
P9	6 October Bridge between Zamalk and Agozah	5695	3197	9685
P10	Ahmed Helmy Str./ Before Abo Wafya Bridge	606	726	3749
P11	Ramses St. between Ghmara and Ahmed Said St. (One Way to Abasia)	4448		4964
P12	Lotifi Al Said St. between Abasia and Ghamrah (One Way to Ramses Square)	4111		4648
P13	Salah Salem Str./Between Elfangary and Abbasey	3773	5454	4575
P14	Cornish El-Nil /Between 15th May & El-Sahel Bridge	3460	3249	5982
P15	Gamal Abd El-Naser (El-Nile St.)/Kornish al Agouza	3513	4192	8020
		57.043	44.447	99.675

Based on the traffic counts, the total number of vehicles in peak hours in the eleven corridors is estimated around 605.000 PCU per morning and evening peak hours. Similarly, the total number of vehicles in peak hours in the entire GCMA is approximated to 1.210.000 PCU per morning and evening peak hours.

Given the figures above, the total direct cost of traffic congestion for the entire GCMA is estimated as follows:

Table 4.13: Comparison Traffic Counts and Emme Assigned Traffic (ratio count/model) (PM)

No	Road name	Direction 1	Direction 2
P1	Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd	0,33	0,34
P2	Gesr El-Suez/between Ring Road and Ainshams Str.	1,07	0,55
P3	Suez Desert Road / Between KM 4.5 and Ring Road	0,44	0,22
P4	Ring Road / Carfour Al Maadi	1,04	1,27
P5	Ring Road / Above Cairo-Alex Desert Road	0,43	0,45
P6	26th July / Between Railway and Ring Road	0,44	0,33
P7	Al-Ahram Street / Electricity Station	0,59	0,42
P8	Middle of Abbas Bridge	0,23	0,32
P9	6 October Bridge between Zamalk and Agozah	0,59	0,33
P10	Ahmed Helmy Str./ Before Abo Wafya Bridge	0,16	0,19
P11	Ramses St. between Ghmara and Ahmed Said St. (One Way to Abasia)	0,90	
P12	Lotifi Al Said St. between Abasia and Ghamrah (One Way to Ramses Square)	0,88	
P13	Salah Salem Str./Between Elfangary and Abbasey	0,82	1,19
P14	Cornish El-Nil /Between 15th May & El-Sahel Bridge	0,58	0,54
P15	Gamal Abd El-Naser (El-Nile St.)/Kornish al Agouza	0,44	0,52

As the results show, there is a major difference between traffic counts and the Emme model in most of the count stations. It is recommended to further analyse these differences before using the present model for transport planning purposes.

4.10 Breakdown of Traffic Congestion costs

Tables 4.14 and 4.15 outline congestion costs breakdown for the entire GCMA for the flowing vehicular modes:

- Passenger cars
- Transit (incl. Taxi, Microbus, Minibus, Bus)
- Freight transport

As the results show, the share of passenger cars in traffic congestion costs is the highest (56%). Public transport also contributes significantly in traffic congestion costs (41%). The share of freight transportation is the lowest (7 %).

Table 4.8:Breakdown of traffic congestion costs for the entire GCMA (Approach 1)

GCMA		Excess Fuel cost users	Reliability cost	Delay cost	Emission Cost	Fuel Subsidy	Total cost
Vehicular mode	Passenger Car	1.554.736.357	1.532.168.985	2.827.446.364	124.543.284	1.900.233.325	7.939.128.316
	Transit	711.745.492	1.857.479.502	2.251.811.697	56.433.676	852.863.972	5.730.334.339
	Freight	148.912.175	27.061.318	156.030.239	13.621.922	148.912.175	494.537.828

Table 4.9:Breakdown of traffic congestion costs for the entire GCMA (Approach 2):

GCMA		Excess Fuel cost users	Reliability cost	Delay cost	Emission Cost	Fuel Subsidy	Total cost
Vehicular mode	Passenger Car	1.412.431.994	1.532.168.985	2.559.609.174	111.121.818	1.726.305.771	7.341.637.743
	Transit	637.997.790	1.857.479.502	2.043.672.258	50.352.074	766.199.755	5.355.701.378
	Freight	118.584.427	27.061.318	131.491.781	12.153.949	118.584.427	407.875.903

4.11 Zonal Based Direct Economic Cost of Traffic Congestion

In this section the distribution of congestion cost to traffic zones is dealt with. In order to determine direct economic cost in a disaggregate level for each zone of GCMA; the consultant considers the following factors for each zone:

- Geographic size
- Local road types
- Traffic network types
- Number of available lanes in the traffic network
- Land use

Figure 4.5 illustrates local road types in GCMA. Local road types are divided into 3 classes:

- Dual Carriage Road
- Main Paved Road
- Secondary Paved Road

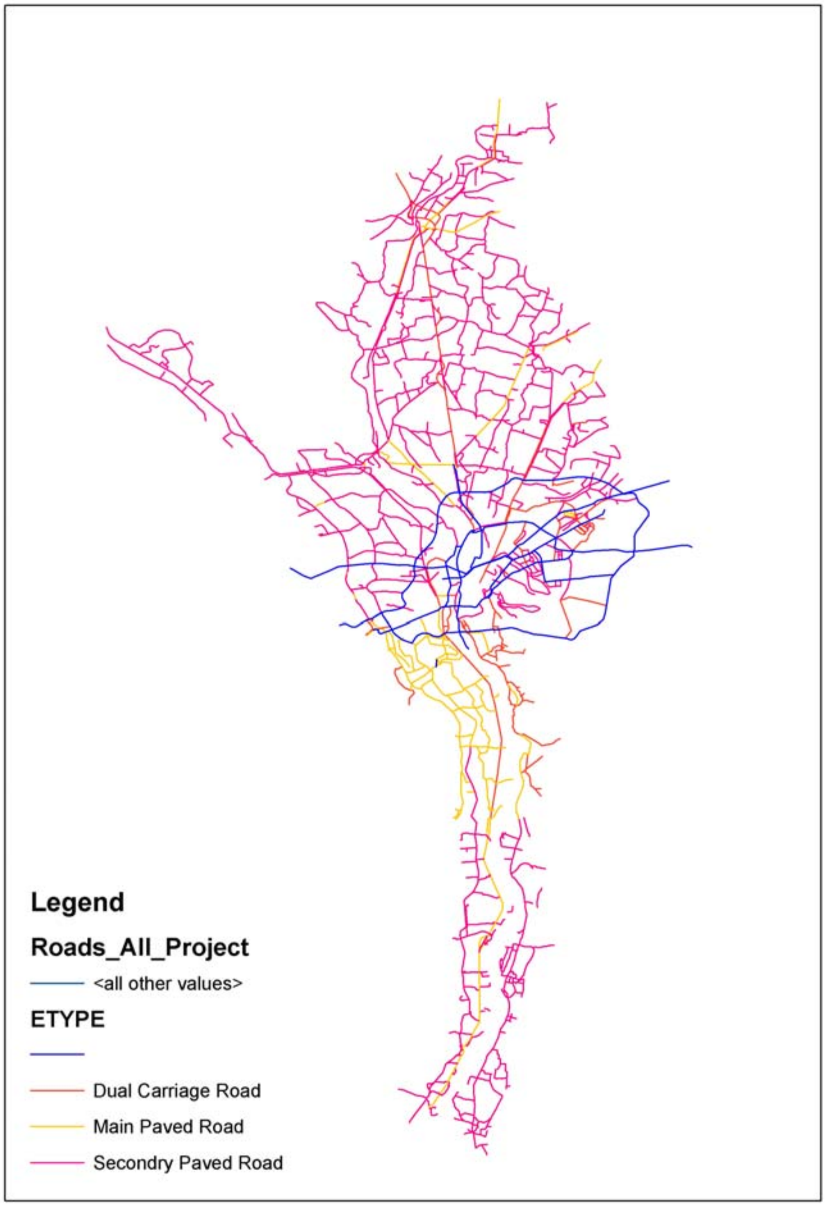


Figure 4.5 Local road types in GCMA

As is shown, most of the local roads in the suburban area belong to dual carriage road class with one lane available capacity in each direction. Excluding interzonal trips that are normally made via local network, it is not expected that main traffic between zones use such local roads.

Figure 4.6 illustrates traffic network types in the entire GCMA. The network consists of 5 road types as follows:

- Inter- Urban Primary Highway
- Regional Primary Highway

- Urban Expressway
- Urban Primary Street
- Other

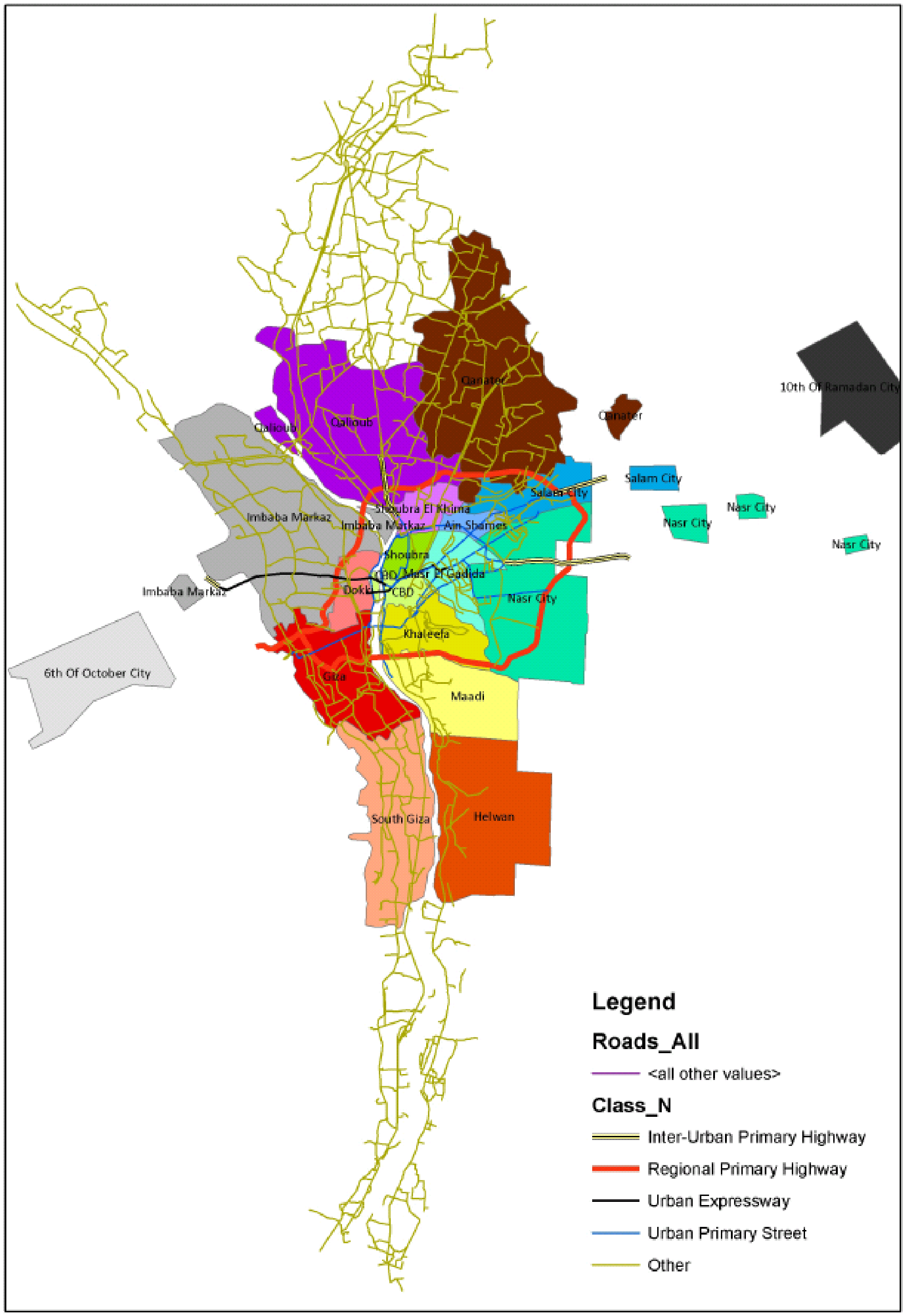


Figure 4.6 **Traffic Network types in GCMA**

Table 4.16 outlines GCMA zones existing network types:

Table 4.10: GCMA zones network types

Zone	InterUrban Primary Highway	Regional Primary Highway	Urban Expressway	Urban Primary Street	Local
South Giza					
Helwan					
10th of Ramadan					
6th of October					
Giza					
Imbaba Markaz					
Maadi					
Khaleefa					
Dokki					
CBD					
Shoubra					
Nasr City					
Ain Shams					
Masr Al Gadida					
Salam City					
Shoubra El Khima					
Qanater					
Qalioub					

Figure 4.7 illustrates the number of lanes in the main corridors of the region.

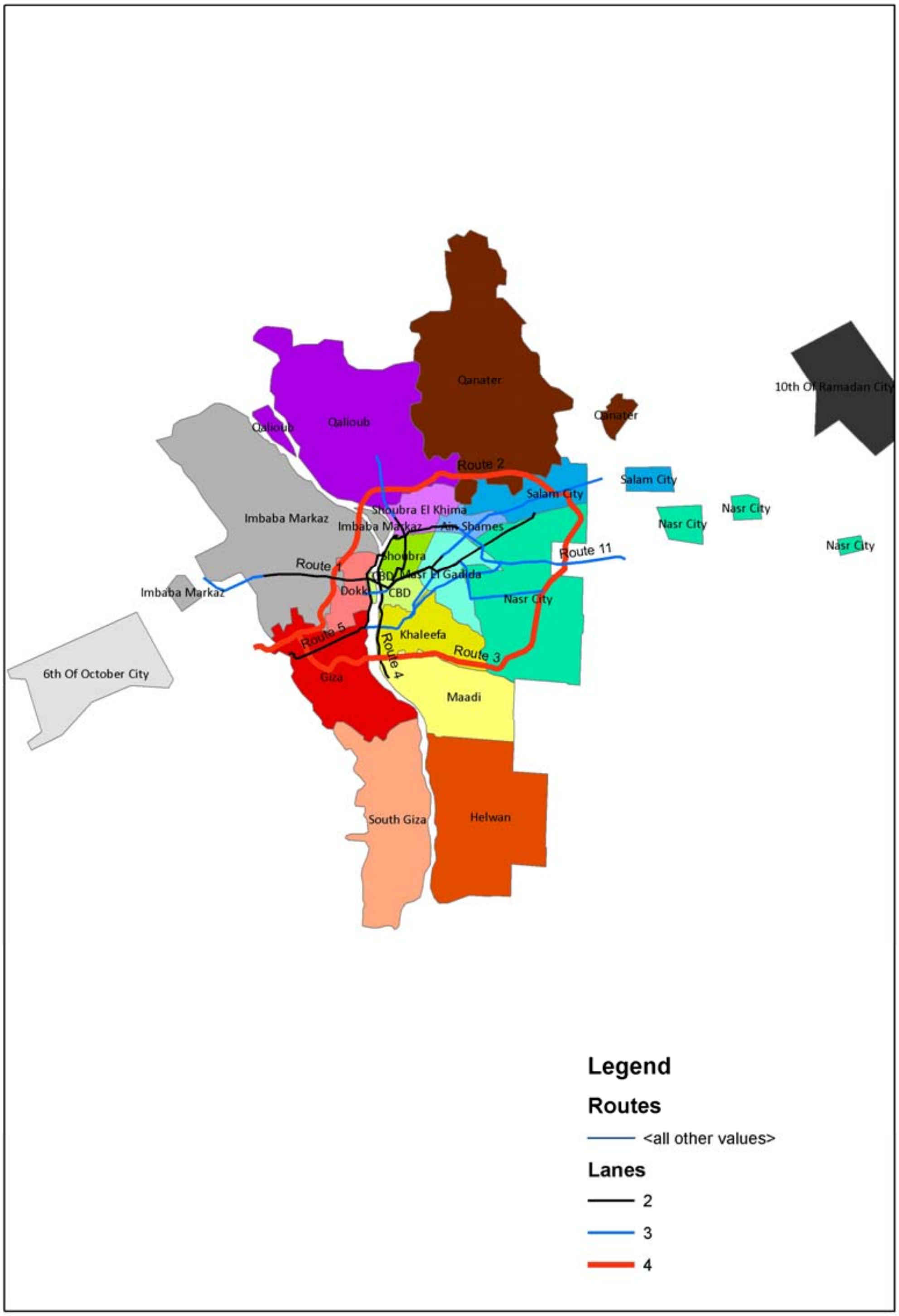


Figure 4.7 Number of Lanes in Main corridors of GCMA

As it is shown in the most of regions, especially suburbs, local roads having one lane in each direction are predominant. Although the ring road contains 4 lanes, the number of lanes in other main corridors is commonly limited to 3, or even 2.

Figure 4.8 illustrates the land use as well as network classes in the entire GCMA. Agriculture is the predominant land use in the most of the region especially in the suburbs.

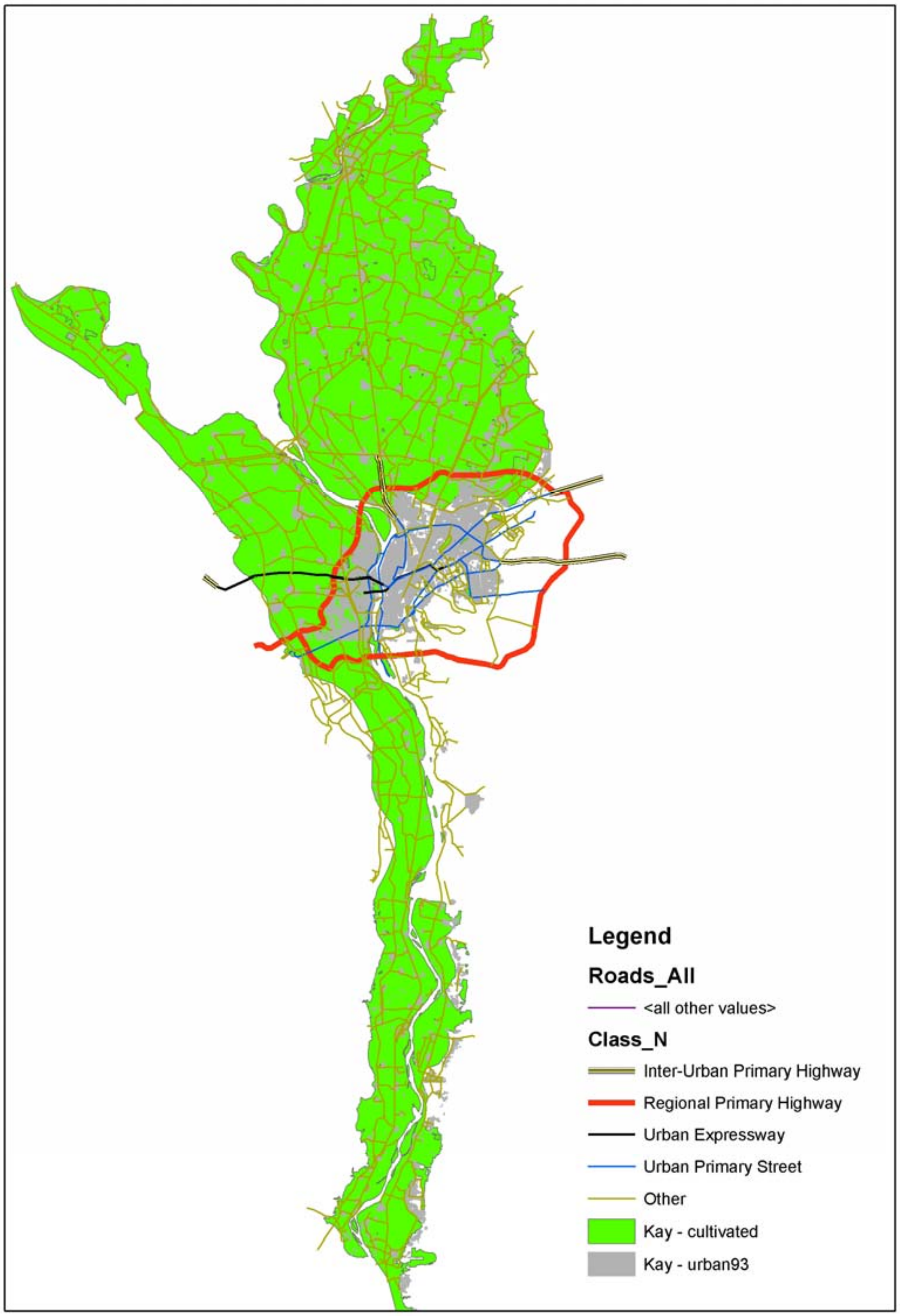


Figure 4.8 Land use and Network classes in the GCMA

Table 4.17 outlines the land use of GCMA zones.

Table 4.11: Predominant Land Use of GCMA

Zone	Agriculture	Urbanized
South Giza		
Helwan		
Giza		
Imbaba Markaz		
Maadi		
Khaleefa		
Dokki		
CBD		
Shoubra		
Nasr City		
Ain Shams		
Masr Al Gadida		
Salam City		
Shoubra El Khima		
Qanater		
Qalioub		

In order to calculate the share of each traffic zone of total direct economic of traffic congestion the aforementioned information are used by the consultant. The following factors are used to determine the share of each traffic zone from congestion:

- Number of originated and attracted trips from the adjusted OD matrix from JICA for 2010 *as proxy for traffic flow*
- Network type(s) *as proxy for design road capacity and free flow speed*
- Number of trips per lane-kilometer *as proxy for actual road capacity and average speed*
- Land Use *as proxy for level of congestion*
- The Network length

The congestion costs in the eleven corridors cover the following zones: Salam City, Nasr City, Khaleefa, Giza, Dokki, CBD, Masr El Gadida, Shoubra, Shoubra El Khima, Part of Imbaba Markaz and Ain Shams.

The share of each aforementioned zone based on the trip production/attraction, the network type and the network capacity are approximated (table 4.18).

Table 4.12: Traffic congestion cost in traffic zones in the GCMA

District	Share of Congestion (%)	Congestion cost Million LE(approach 1)	Congestion cost Million LE (approach 2)
Ain Shams	3.4	237.9	220.1
CBD	5.8	410.5	379.8
Dokki	8.3	592.0	547.8
Giza	14.7	1,043.4	965.5
Khaleefa	7.5	530.1	490.5
Masr El Gadid	19.0	1,345.3	1,244.8

Nasr City	23.6	1,675.8	1,550.7
East side Imbaba Markaz	6.2	443.1	410.0
Salam City	3.8	270.3	250.1
Shoubra	5.5	389.5	360.5
Shoubra El Khima	2.2	156.0	144.3
Total	100.0	7,094.1	6,564.4

Similarly, the method is applied for suburban areas. Table 4.19 summarizes the congestion costs for traffic zones located in the suburbs.

Table 4.13: Traffic congestion cost in suburban traffic zones in the GCMA

District	Share of Congestion (%)	Congestion cost Million LE(approach 1)	Congestion cost Million LE (approach 2)
10th of Ramadan	6.3	445.6	412.3
6th of October	8.5	600.0	555.2
Helwan	3.0	213.0	197.1
Imbaba Markaz	13.2	934.1	864.4
Maadi	13.5	957.7	886.2
Qalioub	22.8	1617.1	1496.4
Qanater	24.5	1737.8	1608.0
South Giza	8.3	588.7	544.8
Total	100.0	7,094.1	6,564.4

4.12 Reflection of the Applied Methodology

The calculation method applied, which to a large degree is based on the TTI method, has provided a sound basis for the direct congestion costs for GCMA within the available data and information. The method has been extended using two different approaches, which provide comparable results for the overall direct costs. The method is replicable and justifiable, though the calculation method can be enhanced in future to yield more accurate results. The following issues could be elaborated:

Fuel efficiency calculation

The fuel efficiency calculation based on a linear regression model which has been developed for the US in line with American car standards and existing fuel octane in US. Thus, the formulation needs to be adjusted for the Cairo region based on fleet ages, composition, vehicle motor standards and efficiency, and widely used fuel octane.

Reliability indicator

The consultant uses the standard deviation and thus coefficient of variation (COV) as the measure for travel time reliability. For a more accurate measure, the buffer index could be chosen as well, because it relates to the reliability of an individual vehicle trip. The travel rates used in this calculation can be derived from average speed readings and the length of a route. This measure will help determining the impact of congestion on one vehicle traveling on a segment of roadway during a specific time period.

The buffer index represents the reliability of travel rates associated with single vehicles. This measure may be beneficial to the public because it tells them how congestion will affect them as individuals. For example a buffer index of 40% means that a traveler should budget an additional 8 minute buffer for a 20 minute average peak travel time to ensure on time arrival “most” of the time (where “most” is defined as 95% of the time).

However, it should be noted that in practice the buffer time varies across the users because of each user’s individual experiences with variability and because of each user’s individual requirement for arriving at the destination on time.

To summarize, the consultant believes buffer time related indicators such as the Buffer Time Index and Planning Time Index are appropriate monitors to describe and communicate travel time reliability to planners as well as users. Other more simple measures such as travel time percentiles, median travel times and the standard deviation of travel time may also serve as appropriate indicators, but they should be used with caution, as relevant characteristics of the travel time distributions could be easily overlooked. For instance, using the standard deviation of travel time as a utility component in route choice may results in biased outcomes.

To estimate the unreliability associated cost for the entire network, using the standard deviation of travel time seems to be accurate enough since the indicator does not need to express traveler’s behavior facing travel time unreliability.

In other words, applying a buffer time indicator (e.g. the buffer time index) is essential when transport planners particularly deal with the way in which travelers make their decision (mode choice, route choice, and departure time choice).

Monetizing unreliability

When unreliability is measured as the standard deviation of travel time, data for the valuation of the standard deviation should be obtained through a stated preference survey by including a representation of the variance and the mean travel time as attributes. Thus, a utility function is specified that includes the mean journey duration as well as the standard deviation of the journey duration. Parameters for both variables are estimated usually on the stated preference data.

The ratio of coefficient for the standard deviation to the coefficient for the mean travel time can be calculated. This gives the disutility of a minute standard deviation of travel time in terms of minutes of mean travel time. A monetary value for unreliability can be derived by combining this with a value of time.

Given the lack of stated preference survey, the consultant used quantitative results on value of reliability in passenger transport from European studies carried out in recent years. Regarding the potential differences in trip patterns, peak hours, commuting trips between EU countries and Egypt, estimation of unreliability associated costs would be more precise if a SP survey performed in the region to derive a monetary value of 1 minute standard deviation of travel time in the Cairo Region.

Coverage of the entire GCMA

The methodology that was applied to estimate the direct economic cost of traffic congestion is based on several assumptions that impact accuracy. Therefore, the consultant believes in order to gain an accurate estimation of traffic congestion cost in the GCMA, a complete and detailed transport network is needed, socio economic information is needed, an effective transport model in a commonly used transport software should be developed, and finally Stated Preference survey to derive reliability perception need to be carried out.

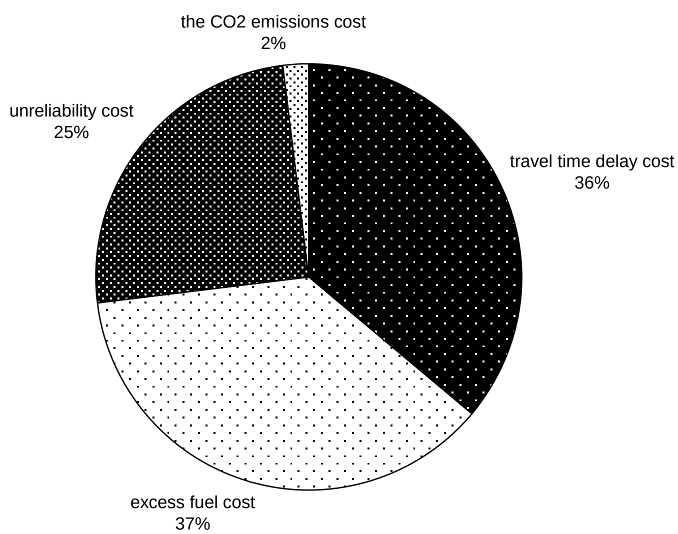
The systematic procedure that the consultant recommends to obtain more accurate results consists of the following steps:

- Trip generation is estimated based on existing land use. Thus, a comprehensive socio-economic data are required.
- The detailed transport, as well as transit networks should be designed in ARC GIS based software (e.g. Map Info) and then linked to commercial softwares such as Emme, TransCad, or Visum.
- Design as well as actual transport and transit network specifications including, speed, length, number of lanes, types of right of way, on site parking places, bus and micro bus stops, signal setting at intersection, etc are determined and implemented into the model.
- Travel time functions (e.g. adapted BPR function) should be allocated to the network depending on road type. For the links suffering from incidental delays, BPR functions should be adjusted accordingly.
- TTI or FHWA recurrent as well as nonrecurring delay functions, reliability indicators, the fuel efficiency function, and the air emission function are applied to the model to estimate delay costs, unreliability costs, excess fuel cost, excess fuel subsidy, and emission cost.
- The four steps of the classical urban transportation planning system model consisting: Trip generation, Trip Distribution, Mode Choice, Route Assignment are done by running commercial packages such as Emme, TransCad, or Visum.
- Given outputs, several sensitivity analyses are carried out in order to test the accuracy of the model.
- The most accurate outputs are chosen as the reliable result.

5 Conclusions and some recommendations for Phase II

This study demonstrates that traffic congestion is a serious problem in the Cairo metropolitan area with substantial adverse effects on personal travel time, vehicle operating costs, air quality, fuel cost and subsidy, and also reliability.

The consultant showed that without investments in urban transportation in the Greater Cairo, it is expected that the total annual direct congestion costs for the GCMA is estimated in the range of **13 to 14 billion LE.** The highest shares of the total direct cost are those of the travel time delay cost (36%), consisting of recurrent and non-recurrent congestion costs, and excess fuel cost (37%), of which half is paid by users (retail price of fuel) and the other half is additional costs to the Government (fuel subsidies); followed by unreliability cost (25%); and finally, the CO_2 emissions cost has a fairly small share of less than 2% of total costs.



Given, the first phase study result in terms of significance of economic costs of traffic congestion in the region, the second phase should involve prioritizing and recommending a package of traffic management and investment measures for congestion reduction.

The findings of the Phase 1 of the study will undoubtedly be utilized in Phase 2. Further to the analyses that were completed to this point, the capacity constraints of the transport network in Greater Cairo may be identified, in order to input such data in the demand and congestion cost model required in Task 3 of Phase 2.

In terms of additional data needed for Phase 2, available forecasts and plans shall be sought to help identify the requested possible scenarios based on income growth, urbanization, travel patterns (Task 3, Phase 2). The Consultant also needs to know of investment plans that are currently in place regarding city road network, public transport system, metro system, rail system, etc. (Task 4, Phase 2).

The Consultant may also benefit from the additional data that would be collected to refine and confirm some of the results of Phase 1. For instance, the collection of a more complete set of vehicle registration data, particularly in terms of vehicle age and composition, would help refine the calculated estimate for CO_2 emissions due to traffic congestion. Additionally, the generalization of congestion costs that were calculated for the surveyed corridors to cover the entire study area would be assessed.

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Annex 2: Glossary

Symbol	Unit	Explanation
ADT	Vehicles per day	The total traffic volume during a given time period, ranging from 2 to 364 consecutive days, divided by the number of days in that time period,
C	Pc/hr	Road capacity
COV	-	Coefficient of variation of travel time
DC	LE/year	The annual recurring and nonrecurring delay cost
DVKT	Vehicle km per day	The average daily traffic (ADT) of a section of roadway multiplied by the length of that section of roadway
L	Km	Corridor length
α	-	Road incident delay factor
N_D	-	The number of cases of material injuries
O	passengers	Vehicle occupancy factor
P	-	The Number of cases of personal injuries
PHF	-	The peak hour factor
$\overline{T}$	Hr	The mean travel time
STD	Hr	The standard deviation of travel time
U_D	LE	The average unitary value of material damage
U_P	LE	The average unitary value of personal damage
V	Pc/hr	Traffic flow rate
V_f	Km/hr	Free flow speed
V_p	Km/hr	Average speed during peak hours
VHD	Vehicle hour	The vehicle hour delay
VOT	LE/hr	Value of time

Annex 3: Overview of Existing Data

(A): The total number of vehicles (by type)

Table A3.1: No. of licensed vehicles by type of vehicles & governorate up to Dec 2008

Governorate	Bury's cars	Public sector	Customs Plates	Commercial & Temporary	Bus School	Bus Travel	Bus Tourism	Bus Private	Bus Public	Taxi	Carvan	Private Cars
Cairo	954	10264	5765	12167	4133	4452	7320	11826	6669	71370	579	973374
Alexandria*	85	2496	0	1215	600	4116	233	2942	1109	18062	46	270502
Giza	379	714	0	797	1210	8831	1197	4809	803	32015	395	363651
Port Said	12	244	236	335	14	187	48	255	97	9480	3	44541
Suez	7	907	4527	241	10	514	2	395	60	3375	0	26913
Ismailia	2	478	0	342	42	91	4	401	177	5002	4	28200
Damietta	24	990	7	339	41	129	0	186	189	4825	0	30269
Sharkia	7	561	0	350	115	1401	212	2312	1297	14470	11	64664
Dakahlia	22	1989	0	847	219	1155	95	446	425	15133	1	65956
Behera	1	1262	0	313	46	443	4	573	551	15491	0	24437
Gharbia	11	4907	0	656	76	445	12	361	2478	13469	3	52418
Menuofia	5	568	0	289	42	743	4	381	740	13379	0	31644
KafrElSheikh	5	1342	0	205	5	123	11	52	226	6282	0	16969
Kalyoubia	56	1195	0	168	220	1508	22	1160	218	16999	0	39018
Foyoum	4	336	0	73	11	338	8	132	220	10625	0	17627
Beni-Suef	3	163	0	65	15	150	7	167	251	7411	0	20658
Menia	9	223	0	158	73	170	8	263	226	5250	0	21843
Asyout	43	780	0	149	46	102	5	241	192	10873	0	33614
Suhag	4	477	0	186	91	71	4	92	122	11396	0	22501
Qena	18	286	0	53	9	71	9	246	152	8938	0	14290
Aswan	1	370	86	55	2	44	396	396	67	8825	2	11243
Matrouh	1	152	11760	33	9	11	18	34	43	4477	0	4635
Red Sea	27	374	1044	167	32	137	2515	386	200	2271	61	12293
El-Wadi El Gidid	4	95	0	8	0	16	25	21	34	808	0	2309
North Sinai	1	59	17	15	3	33	0	24	8	1989	0	3062
South Sinai	1	64	5500	12	5	95	1295	307	44	1395	8	4644

Luxor	3	60	0	27	0	29	1647	40	0	2683	0	5548
Total	1689	31356	28942	19265	7069	25405	15101	28452	16598	316293	1113	2206823

* Including Alexandria Port

Governorate	Governorate	Government	Political Authority	Motorcycle	Tractor	Truck	Lorries	Total
Cairo	6184	12617	4026	154520	490	10067	118203	306107
Alexandria*	1221	2415	-	19681	304	8131	61999	93751
Giza	3361	7870	-	100235	634	3958	75710	191768
Port-Said	616	514	-	14038	25	1127	6092	22412
Suez	598	418	-	15903	53	963	6162	24097
Ismailia	914	732	-	13776	440	560	13835	30257
Damietta	1332	421	-	43128	339	1684	18205	65109
Sharkia	3078	1592	-	67133	3223	4056	59959	139041
Dakahlia	1417	1087	-	53786	1949	7005	59886	125130
Behera	3173	1836	-	28038	4248	7055	53367	97717
Gharbia	2719	6704	-	61264	4669	12900	42444	130700
Menuofia	836	2625	-	79505	994	2033	25824	111817
Kafr-ElSheikh	996	2811	-	13871	815	1264	21721	41478
Kalyoubia	1013	708	-	67702	131	1525	25255	96334
Fayoum	1087	2214	-	61223	1339	1980	15185	83028
Beni-Suef	655	1636	-	42575	181	406	20226	65679
Menia	1695	2669	-	27836	878	988	27531	61597
Asyout	1238	2232	-	19724	783	1462	29749	55188
Suhag	862	1435	-	23762	637	1183	25100	52979
Qena	697	1334	-	38600	265	761	15346	57003
Aswan	1020	1281	-	11533	161	238	11432	25665
Matrouh	746	427	-	1783	23	271	8875	12125
Red Sea	539	486	-	4987	10	839	9181	16042
El-Wadi El-Gidid	757	1004	-	9913	118	168	2257	14217

North Sinai	1576	530	-	1754	274	192	7009	10335
South Sinai	513	425	-	2782	2	91	4816	8629
Luxur	692	320	-	16729	79	25	2480	20325
Total	38535	58343	4026	995781	23064	70932	767849	1958530

* Including Alexandria Port

Source: Central Agency for Public Mobilization and Statistics (CAPMAS)

B) Public transport Demand, Capacity, Fleet Composition And Age

Fuel economy as an element in direct economic congestion costs will be estimated based on information on the public transport fleet composition and age. Furthermore, determining the public transportation demand and capacity allows estimating the number of passengers who might suffer from traffic congestion and the consequent delay. The tables below outline the public transport demand, capacity, fleet composition and age in GCMA in 2007-2008. Public transport demand is estimated according to "The Strategic Urban Development Master Plan Study For A Sustainable Development Of The Greater Cairo Region In The Arab Republic Of Egypt Final Report (Volume 4)."

Public transport capacity is based on the number of cars owned by public transportation companies and authorities distributed by transportation means.

Table A3.2: Public Transport Daily Trip Generation

Sector Zone name	2007	2012	2017	2022	2027	Growth Ratio 2027/2007
6th of October NUC	216,409	390,614	560,358	868,892	1,059,497	4.90
Imbaba Markaz	1,224,960	1,540,847	1,680,565	1,755,701	1,772,260	1.45
Doqi	1,113,289	1,197,862	1,175,722	1,121,626	1,077,006	0.97
Giza	1,538,098	1,694,914	1,684,672	1,642,330	1,617,088	1.05
South Giza	377,277	416,811	415,157	395,258	381,68	1.01
Helwan	675,426	741,484	718,017	686,875	668,821	0.99
Maadi	767,843	887,596	936,307	963,995	975,325	1.27
Khaleefa	703,441	732,048	705,051	658,327	619,705	0.88
CBD	583,372	573,342	522,053	454,552	404,122	0.69
Shobra	807,168	832,971	789,732	720,484	664,455	0.82
Masr El Gedeeda	1,263,771	1,274,377	1,183,954	1,104,493	1,022,950	0.81
Nasr City and New Cairo	997,651	1,172,625	1,286,118	1,623,031	1,801,254	1.81
Ain Shams	798,533	879,825	894,459	881,605	856	1.07
Salam City	628,054	645,219	593,245	523,024	468,512	0.75
Shobra El Kheima	858,262	932,533	926,293	909,425	875,359	1.02
Qalyob	699,653	766,281	771,089	772,34	754,438	1.08
Qanater	999,283	1,209,728	1,308,409	1,458,439	1,539,546	1.54
10th of Ramadan NUC	122,841	198,592	251,867	328,684	393,14	3.20
Total	14,375,331	16,087,669	16,403,068	16,869,081	16,951,158	1.18

Source: The Strategic Urban Development Master Plan Study For A Sustainable Development Of The Greater Cairo Region In The Arab Republic Of Egypt Final Report (Volume 4)

Table A3.3: Public Transport Daily Trip OD Unit 1,000 trips

2007	6th October	Imbaba	Doqi	Giza	S.Giza	CBD	Others	Total
6th october	84	21	19	34	8	3	44	216
Imbaba	21	617	282	132	2	37	130	1,224
Doqi	17	261	383	197	5	45	201	1,113
Giza	35	138	196	824	66	36	240	1,538
S. Giza	8	3	4	67	246	3	44	377
CBD	3	38	44	34	3	61	396	583
Others	45	144	181	247	45	395	8,261	9,321
Total	216	1,225	1,113	1,538	377	583	9,321	14,375
2012	**6th October**	**Imbaba**	**Doqi**	**Giza**	**S.Giza**	**CBD**	**Others**	**Total**
6th October	185	37	29	51	12	4	69	390
Imbaba	37	799	344	158	4	41	155	1,54
Doqi	26	321	390	207	5	42	203	1,197
Giza	53	165	205	916	69	35	248	1,694
S.Giza	12	4	4	71	274	2	46	416
CBD	4	42	41	33	3	58	389	573
Others	70	170	181	254	47	388	9,158	10,273
Total	390	1,541	1,198	1,695	416	573	10,272	16,087
2017	**6th October**	**Imbaba**	**Doqi**	**Giza**	**S.Giza**	**CBD**	**Others**	**Total**
6th October	298	51	36	64	15	4	89	560
Imbaba	52	896	358	164	4	40	162	1,68
Doqi	32	337	371	200	4	37	190	1,175
Giza	65	172	198	916	66	31	233	1,684
S.Giza	15	4	4	68	274	2	45	415
CBD	4	41	36	30	2	51	355	522
Others	89	175	167	238	46	352	9,286	10,356
Total	559	1,679	1,173	1,684	414	520	10,363	16,395
2027	**6th October**	**Imbaba**	**Doqi**	**Giza**	**S.Giza**	**CBD**	**Others**	**Total**
6th October	667	84	51	94	21	6	133	1,059
Imbaba	85	970	349	165	4	33	163	1,772
Doqi	46	329	321	181	3	27	165	1,077
Giza	95	171	180	881	57	23	207	1,617
S.Giza	21	4	3	60	250	1	39	381
CBD	6	34	26	22	1	37	274	404
Others	134	174	141	210	40	272	9,655	10,629
Total	1,057	1,769	1,074	1,615	380	402	10,639	16,94

Source: The Strategic Urban Development Master Plan Study For A Sustainable Development Of The Greater Cairo Region In The Arab Republic Of Egypt Final Report (Volume 4)

Table A3.4: Public transport Capacity in Cairo

Governorates /Technical Case	Working And Valid Units And Total Capacity		Valid Units In Stores	Under Repairing	Expected To Be Repaired	Accident Destruction And Scrap	Total
	No. Of Seats	No. Of Units					
Bus	112145	3167	0	1176	269	208	4820
Tram	4484	59	0	32	0	0	91
Heliopolis Subway	5450	109	2	25	0	8	144
Subway	50589	231	0	0	0	0	231
River Bus	2100	15	0	20	0	0	35
Total	174768	3581	2	1253	269	216	5321

*Public Bus Includes Public Transportation Authority And Cairo Bus **Unit Contains Three Wagons

Source: CAPMAS

Table A3.5: Public transport Capacity in Alexandria

Transportation Means	Working And Valid Units And Total Capacity		Valid Units In Stores	Under Repairing	Expected To Be Repaired	Accident Destruction And Scrap	Total
	No. Of Seats	No. Of Units					
Bus	13183	351	0	111	0	0	462
City Tram	2880	80	0	39	0	0	119
Tram El Ramel	2784	29	0	13	0	0	42
Total	18847	460	0	163	0	0	623

Source: CAPMAS

Table A3.6: Public transport Capacity in Inside Cities

Governorates /Technical Case	Valid & Working Units And Total Capacity		Valid Units In Stores	Under Repair	Expected To Be Repaired	Accident Destruction And Scrap	Total
	No. Of Seats	No. Of Units					
Greater Cairo	112145	3167	0	1176	269	208	4820
Alexandria	13183	351	0	111	0	0	462
Suez	536	18	0	3	0	7	28
6-Oct	368	14	0	1	4	2	21
Damietta	29	1	0	0	0	0	1
Dakahlia	341	12	0	0	0	0	12
Kalyoubia	1858	60	0	3	0	1	64
Kafr El Sheikh	1053	40	0	0	0	0	40
Gharbia	4846	163	12	122	32	0	329
Menoufia	3460	116	0	0	0	0	116
Behera	1296	51	0	2	0	0	53
Ismailia	1212	42	0	1	7	0	50
Giza	1108	41	2	7	0	2	52
Beni Suef	125	3	0	0	0	0	3
Fayoum	116	4	0	0	0	0	4
Menia	73	3	0	1	0	0	4
Asyout	1962	72	0	0	0	8	80
Suhag	234	9	0	1	0	0	10
ASWAN	58	2	0	0	0	0	2

Elwadi El Gidid	33	1	0	0	0	0	1
Total	144036	4170	14	1428	312	228	6152

Source: CAPMAS

Table A3.7: Public transport Capacity in Outside Cities

Regions/Technical Case	Valid & Working Units And Total Capacity		Valid Units In Stores	Under Repairing	Expected To Be Repaired	Accident Destruction And Scrap	Total
	No. Of Seats	No. Of Units					
East Delta	31230	641	0	37	102	0	780
West And Central Delta	36251	733	0	85	15	29	862
Upper Egypt	24539	513	0	92	20	2	627
Rail / Sub-Master	273691	3921	27	24	0	0	3972
Total	365711	5808	27	238	137	31	6241

*West and Central Delta, including the EU **Rail unit is a vehicle

Source: CAPMAS

Table A3.8: Public transport Capacity the Cairo – 6th of October Transport Corridor

System		Capacity per Car (PAX/Car)	Congestion Rate	Transport Capacity by Headway in Minutes (pax./way/hour)				
				1	3	5	10	15
Bus	Ordinary	60	100	3,600	1,200	720	360	240
	Large	100	100	6,000	2,000	1,200	600	400
	Bi-Articulated	270	100	16,200	5,400	3,240	1,620	1,080
LRT		75	120	18,000	6,000	3,600	1,800	1,200
MonoRail		100	120	-	12,000	7,200	3,600	2,400
MRT		140	150	-	16,800	10,080	5,040	3,360
		140	150	-	22,400	13,440	6,720	4,480

Source: The Strategic Urban Development Master Plan Study For A Sustainable Development Of The Greater Cairo Region In The Arab Republic Of Egypt JICA 2009 Update-Final report Vol.4

Table A3.9: Fleet age and composition in Cairo

Brands/ Age Groups	<1	-1	-3	-5	-7	9	Total
Nasr	0	0	0	27	180	3079	3286
Mercedes	0	16	447	149	0	474	1086
Daewoo	0	25	25	0	0	0	50
Kstor	0	0	85	40	0	0	125
Thomas	0	0	0	18	101	58	177
Other	0	0	0	96	0	0	96
Total	0	41	557	330	281	3611	4820

Source: CAPMAS

Table A3.10: Fleet age and composition in Alexandria

Brands/ Age Groups	<1	-1	-3	-5	-7	9	Total
Nasr	15	0	20	59	76	67	237
Mercedes	0	50	0	0	0	0	50
Afico	0	0	0	15	0	0	15
Daewoo	0	30	0	0	0	0	30
Kstor	20	0	0	0	21	0	41
Other	0	0	40	10	23	16	89
Total	35	80	60	84	120	83	462

Source: CAPMAS

Table A3.11: Fleet age and composition Inside Cities

Brands/ Age Groups	<1	-1	-3	-5	-7	-9	Total
Nasr	15	5	46	99	256	3190	3611
Mercedes	0	68	447	155	5	475	1150
Nissan	0	0	0	0	0	8	8
Daihatsu	0	0	3	2	0	28	33
G.M	0	0	0	0	0	3	3
Isuzu	12	3	4	55	59	32	165
Bedford	0	0	0	0	0	3	3
Chevrolet	0	10	8	46	8	39	111
Afico	0	3	3	22	0	77	105
Daewoo	0	55	25	0	0	0	80
Kstor	20	0	85	40	23	0	168
Thomas	0	0	0	18	101	58	177
Other	10	30	99	190	49	160	538
Total	57	174	720	627	501	4073	6152

Source: CAPMAS

Table A3.12: Fleet age and composition Outside Cities

Brands/ Age Groups	<1	-1	-3	-5	-7	9	Total
Nasr	0	0	0	0	65	20	85
Mercedes	30	0	0	0	0	6	36
Scania	0	0	0	1	44	479	524
Renault	0	23	29	4	77	249	382
Afico	17	0	13	22	0	24	76
Man	0	0	0	0	52	61	113
Njublan	0	10	9	10	15	33	77
Daewoo	72	195	231	58	0	0	556
Kstor	0	0	0	0	53	137	190
Other	20	71	70	58	10	1	230
Total	139	299	352	153	316	1010	2269

Source: CAPMAS

Table A3.13: Distribution of Bus and Microbus Following both Public and Private Licenses (2005)

Type of License and Subordination to the Different Governorates (2005)

Governorates	Type of license										Total	
	Public		Private		Tourism		Schools		Trips			
	B.S	P.S	B.S	P.S	B.S	P.S	B.S	P.S	B.S	P.S	B.S	P.S
Cairo	5843	0	4541	5280	0	3072	0	2296	0	3685	10384	14333
Alexandria	906	0	554	2608	0	166	0	379	0	1496	1460	4649
Port Said	68	0	47	156	0	26	0	8	0	34	115	224
Suez	86	0	174	429	0	2	0	4	0	202	260	637
Damietta	47	0	66	105	0	0	0	27	0	42	113	174
Dakahlia	281	0	31	272	0	67	0	78	0	556	312	973
Sharkia	594	0	17	1859	0	27	0	35	0	1381	611	3302
Kalyoubia	247	0	206	431	0	22	0	200	0	1891	453	2544
Kafr El Sheikh	197	0	0	39	0	4	0	4	0	38	197	85
Gharbia	412	0	60	287	0	60	0	25	0	286	472	658
Menoufia	347	0	35	287	0	4	0	17	0	404	382	712
Behera	278	0	47	325	0	1	0	15	0	162	325	503
Ismailia	176	0	145	397	0	3	0	36	0	84	321	520
Giza	696	0	44	2302	0	727	0	755	0	2500	740	6284
Beni Suef	69	0	12	138	0	15	0	15	0	100	81	268
Fayoum	81	0	0	91	0	0	0	3	0	85	81	179
Menia	191	0	51	176	0	0	0	15	0	71	242	262
Asyout	89	0	80	211	0	10	0	32	0	70	169	323
Suhag	64	0	8	99	0	0	0	45	0	35	72	179
Qena	100	0	0	203	0	9	0	6	0	37	100	255
Aswan	52	0	74	228	0	124	0	0	0	19	126	371
Luxor	0	0	16	29	0	687	0	0	0	13	16	729

Red Sea	76	0	8	225	0	945	0	4	0	27	84	1201
El Wadi El Gidid	32	0	12	8	0	15	0	0	0	0	44	23
Matrouh	32	0	0	28	0	4	0	4	0	9	32	45
North Sina	14	0	7	29	0	2	0	1	0	21	21	53
South Sina	22	0	2	152	0	257	0	0	0	59	24	468
Total	11000	0	6237	16394	0	6249	0	4004	0	13307	17237	39954

Source: CAPMAS

C) Accident data

Obtaining accident data including fatality rates, and injury rates will be essential for estimating direct and indirect economic costs of traffic congestion in Cairo. The following tables outline the number of accidents and injuries by the region and the accident type in GCMA in 2007-2008:

Table A3.14: Public transport accident in Cairo

Transport Means Type/ Accident Type	Accident Without Injuries						Accident With Injuries						No. Of Injuries	
	Clashes	Fire	Infantry	Passenger Violation To Regulations	Quarrels	Other	Clashes	Fire	Infantry	Passenger Violation To Regulations	Quarrels	Other	No. Of Injured	No. Of Dead
Bus	1049	50	0	0	13	286	434	0	0	0	0	0	415	43
Tram	15	1	8	0	0	0	9	0	0	0	0	0	6	3
Heliopolis Subway	28	4	0	0	1	0	3	0	0	0	0	0	2	1
Subway	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1092	55	8	0	14	286	446	0	0	0	0	0	423	47

Source: CAPMAS

Table A3.15: Public transport accident in Alexandria

Transport Means Type/ Accident Type	Accident Without Injuries						Accident With Injuries						No. Of Injuries	
	Clashes	Fire	Infantry	Passenger Violation To Regulations	Quarrels	Other	Clashes	Fire	Infantry	Passenger Violation To Regulations	Quarrels	Other	No Of Injured	No. Of Dead
Bus	518	15	0	0	37	151	29	0	0	0	0	0	42	1
City Tram	270	0	0	0	0	0	10	0	0	0	2	0	11	1
Tram El Ramel	33	0	0	0	0	0	48	0	0	0	0	0	45	3
Total	821	15	0	0	37	151	87	0	0	0	2	0	98	5

Source: CAPMAS

Table A3.16: Public transport accident in Inside Cities

Accident Type \.Gov	Accident Without Injuries						Accident With Injuries						No. Of Injuries	
	Clashes	Fire	Infantry	Passenger Violation To Regulations	Quarrels	Other	Clashes	Fire	Infantry	Passenger Violation To Regulations	Quarrels	Other	No. Of Injured	No. Of Dead
Greater Cairo	1049	50	0	0	13	286	434	0	0	0	0	0	415	43
Alexandria	518	15	0	0	37	151	29	0	0	0	0	0	42	1
Suez	1	0	0	0	0	0	1	0	1	0	0	0	8	5
Kafr El Sheikh	0	0	0	0	0	0	2	0	0	0	0	0	2	0
Gharbia	0	0	0	0	0	0	2	0	0	0	0	0	1	1
Menoufia	8	0	0	0	0	0	3	0	0	0	0	0	32	0

Behera	0	0	0	0	0	1	0	0	0	0	0	1	0	1
Total	1576	65	0	0	50	438	471	0	1	0	0	1	500	51

Source: CAPMAS

Table A3.17: Public transport accident in Outside Cities

Accident Type	Accident Without Injuries						Accident With Injuries						No. Of Injuries	
	Clashes	Fire	Infantry	Passenger Violation To Regulations	Quarrels	Other	Clashes	Fire	Infantry	Passenger Violation To Regulations	Quarrels	Other	No Of Injured	No. Of Dead
East Delta	0	1	0	0	0	0	62	0	3	0	0	0	93	24
West and Central Delta	59	4	1	0	0	0	43	0	2	0	0	0	96	24
Upper Egypt	5	9	2	0	0	2	12	0	4	0	0	2	47	13
Rail / sub-master	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	64	14	3	0	0	2	117	0	9	0	0	2	236	61

*West and Central Delta, including the EU

Source: CAPMAS

Table A3.18: Accident Seriousness Rate (Dead or Injured / Accident) by A.R.E Governorates (2008)

Governorate	Number of accidents	Dead	Injured	Total	Dead or Injured/Accident Rate
Cairo	1587	737	1888	2625	1,7
Alexandria	438	179	801	980	2,2
Port Said	302	51	399	450	1,5
Suez	263	157	577	734	2,8
Damietta	470	156	585	741	1,6
Dakahlia	1564	445	2167	2612	1,7
Sharkia	1376	236	1067	1303	0,9
Kalyoubia	320	108	531	639	2
Kafr El Sheikh	453	189	1015	1204	2,7
Gharbia	716	372	1421	1793	2,5
Menoufia	680	179	789	968	1,4
Behera	408	245	872	1117	2,7
Ismailia	1100	214	1393	1607	1,5
Giza	1151	275	2360	2635	2,3
Beni Suef	682	241	1163	1404	2,1
Fayoum	355	100	609	709	2
Menia	269	316	1255	1571	5,8
Asyout	221	156	835	991	4,5
Suhag	193	112	468	580	3
Qena	649	221	1080	1301	2
Aswan	401	164	896	1060	2,6
Red Sea	807	152	1142	1294	1,6
El Wadi El Gidid	248	42	427	469	1,9
Matrouh	679	176	1325	1501	2,2
North Sinai	276	55	307	362	1,3
South Sinai	613	126	1043	1169	1,9
Grand Total	20938	6603	35718	42321	2,1
Highways	4717	1199	9303	10502	2,2

Source: CAPMAS

Table A3.19: The Most Vehicles Causing Accidents on Highways by Type (2008)

Item	No. of Accidents	The Percentage of Importance %
Lorry	1844	39,1
Private Car	1797	38,1
Taxi	561	11,9
Bus	288	6,1
Motor Cycle	78	1,6
Others	151	3,2
Total	4717	100

Source: CAPMAS

Table A3.20: Percentage Distribution of Accidents Causes on Highways (2008)

Accidents Cause	No.	Percentage %
Human Cause	3302	70
Car Technical Status	1038	22
Road Status	94	2
Others	283	6
Total	4717	100

Source: CAPMAS

Table A3.21: Car Accidents by Causes (2008)

Item	No.	Percentage %
Tire Explosion	4020	19,2
Car Defects	293	1,4
Wrong Subway Exit	314	1,5
Sudden Stop	607	2,9
Weather Statues	712	3,4
Car Coup	1717	8,2
Wheel Imbalance	2073	9,9
Driver Unconsciousness	2303	11
Wrong Exceed	2554	12,2
Vehicles collision	2554	12,2
Increased Speed	3016	14,4
Others	775	3,7
Total	20938	100

Source: CAPMAS

D) Unit vehicle operation costs:

The unit vehicle operating cost (VOC) by vehicle type was estimated based on an analysis of actual performance data collected from different transport operators, as well as automobile dealers. Estimation of VOC considered the following components:

- Representative vehicle
- Vehicle characteristics
- Vehicle prices
- Tire prices
- Fuel and lubricants
- Maintenance costs
- Bus crew cost
- Depreciation
- Insurance costs

The table below summarizes Estimated Unit Vehicle Operating Cost (VOC) based on “the strategic urban development master plan study for a sustainable development of the greater Cairo region in the Arab republic of Egypt” update in 2009:

Table A3.22: Estimated Unit Vehicle Operating Cost

Vehicle Type		Passenger Car	Shared taxi	Pick-up	Bus	Articulated Bus	Minibus	Light Truck	Medium Truck	Heavy Truck
Distance related VOC LE / 000 KM	Fuel cost	196.88	263.86	229.10	597.96	1195.92	217.80	396.00	495.00	594.00
	Lubricant cost	31.35	78.38	62.70	78.38	156.75	62.70	125.40	156.75	156.75
	Tire cost	23.40	33.00	20.57	122.73	163.64	57.12	43.62	90.00	276.92
	Maintenance Spare Parts Costs	56.38	20.70	35.98	37.33	366.83	24.16	90.43	85.53	68.77
	Depreciation cost	97.14	75.37	35.00	355.37	3686.32	153.31	658.31	518.90	385.12
	S-Total	405.14	471.31	383.35	1191.76	4569.45	515.08	1313.75	1346.18	1481.57
	Overhead cost	0.00	70.70	30.67	238.35	913.89	103.02	459.81	471.16	518.55
	Total	405.14	542.00	414.02	1430.12	5483.34	618.09	1773.56	1817.35	2000.12
Time related VOC LE/hour	Crew cost	0.00	4.98	7.03	8.28	11.58	6.63	8.28	8.28	11.58
	Maintenance labor cost	1.09	1.02	1.09	1.38	1.82	0.74	2.01	3.27	3.63
	Insurance cost	0.09	0.05	0.18	0.18	1.34	0.07	0.70	1.07	0.88
	Depreciation cost	1.26	0.41	0.71	0.63	6.16	0.27	3.54	3.35	2.70
	S-Total	2.44	6.45	9.01	10.46	20.90	7.71	14.53	15.97	18.79
	Overhead cost	0.00	0.97	0.72	2.09	4.18	1.54	5.09	5.59	6.58
	Total	2.44	7.42	9.73	12.56	25.08	9.25	19.62	21.56	25.36
	Annual Hours	800	4500	1200	4800	4800	4800	1300	1500	2250
	Annual KM	40000	105000	60000	76000	76000	67500	50000	75000	125000
	Conversion to km base	48.79	318.08	194.60	793.14	1583.78	657.52	510.09	431.24	456.55

E) Fuel cost

Information about the market price of fuel and lubricants was obtained by interviewing gasoline stations and some car dealers. Based on an interview with a petroleum company in Cairo, the factors in the table below were incorporated when converting the market prices to economic prices. For gasoline, there is no sales tax or subsidy. However, there is some subsidy for diesel. (Source: The Strategic Urban Development Master Plan Study for a Sustainable Development of the Greater Cairo Region in the Arab Republic of Egypt- Update 2009). The table below outlines quantity, value and type of fuel used in operation in 2007-08 in GCMA.

Table A3.23: Quantity, Value and Type of Fuel Used in Operation in Cairo - Value by 1000 2007/2008

Transportation Means /Fuel Type	Solar		Gasoline		Natural Gas		Electricity		Oilers	
	Monetary Value	Quantity By 1000 Liters	Monetary Value	Quantity By 1000 Liters	Monetary Value	Quantity By 1000 M3	Monetary Value	Quantity By 1000 Kw	Monetary Value	Quantity By 1000 Kl
Bus	90625	109955	435	335	1569	3359	0	0	18569	2725
Tram	0	0	0	0	0	0	1159	1423	217	22
Heliopolis Subway	0	0	0	0	0	0	1692	8591	129	15
Subway	0	0	0	0	0	0	35113	390150	223	37
River Bus	324	406	0	0	0	0	0	0	102	10
Total	90949	110361	435	335	1569	3359	37964	400164	19240	2809

Source: CAPMAS

Table A3.24: Quantity, Value and Type of Fuel Used in Operation in Alexandria - Value by 1000 L.E 2007/2008

Transportation Means /Fuel Type	Solar		Gasoline		Natural Gas		Electricity		Oilers	
	Monetary Value	Quantity By 1000 Liters	Monetary Value	Quantity By 1000 Liters	Monetary Value	Quantity By 1000 M3	Monetary Value	Quantity By 1000 Liters	Monetary Value	Quantity By 1000 Kg
Bus	14026	15993	0	0	0	0	0	0	1720	215
City Tram	0	0	0	0	0	0	2978	12561	15	3
Tram El Ramel	0	0	0	0	0	0	3594	15901	319	33
Total	14026	15993	0	0	0	0	6572	28462	2054	251

* Greases Are Supplied With Oilers, Source: CAPMAS

Table A3.25: Quantity, Value and Type of Fuel Used in Operation in Inside Cities- Value by 1000 2007/2008

Governorates/Fuel Type	Solar		Gasoline		Natural Gas		Oilers*	
	Monetary Value	Quantity By 1000 Liters	Monetary Value	Quantity By 1000 Liters	Monetary Value	Quantity By 1000 M3	Monetary Value	Quantity By 1000 Kg
Greater Cairo	90625	109955	435	335	1569	3359	18569	2725
Alexandria	14026	15993	0	0	0	0	1720	215
Suez	232	292	0	0	0	0	29	4
6-okt	117	144	0	0	0	0	16	2
Damietta	40	50	0	0	0	0	56	9
Dakahlia	215	199	0	0	0	0	45	7
Kalyoubia	844	823	0	0	0	0	293	24
Kafr El Sheikh	354	390	3	3	0	0	92	13
Gharbia	2404	2750	23	23	0	0	504	62
Menoufia	2346	2844	0	0	1	2	369	53
Behera	528	587	3	3	0	0	114	17
Ismailia	1117	1110	0	0	0	0	131	17
Giza	559	583	0	0	0	0	146	19
Beni Suef	31	41	3	3	0	0	4	0
Fayoum	23	27	0	0	0	0	7	1
Menia	19	19	0	0	0	0	5	1
Asyout	560	534	0	0	0	0	95	11
Suhag	52	60	2	2	0	0	24	3
ASWAN	36	32	0	0	0	0	15	1
Elwadi El Gidid	9	11	0	0	0	0	2	0
Total	114137	136444	469	369	1570	3361	22236	3184

*Greases Are Supplied With Oilers In Some Sources

Source: CAPMAS

Table A3.26: Quantity, Value and Type of Fuel Used in Operation in Outside Cities -Revenues by 1000 L.E. 2007/2008

Regions /Fuel Type	Solar		Gasoline		Natural Gas		Oilers	
	Monetary value	Quantity By 1000 Liters	Monetary value	Quantity By 1000 Liters	Regions	Quantity By 1000 M3	Regions	Quantity By 1000 Kg
East Delta	25585	23259	140	104	0	0	4231	445
West and Central Delta	23239	28217	102	78	0	0	3234	464
Upper Egypt	18632	22824	96	96	0	0	2995	399
Total	67456	74300	338	278	0	0	10460	1308

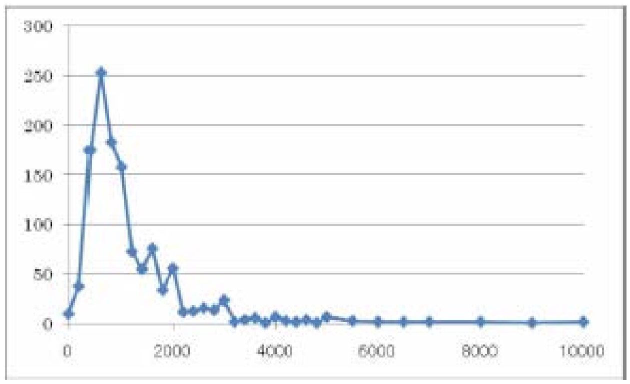
Source: CAPMAS

Unit Fuel costs in Egypt (2008- Reuters):

Gasoline Regular 95: 1.75 LE / Liter
Diesel 1.00 LE / Liter

F) Household income and Value of Time

Between June and July 2007, a household opinion poll survey was carried out in the Cairo Master Plan (phase 1) to clarify the public perceptions of urban planning. The survey results provided useful information about households (HH), including their income. According to the survey, average household income in the study area of the Master Plan phase was estimated at 1,134 LE / HH / Month or 13,590 LE / HH / Year (USD 2,470 / HH / Year) in 2007. The number of workers per household was estimated at 1.09 in 2007, so that the income per worker is estimated at 1,037 LE / month or 12,440 LE / Year (USD 2,260 / Year). Figure below shows the household income distribution.



The table below outlines the average household income by Household Income Group:

Table A3.27: The average household income by Household Income Group (2007)

Group	Monthly household Income Group	Share (%)	Average Household Income
Low Income	Less than 420 LE	18.1	291
Middle Income	1670 LE> I > 420 LE	64.6	877
High Income	Above 1670 LE	17.2	2985
Total/ Average		100.0	1134

The table below outlines socioeconomic framework in the study area:

Table A3.28: Socio-Economic Framework in the Study Area

Indicator		Unit	2006	2007	2012	2017	2027
Population		1000	16,101	16,464	18,411	20,369	24,192
No. of Household		1000	4,007	4,097	4,582	5,069	6,021
Household size		Person/household	4.02	4.02	4.02	4.02	4.02
Age Structure		%	28.7	29.0	29.9	31.0	32.1
Labor force		1000	4,613	4,777	5,506	6,316	7,761
Unemployment		%	7	6	6	5	5
No. of Workers	Primary	1000	260	266	306	349	427
	Secondary	1000	1,667	1,741	2,014	2,311	2,824
	Tertiary	1000	2,384	2,467	2,876	3,223	4,126
	Total	1000	4,310	4,475	5,196	5,982	7,378
Household Income		LE/HH	1,072	1,134	1,488	1,886	2,911
No. of Workers in the Household		Worker/HH	1.08	1.09	1.13	1.18	1.23
Worker's income		LE/worker	997	1,038	1,312	1,598	2,376

Source: The Strategic Urban Development Master Plan Study For A Sustainable Development Of The Greater Cairo Region In The Arab Republic Of Egypt JICA 2009 Update-Final report Vol.4

The average monthly income per worker was estimated as shown in Table A3.29. The assumption that the number of working days was 22 days per month and the working time of 8 hours per day resulted in the estimated number of working hours being 176 hours per month.

The predicted hourly average income per worker from 2007 up to 2027 was estimated, as shown in Table A3.29.

Table A3.29: Average Monthly Income and Hourly Income per Worker

Year		Unit	2006	2007	2012	2017	2027
Household income	Low and Middle Income Household	LE/month	746	982	1,245	1,921	
	High and Middle Households	LE/month	1,322	1,529	1,863	2,769	
	High Income Household	LE/month	2,985	3,916	4,964	7,664	
Workers in household		Worker/household	1.09	1.09	1.09	1.09	
Worker's income	Low and Middle Income Household	LE/month	687	901	1,142	1,763	
	High and Middle Households	LE/month	1,038	1,312	1,598	2,376	
	High Income Household	LE/month	2,739	3,593	4,554	7,031	
Working hours per month		Hour/month	176	176	176	176	
Hourly worker's income	Low and Middle Income Household	LE/month	3.90	5.12	6.49	10.02	
	High and Middle Households	LE/month	6.89	7.45	9.08	13.50	
	High Income Household	LE/month	15.56	20.41	25.88	39.95	

Source: The Strategic Urban Development Master Plan Study For A Sustainable Development Of The Greater Cairo Region In The Arab Republic Of Egypt JICA 2009 Update-Final report Vol.4

The hourly time values for transport users were estimated based on the hourly workers income. In this estimation, the following assumptions were adopted:

• Public transport users comprise middle and low income groups;

• Car users comprise the high income group; and

• Taxi and shared taxi users, including air conditioned bus users, comprise high and middle income groups.

The estimated hourly time value for transport users was predicted for 2007 up to 2027, as shown in the following table:

Table A3.30: Estimated Hourly Time Value for Transport Users from 2007 to 2027

Year	Unit	2007	2012	2017	2027
Public Transport Users	LE/Hour/Person	2.95	3.86	4.90	7.56
Car Users	LE/Hour/Person	11.75	15.41	19.54	30.16
Taxi and Shared Taxi Users	LE/Hour/Person	5.20	5.63	6.86	10.19

Source: The Strategic Urban Development Master Plan Study For A Sustainable Development Of The Greater Cairo Region In The Arab Republic Of Egypt JICA 2009 Update-Final report Vol.4

G) Vehicle ownership

Vehicle ownership by household income is tabulated from the Household Interview Survey (HIS) database (2000). Then they have been updated for 2007 given the following adjustments:

- The increase in the number of cars
- Population growth
- HH income indicator growth

Table A3.31: Monthly Income Indicator and Car Ownership per household (2007)

Monthly Income Indicator	Car Ownership per household
< 200	0.09
201-300	0.22
301-400	0.50
401-500	0.92
501-1000	1.15

Source: The Strategic Urban Development Master Plan Study For A Sustainable Development Of The Greater Cairo Region In The Arab Republic Of Egypt JICA 2009 Update-Final report Vol.4

H) Percentage of daily traffic in the peak hour

Given Annex 3.4 of "Public Private Partnership Program for Cairo Urban Toll Expressway Network Development" which contains the necessary base data and information, drawings, calculations and other information produced during the course of the Study, the percentage of daily traffic in peak hour in 26 corridors has been derived as follows:

Table A3.32: Percentage of 16 hour traffic volume in the peak hour (2005)

Site	Direction	Peak hour factor (ADT %)
Warraq Bridge	Qalyobeya	8,83%
	Giza	10,04%
Rodh El-Farag Bridge	Cairo	8,17%
	Giza	11,56%
Imbaba Bridge	Cairo	9,61%
	Giza	10,30%
15th of May Bridge	Cairo	9,06%
	Giza	9,61%
6th of October Bridge	Cairo	9,24%
	Giza	8,49%
Galaa Bridge	Cairo	10,19%
	Giza	10,45%
Gamah Bridge	Cairo	10,23%
	Giza	9,95%
Giza Bridge	Cairo	8,31%
	Giza	7,94%
Moneeb Bridge	Cairo	10,33%
	Giza	10,31%
Marazeeq Bridge	Cairo	11,20%
	Giza	8,08%
26th of July Corridor	Lebanon Sq.	9,75%
	6th of October City	8,99%
Suez Desert Road	Suez	9,90%
	Cairo	9,85%
Alex. Agriculture Road	Alexandria	9,04%
	Cairo	8,38%
Ismailia Agriculture Road	Ismailia	9,47%
	Cairo	9,26%
Ismailia Desert Road	Ismailia	9,84%
	Cairo	8,20%
Autostrade	Cairo Airport	9,95%
	Helwan	11,13%
Nasr Road	Cairo Airport	8,69%
	Helwan	8,47%
Gesr El-suez St.	Ismailia	7,73%
	CBD	9,97%
Abo Bakr El-Sedeeq St.	Orooba St.	11,22%
	Tagneed Sq.	9,86%
Kablat St.	Mataria Sq.	8,02%
	Ismailia Canal	8,00%
Lotfy El-Sayed St.	Ramsis Sq.	7,91%
Ahmed Helmy St.	Qalyob	10,34%
	CBD	11,30%
Ramsis St.	Abbassia Sq.	8,19%
	Ramsis Sq.	10,89%
Salah salem Road	Cairo Airport	8,25%
	Giza Sq.	8,28%
Tereat El-Zomor Road	Haram st.	9,26%
	Ring Road	9,36%
Sudan St.	Imbaba	8,03%
	Haram St.	7,77%

Source: The JICA study of 2005 (Cairo Urban Toll Expressway Network Development)

Table A3.33: Peak Hour Traffic Volumes on Main Bridges and Arterial Roads (2005)

Site	No.	Site Name	Direction		Peak Hour Traffic Volume		Peak Hour (O'clock)	
			Dir 1:To	Dir 2: To:	Dir 1	Dir 2	Dir 1	Dir 2
Bridges	1	Warraq Br.	Qaliobeya	Giza	2,192	2,125	18:00	8:00
	2	Rodh El-Farag Br.	Cairo	Giza	3,604	4,572	10:00	20:00
	3	Imbaba Br.	Cairo	Giza	817	1,347	8:00	2:00
	4	15th of May Br.	Cairo	Giza	4,300	6,862	12:00	12:00
	5	6th of October. Br.	Cairo	Giza	13,400	9,747	8:00	11:00
	6	Galaa Br.	Cairo	Giza	2,962	2,803	9:00	13:00
	7	Gamah Br.	Cairo	Giza	3,357	3,800	8:00	9:00
	8	Giza Br.	Cairo	Giza	3,259	3,433	15:00	17:00
	9	Moneeb Br.	Cairo	Giza	4,516	6,222	12:00	9:00
	10	Marazeeq Br.	Cairo	Giza	704	502	7:00	16:00
Arterials	11	26th of July Cdr	6th October	Lebanon Sq.	3,176	4,204	10:00	16:00
	12	Suez Desert Rd	Suez	Cairo	1,692	1,851	8:00	15:00
	13	Alex. Agr. Rd	Alexandria	Cairo	3,975	3,780	16:00	7:00
	14	Ismailia Agr. Rd	Ismailia	Cairo	1,290	1,255	16:00	20:00
	15	Ismailia Desert Rd	Ismailia	Cairo	3,832	3,328	9:00	13:00
	16	Autostrade	Cairo Ap.	Helwan	1,443	2,018	8:00	18:00
	17	Nasr Rd	Cairo Ap.	Helwan	8,050	6,529	8:00	12:00
Expressway Routes	18	Gesr El Suez st.	Ismailia	CBD	2,619	3,346	15:00	15:00
	19	Suez Desert Road	Suez	Cairo	2,258	2,151	20:00	21:00
	20	Abo Bakr El-Sedeeq st.	Orooba s.	Tagneed Sq.	2,753	2,458	12:00	18:00
	21	Kablat st.	Mataria Sq.	Ismailia Canal	980	828	11:00	17:00
	22	Lotfy El- Sayed st.	Ramsis Sq.		4,078		10:00	
	23	Autostrade	Cairo Airport	Hewan	2,354	3,122	16:00	15:00
	24	Ahmed Helmey St.	Qalyob	CBD	1,624	2,223	13:00	8:00
	25	Ramsis st.	Abbassia Sq.	Ramsis Sq.	3,067	4,668	12:00	8:00
	26	Saleh Salem Road	Cairo Airport	Giza Sq.	3,719	3,804	16:00	10:00
	27	Tereat El-Zomor Rd.	Haram st.	Ring Rd.	2,298	1,701	20:00	21:00
	28	Sudan St.	Imbaba	Haram st.	1,281	1,514	16:00	9:00

Peak Hour Factor, Directional Factor and K-Factor

Based on the aforementioned survey summaries, different factors describing the characteristics of traffic flow could be estimated. These factors include Peak Hour Factor (PHF), Directional factor (D) and percentage of peak hour volume as related to the daily traffic volume as shown in Table A3.34.

The peak hour factor (PHF) varies from 0.72 to 0.93 with an average of 0.84 for the Nile bridges compared with 0.81, 0.97 and 0.87 for major arterials, respectively. As for the new sites on the expressway corridors, PHF varies from 0.82 to 0.95 with 0.88 as an average. This implies that in some locations, the variation of traffic volumes within the peak hour can not be neglected. If the whole set of the count stations is considered, PHF reaches 0.86 as overall average within the study area.

The average value of distributional factor (D) accounts form 0.65, 0.62 and 0.67 for bridges, arterials and new sites, respectively with an overall average of 0.65. This indicates the traffic volume is not evenly balanced between the two directions of travel. Similarly, the value of design traffic volume divided by daily traffic volume (K) is estimated. It can be observed that K-factor, which is estimated by dividing the peak hour volume by the observed/estimated daily traffic for each count station, varies from 6.1% to 10.3% with an average of 8.4% for Nile bridges compared with 6.6%, 8.4% and 7.8% for major arterials, respectively. As for the count stations located on the expressway corridors (new sites), the K-factor ranges from 6% to 12% with 8% as an average. A value of 8.1% for K-factor can be considered as an overall average for the study area.

Table A3.34: Characteristics of Observed Traffic Volume at Different Count Stations in 2005

Site	No.	Site Name	PHF	D	K
Bridges	1	Warraq Br.	0.72	0.59	9.2%
	2	Rodh El-Farag Br.	0.87	0.71	7.4%
	3	Imbaba Br.	0.86	0.72	8.9%
	4	15th of May Br.	0.78	0.60	10.3%
	5	6th of October. Br.	0.78	0.67	8.2%
	6	Galaa Br.	0.88	0.60	8.4%
	7	Gamah Br.	0.82	0.67	8.2%
	8	Giza Br.	0.93	0.61	6.1%
	9	Moneeb Br.	0.85	0.68	8.6%
	10	Marazeeq Br.	0.89	0.63	8.4%
Average of Nile Bridges			**0.84**	**0.65**	**8.4%**
Arterials	11	26th of July Cdr	0.84	0.65	8.2%
	12	Suez Desert Rd	0.90	0.57	8.4%
	13	Alex. Agr. Rd	0.93	0.61	6.6%
	14	Ismailia Agr. Rd	0.80	0.57	8.4%
	15	Ismailia Desert Rd	0.81	0.61	8.1%
	16	Autostrade	0.88	0.70	8.2%
	17	Nasr Rd	0.97	0.60	6.8%
Average of major arterials			**0.87**	**0.62**	**7.8%**
Expressway Routes	18	Gesr El Suez st.	0.87	0.56	8.6%
	19	Suez Desert Road	0.87	0.67	6.4%
	20	Abo Bakr El- Sedeeq st.	0.88	0.60	8.8%
	21	Kablat st.	0.88	0.60	6.9%
	22	Lotfy El- Sayed st.	0.95	1.00	7.0%
	23	Autostrade	0.92	0.58	12.3%
	24	Ahmed Helmey St.	0.86	0.77	7.9%
	25	Ramsis st.	0.94	0.69	8.4%
	26	Saleh Salem Road	0.82	0.66	6.4%
	27	Tereat El- Zomor Rd.	0.84	0.66	8.1%
	28	Sudan St.	0.91	0.59	6.7%
Average of Expressway Corridors			**0.88**	**0.67**	**8.0%**
Overall average			**0.86**	**0.65**	**8.1%**

Source: The JICA study of 2005 (Cairo Urban Toll Expressway Network Development)

I) Passenger Car Unit

Vehicle demand/capacity is expressed in terms of passenger car units (PCU). Given the strategic urban development master plan study for sustainable development of the greater Cairo region in the Arab republic of Egypt (March 2008), the following PCUs have been derived:

Table A3.35: Passenger Car Units (PCU)

Vehicle Type	Motorcycle	Light Vehicle(1)	Small Truck(2)	Medium Truck(3)
PCU	0.33	1.00	2.00	2.50
Vehicle Type	Large Truck(4)	Micro Bus(5)	Mini Bus	Standard Bus
PCU	3.00	1.50	2.00	2.50

Note:
(1): Light Vehicle: Car, Pick-up, Taxi, Van
(2): Small Truck: Two Axles Truck
(3): Medium Truck: Three Axles
(4): Large Truck: More than Three Axles
(5): Micro Bus: Shared Taxi

J) Vehicle Occupancy Factor

Based on the strategic urban development master plan study for sustainable development of the greater Cairo region in the Arab republic of Egypt (March 2008), the following Vehicle Occupancy Factors have been derived:

Table A3.36: Vehicle Occupancy Factors (Passengers/Vehicle)

Trip Purpose	Car Occupancy	Taxi Occupancy
Homebased Work	1.5	2.0
Homebased Education	2.4	3.0
Homebased others	2.1	2.5
Non homebased	1.7	2.0

K) Origin Destination Matrix

Origin-Destination matrices have been derived from the results of the study of “Public Private Partnership Program for Cairo Urban Toll Expressway Network Development” OD matrices are classified into the following categories:

- Passenger Car
- Taxi
- Bus
- Truck
- All Vehicle

These OD matrices are presented in Tables B-1 through B-10 in Annex B.

Annex 4: Principal Corridors Collective and Individual Assessment, Estimation Procedures

[separate pfd file]

ANNEX 4

1. Principal Corridors Collective Assessment

a) Average Speed Plots
b) Speed Indices Plots
c) Coefficients of Variation Plots

2. Principal Corridors Individual Assessment

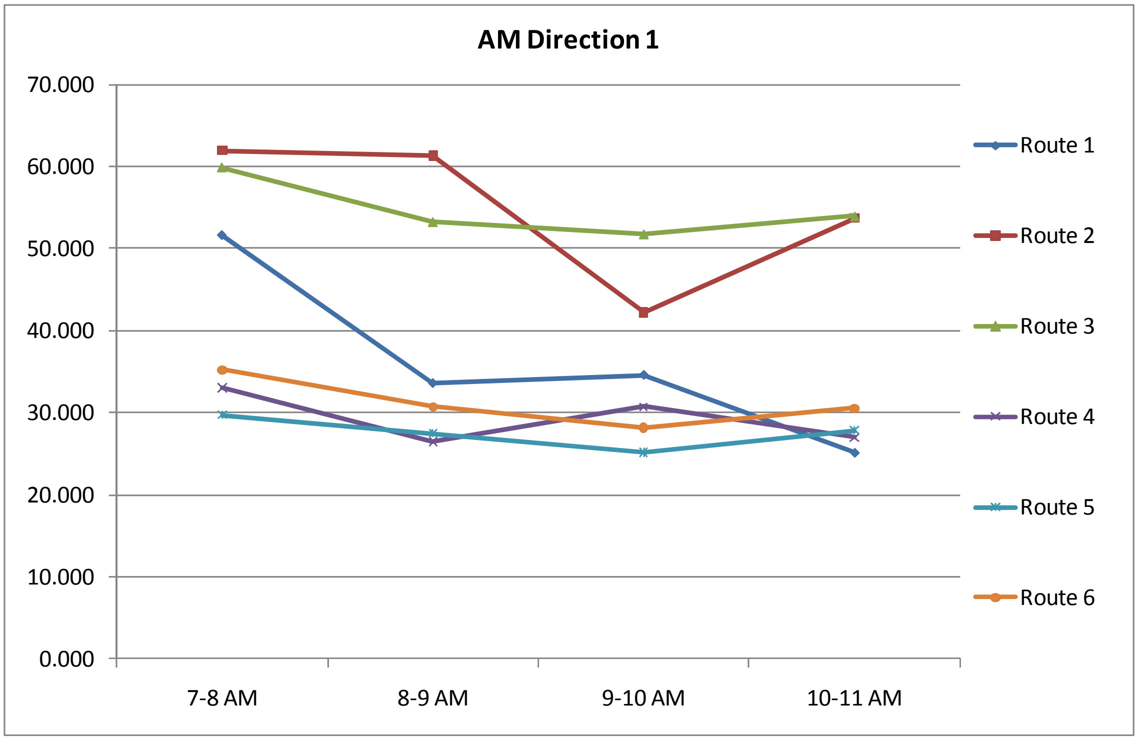
a) Space - Time Plots
b) Field Photos

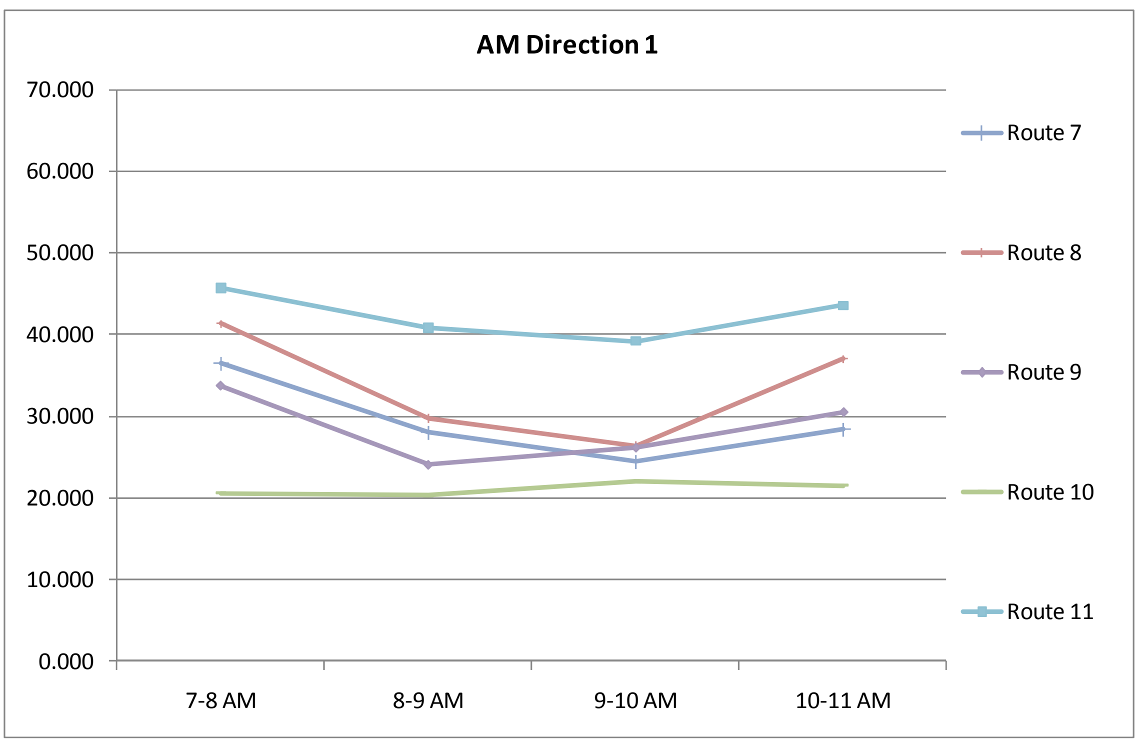
3. Estimation Procedures

a) Route Average Speed Estimation Procedure
b) Route Free flow Speed Estimation Procedure

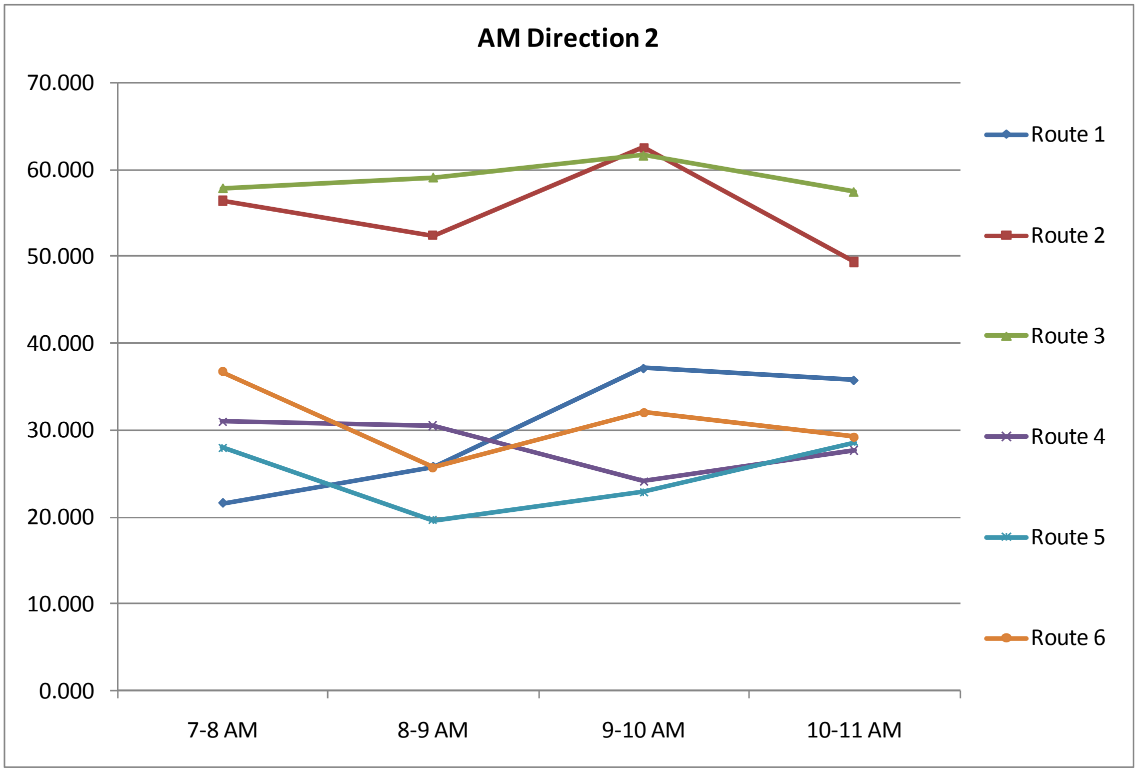
1. Principal Corridors Collective Assessment

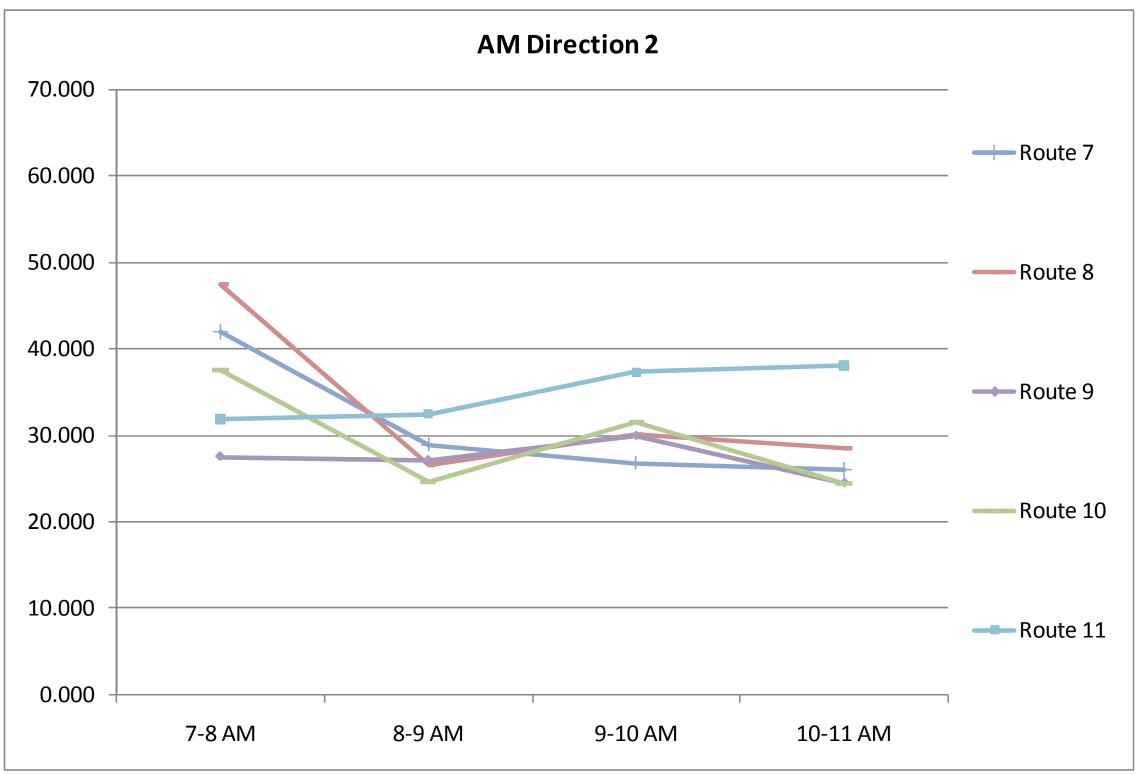
a) Average Speed Plots



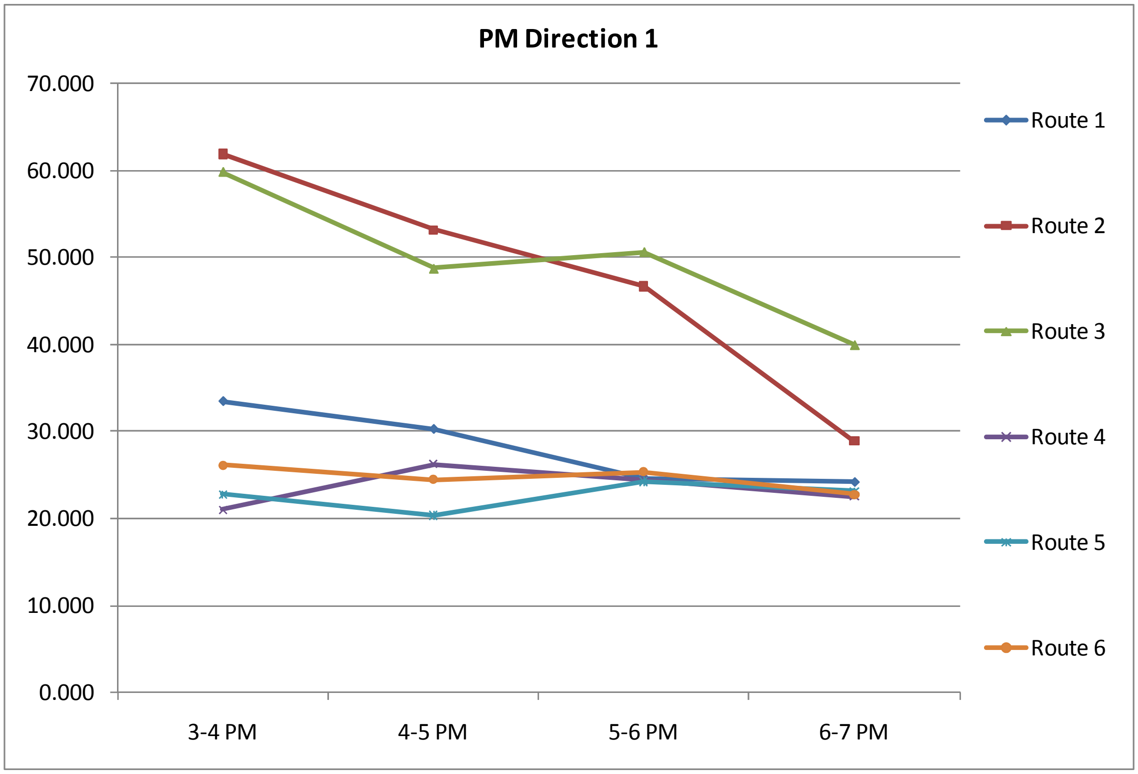


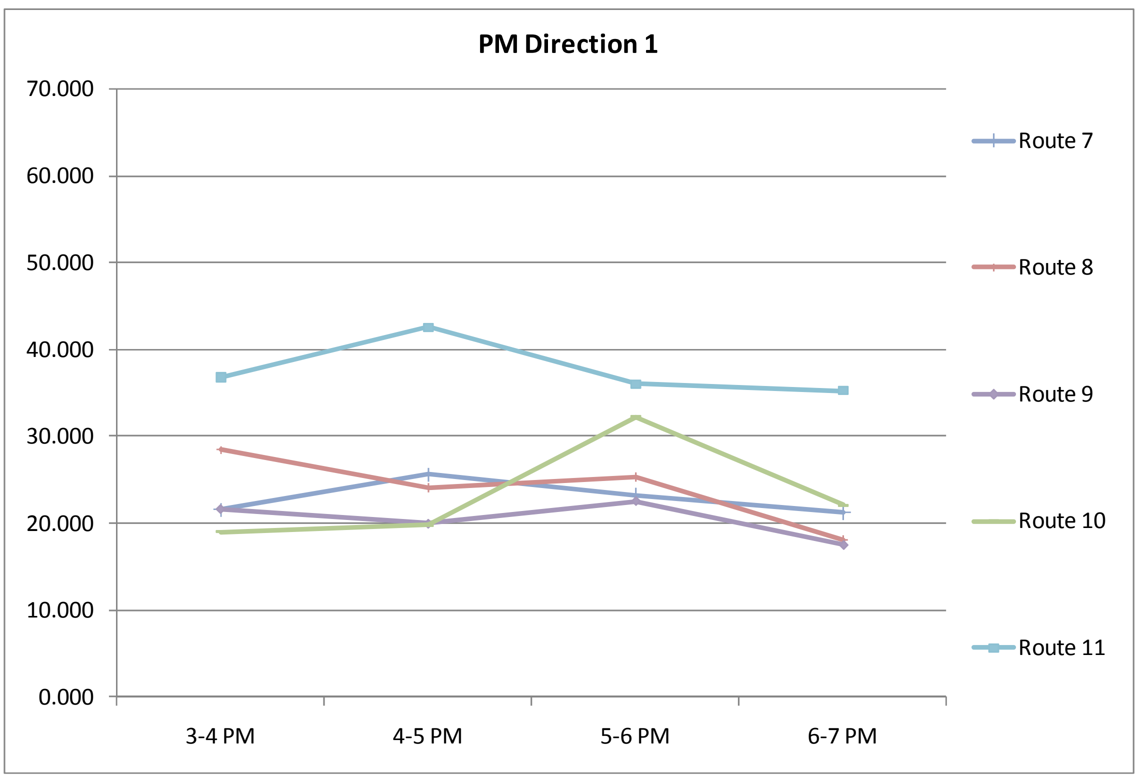
Average Speed Plots (Continued)



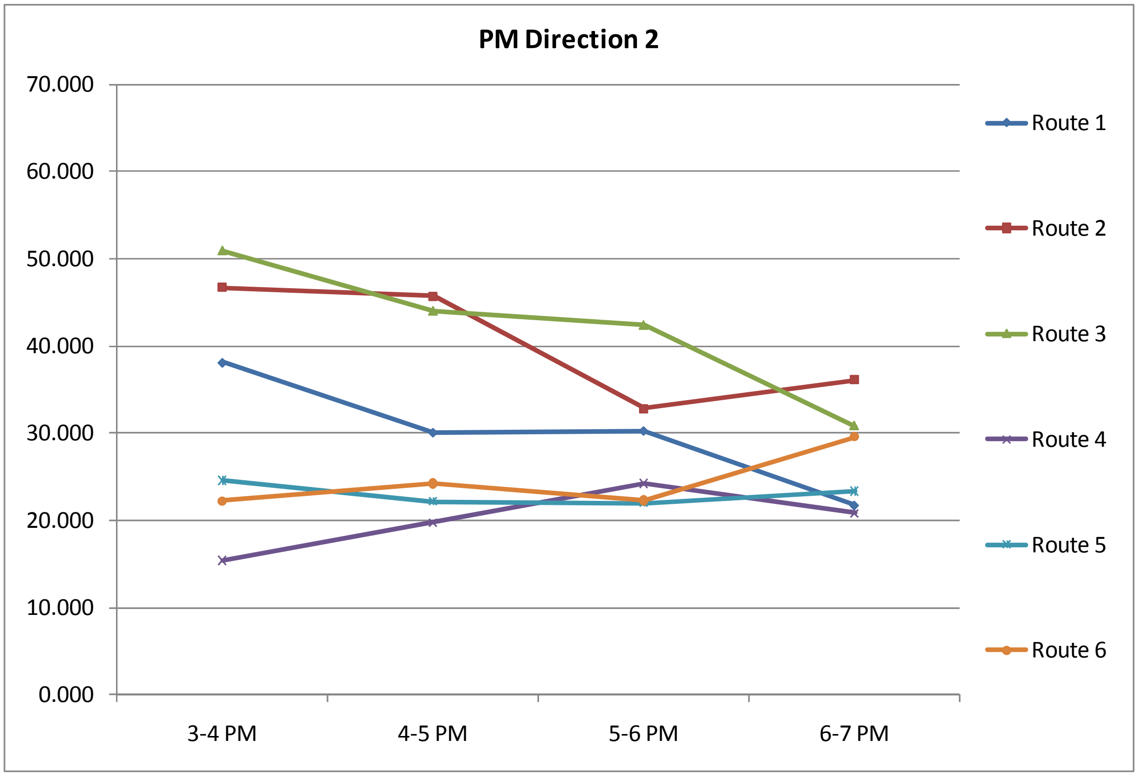


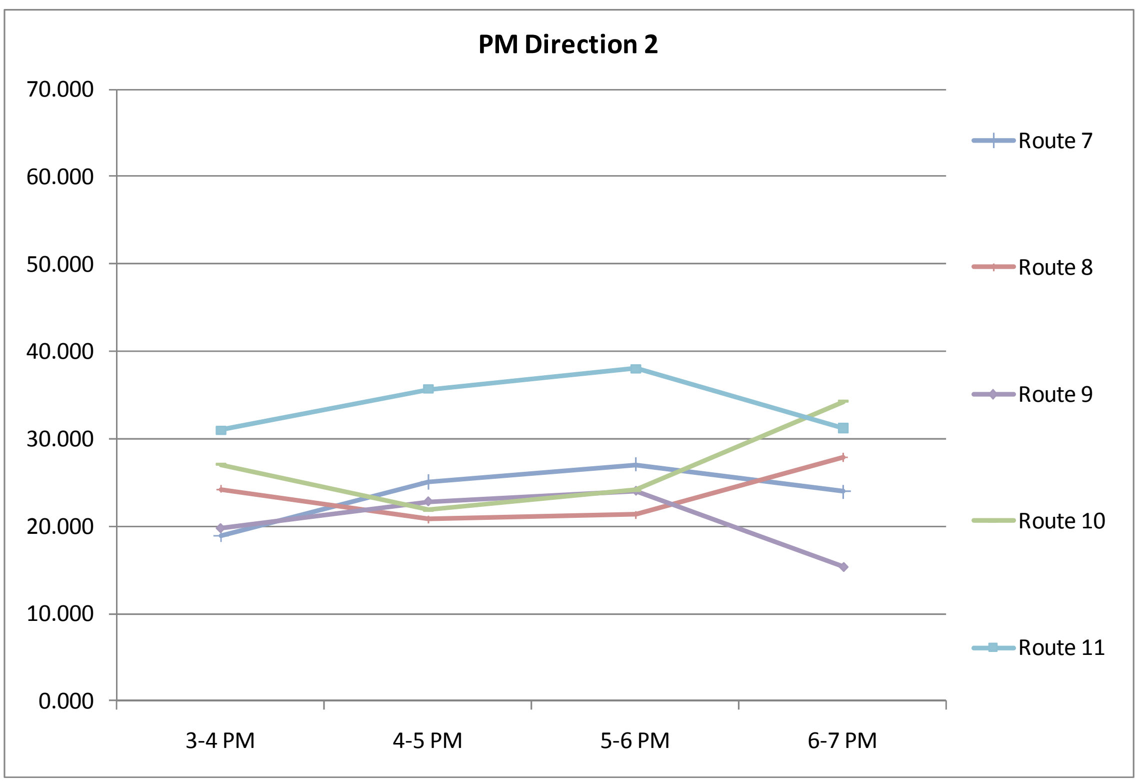
Average Speed Plots (Continued)



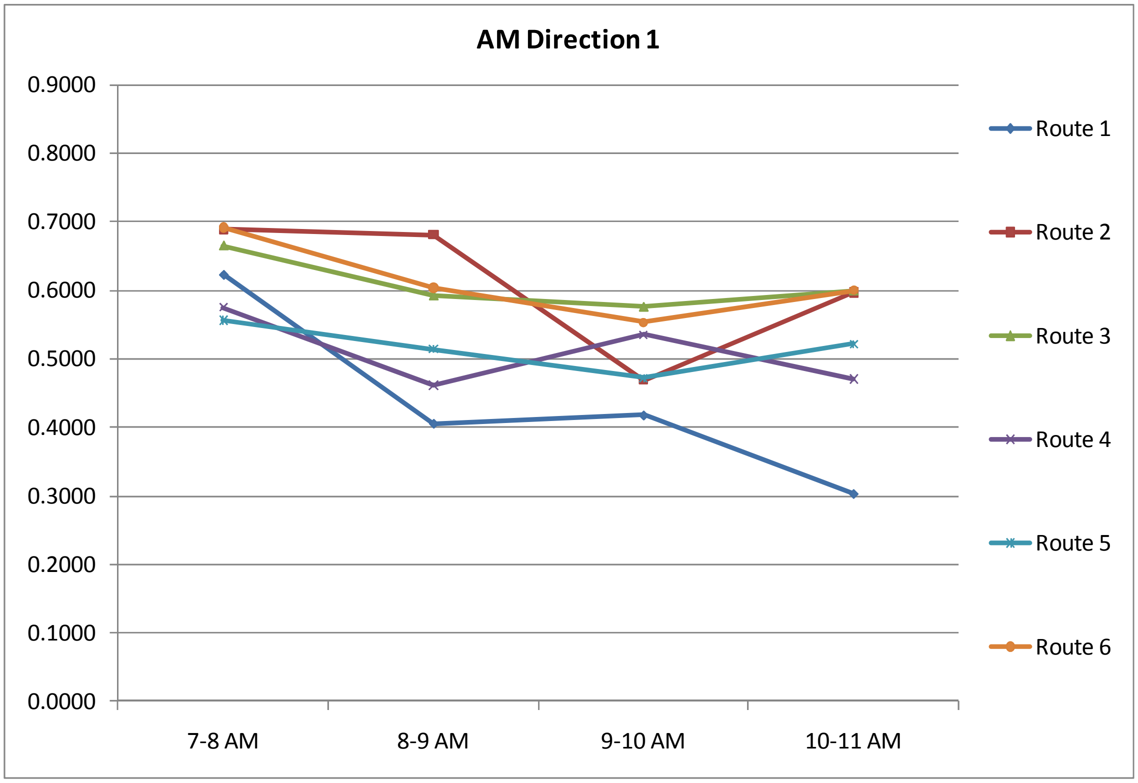


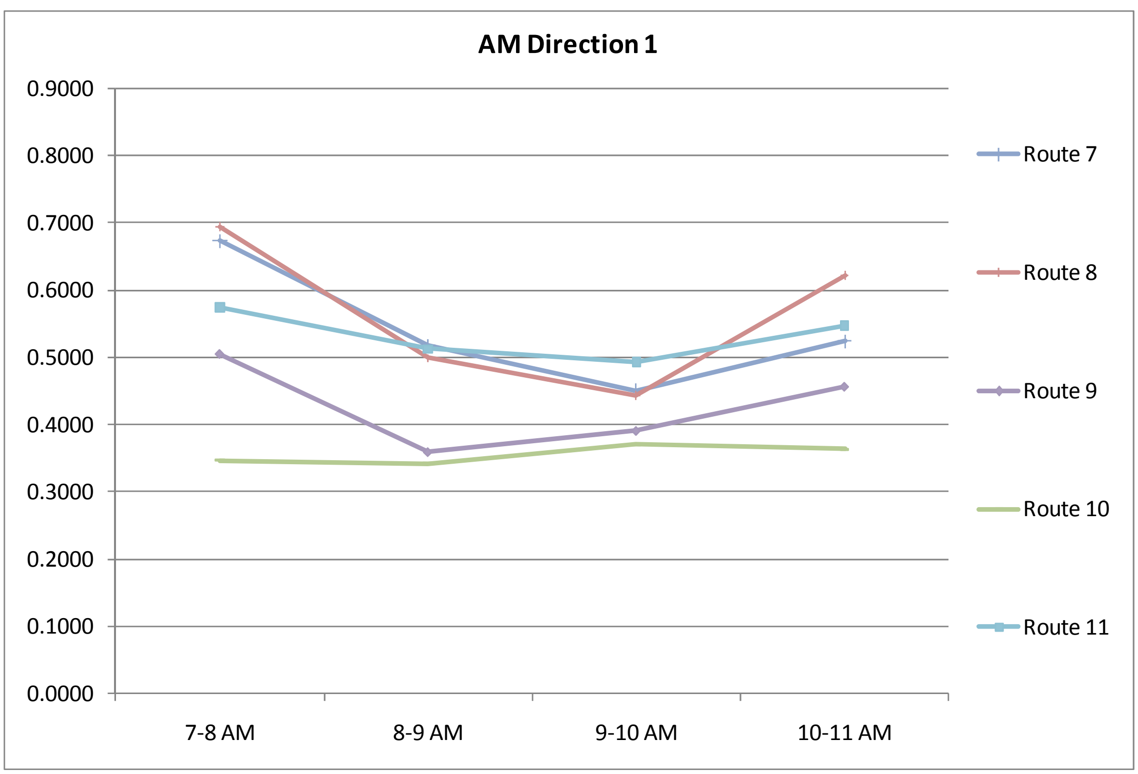
Average Speed Plots (Continued)



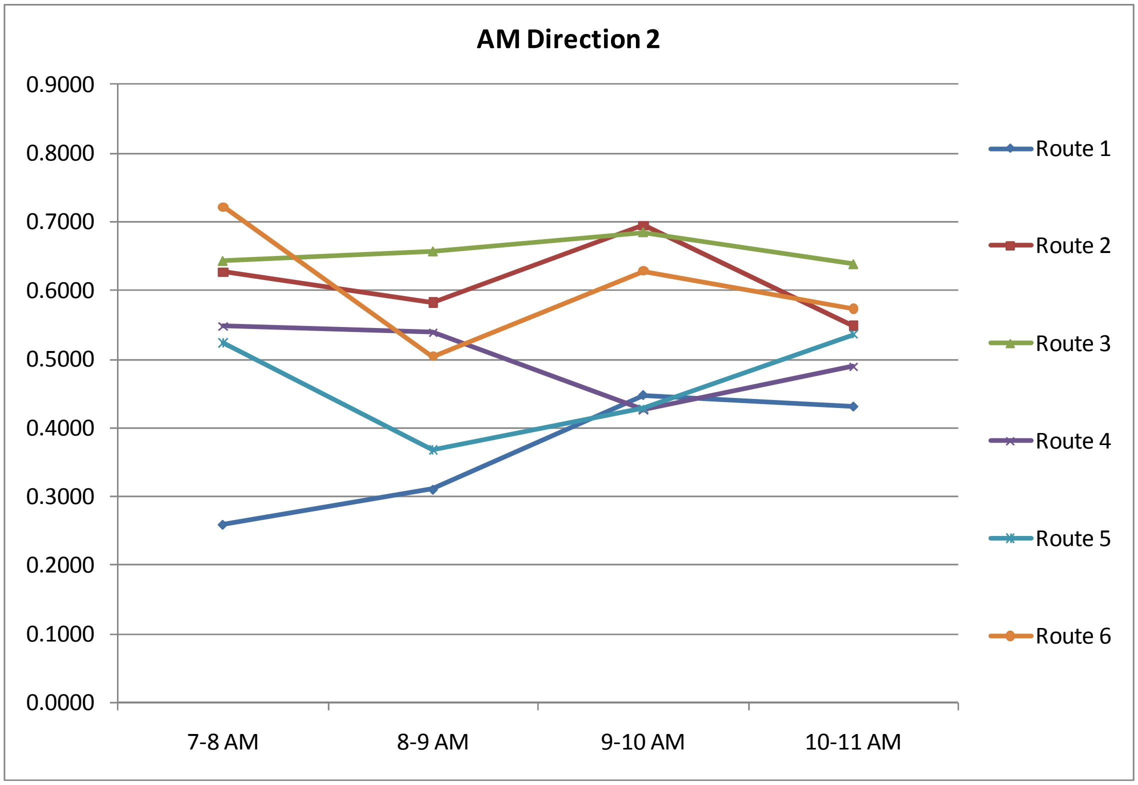


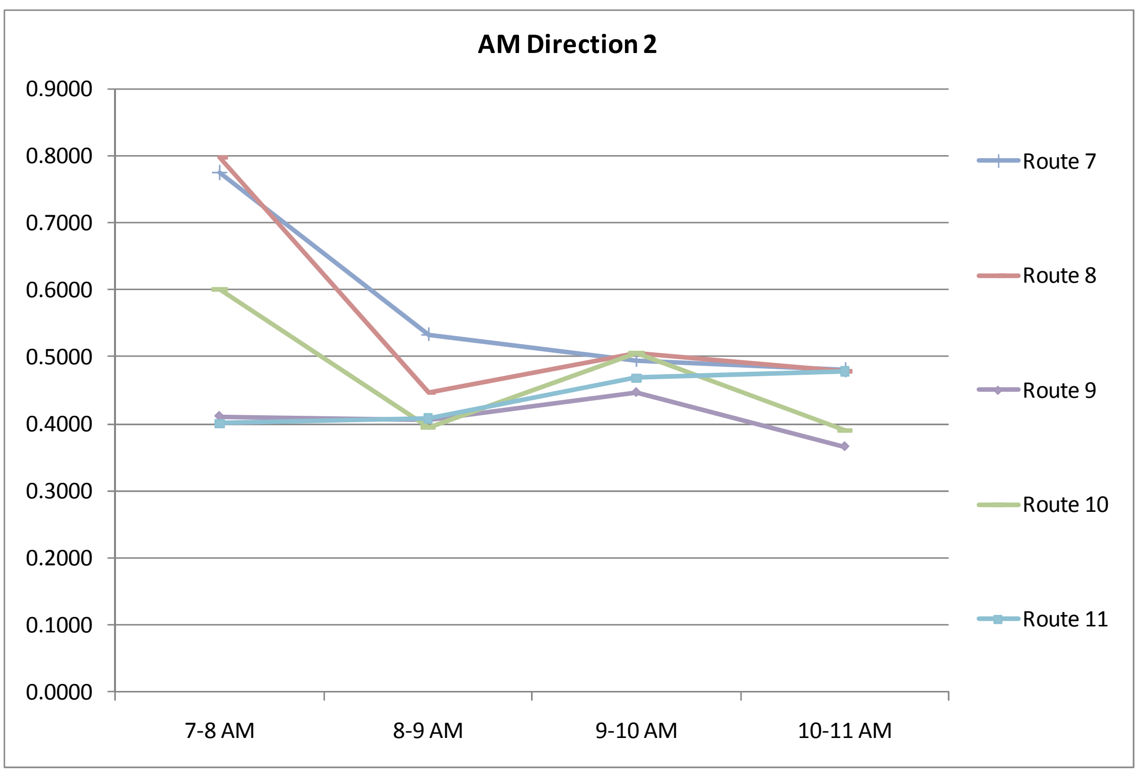
b) Speed Indices Plots



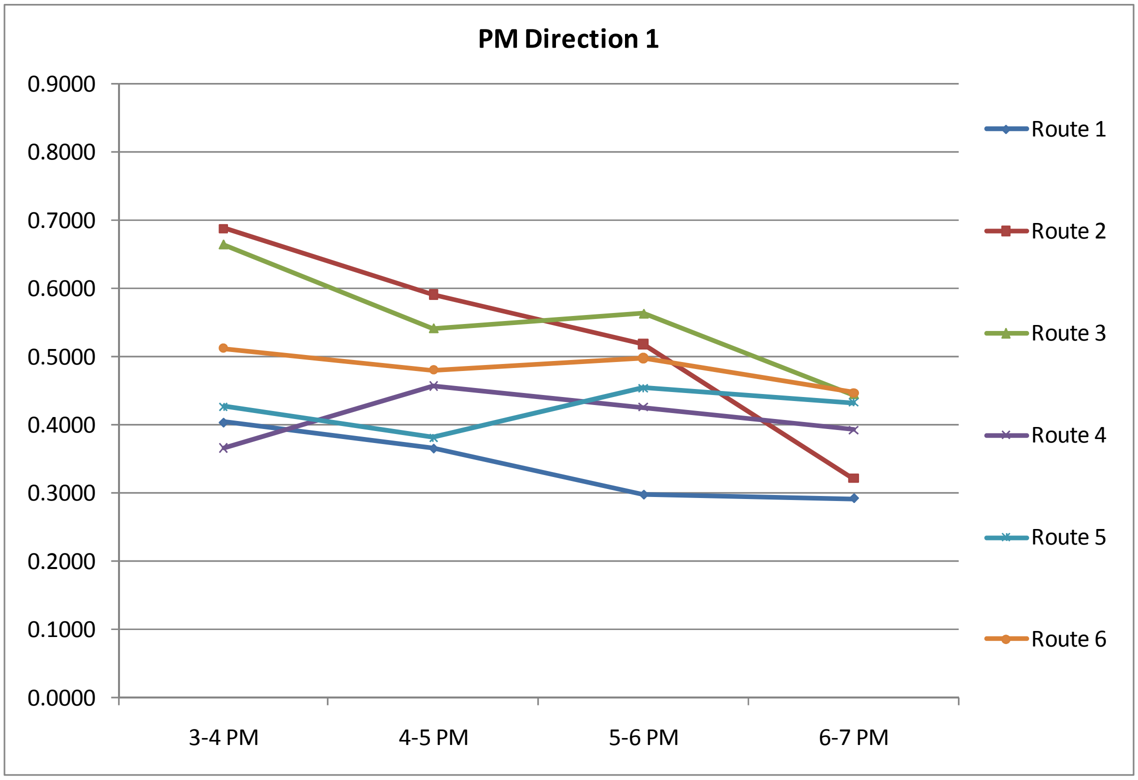


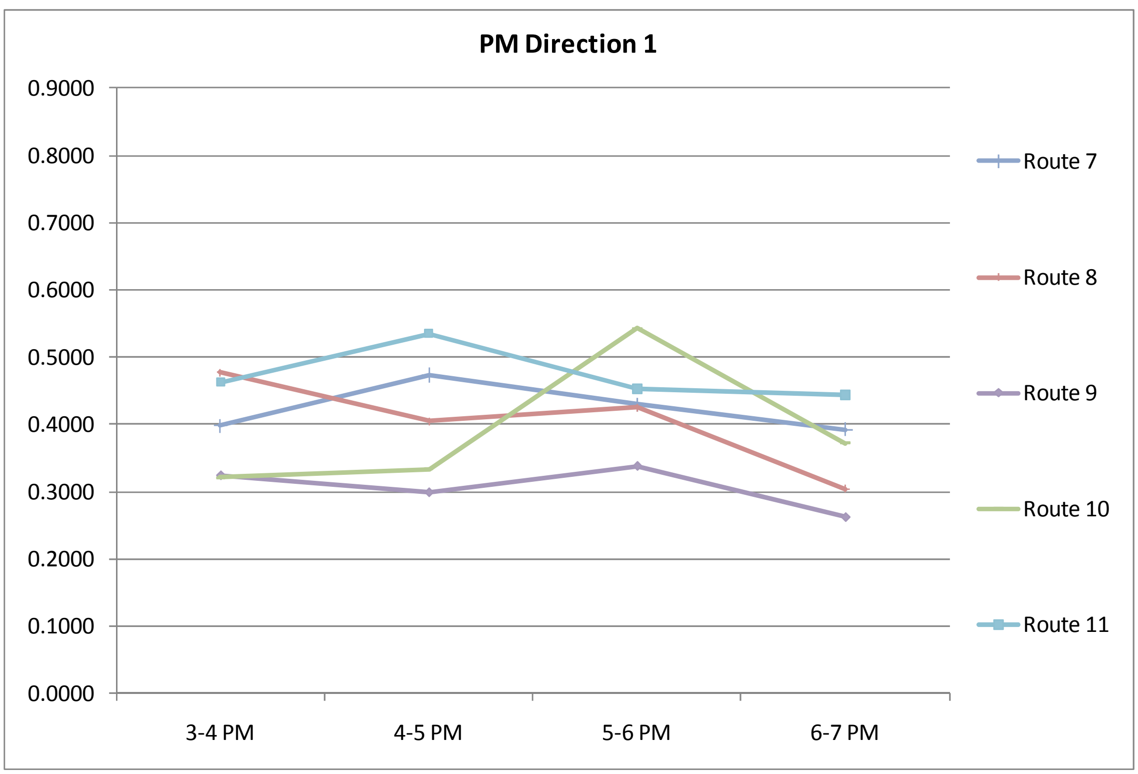
Speed Indices Plots (Continued)



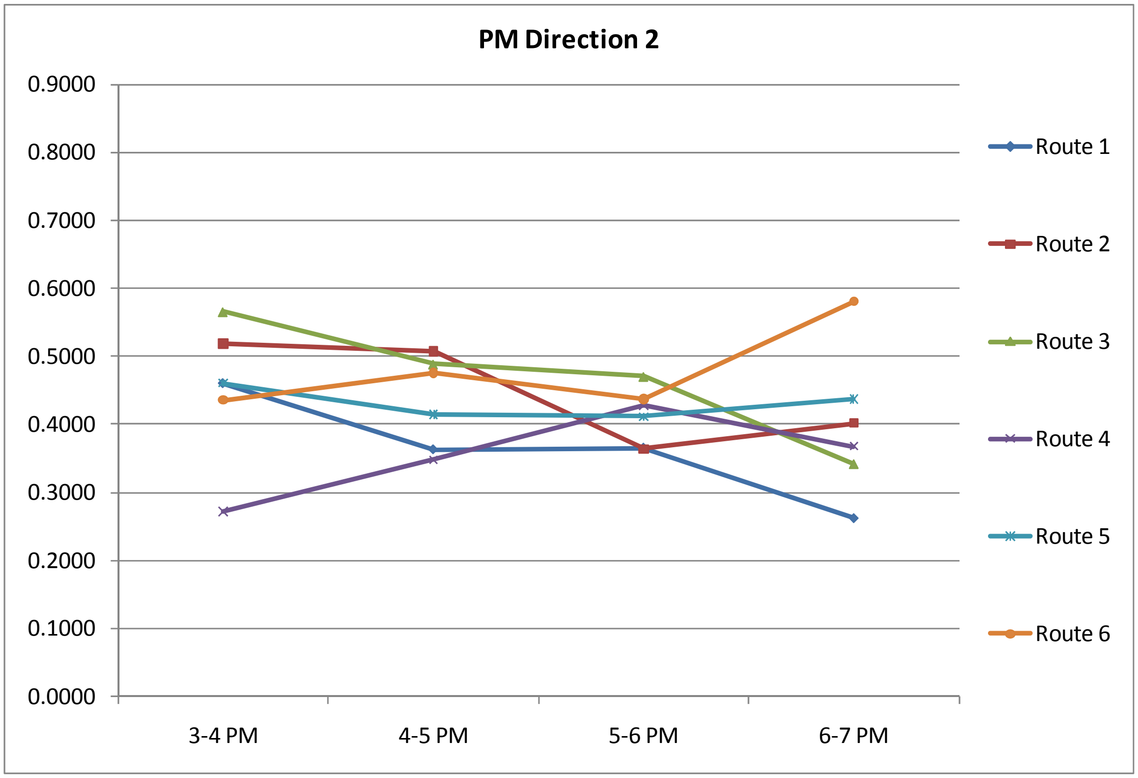


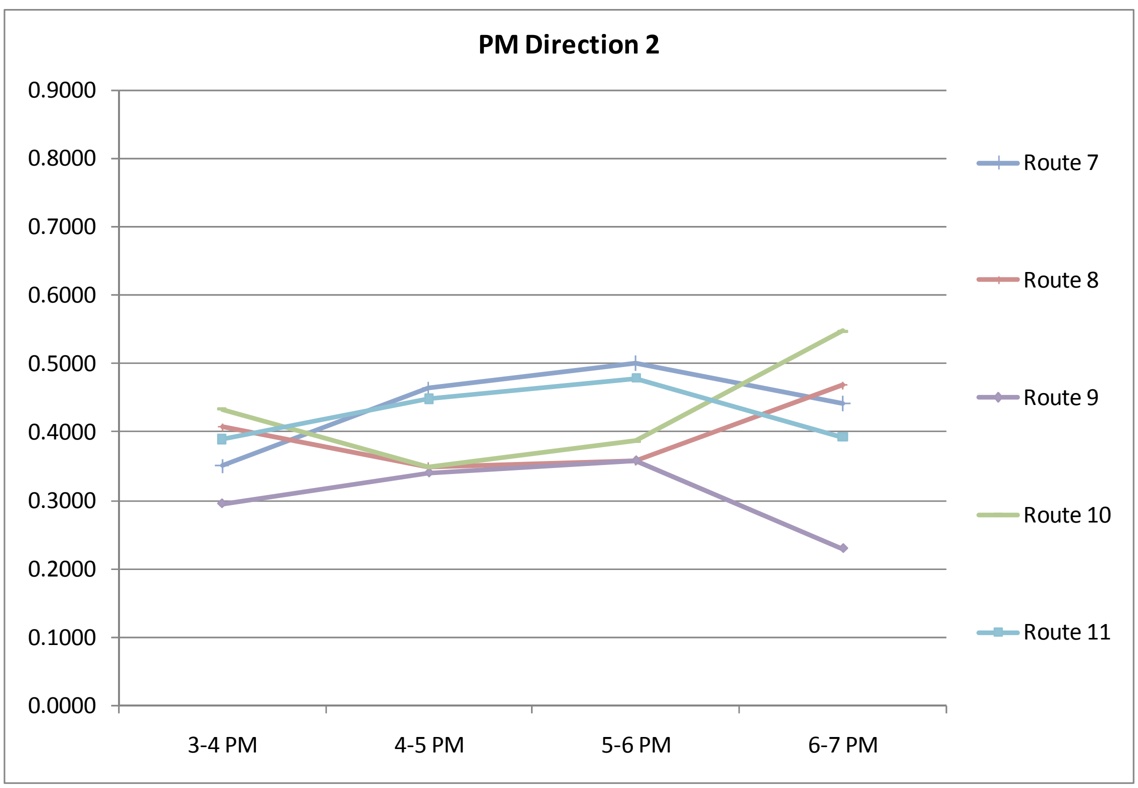
Speed Indices Plots (Continued)





Speed Indices Plots (Continued)





Comments and Observations

On the speed indices of Route 1, 4 (Direction 1) and Route 2, 6 (Direction 2):

The end of the morning peak, dominated by work and school trips, overlaps with the midday period, which is characterized by trips for shopping, banking, and governmental services. This overlap results in the congestion levels increasing towards the midday.

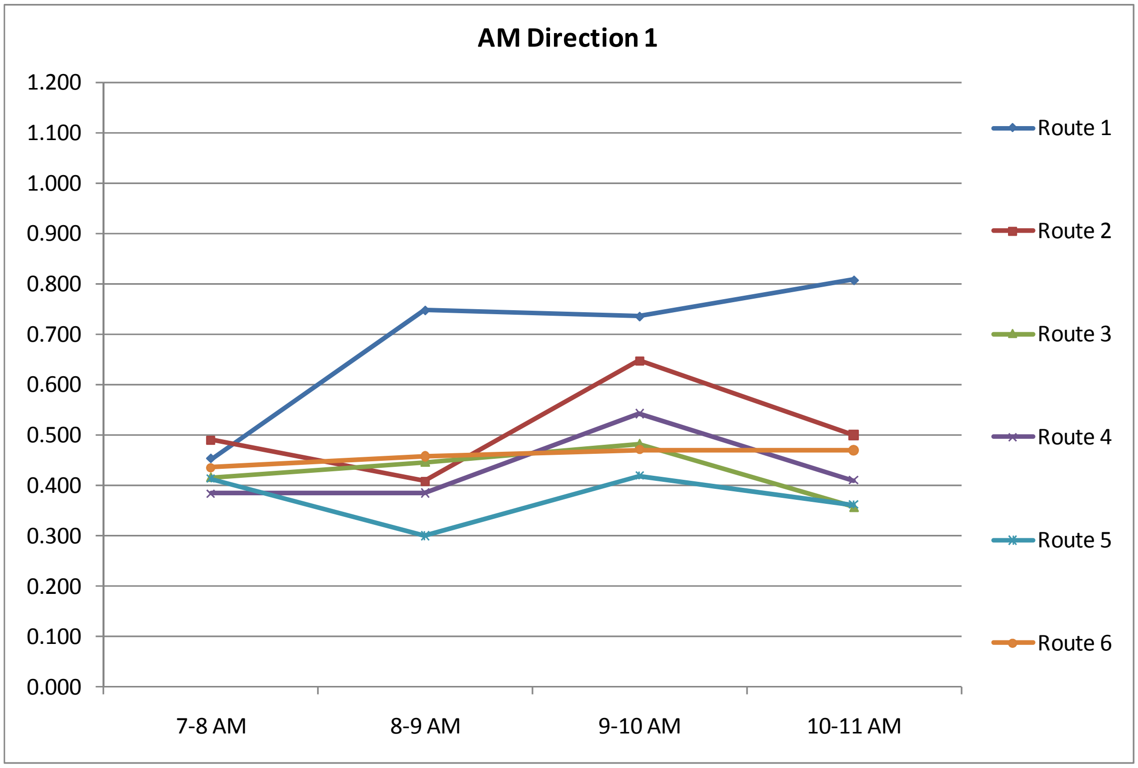
Congestion on Route 1 (Direction 2):

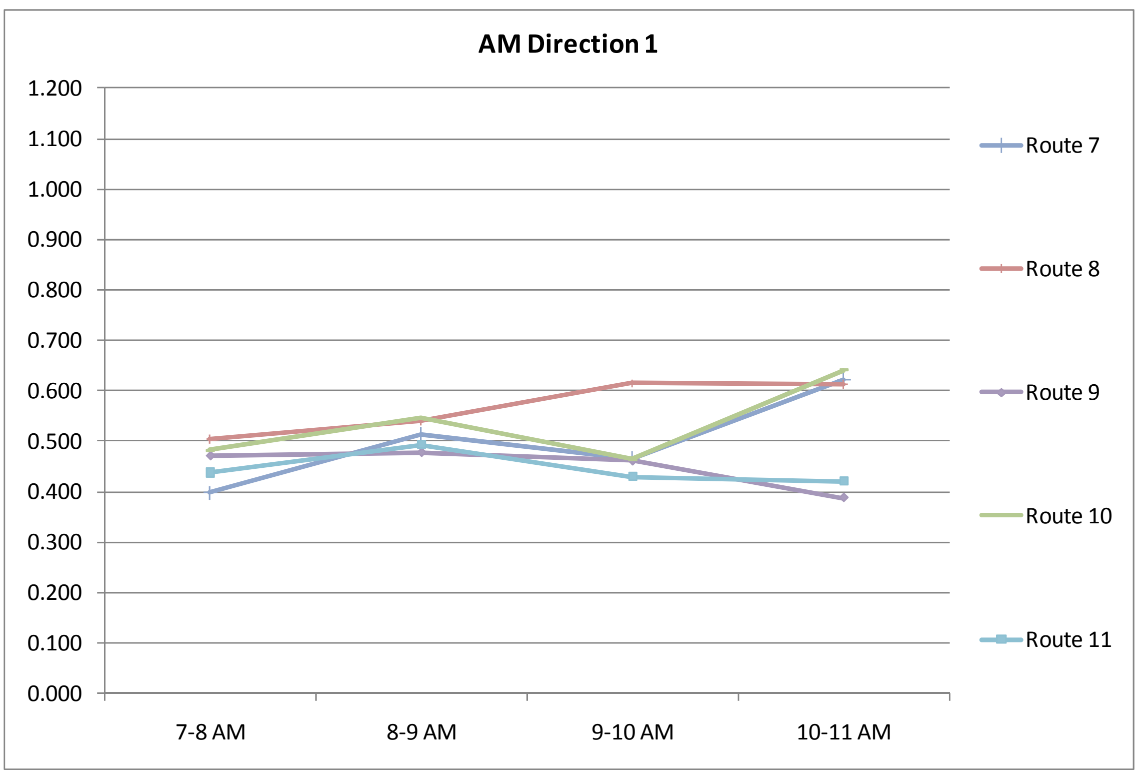
The 26th of July corridor is a major corridor that links Cairo/Giza to 6th of October city and Cairo/Alex Desert Road. Many large scale businesses as well as a huge industrial zone is located on this side of the Corridor inducing high directional peak hour traffic volume for direction 2 during the early AM peak and direction 1 during the PM peak.

Congestion witnessed after the PM peak period:

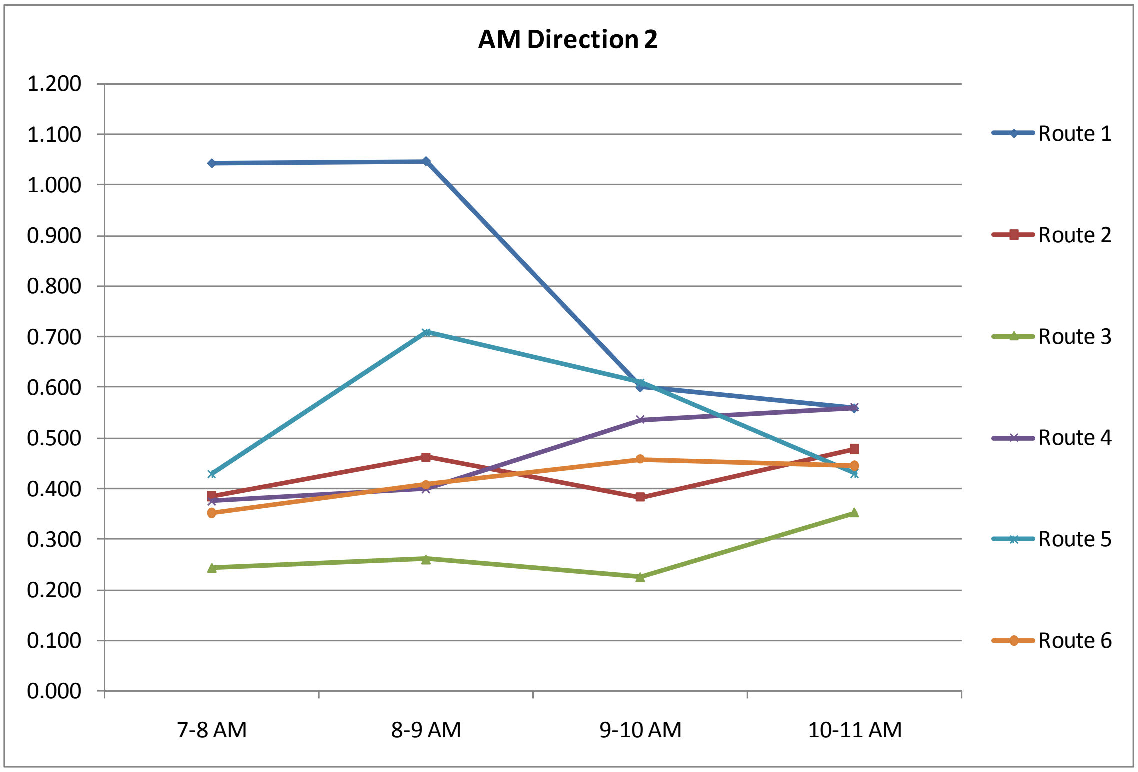
The end of the evening peak, dominated by work trips, overlaps with night time which is characterized by trips for socialization, shopping, entertainment…etc. This overlap results in congestion levels increasing towards the end of the evening peak period.

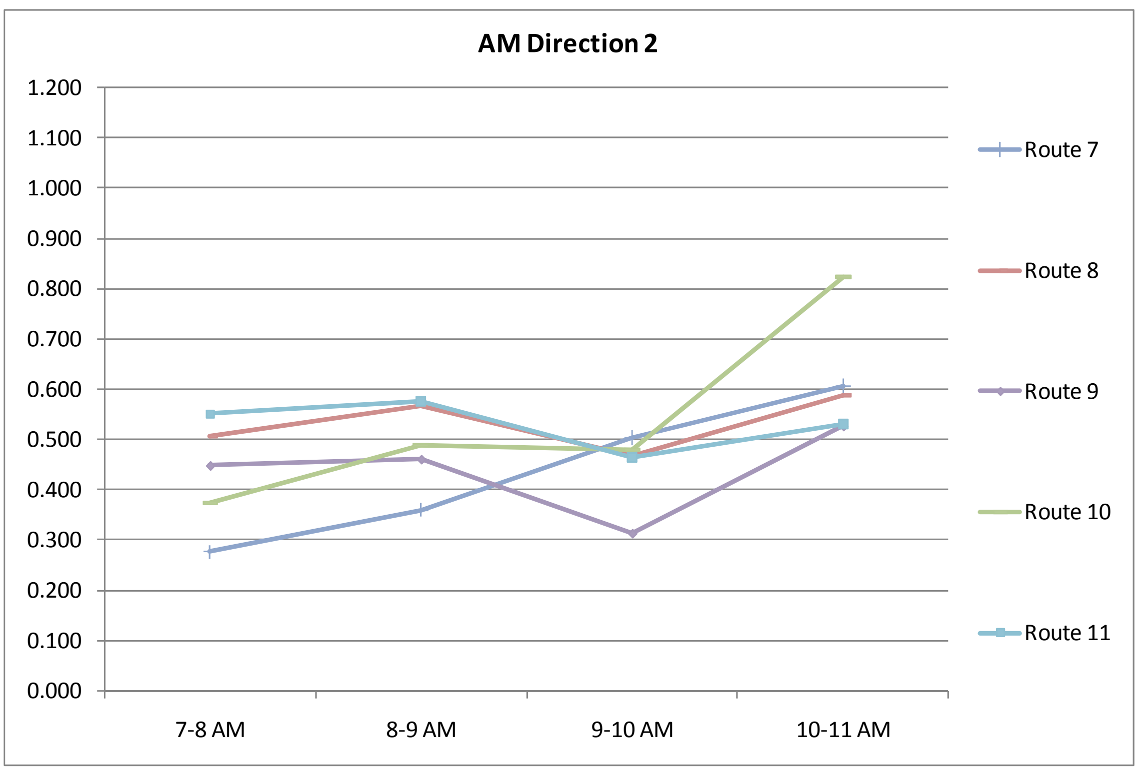
c) Coefficients of Variation Plots



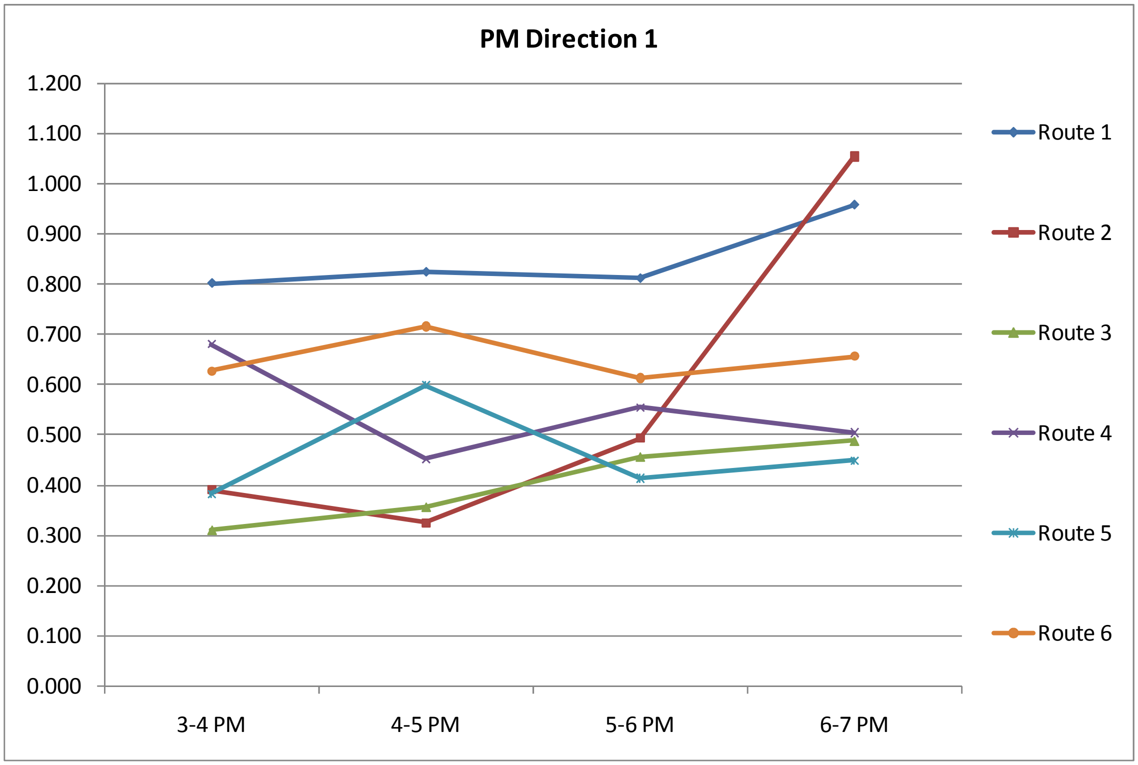


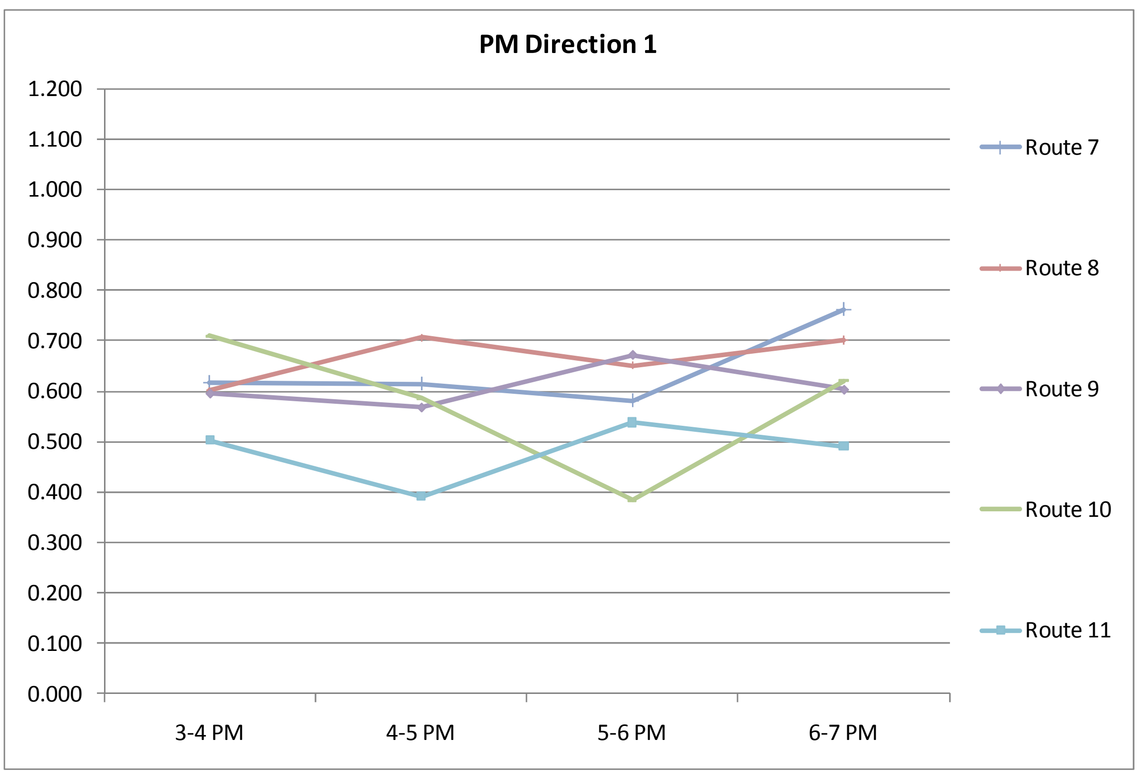
Coefficients of Variation Plots (Continued)



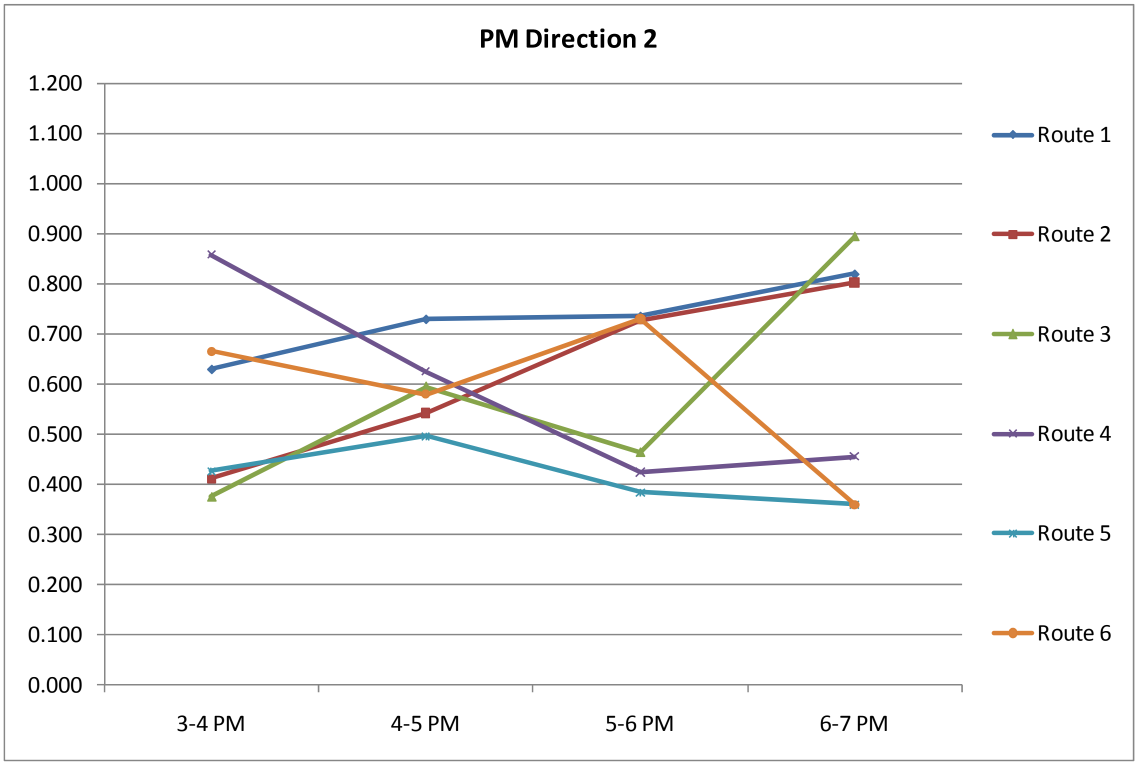


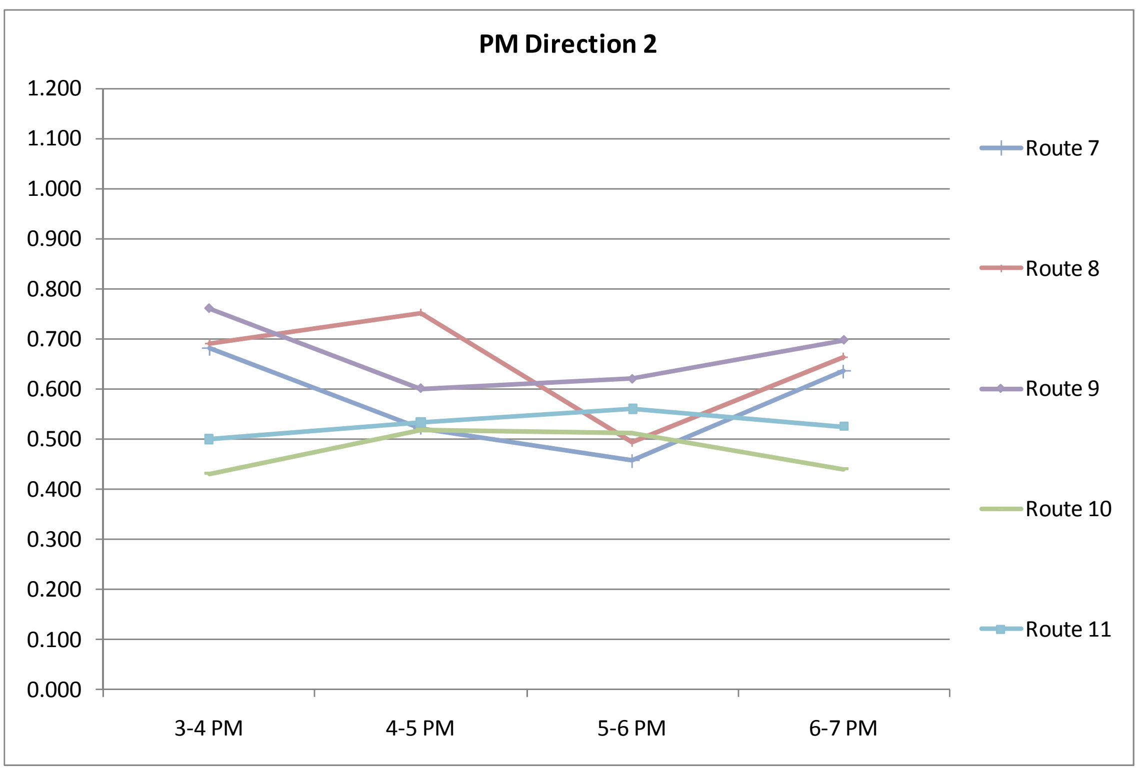
Coefficients of Variation Plots (Continued)





Coefficients of Variation Plots (Continued)



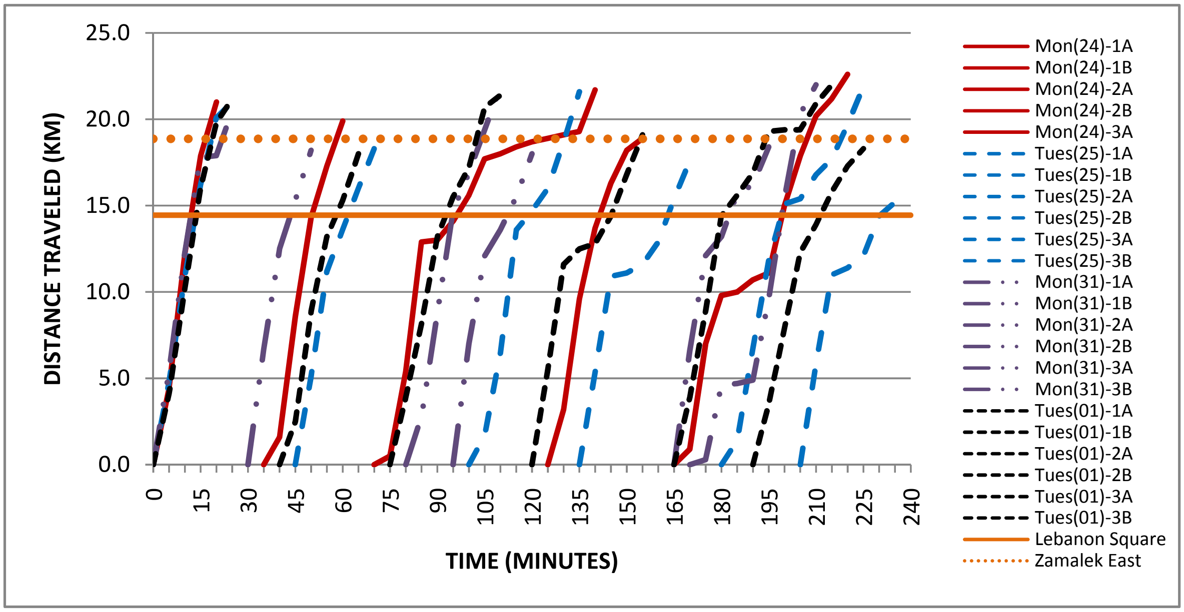


2. Principal Corridors Individual Assessment

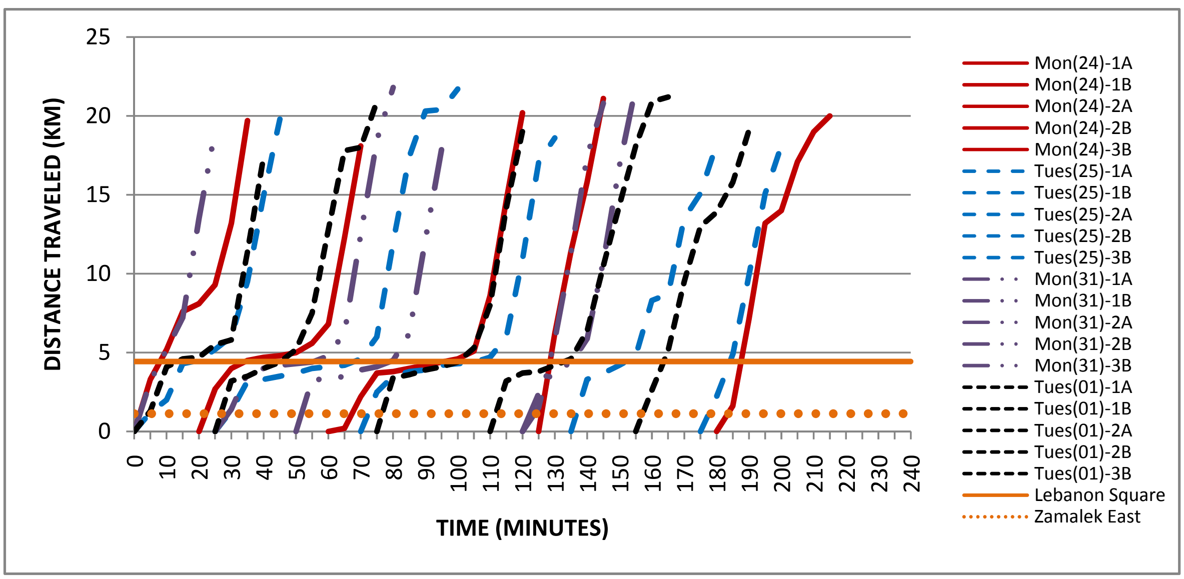
a) Space-Time Plots

- The survey during the morning peak period started at 7:00 AM and ended at 11:00 AM
- The survey during the evening peak period started at 3:00 PM and ended at 7:00 PM

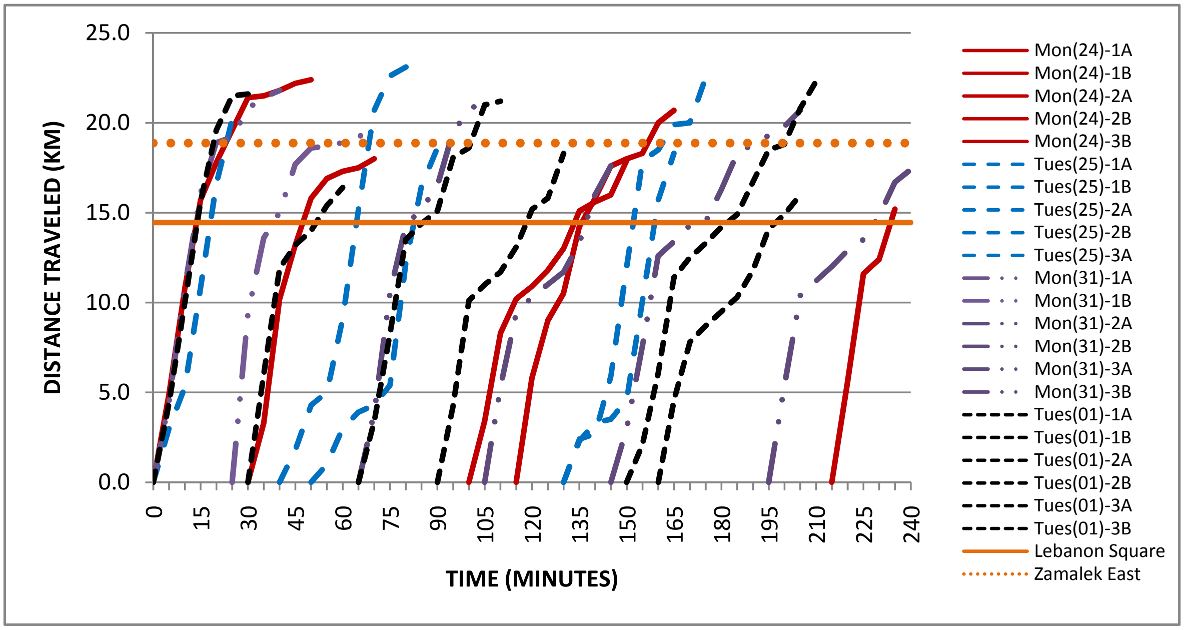
Route 1- AM Direction 1



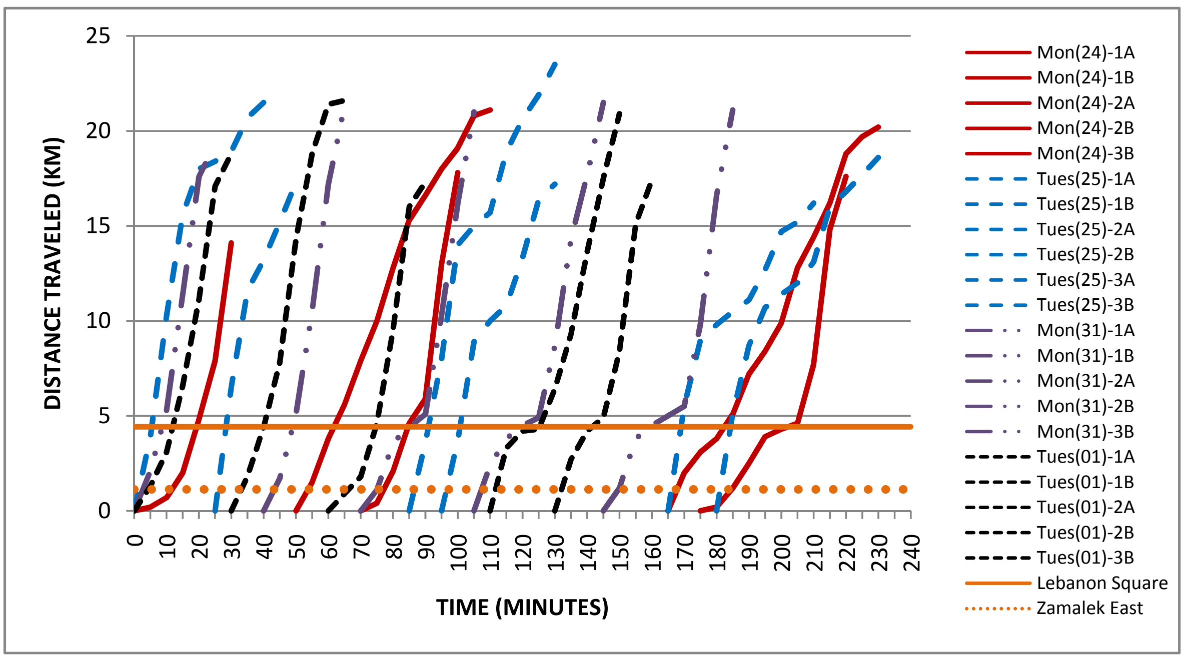
Route 1- AM Direction 2



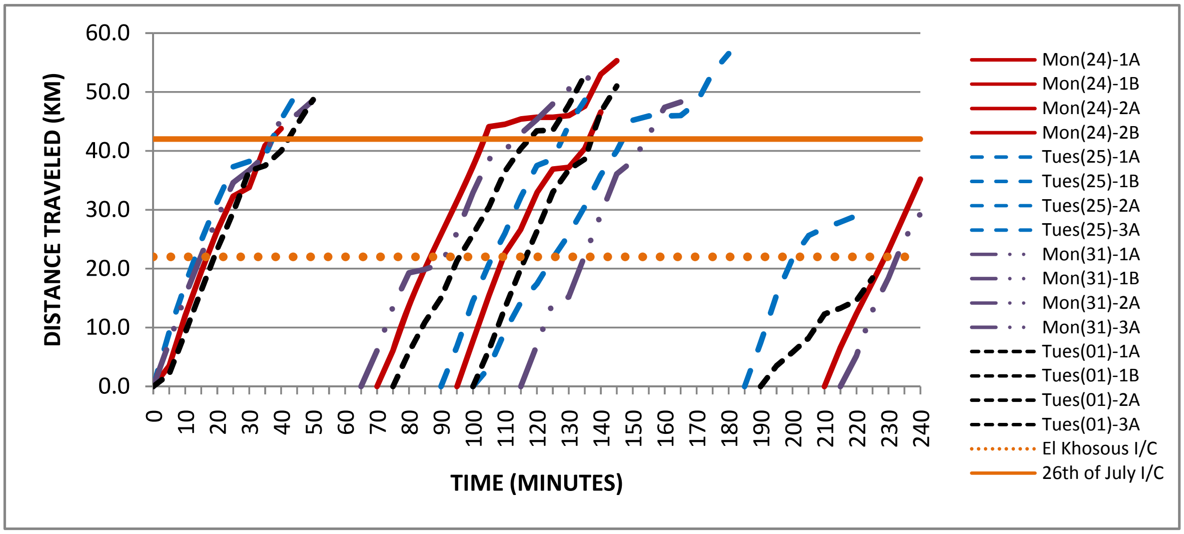
Route 1- PM Direction 1



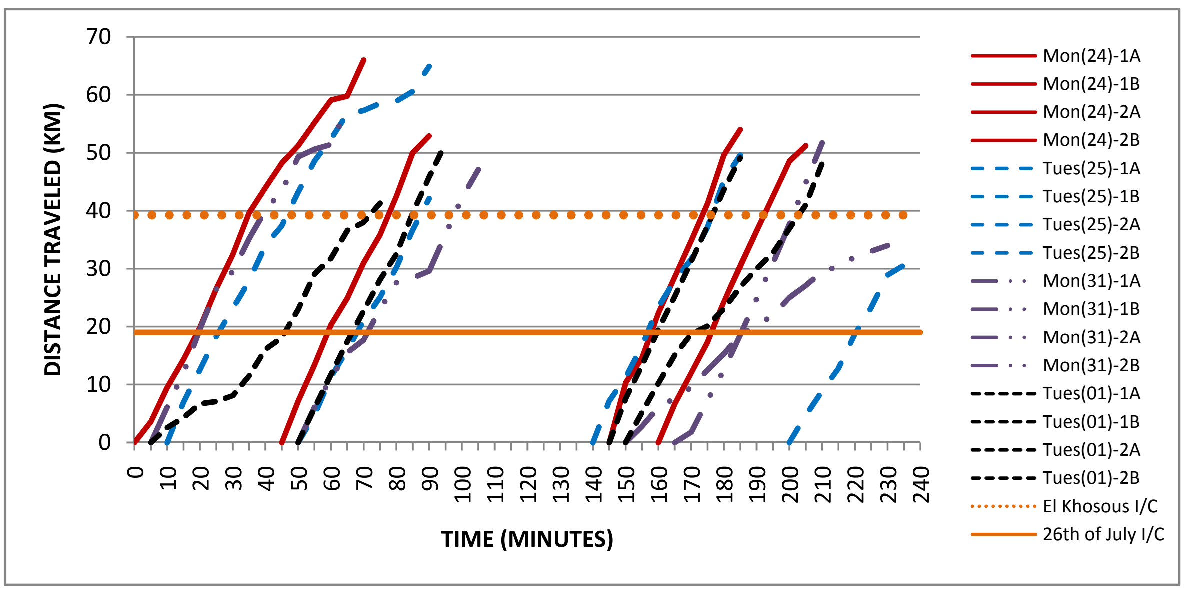
Route 1- PM Direction 2



Route 2- AM Direction 1



Route 2- AM Direction 2



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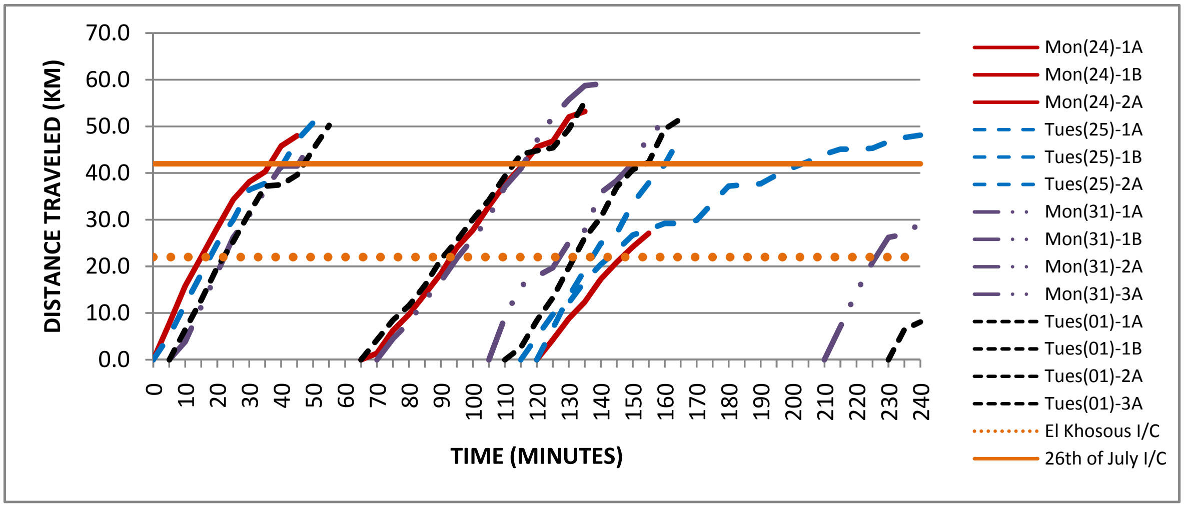

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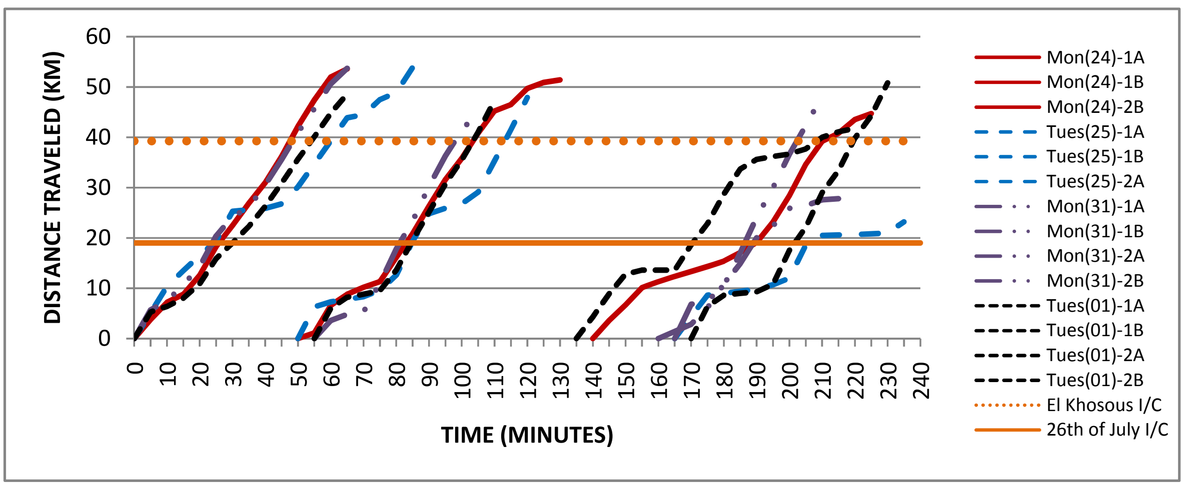
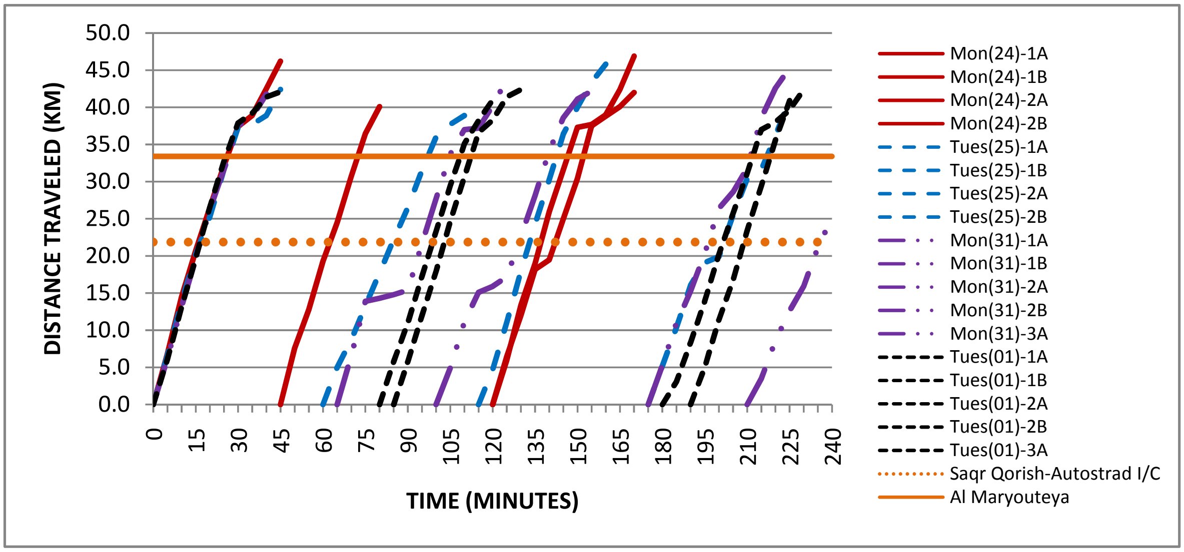
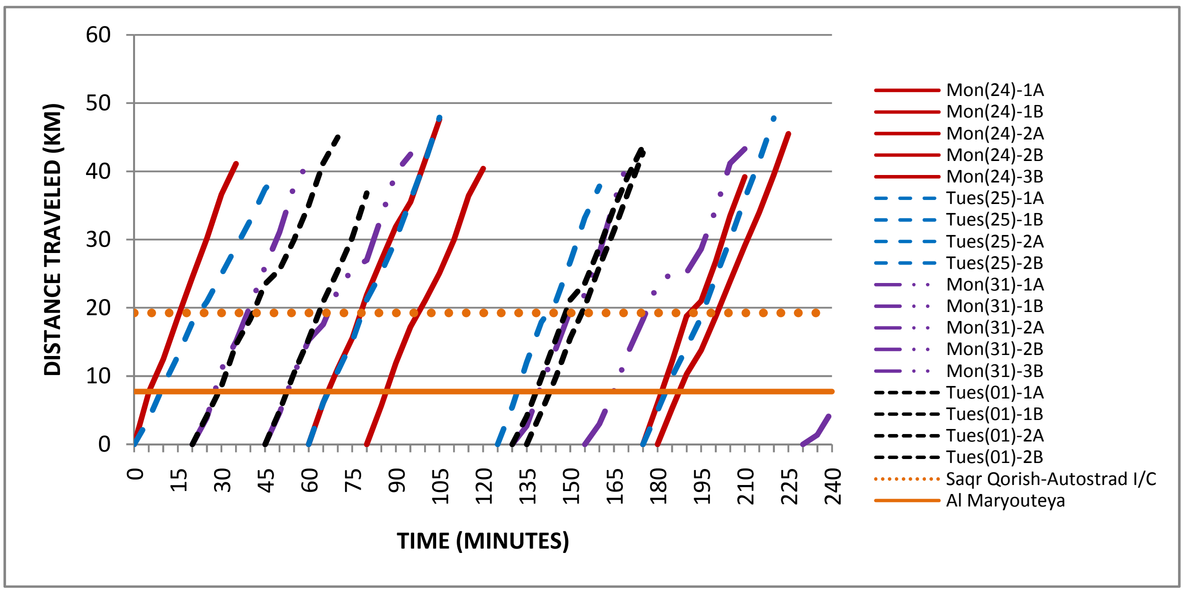


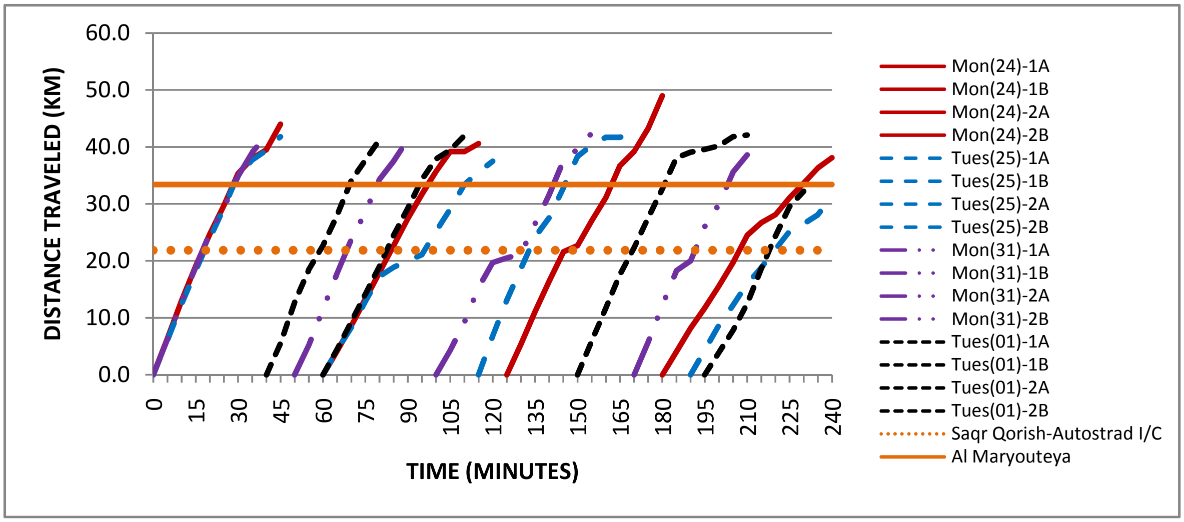
Route 3- AM Direction 1



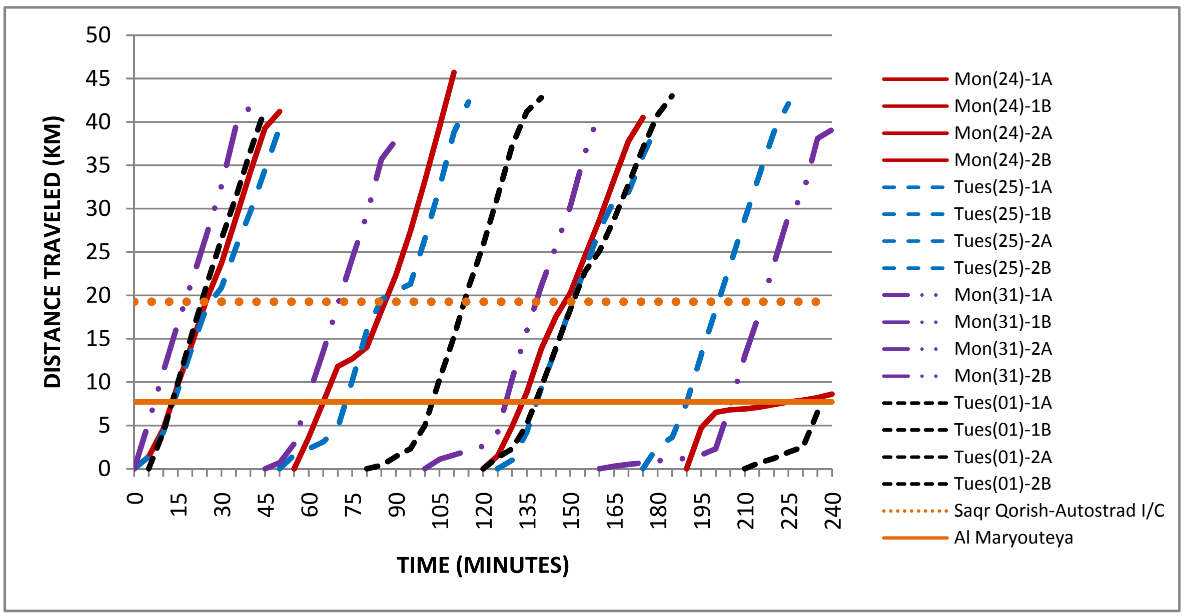
Route 3- AM Direction 2



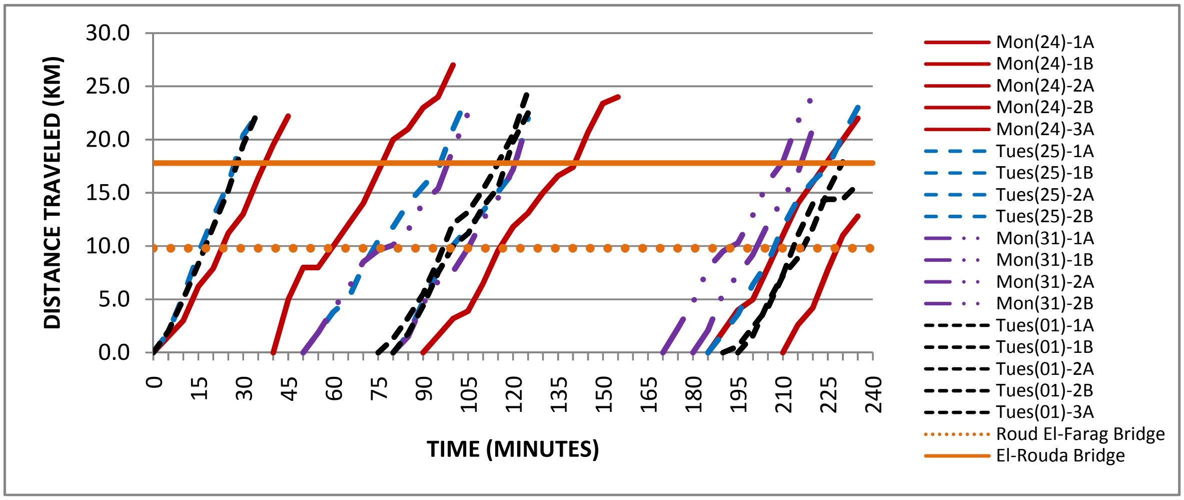
Route 3- PM Direction 1



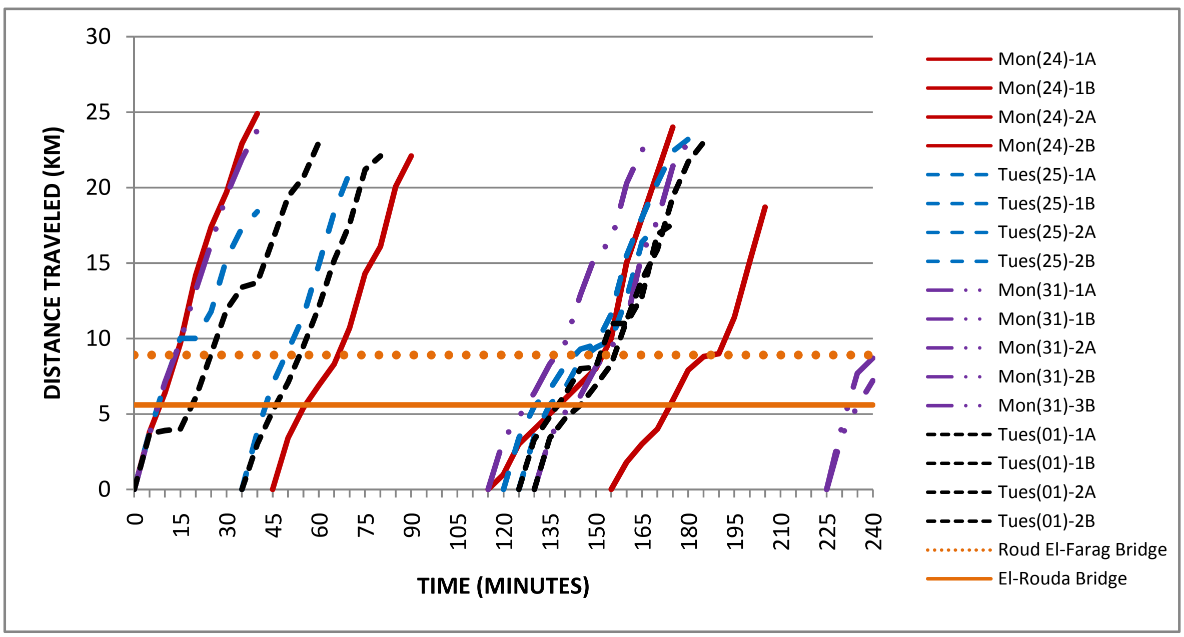
Route 3- PM Direction 2



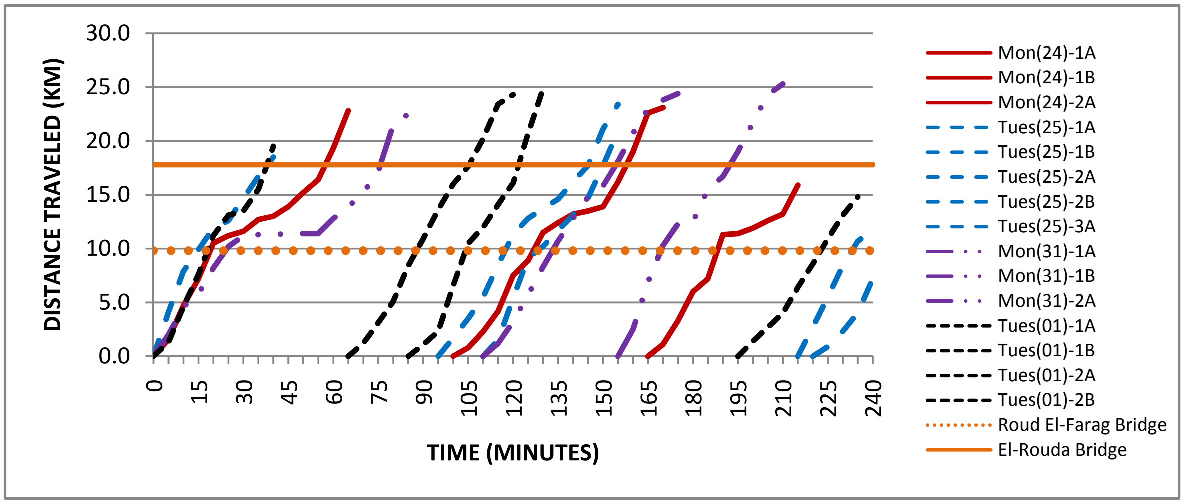
Route 4- AM Direction 1



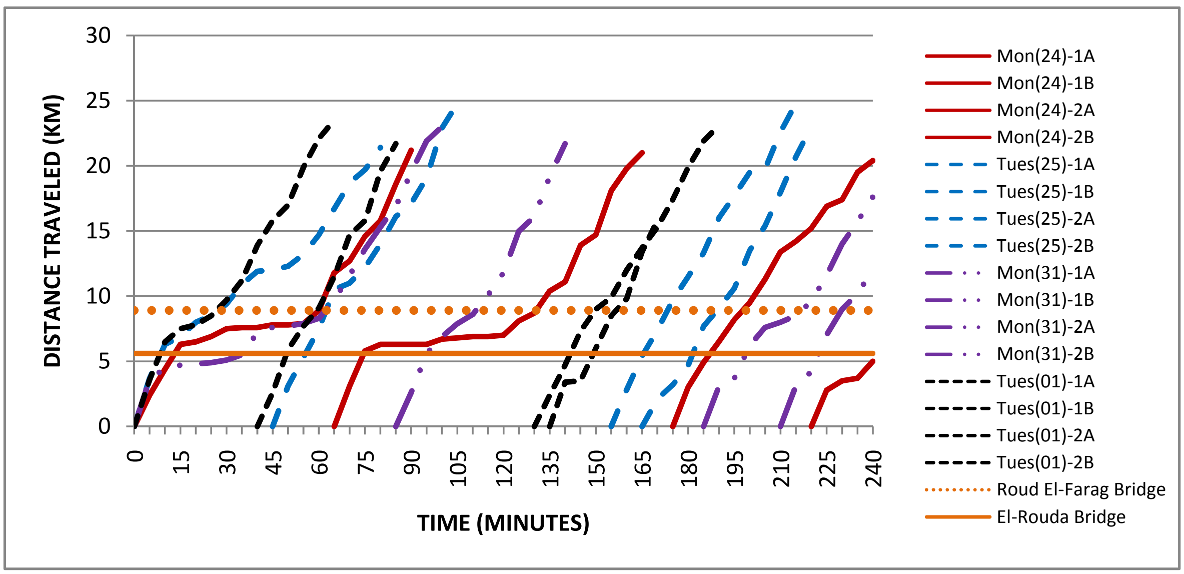
Route 4- AM Direction 2



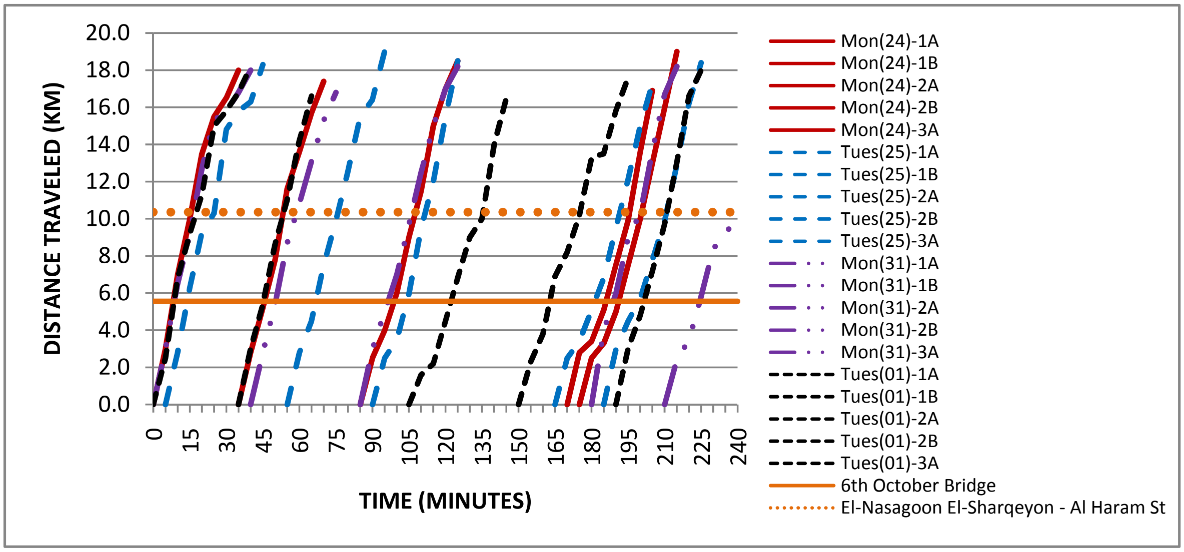
Route 4- PM Direction 1



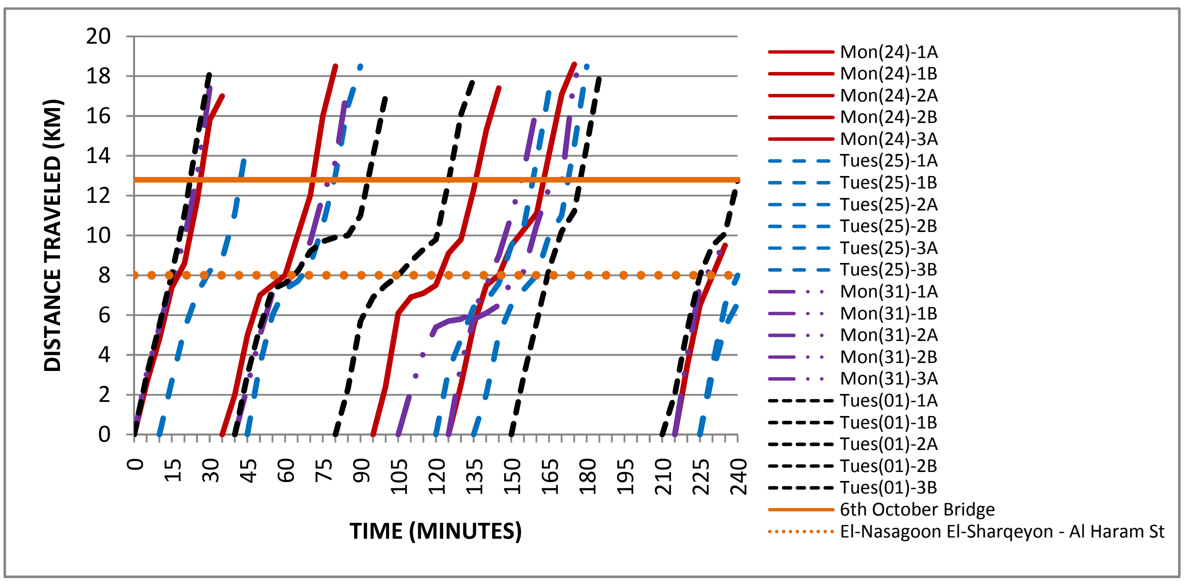
Route 4- PM Direction 2



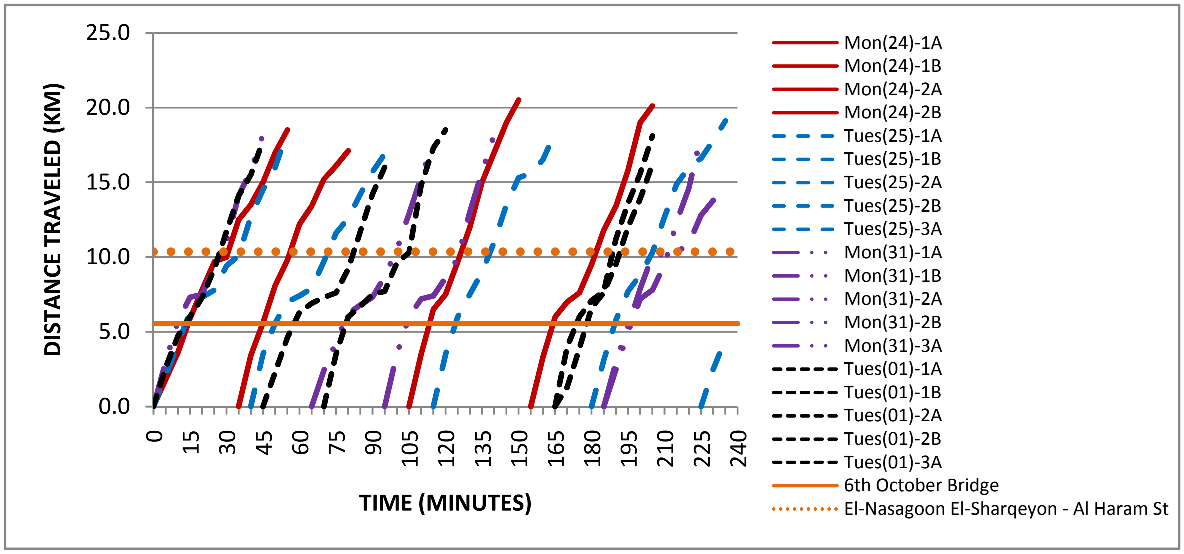
Route 5- AM Direction 1



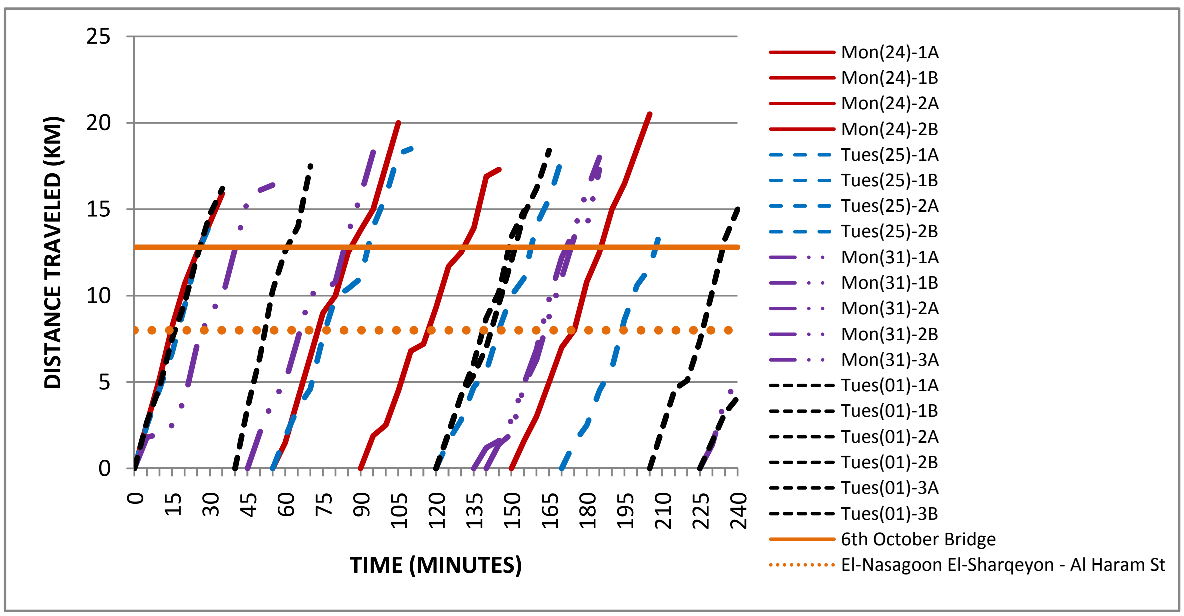
Route 5- AM Direction 2



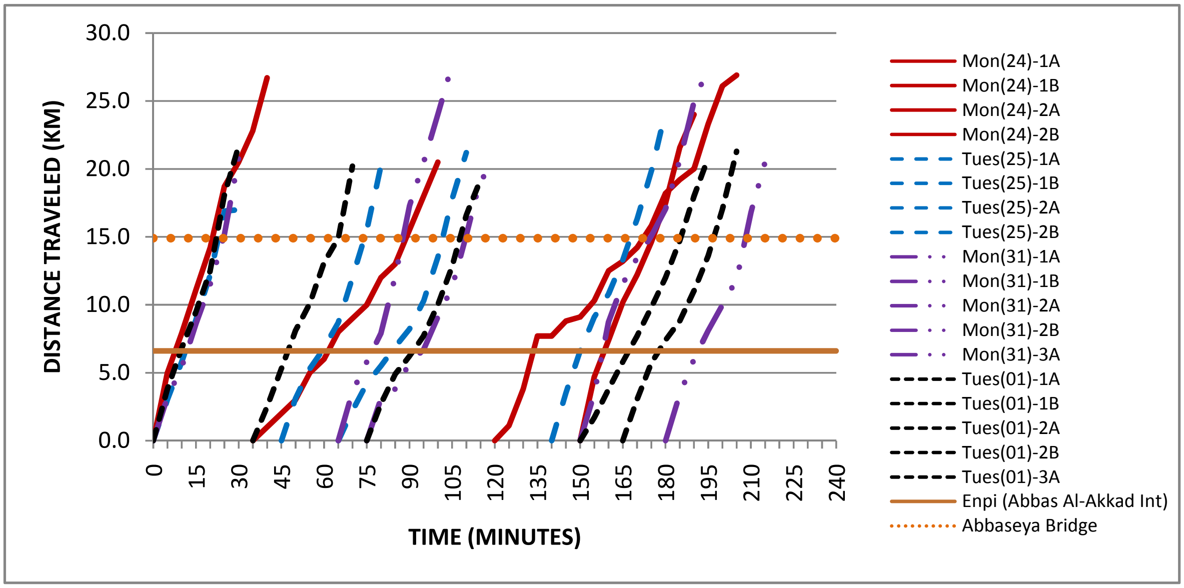
Route 5- PM Direction 1



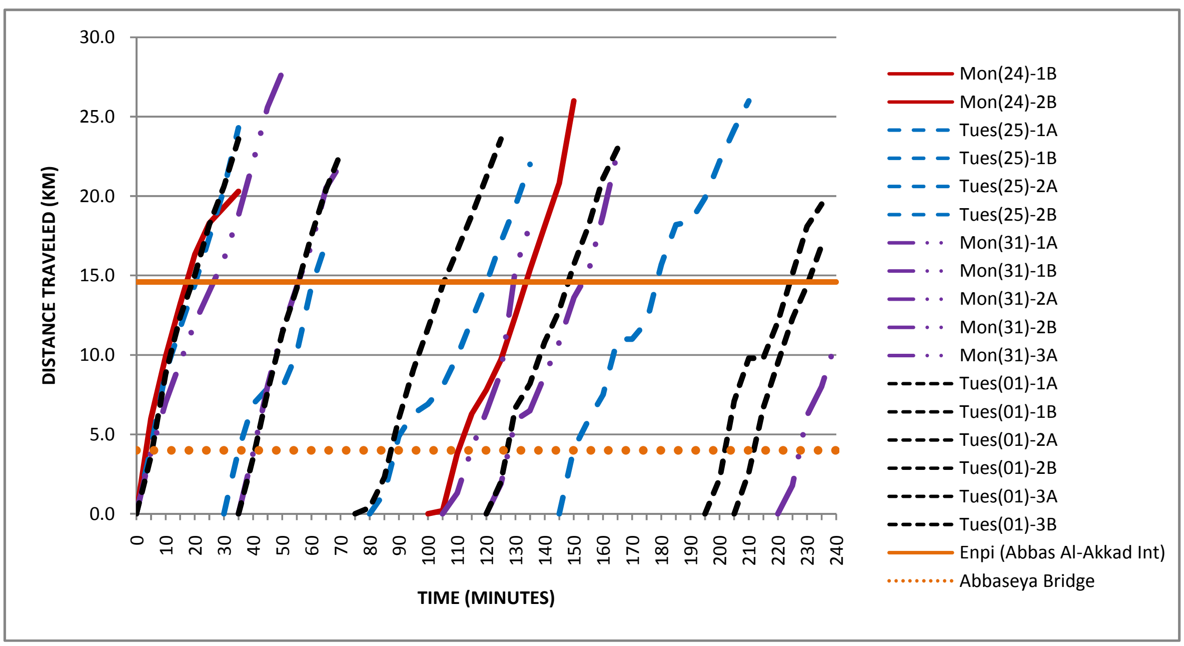
Route 5- PM Direction 2



Route 6- AM Direction 1



Route 6- AM Direction 2



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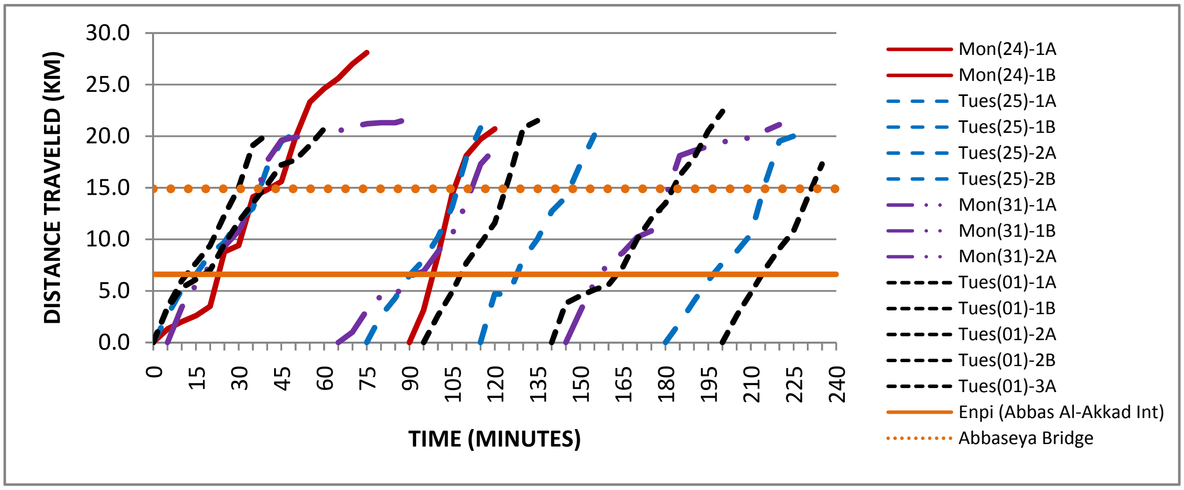
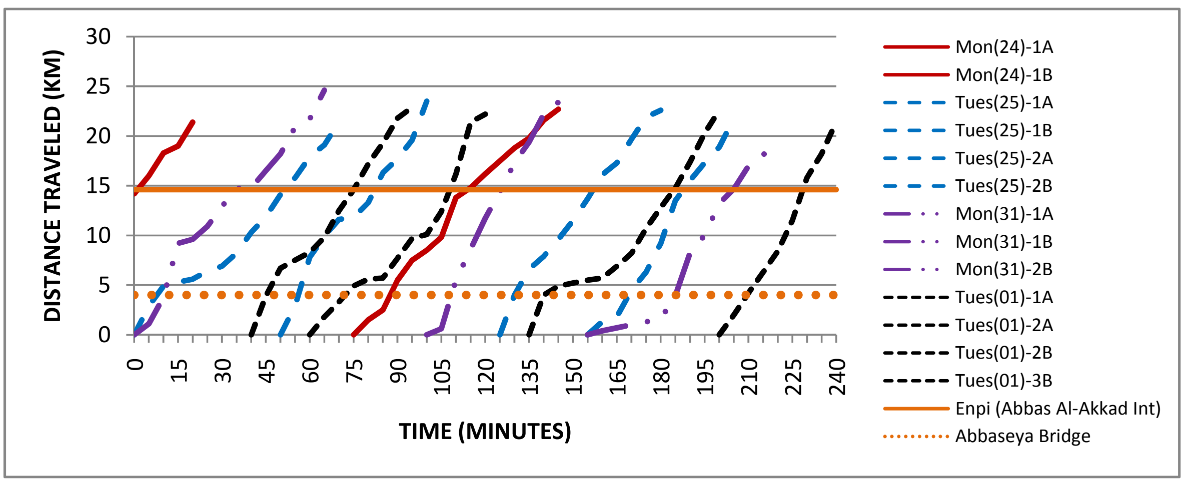
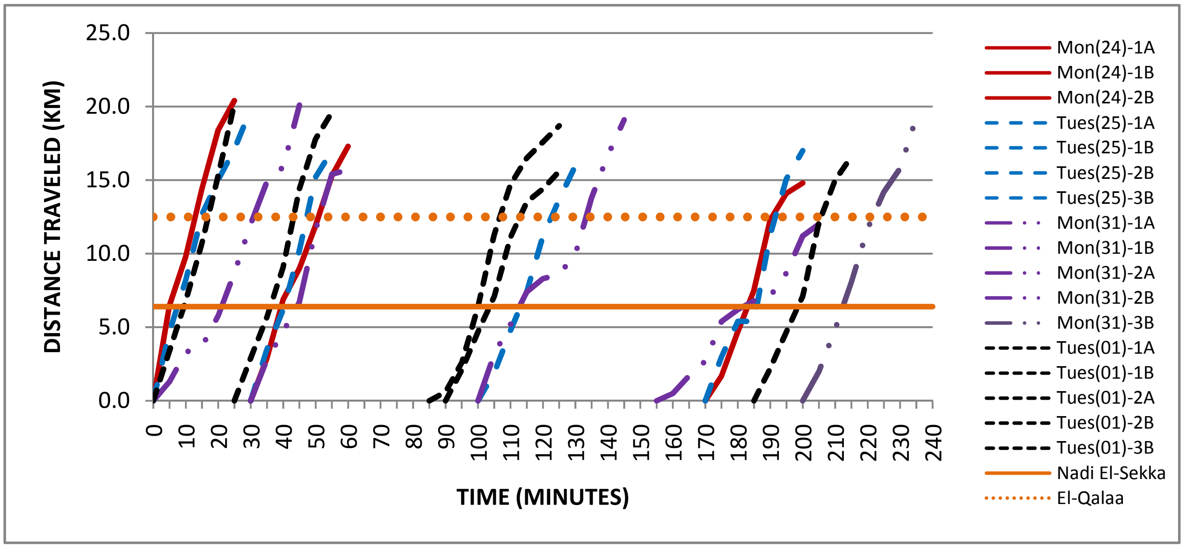


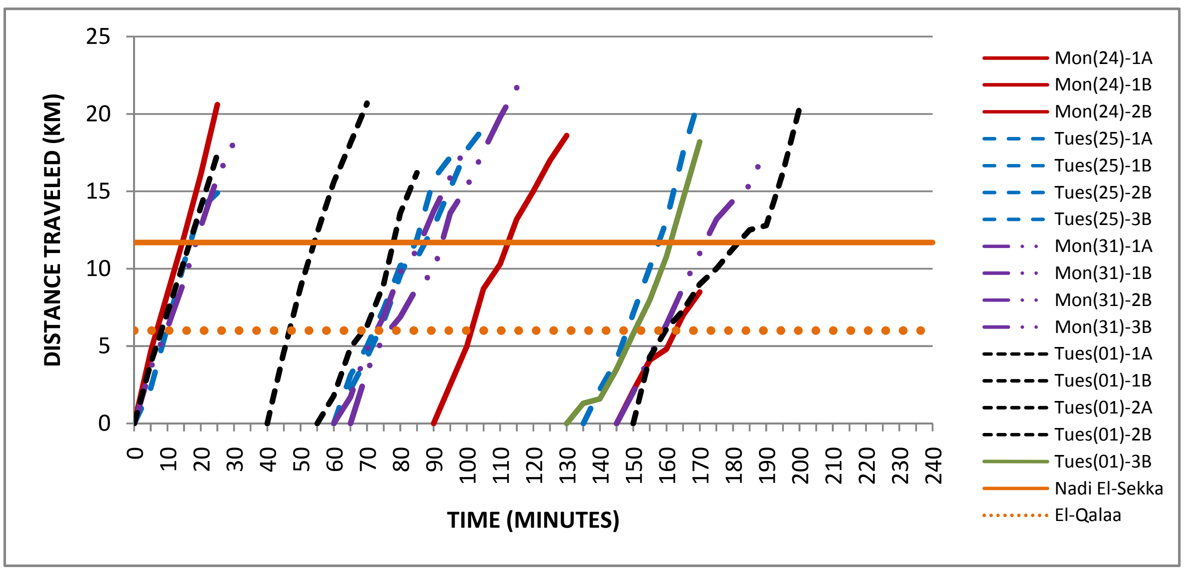
Route 6- PM Direction 2



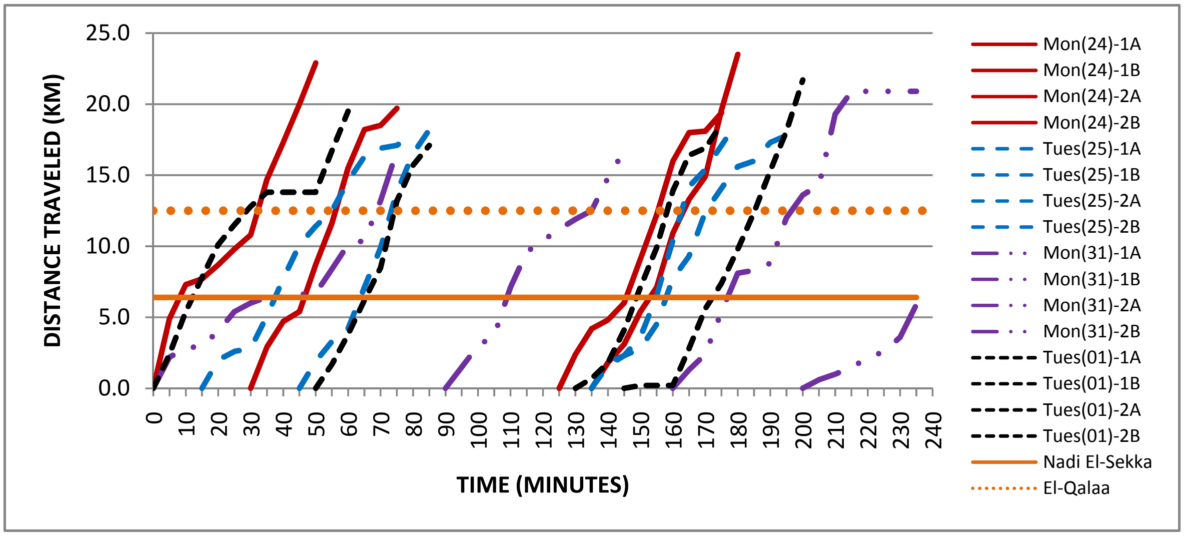
Route 7- AM Direction 1



Route 7- AM Direction 2



Route 7- PM Direction 1



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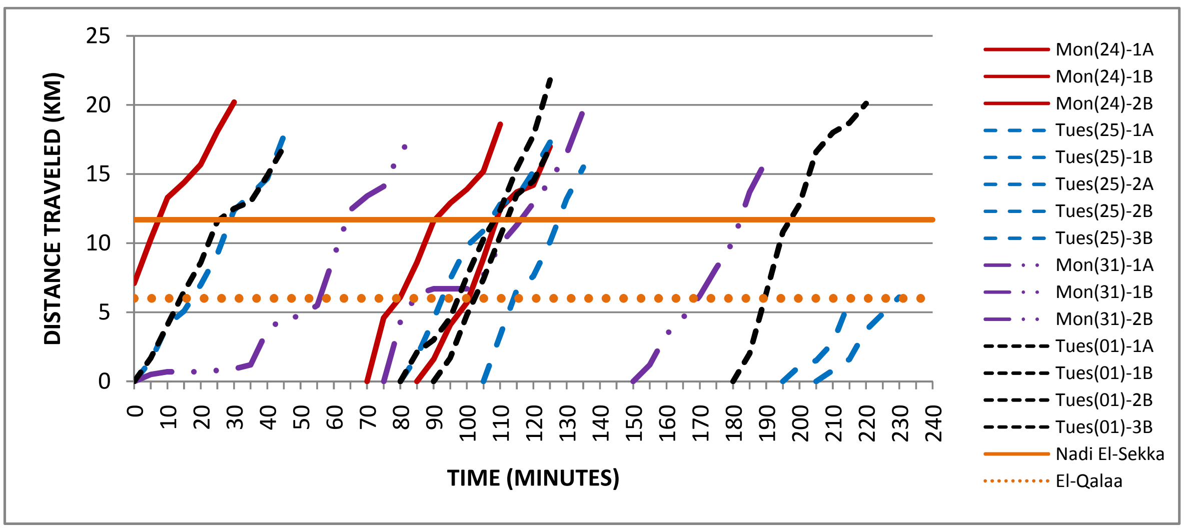
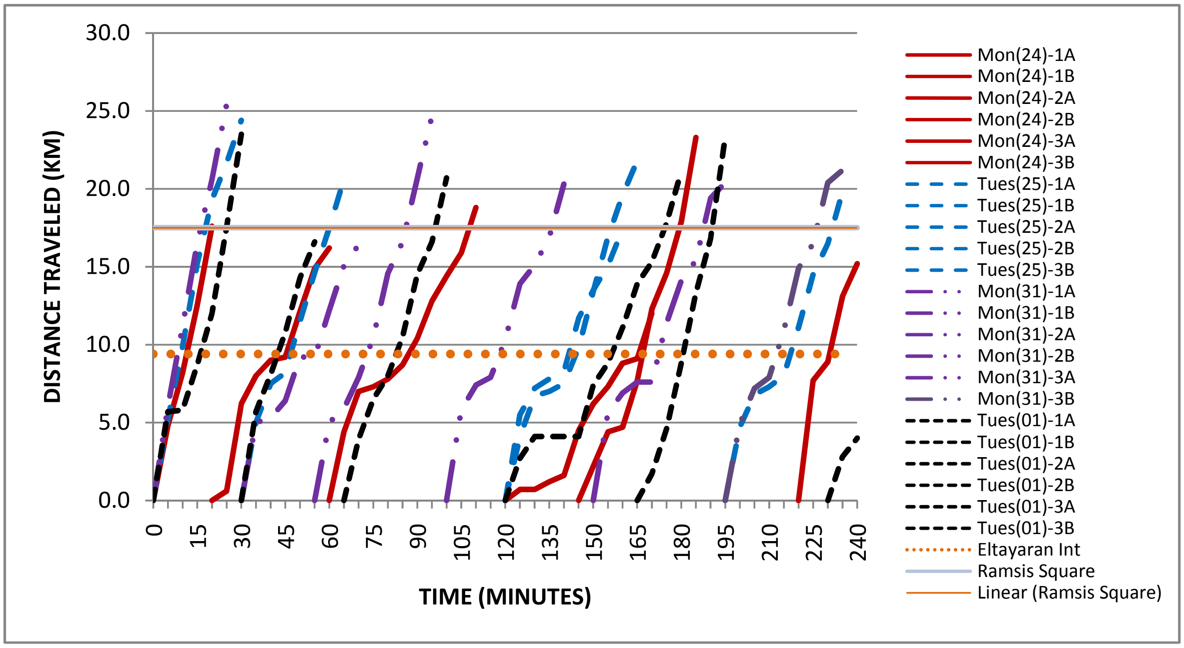
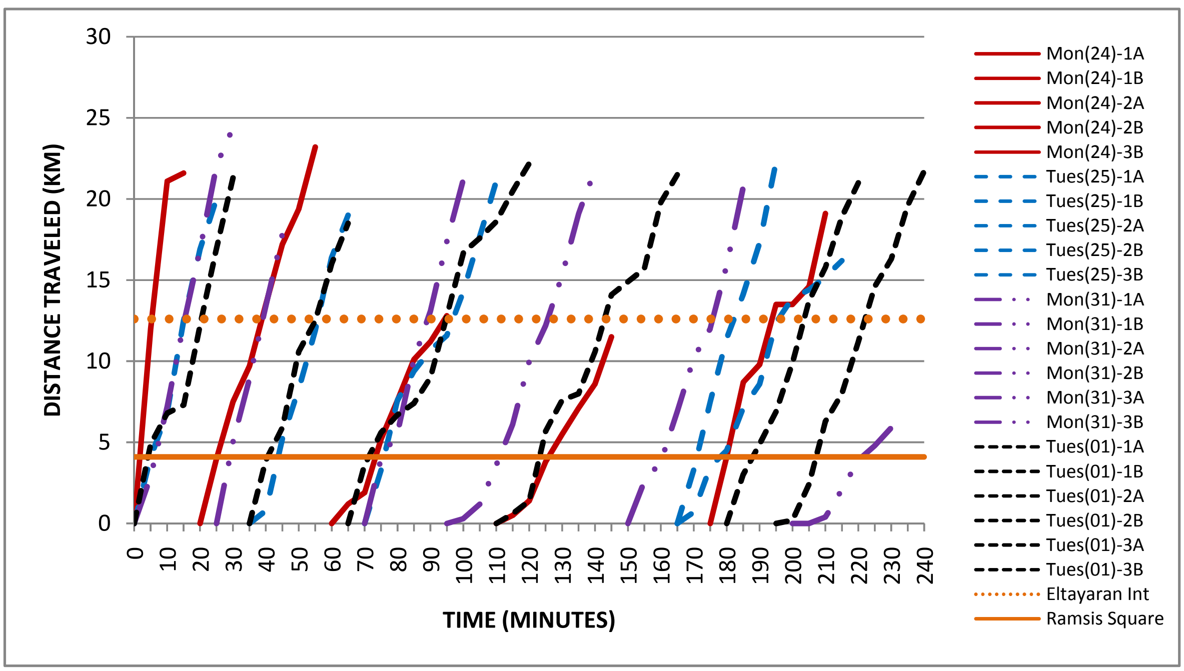


Route 8- AM Direction 1



Route 8- AM Direction 2



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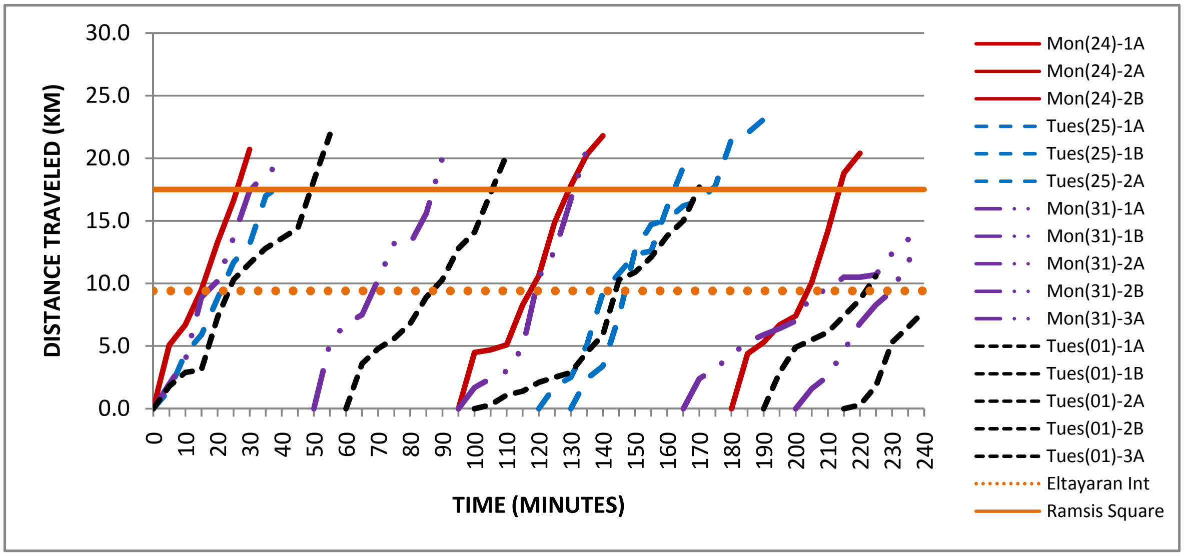

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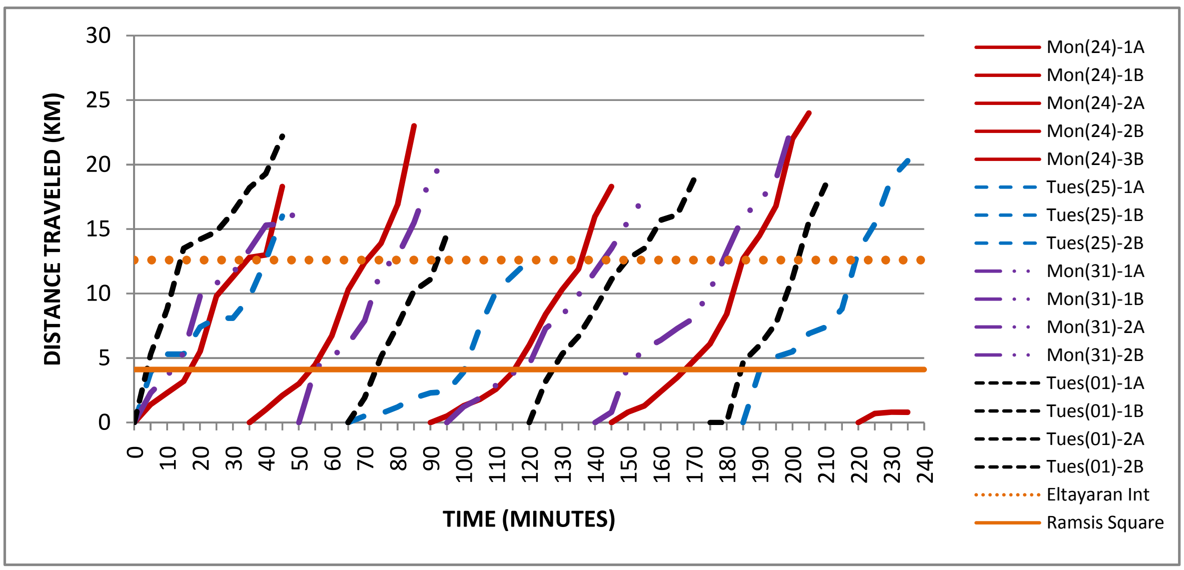
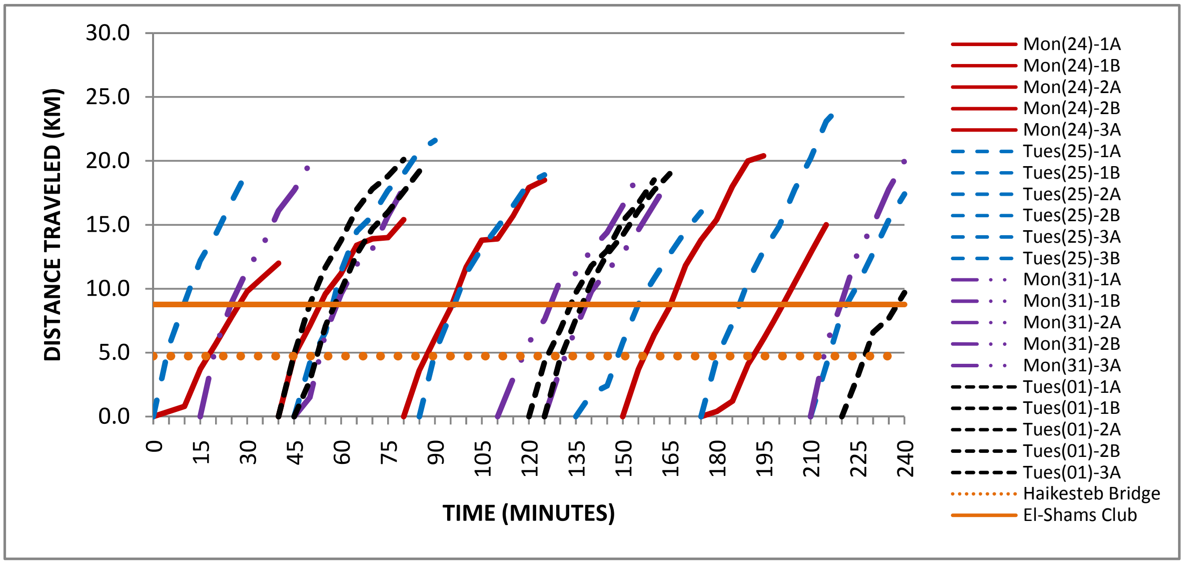
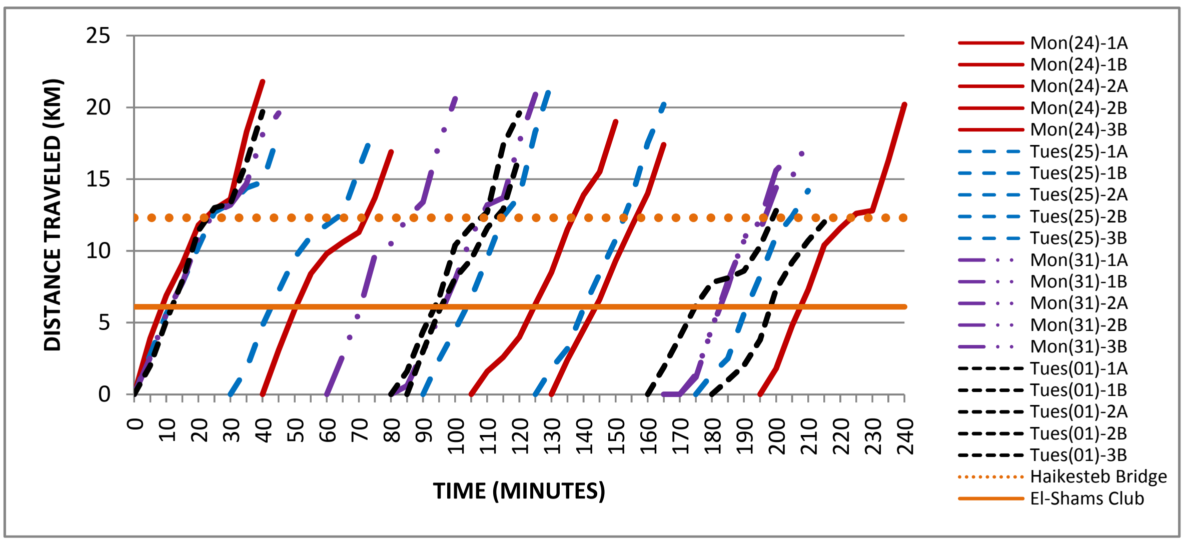


Route 9- AM Direction 1



Route 9- AM Direction 2



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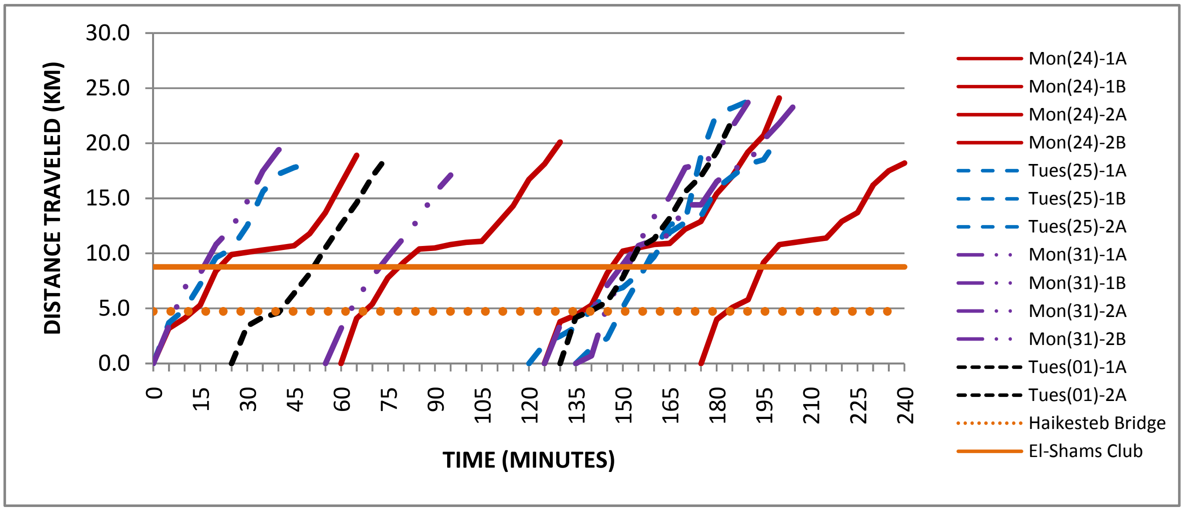
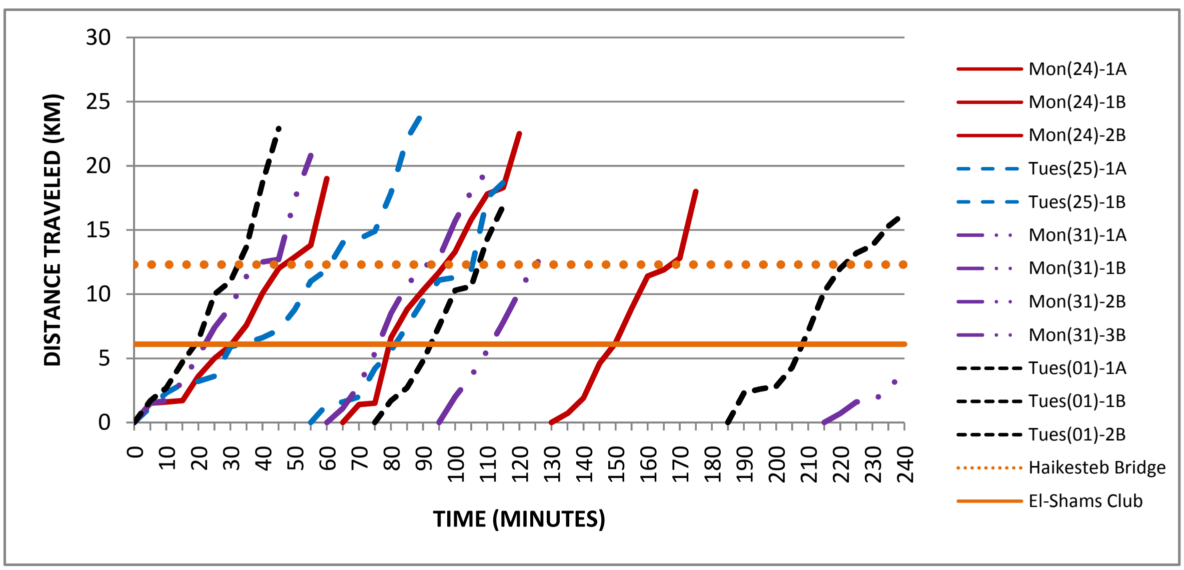
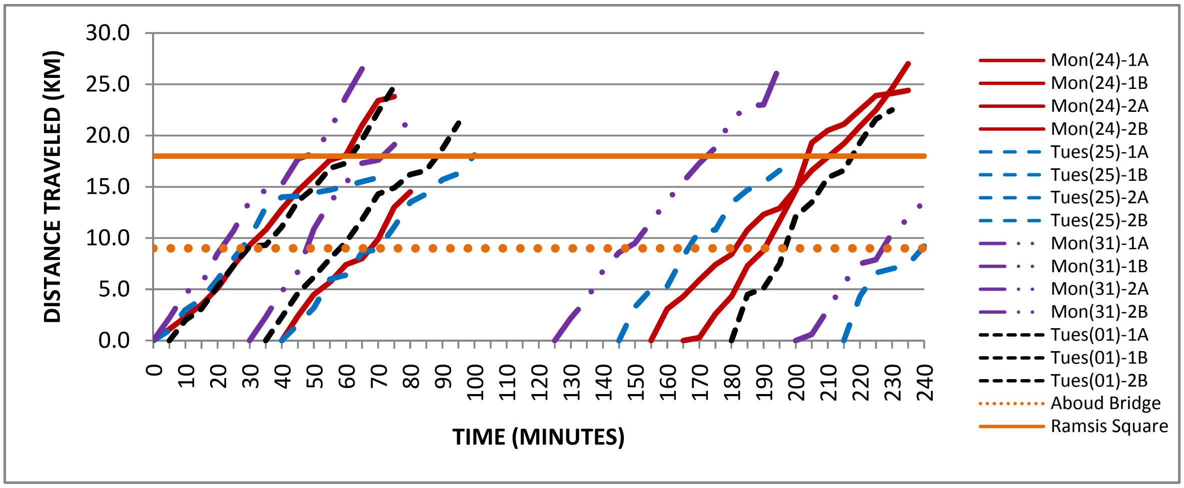


Route 9- PM Direction 2



Route 10- AM Direction 1



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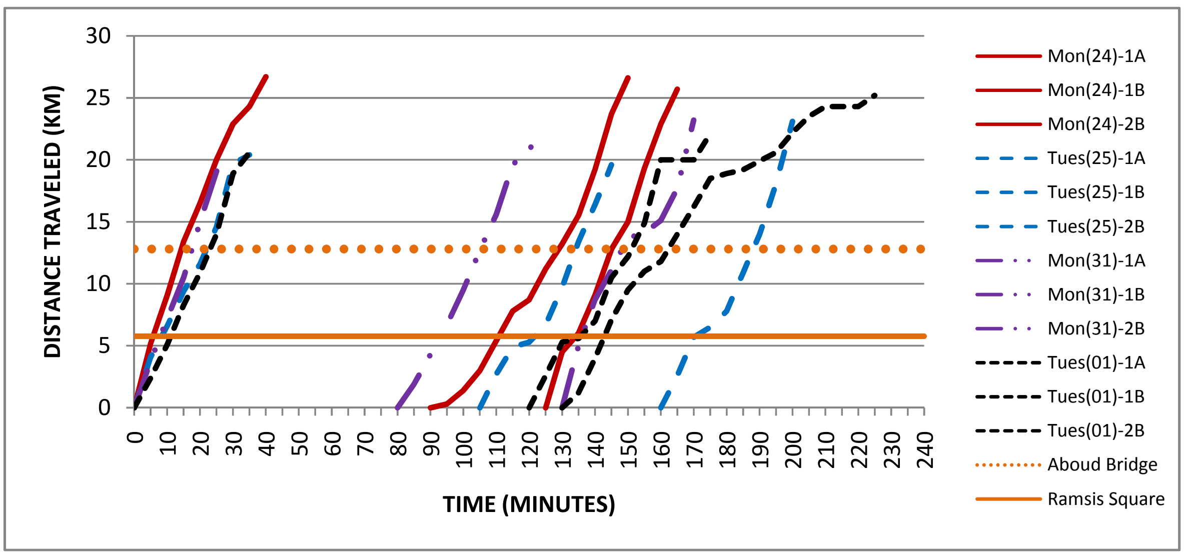
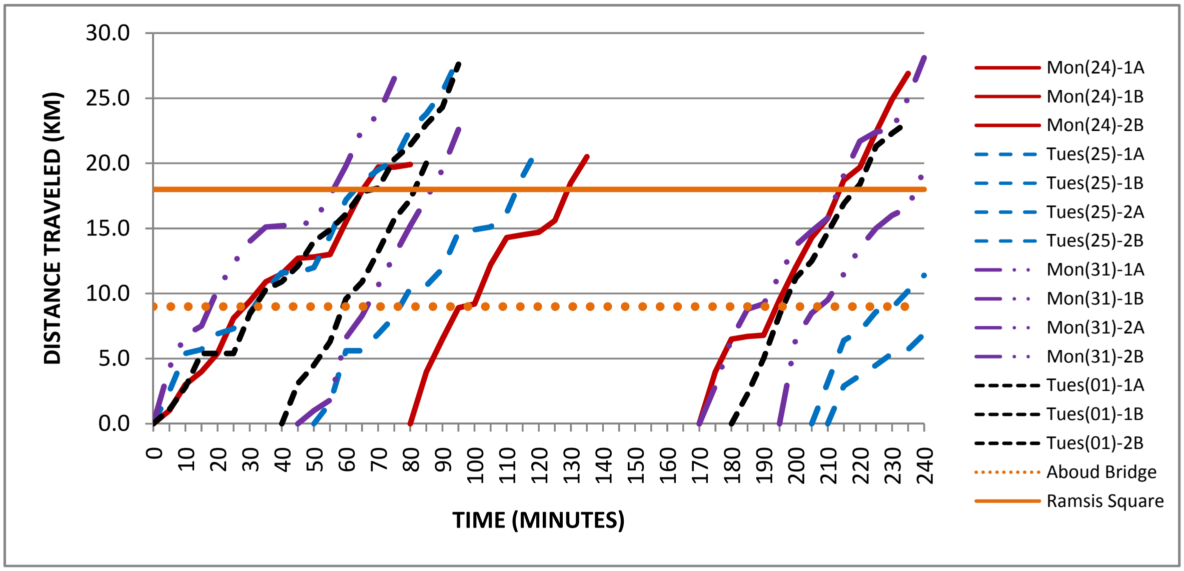
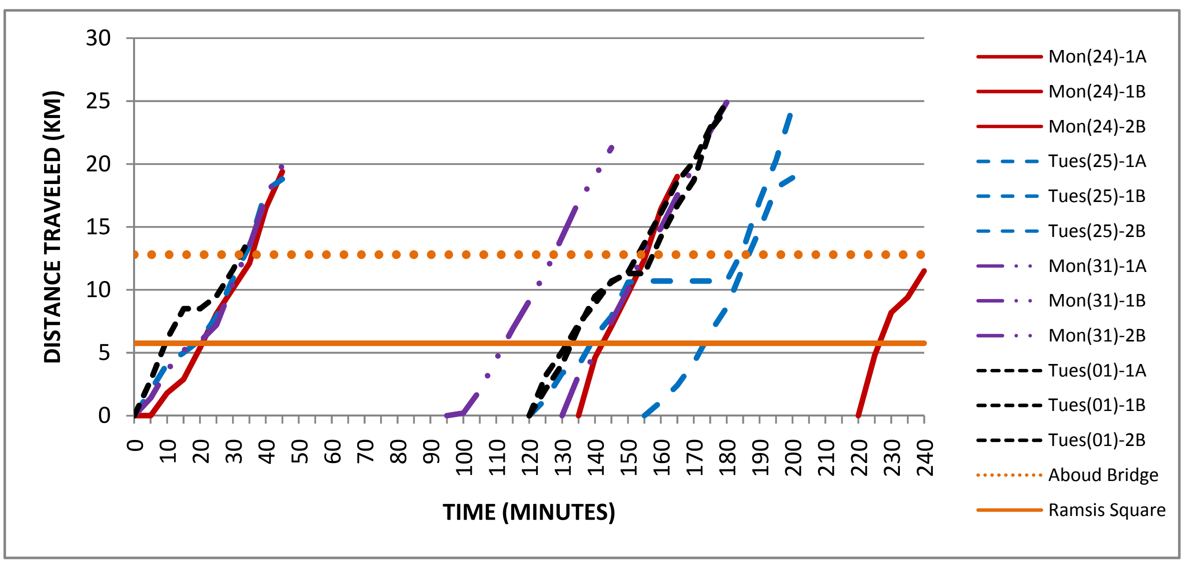


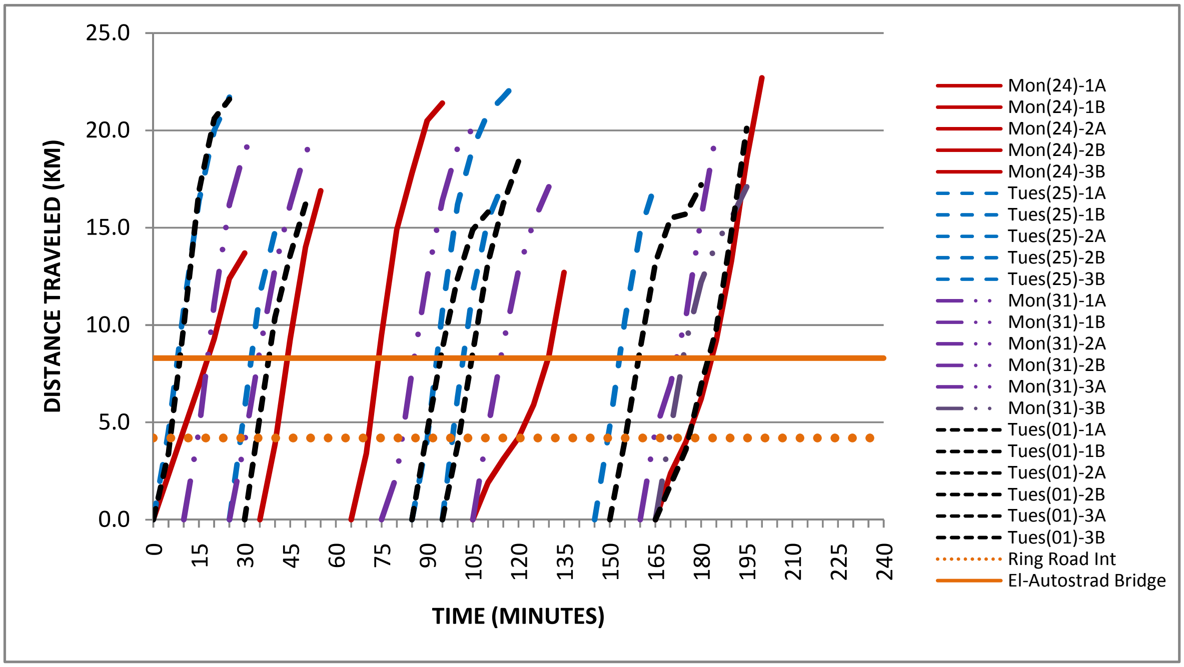
Route 10- PM Direction 1



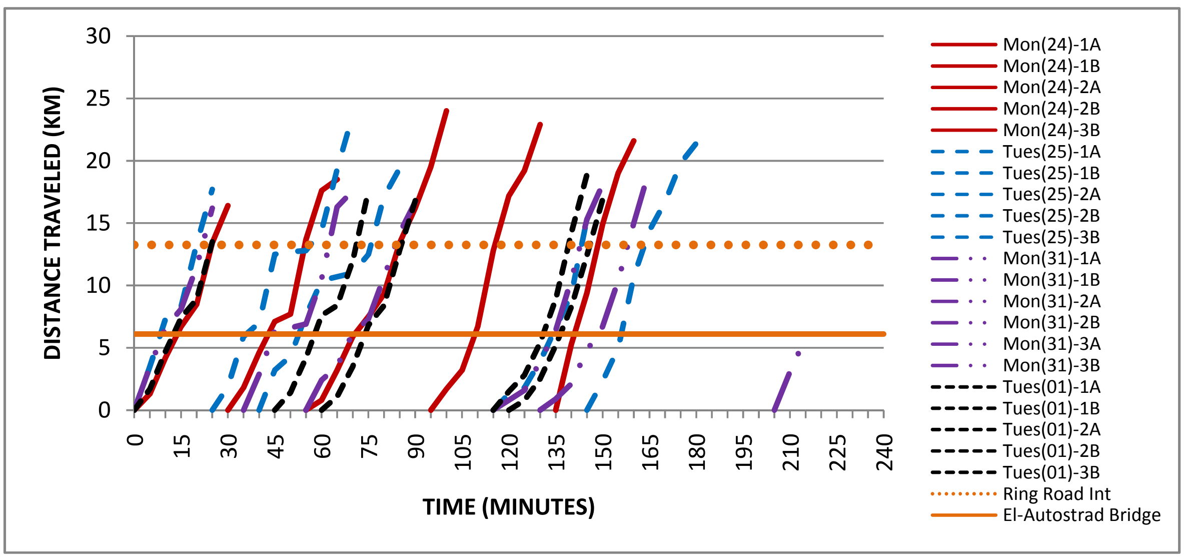
Route 10- PM Direction 2



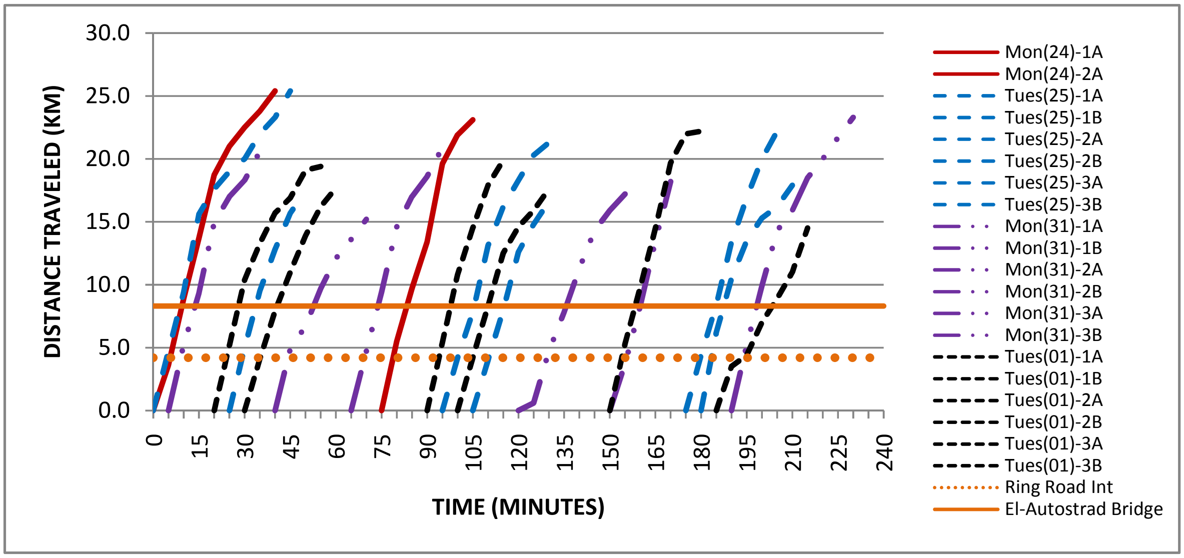
Route 11- AM Direction 1



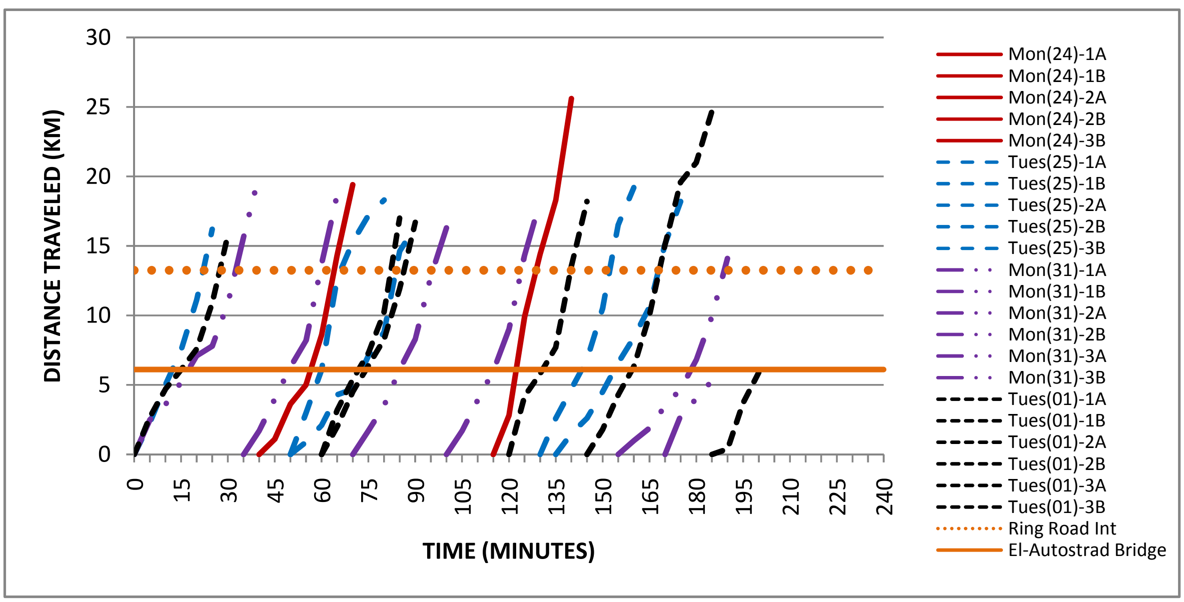
Route 11- AM Direction 2



Route 11- PM Direction 1



Route 11- PM Direction 2



b) Field Photos

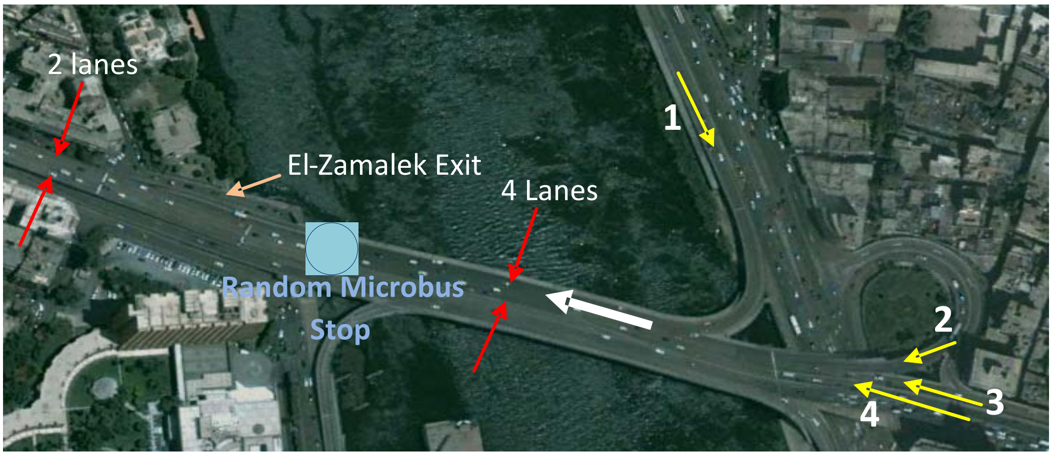


Fig. 1: Route 1, Location 1 - Satellite Photo by Google

Fig. 2: Route 1, Location 1 – Photo by Traffic Control Center

Fig. 3: Route 1, Location 2 (Direction 2: Abo-ElFeda) - Satellite Photo by Google

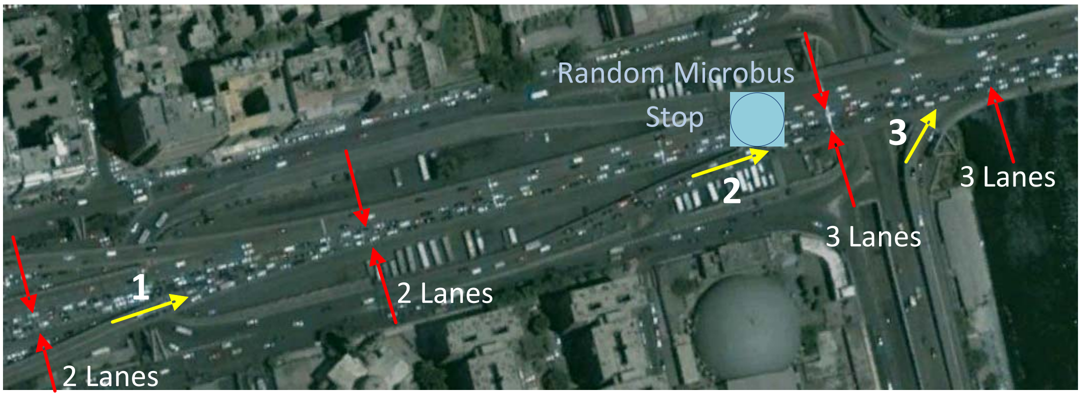


Fig. 4: Route 1, Location 2 (Direction 1: Sphinx Square till Kornish El-Agouza) - Satellite Photo by Google

Fig. 5: Route 1, Location 3 (Direction 2: Exit of El Tarsana Club) - Satellite Photo by Google

Fig. 6: Route 1, Location 3 (Direction 2: El Sudan Street) - Satellite Photo by Google

Fig. 7: Route 1, Location 3 (Direction 2: El Sudan Street) - Photo by Traffic Control Center

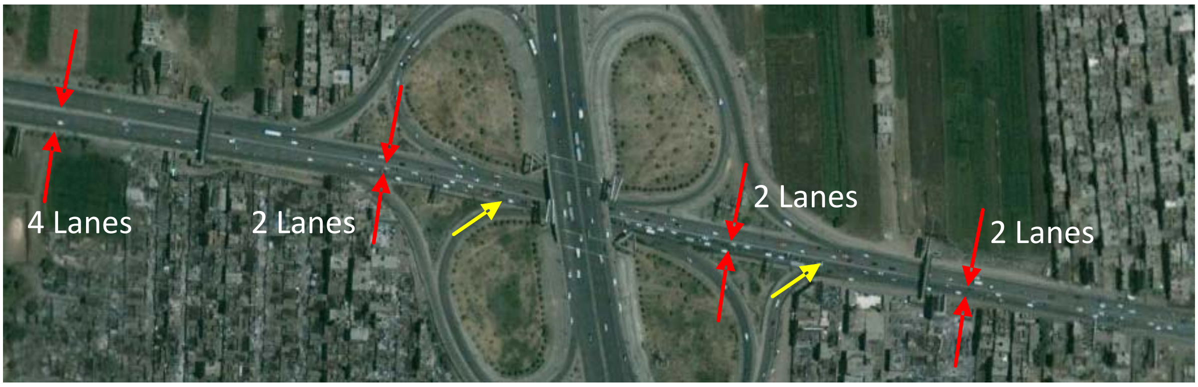


Fig. 8: Route 1, Location 3 (Direction 1: Ring Road Interchange) - Satellite Photo by Google

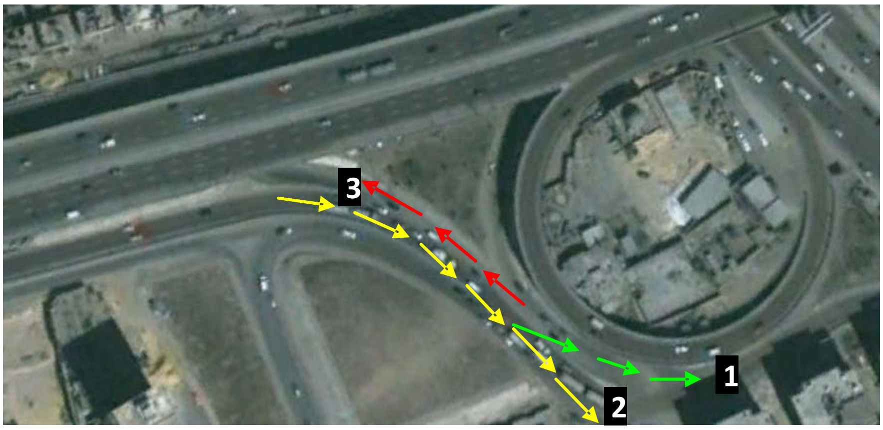


Fig. 9: Route 3, Location 2 (Both Directions: Autostrad interchange) - Satellite Photo by Google

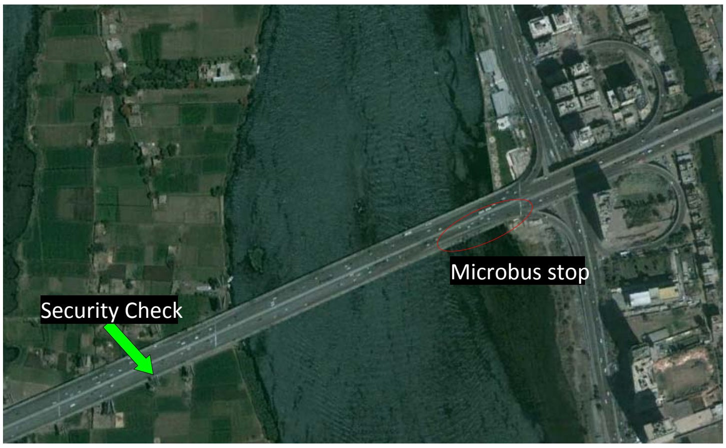


Fig. 10: Route 3, Location 3 (Direction 2) - Satellite Photo by Google

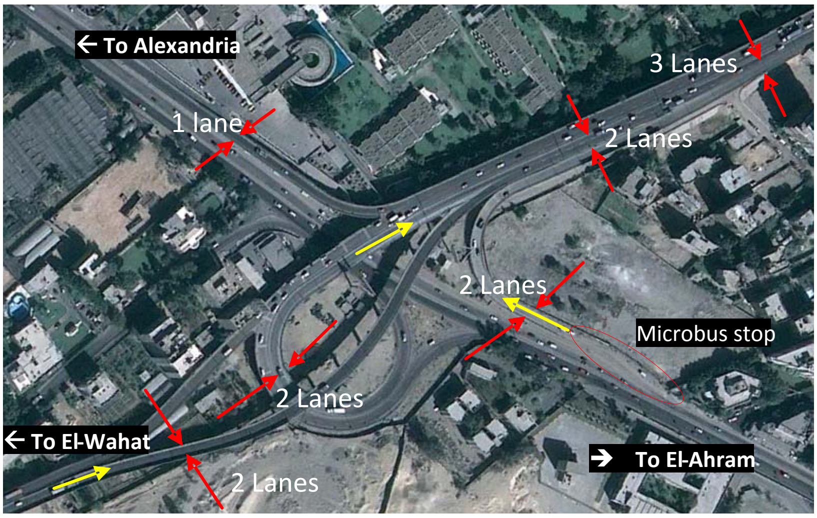


Fig. 11: Route 3, Location 6 (Direction 2: El-Sahrawy Interchange) - Satellite Photo by Google

Fig. 12: Route 5, Location 1 (Direction 2: Near Imbaba Bridge) - Satellite Photo by Google

Fig. 13: Route 5, Location 2 (Both directions: El-Kit Kat square) - Satellite Photo by Google

Fig. 14: Route 5, Location 3 (Direction 1: October 6th bridge - Agouza Exit) - Satellite Photo by Google

Fig. 15: Route 5, Location 4 (Direction 2: Before Giza security municipality) - Satellite Photo by Google

Fig. 16: Route 5, Location 5 (Direction 1: Before El-Giza Bridge) - Satellite Photo by Google

Fig. 17: Route 6, Location 2 (Both directions: El-Salam Mosque) - Satellite Photo by Google

Fig. 18: Route 6, Location 3 (Direction 1: Rabaa El-Adaweya Intersection) - Satellite Photo by Google

Fig. 19: Route 6, Location 4 (Direction 1: El-Rahman El-Raheem Mosque) - Satellite Photo by Google

Fig. 20: Route 6, Location 5 (Direction 1: El-Rahman El-Raheem Mosque) - Satellite Photo by Google

Fig. 21: Route 6, Location 6 (Direction 1: El-Azhar Tunnel) - Satellite Photo by Google

Fig. 22: Route 7, Location 1 (Directions 1 & 2: From Ahmed Fakhry Str. To Abbas El-Akkad Str.) - Satellite Photo by Google

Fig. 23: Route 7, Location 1 (Directions 1 & 2: Fom Ahmed Fakhry Str. To Abbas El-Akkad Str) - Photo by Traffic Control Center

Fig. 24: Route 7, Location 2 (Direction 2: Prior to Youssif Abbas Intersection) - Satellite Photo by Google

Fig. 25: Route 7, Location 2 (Direction 2: Prior to Youssif Abbas Intersection) - Photo by Traffic Control Center

Fig. 26: Route 7, Location 4 (Direction 2: El-Deweyqa entrance) - Satellite Photo by Google

Fig. 27: Route 7, Location 4 (Direction 2: El-Deweyqa entrance) - Photo by Traffic Control Center

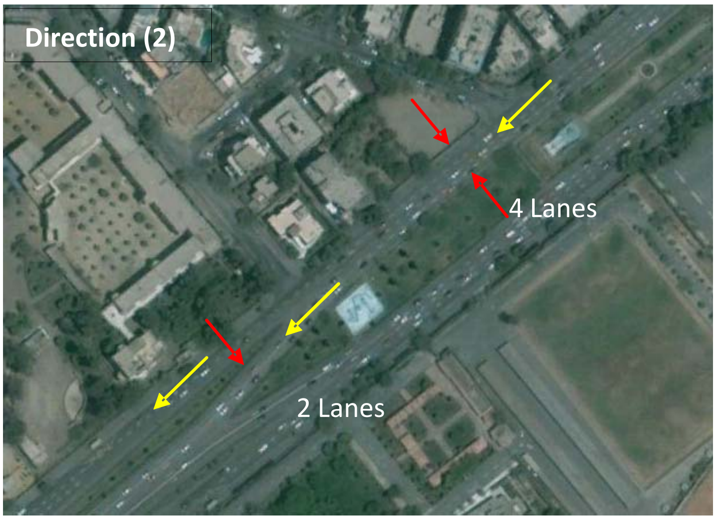


Fig. 28: Route 8, Location 1 (Directions 1 & 2: El-Galaa Bridge) - Satellite Photo by Google

Fig. 29: Route 8, Location 4 (Direction 1: El-Orouba Entrance to 6th October Bridge) - Satellite Photo by Google

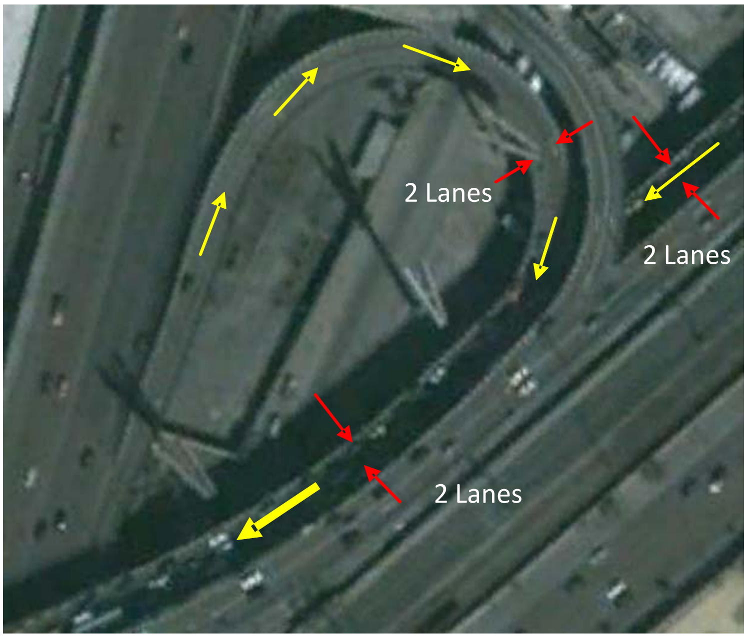


Fig. 30: Route 8, Location 5 (Direction 1: Ghamra Bridge entrance) - Satellite Photo by Google

Fig. 31: Route 8, Location 6 (Direction 1: Ramsis Exit – Tahrir Entrance) - Satellite Photo by Google

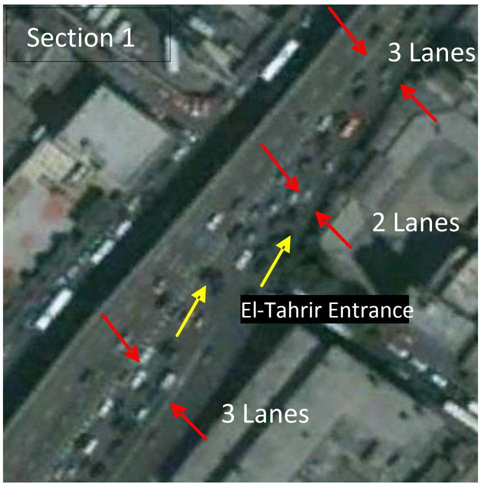


Fig. 32: Route 8, Location 6 (Direction 1: Ramsis Exit – Tahrir Entrance) - Satellite Photo by Google

Fig. 33: Route 9, Location 1 (Direction 2: At Mawqaf El-Asher) - Satellite Photo by Google

Fig. 34: Route 9, Location 2 (Direction 1: Under the Hikesteb Bridge) - Satellite Photo by Google

Fig. 35: Route 9, Location 2 (Direction 1: Under the Hikesteb Bridge) - Photo by Traffic Control Center

Fig. 36: Route 9, Location 3 (Directions 1 & 2: Abdel Aziz Fahmy intersection) - Satellite Photo by Google

Fig. 37: Route 9, Location 4 (Directions 1&2: El-Qobba Intersection) - Satellite Photo by Google

Fig. 38: Route 9, Location 4 (Directions 1&2: El-Qobba Intersection) - Photo by Traffic Control Center

Fig. 39: Route 9, Location 4 (Direction 2: Upstream of El-Qobba Intersection) - Photo by Traffic Control Center

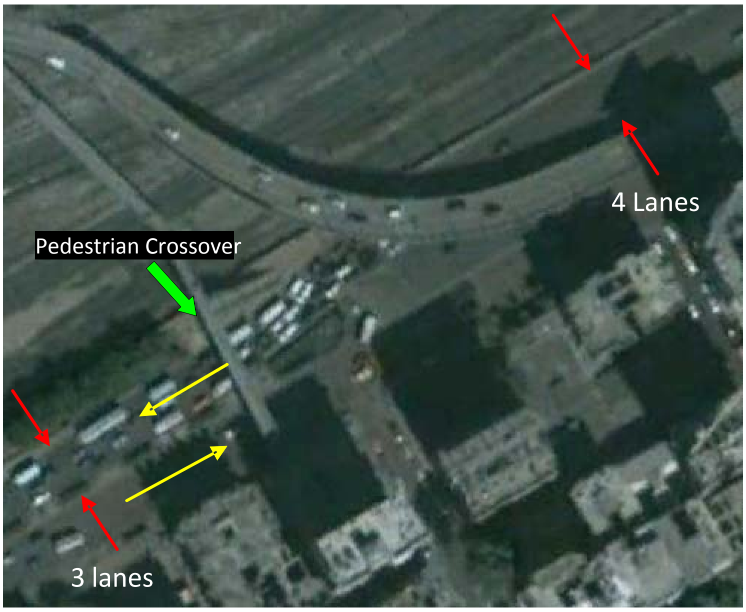


Fig. 40: Route 10, Location 4 (Direction 1: Near October 6th-Ghamra Exit) - Satellite Photo by Google

Fig. 41: Route 10, Location 4 (Direction 1: In front of Ramsis Light Rail Station) - Photo by Traffic Control Center

Fig. 42: Route 10, Location 5 (Direction 1: Beginning of Shoubra tunnel) - Satellite Photo by Google

Fig. 43: Route 10, Location 5 (Direction 2) - Satellite Photo by Google

Fig. 44: Route 10, Location 6 (Direction 2) - Satellite Photo by Google

3. Estimation Procedures

a) Route Average Speed Estimation Procedure

Estimation Procedure

- Problem Statement: To calculate the average speed and the coefficient of variation (of speeds) per hour per peak period per direction per route given floating-car data for 4 days for 2 peak periods consisting of 5 minute intervals of distance measurements.
- To 'solve' the problem we first had to determine an appropriate aggregation procedure for the data. We can treat the 4 dates as a sample space for each hour. Essentially, this means that each 5 minute interval of distance measurement for each hour is given an equal weight regardless of the date/day that it occurs on. This is the chosen method.
- An alternative method would give each day the same weight (the average is computed for each day and then the average is taken across all 4 days). However, this method has the shortcoming that given a particular route during a particular hour in a particular direction on a particular date- let's say (Route 1 6PM Direction 2)- we find that Monday 31-05-2010 has only one distance recorded during that hour. Yet, if this procedure were used Monday 31-05-2010 would be given an equal weight as other days which have many recorded distances during that hour. Therefore, we rejected this method.
- Still another method would treat each day (Monday or Tuesday) as a sample space and average the average speed for Monday and Tuesday. This method would treat Monday as having a particular pattern of traffic and Tuesday as having a separate pattern of traffic. This method would be more ideal if the traffic patterns on Monday and Tuesday varied significantly. However, since the average has been requested over all 4 days and there seems to be similarity (see the average speed per day per car) between Monday and Tuesday patterns we did not use this procedure.
- Explicit formulation of the solution:
  - If $d_1, d_2, \dots, d_n$ are all the recorded marginal distances for a particular hour irrespective of the date or car (over all 4 days and both cars), and $t_1, t_2, \dots, t_n$ are the corresponding times then an estimation for average speed during that hour is given by Eq. 1:
$$\mu = \frac{d_1 + d_2 + \cdots + d_n}{t_1 + t_2 + \cdots + t_n} \, (1)$$
  - Because of the sampling in uniform intervals of time (5 mins.) $t_i = t_j$ for $1 \leq i, j \leq n$. Therefore, Eq. 1 can be written in the following form:
$$\hat{\mu} = \frac{\frac{d_1}{t} + \frac{d_2}{t} + \cdots + \frac{d_n}{t}}{n} \, (2)$$

    i.e. as an average of speeds. This facilitates the calculation of the coefficient of variation, where the standard deviation is taken from the sample data $\frac{d_i}{t}$. The reason we mention this is because Eq. 1 and Eq. 2 produce different results in the calculation of the standard deviation and mean when $t_i \neq t_j$.

- Then the coefficient of variation can be written:

$$c_v = \frac{\sqrt{\widehat{\sigma^2}}}{\hat{\mu}}$$

  where $\widehat{\sigma^2}$ is the unbiased estimator of the variance of the speeds $\frac{d_i}{t}$.

- In the ideal situation we would want to have a maximum amount of sample data distributed equally in both distance and time domains since the traffic depends on attributes of the road network as well as time of day. Due to experimental constraints the traffic is considered to assume a possible different state for each trip depending on the incidence of floating cars along the route.

Matlab Function

- Finally, the average speeds for the 11 routes can be found in the excel file “Speeds per hour.xlsx”. A specially tailored Matlab function was designed to handle the irregularly formatted and large amount of data.
- The Matlab function serves as an input/output mechanism which takes as input the floating car data (recorded marginal distances) for each hour per peak period per direction on all the routes. This input is irregular in the sense that the distance data occurs in trip ‘clusters.’ Furthermore the data entered into Excel begins each trip with a marginal distance of zero. Therefore, the function has two main purposes: 1) To remove all non-numerical data; 2) To remove all zeros at the beginning of each trip so as to exclude them from the average. The first task can be handled by a built-in Matlab function; the second must use an algorithm. After these two tasks have been preformed the calculation of average distances (Eq. 1) and coefficients of variation is trivial. The output is sent back to Excel.

b) Route Free Flow Speed Estimation Procedure

The following section describes a procedure for estimating free flow speeds using speed limit, length of route section, number of intersections along each section, as well as assumed acceleration and deceleration rates.

Principles

- The free flow speed along a corridor is the speed experienced by motorists under uncongested conditions (at near zero flow and density conditions).
- The free flow speed along freeway sections is close to the posted speed limit. Along arterial corridors with controlled/uncontrolled intersections, the free flow speed includes delay effects at intersections, and accordingly we can't use the posted speed limit directly.
- In Cairo, the free flow speed during peak periods is perhaps different from the free flow speed measured during late night hours when traffic flow/density is low. This is due to poor user compliance of traffic rules and inadequate enforcement of intersection control (both factors causing near zero delays at intersections), and due to the traffic/security checkpoints at random locations along expressways and arterials (which cause extra delays typical only of late night hours). Accordingly, the free flow speed cannot be "measured" adequately at late night hours.
- The free flow speed can be estimated using simulation or analytical methods. We opt for the latter.

Assumptions

- Along limited-access freeway sections, motorists travel at the posted speed limit under free flow conditions.
- Along arterials, motorists come to a full stop at each signalized and unsignalized intersection under free flow conditions, but they do not experience waiting delays. This represents an approximation of the average delays at intersections in real life, where motorists under uncongested conditions may stop at some intersections and wait briefly but pass through others without stopping.
- Further delays are experienced at intersections with U-turns.
- At each arterial section, the vehicle accelerates from zero speed at the start of the section, reaches speed limit, cruises at that speed, then decelerates to a speed of zero at the end of the section.

Estimation procedure for arterials

- Suppose you have a corridor with multiple sections, each having a length S_i and speed limit V_i.
- Total corridor travel time under free-flow conditions = T = (S_1/V_1 + S_2/V_2 + …….) + "lost time" at intersections + additional delays due to U-turns
- Lost time at the start of section 1 = V_1 / 2a
  - o Where a is the acceleration rate
  - o This time represents the difference between the time to travel the accelerating distance at V_1 and the time to accelerate from 0 to V_1 over the same distance; the kinematic equations assuming uniform acceleration are used.
- Lost time at the end of section 1 = V_1 / 2d
  - o Where d is the deceleration rate.
- Lost time at the start of section 2 = V_2 / 2a

- Lost time at the end of section 2 = V_2 / 2d
- Additional delay at an intersection with a U-turn = a fixed value of say 2 minutes.
- Free Flow Speed = (S1 + S2 + S3 + ….) / T
- The speed index is then the average speed (from the first part) divided by the free flow speed.

Matlab function

- As before, a pair of Matlab functions is used to expedite the calculations. The first function takes as input the data on section class, speed limit, and section length. It then performs the calculations described above.
- The second function takes the resulting free flow speed estimates calculates the speed index, organizes the data into a table, and outputs to excel the results.

Annex 5: Origin Destination Matrices 2005 and 2012

[separate pdf file]

ANNEX 5

Origin-Destination Matrices:
Daily vehicle trips in the years 2005 and 2012 according to "Public Private Partnership Program for Cairo Urban Toll Expressway Network Development" Study by JICA

Table B.1: OD matrix passenger car 2005

OD Matrix for passenger cars 2005

	6th of October	Imbaba Markaz	Dokki	Giza	South Giza	Helwan	Maadi	Khaleefa	CBD	Shoubra	Masr El Gadida	Nasr City	Ain Shams	Salam City	Shoubra El Khima	Qalioub	Qanater	10th of Ramadan
6th of October	1.997	215	472	1.165	95	52	159	176	273	89	113	97	37	24	51	24	13	1
Imbaba Markaz	215	25.703	20.607	14.533	1.010	1.108	3.010	3.902	10.840	4.570	4.812	3.541	2498	2.396	4.100	4.419	2.275	79
Dokki	472	20.607	56.498	33.626	4.085	4.108	10.184	13.241	28.546	14.431	14.476	9.966	6425	4.631	10.026	5.778	4.071	213
Giza	1.165	14.534	33.626	62.560	8.111	4.709	12.187	14.519	20.364	7.449	9.115	7.131	3485	2.214	4.079	2.052	1.367	92
South Giza	95	1.010	4.085	8.111	14.311	4.065	2.008	1.914	2.693	826	1.137	948	359	232	471	185	113	8
Helwan	52	1.108	4.109	4.709	4.065	47.937	11.498	4.429	7.010	2.419	4.698	4.921	1678	1.092	1.054	371	543	47
Maadi	159	3.010	10.184	12.187	2.008	11.498	29.649	11.266	14.986	4.493	8.276	7.756	2861	1.853	2.042	967	1.166	100
Khaleefa	176	3.902	13.241	14.519	1.914	4.430	11.267	12.891	14.073	5.875	10.179	8.849	3992	2.681	2.894	941	1.089	66
CBD	273	10.840	28.546	20.364	2.692	7.010	14.987	14.074	22.782	19.785	21.510	16.202	10.857	7133	10.950	4.087	3.843	136
Shoubra	89	4.570	14.431	7.449	826	2.419	4.493	5.875	19.784	20.025	16.783	10.192	7564	4.590	9.413	3.827	3.055	132
Masr El Gadida	113	4.813	14.476	9.115	1.137	4.698	8.276	10.179	21.510	16.783	42.147	28.467	20.079	11.945	10.185	4042	6.132	493
Nasr City	97	3.541	9.966	7.131	948	4.921	7.756	8.849	16.201	10.192	28.467	43.828	14.485	12.729	6829	3.550	6.447	2.110
Ain Shams	37	2.498	6.425	3.485	359	1.677	2.861	3.992	10.857	7.564	20.079	14.485	17.001	9.024	5.976	3.116	4.876	285
Salam City	24	2.396	4.631	2.214	232	1.092	1.854	2.681	7.133	4.590	11.945	12.729	9.024	14.778	5568	4.611	8.131	413
Shoubra El Khima	51	4.100	10.026	4.079	471	1.054	2.042	2.894	10.950	9.413	10.185	6.829	5976	5.568	17.967	6.682	6.094	191
Qalioub	24	4.420	5.778	2.052	185	371	967	941	4.088	3.827	4.041	3.550	3116	4.611	6.683	22.155	5030	126
Qanater	13	2.275	4.071	1.367	113	543	1.166	1.088	3.843	3.055	6.130	6.447	4876	8.132	6.094	5.029	29.805	470
10th of ramadan	1	79	213	92	8	47	100	66	136	132	493	2.110	285	413	191	126	470	
Total	5.053	109.621	241.385	208.758	42.570	101.739	124.464	112.977	216.069	135.518	214.586	188.048	114.598	94.046	104.573	71.962	84.520	4.962

Table B.2: OD matrix for passenger car 2012

OD Matrix for passenger cars 2012

	6th of October	Imbaba Markaz	Dokki	Giza	South Giza	Helwan	Maadi	Khaleefa	CBD	Shoubra	Masr El Gadida	Nasr City	Ain Shams	Salam City	Shoubra El Khima	Qalioub	Qanater	10th of Ramadan
6th of October	21.212	4.151	6.386	17.483	1.247	1.108	1.608	2.618	5.114	1.330	1.473	982	684	471	1.011	729	443	13
Imbaba Markaz	4.151	61.759	27.722	16.718	1.157	1.719	3.401	4.965	14.079	4.676	7.061	5.779	2071	1.348	2.828	2.947	911	153
Dokki	6.386	27.722	72.910	39.307	4.154	7.029	12.516	16.028	34.768	15.790	21.293	16.778	7707	5.419	10.552	6.329	4.550	565
Giza	17.483	16.717	39.307	89.254	9.994	5.993	12.787	17.479	27.466	9.312	12.722	10.639	4262	3.080	5.716	3.420	2.244	395
South Giza	1.247	1.157	4.154	9.994	28.085	4.329	2.126	2.349	3.847	1.086	1.810	1.557	505	354	627	336	218	40
Helwan	1.108	1.719	7.029	5.993	4.328	67.824	14.456	5.107	8.988	2.818	5.692	4.309	1769	1.251	1.951	1.137	843	149
Maadi	1.608	3.401	12.516	12.787	2.126	14.456	42.105	13.824	18.351	5.685	11.615	9.549	3119	2.323	3.281	2.039	1.550	298
Khaleefa	2.618	4.965	16.028	17.478	2.349	5.107	13.824	18.924	18.645	8.251	15.043	14.521	4520	3.358	4.356	2.004	1.683	272
CBD	5.115	14.079	34.767	27.467	3.847	8.987	18.350	18.646	29.367	23.506	27.709	26.643	12.364	9.218	13.500	6.671	5.871	392
Shoubra	1.330	4.675	15.790	9.312	1.086	2.818	5.685	8.251	23.506	32.165	21.444	15.730	8877	5.271	11.757	5.950	4.393	388
Masr El Gadida	1.473	7.060	21.294	12.721	1.810	5.692	11.615	15.043	27.709	21.444	69.267	56.592	28.393	19.671	14.616	6566	10.060	1.375
Nasr City	982	5.780	16.778	10.639	1.557	4.309	9.549	14.521	26.644	15.728	56.591	103.996	22.444	21.402	11.419	5.475	9.103	7.641
Ain Shams	684	2.071	7.707	4.262	505	1.769	3.119	4.520	12.364	8.877	28.393	22.444	22.215	12.189	8.080	3.635	5.947	1.595
Salam City	471	1.347	5.419	3.080	354	1.251	2.323	3.358	9.218	5.271	19.671	21.402	12.189	24.876	5886	4.033	8.484	1.397
Shoubra El Khima	1.011	2.828	10.552	5.716	627	1.951	3.281	4.356	13.500	11.757	14.616	11.419	8.080	5.886	19.080	9.462	6.629	493
Qalioub	729	2.947	6.329	3.420	336	1.137	2.039	2.004	6.671	5.950	6.566	5.476	3635	4.033	9.462	31.891	5.430	178
Qanater	443	911	4.550	2.243	218	843	1.551	1.683	5.871	4.393	10.058	9.103	5947	8.485	6.629	5.431	57.537	715
10th of ramadan	13	153	565	395	40	149	298	272	392	388	1.375	7.641	1595	1.397	493	178	715	17.276
Total	68.064	163.442	309.803	288.269	63.820	136.471	160.633	153.948	286.500	178.427	332.399	344.560	150.376	130.032	131.244	98.233	126.611	33.335

Table B.3: OD matrix for Taxi 2005

OD Matrix for Taxi 2005

	6th of October	Imbaba Markaz	Dokki	Giza	South Giza	Helwan	Maadi	Khaleefa	CBD	Shoubra	Masr El Gadida	Nasr City	Ain Shams	Salam City	Shoubra El Khima	Qalioub	Qanater	10th of ramadan
6th of October	698	48	89	285	14	5	25	19	23	7	6	5	3	1	9	2	1	0
Imbaba Markaz	48	10.859	6.109	4.617	184	175	627	887	2.431	1.124	990	618	576	570	1.257	1.233	519	12
Dokki	89	6.109	17.917	8.903	812	723	2.137	2.948	5.725	3.528	2.749	1.554	1403	987	2.760	1.254	800	27
Giza	285	4.617	8.903	20.110	2.363	981	3.075	3.724	3.962	1.805	1.706	1.167	755	455	1.106	377	240	11
South Giza	14	184	812	2.363	5.547	1.094	402	321	345	117	113	88	47	26	82	16	10	0
Helwan	5	175	723	981	1.094	16.976	3.188	938	1.102	458	836	947	335	209	222	32	65	7
Maadi	25	627	2.138	3.075	402	3.188	9.412	2.965	2.823	928	1.733	1.586	606	353	464	113	164	10
Khaleefa	19	887	2.948	3.724	321	938	2.965	3.792	2.868	1.302	2.204	1.711	896	551	755	104	161	9
CBD	23	2.432	5.726	3.962	345	1.102	2.823	2.868	5.876	4.673	3.948	2.367	2.268	1.424	2.938	691	662	14
Shoubra	7	1.124	3.528	1.805	117	458	928	1.302	4.673	6.793	4.431	2.166	2147	1.157	3.099	887	636	21
Masr El Gadida	6	990	2.749	1.706	113	836	1.733	2.204	3.949	4.431	11.066	6.092	5.784	3.190	2.946	751	1.327	106
Nasr City	5	618	1.554	1.167	88	947	1.586	1.711	2.367	2.166	6.092	10.516	3.584	3.182	1.708	622	1.418	455
Ain Shams	3	576	1.403	755	47	335	606	896	2.268	2.147	5.784	3.584	6.142	2.867	1.930	758	1.316	70
Salam City	1	570	987	455	26	209	353	551	1.424	1.157	3.190	3.182	2.867	5.398	1.762	1.308	2.580	105
Shoubra El Khima	9	1.257	2.760	1.106	82	222	464	755	2.938	3.099	2.946	1.708	1930	1.762	7.630	2.240	1.971	53
Qalioub	2	1.233	1.254	377	16	32	113	104	691	887	751	622	758	1.308	2.240	8.194	1.400	29
Qanater	1	519	800	240	10	65	164	161	662	636	1.327	1.418	1316	2.580	1.971	1.400	11.458	152
10th of ramadan	0	12	27	11	0	7	10	9	14	21	106	455	70	105	53	29	152	6.905
Total	1.240	32.837	60.427	55.642	11.581	28.293	30.611	26.155	44.141	35.279	49.978	39.786	31.487	26.125	32.932	20.011	24.880	7.986

Table B.4: OD matrix for Taxi 2012

OD Matrix for Taxi 2012

	6th of October	Imbaba Markaz	Dokki	Giza	South Giza	Helwan	Maadi	Khaleefa	CBD	Shoubra	Masr El Gadida	Nasr City	Ain Shams	Salam City	Shoubra El Khima	Qalioub	Qanater	10th of ramadan
6th of October	5.448	929	1.172	4.073	272	192	274	428	721	216	204	118	96	65	172	102	51	0
Imbaba Markaz	929	22.743	7.642	4.771	193	283	618	1.060	2.976	979	1.413	948	377	217	677	740	135	34
Dokki	1.172	7.642	22.939	9.956	762	1.293	2.507	3.443	6.940	3.589	4.128	2.626	1606	1.088	2.681	1.289	844	138
Giza	4.073	4.773	9.956	28.197	2.812	1.151	2.904	4.157	5.195	2.001	2.210	1.548	838	592	1.417	638	378	121
South Giza	272	193	762	2.812	9.568	1.064	364	402	536	153	216	159	64	47	109	34	25	6
Helwan	192	283	1.293	1.149	1.064	22.619	3.750	945	1.387	461	910	595	295	198	417	143	110	37
Maadi	274	618	2.507	2.903	364	3.750	12.950	3.450	3.371	1.124	2.307	1.650	582	411	731	291	206	58
Khaleefa	428	1.060	3.444	4.157	402	945	3.450	5.684	3.823	1.794	3.190	2.649	897	639	1.082	279	256	63
CBD	721	2.976	6.940	5.195	536	1.387	3.371	3.824	7.952	5.311	4.960	3.718	2.431	1.801	3.328	1.181	1.047	77
Shoubra	216	979	3.589	2.001	153	461	1.124	1.794	5.311	10.502	5.268	3.163	2.272	1.217	3.536	1.377	983	90
Masr El Gadida	204	1.413	4.128	2.210	216	910	2.307	3.191	4.960	5.268	18.066	11.770	7.731	5.118	3.988	1.260	2.331	387
Nasr City	118	949	2.628	1.548	158	595	1.650	2.649	3.718	3.163	11.769	26.046	5.148	5.012	2.722	868	1.899	2.089
Ain Shams	96	377	1.606	838	64	295	582	897	2.431	2.272	7.731	5.148	7.529	3.575	2.407	829	1.551	574
Salam City	65	217	1.088	592	47	198	411	639	1.801	1.217	5.118	5.012	3.575	8.514	1.626	991	2.435	442
Shoubra El Khima	172	677	2.681	1.417	109	417	731	1.082	3.328	3.536	3.988	2.722	2.407	1.626	12.093	2.929	1.948	150
Qalioub	102	740	1.289	638	34	143	291	279	1.181	1.377	1.260	868	829	991	2.929	11.219	1.460	40
Qanater	51	135	844	378	24	110	205	256	1.047	983	2.331	1.899	1.551	2.435	1.948	1.460	19.898	187
10th of ramadan	0	34	138	121	6	37	58	63	77	90	387	2.089	574	442	150	40	187	16.926
Total	14.533	46.738	74.646	72.956	16.784	35.850	37.547	34.243	56.755	44.036	75.456	72.728	38.802	33.988	42.013	25.670	35.744	21.419

Table B.5: OD matrix for Bus 2005

OD Matrix for Bus 2005

	6th of October	Imbaba Markaz	Dokki	Giza	South Giza	Helwan	Maadi	Khaleefa	CBD	Shoubra	Masr El Gadida	Nasr City	Ain Shams	Salam City	Shoubra El Khima	Qalioub	Qanater	10th of ramadan
6th of October	87	2	5	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Imbaba Markaz	2	1.276	581	479	10	5	43	55	141	80	58	32	38	40	120	95	39	0
Dokki	5	581	1.552	853	48	36	148	177	246	278	153	58	98	69	293	94	51	1
Giza	24	479	853	2.131	218	61	275	269	180	147	98	51	56	33	104	22	13	1
South Giza	0	10	48	218	646	105	18	15	9	2	2	1	1	0	5	0	0	0
Helwan	0	5	36	61	105	2.137	327	52	38	24	36	67	22	14	17	0	3	0
Maadi	0	43	148	275	18	327	1.018	234	135	54	116	116	43	22	35	0	5	0
Khaleefa	0	55	177	269	15	52	234	218	55	70	110	74	54	29	51	0	6	0
CBD	0	141	246	180	9	38	135	55	17	238	106	36	121	68	232	25	37	0
Shoubra	0	80	278	147	2	24	54	70	238	660	365	141	197	97	345	51	48	1
Masr El Gadida	0	58	153	98	2	36	116	110	106	365	854	400	556	278	298	35	96	9
Nasr City	0	32	58	51	1	67	116	74	36	141	400	786	289	255	161	35	119	50
Ain Shams	0	38	98	56	1	22	43	54	121	197	556	289	689	302	216	49	114	6
Salam City	0	40	69	33	0	14	22	29	68	97	278	255	302	618	203	109	250	9
Shoubra El Khima	0	120	293	104	5	17	35	51	232	345	298	161	216	203	1.090	237	205	6
Qalioub	0	95	94	22	0	0	0	0	29	51	35	35	49	109	237	874	118	1
Qanater	0	39	51	13	0	3	5	6	37	48	96	119	114	250	205	118	1.269	21
10th of ramadan	0	0	1	1	0	0	0	0	0	1	9	50	6	9	6	1	21	803
Total	118	3.094	4.741	5.015	1.080	2.944	2.589	1.469	1.688	2.798	3.570	2.671	2.851	2.396	3.618	1.745	2.394	908

Table B.6: OD matrix for Bus 2012

OD Matrix
for Bus 2012

	6th of October	Imbaba Markaz	Dokki	Giza	South Giza	Helwan	Maadi	Khaleefa	CBD	Shoubra	Masr El Gadida	Nasr City	Ain Shams	Salam City	Shoubra El Khima	Qalioub	Qanater	10th of ramadan
6th of October	2.049	59	84	392	18	10	15	19	28	11	10	3	4	3	12	4	2	0
Imbaba Markaz	59	2.478	619	373	10	15	31	51	138	50	82	39	15	9	40	52	3	0
Dokki	84	619	1.908	847	42	85	167	197	291	241	237	98	113	63	227	85	50	5
Giza	392	373	847	2.791	228	59	202	274	217	131	94	45	59	32	116	37	21	5
South Giza	18	10	42	228	1.049	80	14	16	15	3	3	1	0	0	5	1	1	0
Helwan	10	15	85	59	80	2.513	346	44	56	18	35	17	13	9	32	5	3	1
Maadi	15	31	167	202	14	346	1.291	253	156	54	128	73	26	17	62	11	8	0
Khaleefa	19	51	197	274	16	44	253	358	66	73	145	113	37	25	71	8	13	0
CBD	28	138	291	217	15	56	156	66	67	262	101	45	114	80	233	52	51	0
Shoubra	11	50	241	131	3	18	54	73	262	992	362	181	170	72	326	78	62	3
Masr El Gadida	10	82	237	94	3	35	128	145	101	362	1.331	748	676	426	336	60	138	18
Nasr City	3	39	98	45	1	17	73	113	45	181	748	2.194	369	350	207	33	113	143
Ain Shams	4	15	113	49	0	13	26	37	114	170	676	369	794	327	227	48	114	47
Salam City	3	9	63	32	0	9	17	25	80	72	426	350	327	900	139	67	203	30
Shoubra El Khima	12	40	227	116	5	32	62	71	233	326	336	207	227	139	1.564	284	164	8
Qalioub	4	52	85	37	1	5	11	8	52	78	60	33	48	67	284	1.186	105	0
Qanater	2	3	50	21	1	3	8	13	51	62	138	113	114	203	164	105	2.116	10
10th of ramadan	0	0	5	5	0	1	0	0	0	3	18	143	47	30	8	0	10	1.695
Total	2.723	4.064	5.359	5.913	1.486	3.341	2.854	1.763	1.972	3.089	4.930	4.772	3.153	2.752	4.053	2.116	3.177	1.965

Table B.7: OD matrix for Truck 2005

OD Matrix
for Truck 2005

	6th of October	Imbaba Markaz	Dokki	Giza	South Giza	Helwan	Maadi	Khaleefa	CBD	Shoubra	Masr El Gadida	Nasr City	Ain Shams	Salam City	Shoubra El Khima	Qalioub	Qanater	10th of ramadan
6th of October	0	753	634	620	102	178	193	524	1.849	559	314	559	152	349	246	68	94	0
Imbaba Markaz	753	655	1.561	1.121	145	136	194	366	1.427	445	79	131	237	543	67	87	368	438
Dokki	634	1.561	2.740	2.896	426	692	501	1.262	3.216	659	507	447	81	148	498	185	256	277
Giza	620	1.121	2.896	5.827	834	606	1.124	2.120	2.643	290	883	1.289	55	147	601	319	325	308
South Giza	102	145	426	834	626	942	237	500	318	10	330	890	0	8	116	81	110	166
Helwan	178	136	692	606	942	2.166	2.198	928	2.140	256	924	1.893	438	521	204	122	230	574
Maadi	193	194	501	1.124	237	2.198	2.752	1.690	1.267	231	1.303	1.617	262	334	133	63	202	246
Khaleefa	524	366	1.262	2.120	500	928	1.690	2.369	3.487	750	1.688	1.366	889	437	93	100	329	270
CBD	1.849	1.427	3.216	2.643	318	2.140	1.267	3.487	12.431	3.088	4.299	1.816	1.303	851	1.038	1.132	548	546
Shoubra	559	445	659	290	10	256	231	750	3.088	677	1.564	1.010	243	707	649	370	561	498
Masr El Gadida	314	79	507	883	330	924	1.303	1.688	4.299	1.564	2.489	2.124	613	926	567	394	484	717
Nasr City	559	131	447	1.289	890	1.893	1.617	1.366	1.816	1.010	2.124	2.651	952	584	819	418	600	390
Ain Shams	152	237	81	55	0	438	262	889	1.303	243	613	952	292	554	117	0	91	467
Salam City	349	543	148	147	8	521	334	437	851	707	926	584	554	941	123	318	177	557
Shoubra El Khima	246	67	498	601	116	204	133	93	1.038	649	567	819	117	123	549	79	193	148
Qalioub	68	87	185	319	81	122	63	100	1.132	370	394	418	0	318	79	331	345	251
Qanater	94	368	256	325	110	230	202	329	548	561	484	600	91	177	193	345	539	198
10th of ramadan	0	438	277	308	166	574	246	270	546	498	717	390	467	557	148	251	198	87
Total	7.194	8.753	16.986	22.008	5.841	15.148	14.547	19.168	43.399	12.567	20.205	19.556	6.746	8.225	6.240	4.663	5.650	6.138

Table B.8: OD matrix for Truck 2012

OD Matrix for Truck 2012

	6th of October	Imbaba Markaz	Dokki	Giza	South Giza	Helwan	Maadi	Khaleefa	CBD	Shoubra	Masr El Gadida	Nasr City	Ain Shams	Salam City	Shoubra El Khima	Qalioub	Qanater	10th of ramadan
6th of October	1.116	2.370	2.722	1.538	84	163	170	451	1.590	465	322	687	344	287	434	1.133	95	1.433
Imbaba Markaz	2.370	425	3.346	1.850	120	145	138	267	1.381	369	69	75	211	432	47	44	292	679
Dokki	2.722	3.346	3.865	3.330	279	458	332	858	2.623	1.551	792	214	215	385	1.524	116	208	568
Giza	1.538	1.850	3.330	5.301	565	596	745	1.738	1.697	333	941	1.251	29	86	372	198	315	370
South Giza	84	120	279	565	428	1.916	343	557	342	6	290	425	2	7	73	50	82	182
Helwan	163	145	458	596	1.916	1.949	3.341	1.275	1.367	167	840	854	254	326	255	79	280	753
Maadi	170	138	332	745	343	3.341	3.051	1.282	851	151	786	1.100	177	210	78	40	226	295
Khaleefa	451	267	858	1.738	557	1.275	1.282	1.633	3.436	507	2.727	932	574	294	48	63	280	316
CBD	1.590	1.381	2.623	1.697	342	1.367	851	3.436	11.727	2.408	3.084	1.012	1.111	621	668	856	458	1.549
Shoubra	465	369	1.551	333	6	167	151	507	2.408	670	1.214	431	164	756	409	492	681	946
Masr El Gadida	322	69	792	941	290	840	786	2.727	3.084	1.214	2.481	1.817	955	503	469	1.010	923	1.359
Nasr City	687	75	214	1.251	425	854	1.100	932	1.012	431	1.817	4.266	698	2.503	501	1.484	873	2.045
Ain Shams	344	211	215	39	2	254	177	574	1.138	164	955	698	186	372	73	364	257	940
Salam City	287	432	385	86	7	326	210	294	621	756	503	2.503	372	644	487	201	171	1.050
Shoubra El Khima	434	47	1.524	372	73	255	78	48	668	409	469	501	73	487	697	143	621	2.435
Qalioub	1.133	44	116	198	50	79	40	63	856	492	1.010	1.484	364	201	143	189	1.085	2.163
Qanater	95	292	208	315	82	280	226	280	458	681	923	873	257	171	621	1.085	1.836	810
10th of ramadan	1.433	679	568	370	182	753	295	316	1.549	946	1.359	2.045	940	1.050	2.435	2.163	810	186
Total	15.404	12.260	23.386	21.265	5.751	15.018	13.316	17.238	36.808	11.720	20.582	21.168	6.926	9.335	9.334	9.710	9.493	18.079

Table B.9: OD matrix for all vehicles 2005

OD Matrix for all vehicles 2005

	6th of October	Imbaba Markaz	Dokki	Giza	South Giza	Helwan	Maadi	Khaleefa	CBD	Shoubra	Masr El Gadida	Nasr City	Ain Shams	Salam City	Shoubra El Khima	Qalioub	Qanater	10 Ramadan
6th of October	2.782	1.018	1.200	2.094	211	235	377	719	2.145	655	433	661	192	374	306	94	108	1
Imbaba Markaz	1.018	38.493	28.858	20.750	1.349	1.424	3.874	5.210	14.839	6.219	5.939	4.322	3349	3.549	5.544	5.834	3.201	529
Dokki	1.200	28.858	78.707	46.278	5.371	5.559	12.970	17.628	37.733	18.896	17.885	12.025	8007	5.835	13.577	7311	5.178	518
Giza	2.094	20.751	46.278	90.628	11.526	6.357	16.661	20.632	27.149	9.691	11.802	9.638	4351	2.849	5.890	2.770	1.945	412
South Giza	211	1.349	5.371	11.526	21.130	6.206	2.665	2.750	3.365	955	1.582	1.927	407	266	674	282	233	174
Helwan	235	1.424	5.560	6.357	6.206	69.216	17.211	6.347	10.290	3.157	6.494	7.828	2473	1.836	1.497	525	841	628
Maadi	377	3.874	12.971	16.661	2.665	17.211	42.831	16.155	19.211	5.706	11.428	11.075	3772	2.562	2.674	1.143	1.537	356
Khaleefa	719	5.210	17.628	20.632	2.750	6.348	16.156	19.270	20.483	7.997	14.181	12.000	5831	3.698	3.793	1.145	1.585	345
CBD	2.145	14.840	37.734	27.149	3.364	10.290	19.212	20.484	41.106	27.784	29.863	20.421	14.549	9476	15.158	5935	5.090	696
Shoubra	655	6.219	18.896	9.691	955	3.157	5.706	7.997	27.783	28.155	23.143	13.509	10.151	6551	13.506	5135	4.300	652
Masr El Gadida	433	5.940	17.885	11.802	1.582	6.494	11.428	14.181	29.864	23.143	56.556	37.083	27.032	16.339	13.996	5222	8.039	1.325
Nasr City	661	4.322	12.025	9.638	1.927	7.828	11.075	12.000	20.420	13.509	37.083	57.781	19.310	16.750	9517	4.625	8.584	3.005
Ain Shams	192	3.349	8.007	4.351	407	2.472	3.772	5.831	14.549	10.151	27.032	19.310	24.124	12.747	8239	3.923	6.397	828
Salam City	374	3.549	5.835	2.849	266	1.836	2.563	3.698	9.476	6.551	16.339	16.750	12.747	21.735	7656	6346	11.138	1.084
Shoubra El Khima	306	5.544	13.577	5.890	674	1.497	2.674	3.793	15.158	13.506	13.996	9.517	8239	7.656	27.236	9238	8.463	398
Qalioub	94	5.835	7.311	2.770	282	525	1.143	1.145	5.940	5.135	5.221	4.625	3923	6.346	9.239	31.554	6.893	407
Qanater	108	3.201	5.178	1.945	233	841	1.537	1.584	5.090	4.300	8.037	8.584	6397	11.139	8463	6.892	43.071	841
10th of ramadan	1	529	518	412	174	628	356	345	696	652	1.325	3.005	828	1.084	398	407	841	7.795
Total	13.605	154.305	323.539	291.423	61.072	148.124	172.211	159.769	305.297	186.162	288.339	250.061	155.682	130.792	147.363	98.381	117.444	19.994

Table B.10: OD matrix for all vehicles 2012

	6th of October	Imbaba Markaz	Dokki	Giza	South Giza	Helwan	Maadi	Khaleefa	CBD	Shoubra	Masr El Gadida	Nasr City	Ain Shams	Salam City	Shoubra El Khima	Qalioub	Qanater	10th of ramadan
6th of October	29.825	7.509	10.364	23.486	1.621	1.473	2.067	3.516	7.453	2.022	2.009	1.790	1128	826	1.629	1.968	591	1.446
Imbaba Markaz	7.509	87.405	39.329	23.712	1.480	2.162	4.188	6.343	18.574	6.074	8.625	6.841	2674	2.006	3.592	3.783	1.341	866
Dokki	10.364	39.329	101.622	53.440	5.237	8.865	15.522	20.526	44.622	21.171	26.450	19.716	9641	6.955	14.984	7.819	5.652	1.276
Giza	23.486	23.713	53.440	125.543	13.599	7.799	16.638	23.648	34.575	11.777	15.967	13.483	5188	3.790	7.621	4.293	2.958	891
South Giza	1.621	1.480	5.237	13.599	39.130	7.389	2.847	3.324	4.740	1.248	2.319	2.142	571	408	814	421	326	228
Helwan	1.473	2.162	8.865	7.797	7.388	94.905	21.893	7.371	11.798	3.464	7.477	5.775	2331	1.784	2.655	1.364	1.236	940
Maadi	2.067	4.188	15.522	16.637	2.847	21.893	59.397	18.809	22.729	7.014	14.836	12.372	3904	2.961	4.152	2.381	1.990	651
Khaleefa	3.516	6.343	20.527	23.647	3.324	7.371	18.809	26.599	25.970	10.625	21.105	18.215	6028	4.316	5.557	2.354	2.232	651
CBD	7.454	18.574	44.621	34.576	4.740	11.797	22.728	25.972	49.113	31.487	35.854	31.418	16.020	11.720	17.729	8760	7.427	2.018
Shoubra	2.022	6.073	21.171	11.777	1.248	3.464	7.014	10.625	31.487	44.329	28.288	19.505	11.483	7316	16.028	7.897	6.119	1.427
Masr El Gadida	2.009	8.624	26.451	15.966	2.319	7.477	14.836	21.106	35.854	28.288	91.145	70.927	37.755	25.718	19.409	8896	13.452	3.139
Nasr City	1.790	6.843	19.718	13.483	2.141	5.775	12.372	18.215	31.419	19.503	70.925	136.502	28.659	29.267	14.849	7.860	11.988	11.918
Ain Shams	1.128	2.674	9.641	5.188	571	2.331	3.904	6.028	16.047	11.483	37.755	28.659	30.724	16.463	10.787	4.876	7.869	3.156
Salam City	826	2.005	6.955	3.790	408	1.784	2.961	4.316	11.720	7.316	25.718	29.267	16.463	34.934	8138	5.292	11.293	2.919
Shoubra El Khima	1.629	3.592	14.984	7.621	814	2.655	4.152	5.557	17.729	16.028	19.409	14.849	10.787	8.138	33.434	12.818	9.362	3.086
Qalioub	1.968	3.783	7.819	4.293	421	1.364	2.381	2.354	8.760	7.897	8.896	7.861	4876	5.292	12.818	44.485	8.080	2.381
Qanater	591	1.341	5.652	2.957	325	1.236	1.990	2.232	7.427	6.119	13.450	11.988	7869	11.294	9.362	8.081	81.387	1.722
10th of ramadan	1.446	866	1.276	891	228	940	651	651	2.018	1.427	3.139	11.918	3156	2.919	3.086	2.381	1.722	36.083
Total	100.724	226.504	413.194	388.403	87.841	190.680	214.350	207.192	382.035	237.272	433.367	443.228	199.257	176.107	186.644	135.729	175.025	74.798

Annex 6: Non-classified Vehicle Counts

[separate pdf file]

ANNEX 6

Non-Classified Vehicle Counts

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Tuesday 6 July, 2010 **Counted By:** Amr Mamdoh
Point No: P1
Name of Street: Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd
Direction: To East Cairo (Cairo-Ismailia Desert Road)

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	929	929	**7.00 - 8.00**	3,632	3,716	0.977
7:15 - 7:30	900					
7:30 - 7:45	895					
7:45 - 8:00	908					
8:00 - 8:15	881	881	**8.00 - 9.00**	3,374	3,524	0.957
8:15 - 8:30	878					
8:30 - 8:45	844					
8:45 - 9:00	771					
9:00 - 9:15	822	858	**9.00 - 10.00**	3,276	3,432	0.955
9:15 - 9:30	818					
9:30 - 9:45	778					
9:45 - 10;00	858					
10:00 - 10:15	761	772	**10.00 - 11.00**	2,915	3,088	0.944
10.15 - 10.30	772					
10.30 - 10.45	703					
10.45 - 11.00	679					
3.00 - 3.15	649	816	**3.00 - 4.00**	2,930	3,264	0.898
3.15 - 3.30	706					
3.30 - 3.45	759					
3.45 - 4.00	816					
4.00 - 4.15	872	872	**4.00 - 5.00**	3,289	3,488	0.943
4.15 - 4.30	837					
4.30 - 4.45	823					
4.45 - 5.00	757					
5.00 - 5.15	761	761	**5.00 - 6.00**	2,940	3,044	0.966
5.15 - 5.30	751					
5.30 - 5.45	750					
5.45 - 6.00	678					
6.00 - 6.15	701	701	**6.00 - 700**	2,714	2,804	0.968
6.15 - 6.30	674					
6.30 - 6.45	675					
6.45 - 7.00	664					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Tuesday 6 July, 2010 **Counted By:** Mohamed Imam
Point No: P1
Name of Street: Ring Road / Between El Khosoos & Cairo-Alex Agr.Rd
Direction: To West of Cairo (Cairo-Alx Desert Road)

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	915	915	**7.00 - 8.00**	3,473	3,660	0.949
7:15 - 7:30	905					
7:30 - 7:45	817					
7:45 - 8:00	836					
8:00 - 8:15	848	881	**8.00 - 9.00**	3,393	3,524	0.963
8:15 - 8:30	833					
8:30 - 8:45	831					
8:45 - 9:00	881					
9:00 - 9:15	825	896	**9.00 - 10.00**	3,242	3,584	0.905
9:15 - 9:30	736					
9:30 - 9:45	896					
9:45 - 10;00	785					
10:00 - 10:15	724	724	**10.00 - 11.00**	2,741	2,896	0.946
10.15 - 10.30	679					
10.30 - 10.45	683					
10.45 - 11.00	655					
3.00 - 3.15	704	925	**3.00 - 4.00**	3,412	3,700	0.922
3.15 - 3.30	862					
3.30 - 3.45	925					
3.45 - 4.00	921					
4.00 - 4.15	883	883	**4.00 - 5.00**	2,890	3,532	0.818
4.15 - 4.30	680					
4.30 - 4.45	673					
4.45 - 5.00	654					
5.00 - 5.15	670	714	**5.00 - 6.00**	2,727	2,856	0.955
5.15 - 5.30	664					
5.30 - 5.45	714					
5.45 - 6.00	679					
6.00 - 6.15	701	762	**6.00 - 700**	2,909	3,048	0.954
6.15 - 6.30	734					
6.30 - 6.45	712					
6.45 - 7.00	762					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Monday 5 July, 2010 **Counted By:** Amr Samir
Point No: P2
Name of Street: Gesr El-Suez/between Ring Road and Ainshams Str.
Direction: To Cairo

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	1,203	1,583	**7.00 - 8.00**	5,442	6,332	0.859
7:15 - 7:30	1,240					
7:30 - 7:45	1,416					
7:45 - 8:00	1,583					
8:00 - 8:15	1,576	1,576	**8.00 - 9.00**	5,971	6,304	0.947
8:15 - 8:30	1,484					
8:30 - 8:45	1,417					
8:45 - 9:00	1,494					
9:00 - 9:15	1,492	1,492	**9.00 - 10.00**	5,791	5,968	0.970
9:15 - 9:30	1,458					
9:30 - 9:45	1,425					
9:45 - 10;00	1,416					
10:00 - 10:15	1,392	1,605	**10.00 - 11.00**	5,627	6,420	0.876
10.15 - 10.30	1,605					
10.30 - 10.45	1,308					
10.45 - 11.00	1,322					
3.00 - 3.15	1,563	1,563	**3.00 - 4.00**	5,320	6,252	0.851
3.15 - 3.30	1,264					
3.30 - 3.45	1,306					
3.45 - 4.00	1,187					
4.00 - 4.15	1,189	1,727	**4.00 - 5.00**	5,656	6,908	0.819
4.15 - 4.30	1,257					
4.30 - 4.45	1,483					
4.45 - 5.00	1,727					
5.00 - 5.15	1,662	1,662	**5.00 - 6.00**	5,882	6,648	0.885
5.15 - 5.30	1,400					
5.30 - 5.45	1,448					
5.45 - 6.00	1,372					
6.00 - 6.15	1,339	1,349	**6.00 - 700**	5,268	5,396	0.976
6.15 - 6.30	1,259					
6.30 - 6.45	1,321					
6.45 - 7.00	1,349					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Monday 5 July, 2010 **Counted By:** Moataz Ahmed
Point No: P2
Name of Street: Gesr El-Suez/between Ring Road and Ainshams Str.
Direction: To Ismalia

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	685	685	**7.00 - 8.00**	2,565	2,740	0.936
7:15 - 7:30	590					
7:30 - 7:45	605					
7:45 - 8:00	685					
8:00 - 8:15	600	800	**8.00 - 9.00**	2,595	3,200	0.811
8:15 - 8:30	595					
8:30 - 8:45	600					
8:45 - 9:00	800					
9:00 - 9:15	730	780	**9.00 - 10.00**	2,915	3,120	0.934
9:15 - 9:30	780					
9:30 - 9:45	745					
9:45 - 10;00	660					
10:00 - 10:15	800	800	**10.00 - 11.00**	2,990	3,200	0.934
10.15 - 10.30	680					
10.30 - 10.45	745					
10.45 - 11.00	765					
3.00 - 3.15	724	724	**3.00 - 4.00**	2,616	2,896	0.903
3.15 - 3.30	658					
3.30 - 3.45	607					
3.45 - 4.00	627					
4.00 - 4.15	691	749	**4.00 - 5.00**	2,656	2,996	0.887
4.15 - 4.30	624					
4.30 - 4.45	592					
4.45 - 5.00	749					
5.00 - 5.15	680	756	**5.00 - 6.00**	2,868	3,024	0.948
5.15 - 5.30	723					
5.30 - 5.45	756					
5.45 - 6.00	709					
6.00 - 6.15	835	843	**6.00 - 700**	3,144	3,372	0.932
6.15 - 6.30	701					
6.30 - 6.45	765					
6.45 - 7.00	843					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Wed. 7 July, 2010 **Counted By:** Amr Samir
Point No: P4
Name of Street: Ring Road / Carfour Al Maadi
Direction: To New Cairo

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	1,889	1,911	**7.00 - 8.00**	7,487	7,644	0.979
7:15 - 7:30	1,911					
7:30 - 7:45	1,799					
7:45 - 8:00	1,888					
8:00 - 8:15	1,711	2,391	**8.00 - 9.00**	7,731	9,564	0.808
8:15 - 8:30	2,009					
8:30 - 8:45	2,391					
8:45 - 9:00	1,620					
9:00 - 9:15	1,759	1,759	**9.00 - 10.00**	6,605	7,036	0.939
9:15 - 9:30	1,699					
9:30 - 9:45	1,676					
9:45 - 10;00	1,471					
10:00 - 10:15	1,677	1,677	**10.00 - 11.00**	6,052	6,708	0.902
10.15 - 10.30	1,559					
10.30 - 10.45	1,326					
10.45 - 11.00	1,490					
3.00 - 3.15	1,668	1,993	**3.00 - 4.00**	7,529	7,972	0.944
3.15 - 3.30	1,915					
3.30 - 3.45	1,953					
3.45 - 4.00	1,993					
4.00 - 4.15	1,702	2,013	**4.00 - 5.00**	7,527	8,052	0.935
4.15 - 4.30	1,801					
4.30 - 4.45	2,013					
4.45 - 5.00	2,011					
5.00 - 5.15	2,117	2,237	**5.00 - 6.00**	8,504	8,948	0.950
5.15 - 5.30	2,105					
5.30 - 5.45	2,045					
5.45 - 6.00	2,237					
6.00 - 6.15	2,156	2,156	**6.00 - 700**	7,725	8,624	0.896
6.15 - 6.30	1,900					
6.30 - 6.45	1,856					
6.45 - 7.00	1,813					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date:	Wed. 7 July, 2010	**Counted By:**	Motaz Ahmed
Point No:	P4		
Name of Street:	Ring Road / Carfour Al Maadi		
Direction:	To Al Maadi		

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	1,765	2,235	**7.00 - 8.00**	7,239	8,940	0.810
7:15 - 7:30	2,235					
7:30 - 7:45	1,336					
7:45 - 8:00	1,903					
8:00 - 8:15	1,007	2,127	**8.00 - 9.00**	6,149	8,508	0.723
8:15 - 8:30	1,405					
8:30 - 8:45	1,610					
8:45 - 9:00	2,127					
9:00 - 9:15	1,368	1,950	**9.00 - 10.00**	6,953	7,800	0.891
9:15 - 9:30	1,733					
9:30 - 9:45	1,950					
9:45 - 10;00	1,902					
10:00 - 10:15	1,652	1,771	**10.00 - 11.00**	6,524	7,084	0.921
10.15 - 10.30	1,771					
10.30 - 10.45	1,537					
10.45 - 11.00	1,564					
3.00 - 3.15	2,371	2,651	**3.00 - 4.00**	9,134	10,604	0.861
3.15 - 3.30	2,195					
3.30 - 3.45	2,651					
3.45 - 4.00	1,917					
4.00 - 4.15	2,307	2,707	**4.00 - 5.00**	9,651	10,828	0.891
4.15 - 4.30	2,433					
4.30 - 4.45	2,707					
4.45 - 5.00	2,204					
5.00 - 5.15	2,644	2,890	**5.00 - 6.00**	9,758	11,560	0.844
5.15 - 5.30	2,444					
5.30 - 5.45	1,780					
5.45 - 6.00	2,890					
6.00 - 6.15	2,180	2,945	**6.00 - 700**	9,875	11,780	0.838
6.15 - 6.30	2,190					
6.30 - 6.45	2,560					
6.45 - 7.00	2,945					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Wed. 7 July, 2010 **Counted By:** Amr Mamdoh
Point No: P5
Name of Street: Ring Road / Above Cairo-Alex Desert Road
Direction: To Al Moniab and New Cairo

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	913	913	**7.00 - 8.00**	3,560	3,652	0.975
7:15 - 7:30	906					
7:30 - 7:45	893					
7:45 - 8:00	848					
8:00 - 8:15	890	890	**8.00 - 9.00**	3,388	3,560	0.952
8:15 - 8:30	841					
8:30 - 8:45	815					
8:45 - 9:00	842					
9:00 - 9:15	785	851	**9.00 - 10.00**	3,234	3,404	0.950
9:15 - 9:30	777					
9:30 - 9:45	821					
9:45 - 10;00	851					
10:00 - 10:15	871	911	**10.00 - 11.00**	3,488	3,644	0.957
10.15 - 10.30	843					
10.30 - 10.45	911					
10.45 - 11.00	863					
3.00 - 3.15	849	849	**3.00 - 4.00**	3,239	3,396	0.954
3.15 - 3.30	845					
3.30 - 3.45	794					
3.45 - 4.00	751					
4.00 - 4.15	760	760	**4.00 - 5.00**	2,935	3,040	0.965
4.15 - 4.30	731					
4.30 - 4.45	712					
4.45 - 5.00	732					
5.00 - 5.15	684	687	**5.00 - 6.00**	2,659	2,748	0.968
5.15 - 5.30	687					
5.30 - 5.45	649					
5.45 - 6.00	639					
6.00 - 6.15	623	623	**6.00 - 700**	2,227	2,492	0.894
6.15 - 6.30	578					
6.30 - 6.45	553					
6.45 - 7.00	473					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Wed. 7 July, 2010 **Counted By:** Mohamed Imam
Point No: P5
Name of Street: Ring Road / Above Cairo-Alex Desert Road
Direction: To Cairo-Alx Agricultural Road

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	828	828	7.00 - 8.00	3,049	3,312	0.921
7:15 - 7:30	757					
7:30 - 7:45	724					
7:45 - 8:00	740					
8:00 - 8:15	746	791	8.00 - 9.00	2,980	3,164	0.942
8:15 - 8:30	746					
8:30 - 8:45	791					
8:45 - 9:00	697					
9:00 - 9:15	811	811	9.00 - 10.00	3,052	3,244	0.941
9:15 - 9:30	801					
9:30 - 9:45	701					
9:45 - 10;00	739					
10:00 - 10:15	710	752	10.00 - 11.00	2,844	3,008	0.945
10.15 - 10.30	752					
10.30 - 10.45	712					
10.45 - 11.00	670					
3.00 - 3.15	780	784	3.00 - 4.00	3,009	3,136	0.960
3.15 - 3.30	784					
3.30 - 3.45	732					
3.45 - 4.00	713					
4.00 - 4.15	753	757	4.00 - 5.00	2,947	3,028	0.973
4.15 - 4.30	757					
4.30 - 4.45	685					
4.45 - 5.00	752					
5.00 - 5.15	685	738	5.00 - 6.00	2,886	2,952	0.978
5.15 - 5.30	728					
5.30 - 5.45	738					
5.45 - 6.00	735					
6.00 - 6.15	715	789	6.00 - 700	2,989	3,156	0.947
6.15 - 6.30	789					
6.30 - 6.45	766					
6.45 - 7.00	719					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Tuseday 6 July, 2010 **Counted By:** Mohamed Shaban
Point No: P6
Name of Street: 26th July / Between Railway and Ring Road
Direction: To Cairo

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	604	1,148	7.00 - 8.00	3,506	4,592	0.764
7:15 - 7:30	615					
7:30 - 7:45	1,148					
7:45 - 8:00	1,139					
8:00 - 8:15	1,120	1,215	8.00 - 9.00	4,693	4,860	0.966
8:15 - 8:30	1,177					
8:30 - 8:45	1,181					
8:45 - 9:00	1,215					
9:00 - 9:15	1,137	1,186	9.00 - 10.00	4,639	4,744	0.978
9:15 - 9:30	1,182					
9:30 - 9:45	1,186					
9:45 - 10;00	1,134					
10:00 - 10:15	1,139	1,205	10.00 - 11.00	4,716	4,820	0.978
10.15 - 10.30	1,184					
10.30 - 10.45	1,205					
10.45 - 11.00	1,188					
3.00 - 3.15	981	1,008	3.00 - 4.00	3,632	4,032	0.901
3.15 - 3.30	1,008					
3.30 - 3.45	866					
3.45 - 4.00	777					
4.00 - 4.15	796	906	4.00 - 5.00	3,368	3,624	0.929
4.15 - 4.30	838					
4.30 - 4.45	828					
4.45 - 5.00	906					
5.00 - 5.15	863	863	5.00 - 6.00	3,225	3,452	0.934
5.15 - 5.30	830					
5.30 - 5.45	780					
5.45 - 6.00	752					
6.00 - 6.15	780	791	6.00 - 700	3,067	3,164	0.969
6.15 - 6.30	791					
6.30 - 6.45	777					
6.45 - 7.00	719					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Tuseday 6 July, 2010 **Counted By:** Yasian Mohamed
Point No: P6
Name of Street: 26th July / Between Railway and Ring Road
Direction: To 6 October City

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	567	605	**7.00 - 8.00**	2,256	2,420	0.932
7:15 - 7:30	530					
7:30 - 7:45	554					
7:45 - 8:00	605					
8:00 - 8:15	605	630	**8.00 - 9.00**	2,284	2,520	0.906
8:15 - 8:30	630					
8:30 - 8:45	551					
8:45 - 9:00	498					
9:00 - 9:15	595	750	**9.00 - 10.00**	2,416	3,000	0.805
9:15 - 9:30	467					
9:30 - 9:45	604					
9:45 - 10;00	750					
10:00 - 10:15	574	727	**10.00 - 11.00**	2,634	2,908	0.906
10.15 - 10.30	627					
10.30 - 10.45	727					
10.45 - 11.00	706					
3.00 - 3.15	770	770	**3.00 - 4.00**	2,589	3,080	0.841
3.15 - 3.30	554					
3.30 - 3.45	570					
3.45 - 4.00	695					
4.00 - 4.15	593	593	**4.00 - 5.00**	2,267	2,372	0.956
4.15 - 4.30	549					
4.30 - 4.45	572					
4.45 - 5.00	553					
5.00 - 5.15	546	766	**5.00 - 6.00**	2,671	3,064	0.872
5.15 - 5.30	766					
5.30 - 5.45	677					
5.45 - 6.00	682					
6.00 - 6.15	613	636	**6.00 - 700**	2,470	2,544	0.971
6.15 - 6.30	586					
6.30 - 6.45	635					
6.45 - 7.00	636					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Monday 5 July, 2010 **Counted By:** Mohamed Shaban
Point No: P7
Name of Street: Al-Ahram Street / Electricity Station
Direction: To Pyramids

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	569	588	**7.00 - 8.00**	2,098	2,352	0.892
7:15 - 7:30	475					
7:30 - 7:45	466					
7:45 - 8:00	588					
8:00 - 8:15	546	569	**8.00 - 9.00**	2,254	2,276	0.990
8:15 - 8:30	569					
8:30 - 8:45	564					
8:45 - 9:00	575					
9:00 - 9:15	598	628	**9.00 - 10.00**	2,434	2,512	0.969
9:15 - 9:30	622					
9:30 - 9:45	586					
9:45 - 10;00	628					
10:00 - 10:15	547	564	**10.00 - 11.00**	2,181	2,256	0.967
10.15 - 10.30	564					
10.30 - 10.45	525					
10.45 - 11.00	545					
3.00 - 3.15	901	901	**3.00 - 4.00**	3,407	3,604	0.945
3.15 - 3.30	890					
3.30 - 3.45	866					
3.45 - 4.00	750					
4.00 - 4.15	802	826	**4.00 - 5.00**	3,172	3,304	0.960
4.15 - 4.30	764					
4.30 - 4.45	826					
4.45 - 5.00	780					
5.00 - 5.15	859	859	**5.00 - 6.00**	3,303	3,436	0.961
5.15 - 5.30	854					
5.30 - 5.45	784					
5.45 - 6.00	806					
6.00 - 6.15	710	845	**6.00 - 700**	3,187	3,380	0.943
6.15 - 6.30	802					
6.30 - 6.45	845					
6.45 - 7.00	830					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Monday 5 July, 2010 **Counted By:** Yasian Mohamed
Point No: P7
Name of Street: Al-Ahram Street / Electricity Station
Direction: To Giza Square

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	483	739	**7.00 - 8.00**	2,622	2,956	0.887
7:15 - 7:30	739					
7:30 - 7:45	705					
7:45 - 8:00	695					
8:00 - 8:15	805	829	**8.00 - 9.00**	3,191	3,316	0.962
8:15 - 8:30	746					
8:30 - 8:45	811					
8:45 - 9:00	829					
9:00 - 9:15	694	830	**9.00 - 10.00**	2,994	3,320	0.902
9:15 - 9:30	830					
9:30 - 9:45	800					
9:45 - 10;00	670					
10:00 - 10:15	592	675	**10.00 - 11.00**	2,445	2,700	0.906
10.15 - 10.30	598					
10.30 - 10.45	580					
10.45 - 11.00	675					
3.00 - 3.15	718	737	**3.00 - 4.00**	2,602	2,948	0.883
3.15 - 3.30	737					
3.30 - 3.45	608					
3.45 - 4.00	539					
4.00 - 4.15	624	647	**4.00 - 5.00**	2,518	2,588	0.973
4.15 - 4.30	612					
4.30 - 4.45	647					
4.45 - 5.00	635					
5.00 - 5.15	450	600	**5.00 - 6.00**	2,090	2,400	0.871
5.15 - 5.30	500					
5.30 - 5.45	540					
5.45 - 6.00	600					
6.00 - 6.15	540	540	**6.00 - 700**	2,060	2,160	0.954
6.15 - 6.30	520					
6.30 - 6.45	495					
6.45 - 7.00	505					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Monday 5 July, 2010 **Counted By:** Mohamed Nagi
Point No: P8
Name of Street: Middle of Abbas Bridge
Direction: To Al Tahiri

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	200	413	**7.00 - 8.00**	1,163	1,652	0.704
7:15 - 7:30	214					
7:30 - 7:45	336					
7:45 - 8:00	413					
8:00 - 8:15	550	550	**8.00 - 9.00**	1,813	2,200	0.824
8:15 - 8:30	432					
8:30 - 8:45	470					
8:45 - 9:00	361					
9:00 - 9:15	427	427	**9.00 - 10.00**	1,546	1,708	0.905
9:15 - 9:30	395					
9:30 - 9:45	380					
9:45 - 10;00	344					
10:00 - 10:15	350	437	**10.00 - 11.00**	1,527	1,748	0.874
10.15 - 10.30	413					
10.30 - 10.45	437					
10.45 - 11.00	327					
3.00 - 3.15	365	437	**3.00 - 4.00**	1,574	1,748	0.900
3.15 - 3.30	437					
3.30 - 3.45	410					
3.45 - 4.00	362					
4.00 - 4.15	436	436	**4.00 - 5.00**	1,666	1,744	0.955
4.15 - 4.30	407					
4.30 - 4.45	420					
4.45 - 5.00	403					
5.00 - 5.15	409	484	**5.00 - 6.00**	1,789	1,936	0.924
5.15 - 5.30	440					
5.30 - 5.45	484					
5.45 - 6.00	456					
6.00 - 6.15	543	543	**6.00 - 700**	2,030	2,172	0.935
6.15 - 6.30	478					
6.30 - 6.45	477					
6.45 - 7.00	532					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Monday 5 July, 2010 **Counted By:** Osama Atiah
Point No: P8
Name of Street: Middle of Abbas Bridge
Direction: To Giza

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	243	419	7.00 - 8.00	1,276	1,676	0.761
7:15 - 7:30	286					
7:30 - 7:45	328					
7:45 - 8:00	419					
8:00 - 8:15	489	630	8.00 - 9.00	2,220	2,520	0.881
8:15 - 8:30	516					
8:30 - 8:45	585					
8:45 - 9:00	630					
9:00 - 9:15	672	672	9.00 - 10.00	2,437	2,688	0.907
9:15 - 9:30	631					
9:30 - 9:45	608					
9:45 - 10;00	526					
10:00 - 10:15	529	559	10.00 - 11.00	2,154	2,236	0.963
10.15 - 10.30	529					
10.30 - 10.45	559					
10.45 - 11.00	537					
3.00 - 3.15	612	719	3.00 - 4.00	2,604	2,876	0.905
3.15 - 3.30	719					
3.30 - 3.45	656					
3.45 - 4.00	617					
4.00 - 4.15	610	610	4.00 - 5.00	2,414	2,440	0.989
4.15 - 4.30	592					
4.30 - 4.45	609					
4.45 - 5.00	603					
5.00 - 5.15	526	621	5.00 - 6.00	2,316	2,484	0.932
5.15 - 5.30	593					
5.30 - 5.45	621					
5.45 - 6.00	576					
6.00 - 6.15	613	692	6.00 - 700	2,521	2,768	0.911
6.15 - 6.30	656					
6.30 - 6.45	560					
6.45 - 7.00	692					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Wed. 7 July, 2010 **Counted By:** Osama Atiah
Point No: P9
Name of Street: 6 October Bridge between Zamalk and Agozah
Direction: To Al Mohandisain and Al Doki

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	1,100	2,071	**7.00 - 8.00**	6,391	8,284	0.771
7:15 - 7:30	1,340					
7:30 - 7:45	1,880					
7:45 - 8:00	2,071					
8:00 - 8:15	2,200	2,995	**8.00 - 9.00**	9,380	11,980	0.783
8:15 - 8:30	2,380					
8:30 - 8:45	2,995					
8:45 - 9:00	1,805					
9:00 - 9:15	2,140	2,140	**9.00 - 10.00**	8,129	8,560	0.950
9:15 - 9:30	2,094					
9:30 - 9:45	1,955					
9:45 - 10;00	1,940					
10:00 - 10:15	1,560	1,700	**10.00 - 11.00**	5,700	6,800	0.838
10.15 - 10.30	1,700					
10.30 - 10.45	1,180					
10.45 - 11.00	1,260					
3.00 - 3.15	1,180	1,342	**3.00 - 4.00**	4,885	5,368	0.910
3.15 - 3.30	1,073					
3.30 - 3.45	1,342					
3.45 - 4.00	1,290					
4.00 - 4.15	1,398	1,412	**4.00 - 5.00**	5,256	5,648	0.931
4.15 - 4.30	1,412					
4.30 - 4.45	1,323					
4.45 - 5.00	1,123					
5.00 - 5.15	1,415	1,415	**5.00 - 6.00**	5,182	5,660	0.916
5.15 - 5.30	1,242					
5.30 - 5.45	1,193					
5.45 - 6.00	1,332					
6.00 - 6.15	1,938	2,100	**6.00 - 700**	7,458	8,400	0.888
6.15 - 6.30	1,780					
6.30 - 6.45	2,100					
6.45 - 7.00	1,640					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Wed. 7 July, 2010 **Counted By:** Mohamed Nagi
Point No: P9
Name of Street: 6 October Bridge between Zamalk and Agozah
Direction: To Cairo-Alx Agricultural Road

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	1,261	2,371	**7.00 - 8.00**	7,147	9,484	0.754
7:15 - 7:30	1,316					
7:30 - 7:45	2,371					
7:45 - 8:00	2,199					
8:00 - 8:15	2,006	2,156	**8.00 - 9.00**	7,352	8,624	0.853
8:15 - 8:30	2,156					
8:30 - 8:45	1,547					
8:45 - 9:00	1,643					
9:00 - 9:15	2,002	2,002	**9.00 - 10.00**	6,512	8,008	0.813
9:15 - 9:30	1,756					
9:30 - 9:45	1,277					
9:45 - 10;00	1,477					
10:00 - 10:15	2,077	2,230	**10.00 - 11.00**	7,605	8,920	0.853
10.15 - 10.30	2,230					
10.30 - 10.45	1,300					
10.45 - 11.00	1,998					
3.00 - 3.15	762	911	**3.00 - 4.00**	3,247	3,644	0.891
3.15 - 3.30	832					
3.30 - 3.45	911					
3.45 - 4.00	742					
4.00 - 4.15	653	715	**4.00 - 5.00**	2,566	2,860	0.897
4.15 - 4.30	715					
4.30 - 4.45	506					
4.45 - 5.00	692					
5.00 - 5.15	514	742	**5.00 - 6.00**	2,424	2,968	0.817
5.15 - 5.30	603					
5.30 - 5.45	565					
5.45 - 6.00	742					
6.00 - 6.15	962	1,322	**6.00 - 700**	4,549	5,288	0.860
6.15 - 6.30	1,050					
6.30 - 6.45	1,215					
6.45 - 7.00	1,322					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Monday 5 July, 2010 **Counted By:** Amr Mamdoh
Point No: P10
Name of Street: Ahmed Helmy Str./ Before Abo Wafya Bridge
Direction: One to Shobra

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	162	209	**7.00 - 8.00**	721	836	0.862
7:15 - 7:30	175					
7:30 - 7:45	175					
7:45 - 8:00	209					
8:00 - 8:15	233	240	**8.00 - 9.00**	909	960	0.947
8:15 - 8:30	240					
8:30 - 8:45	224					
8:45 - 9:00	212					
9:00 - 9:15	171	171	**9.00 - 10.00**	577	684	0.844
9:15 - 9:30	153					
9:30 - 9:45	131					
9:45 - 10;00	122					
10:00 - 10:15	108	108	**10.00 - 11.00**	395	432	0.914
10.15 - 10.30	107					
10.30 - 10.45	99					
10.45 - 11.00	81					
3.00 - 3.15	157	171	**3.00 - 4.00**	635	684	0.928
3.15 - 3.30	142					
3.30 - 3.45	165					
3.45 - 4.00	171					
4.00 - 4.15	148	157	**4.00 - 5.00**	619	628	0.986
4.15 - 4.30	157					
4.30 - 4.45	157					
4.45 - 5.00	157					
5.00 - 5.15	149	152	**5.00 - 6.00**	594	608	0.977
5.15 - 5.30	149					
5.30 - 5.45	152					
5.45 - 6.00	144					
6.00 - 6.15	153	153	**6.00 - 700**	574	612	0.938
6.15 - 6.30	152					
6.30 - 6.45	143					
6.45 - 7.00	126					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Monday 5 July, 2010 **Counted By:** Mohamed Imam
Point No: P10
Name of Street: Ahmed Helmy Str./ Before Abo Wafya Bridge
Direction: Two to Ramses

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	127	158	**7.00 - 8.00**	554	632	0.877
7:15 - 7:30	141					
7:30 - 7:45	128					
7:45 - 8:00	158					
8:00 - 8:15	168	168	**8.00 - 9.00**	596	672	0.887
8:15 - 8:30	163					
8:30 - 8:45	127					
8:45 - 9:00	138					
9:00 - 9:15	121	129	**9.00 - 10.00**	496	516	0.961
9:15 - 9:30	123					
9:30 - 9:45	129					
9:45 - 10;00	123					
10:00 - 10:15	93	93	**10.00 - 11.00**	342	372	0.919
10.15 - 10.30	82					
10.30 - 10.45	83					
10.45 - 11.00	84					
3.00 - 3.15	217	217	**3.00 - 4.00**	814	868	0.938
3.15 - 3.30	209					
3.30 - 3.45	199					
3.45 - 4.00	189					
4.00 - 4.15	179	191	**4.00 - 5.00**	731	764	0.957
4.15 - 4.30	178					
4.30 - 4.45	183					
4.45 - 5.00	191					
5.00 - 5.15	178	181	**5.00 - 6.00**	712	724	0.983
5.15 - 5.30	176					
5.30 - 5.45	177					
5.45 - 6.00	181					
6.00 - 6.15	187	187	**6.00 - 700**	646	748	0.864
6.15 - 6.30	166					
6.30 - 6.45	165					
6.45 - 7.00	128					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Monday 5 July, 2010 **Counted By:** Magady Mubark
Point No: P11
Name of Street: Ramses St. between Ghmara and Ahmed Said St. (One Way to Abasia)
Direction: To Abasiah

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	761	980	**7.00 - 8.00**	3,553	3,920	0.906
7:15 - 7:30	877					
7:30 - 7:45	935					
7:45 - 8:00	980					
8:00 - 8:15	1,075	1,130	**8.00 - 9.00**	4,396	4,520	0.973
8:15 - 8:30	1,095					
8:30 - 8:45	1,096					
8:45 - 9:00	1,130					
9:00 - 9:15	1,250	1,250	**9.00 - 10.00**	4,585	5,000	0.917
9:15 - 9:30	1,080					
9:30 - 9:45	1,155					
9:45 - 10;00	1,100					
10:00 - 10:15	1,120	1,135	**10.00 - 11.00**	4,360	4,540	0.960
10.15 - 10.30	1,110					
10.30 - 10.45	995					
10.45 - 11.00	1,135					
3.00 - 3.15	1,260	1,260	**3.00 - 4.00**	4,615	5,040	0.916
3.15 - 3.30	1,160					
3.30 - 3.45	1,100					
3.45 - 4.00	1,095					
4.00 - 4.15	1,230	1,230	**4.00 - 5.00**	4,350	4,920	0.884
4.15 - 4.30	1,070					
4.30 - 4.45	1,100					
4.45 - 5.00	950					
5.00 - 5.15	1,030	1,240	**5.00 - 6.00**	4,390	4,960	0.885
5.15 - 5.30	1,240					
5.30 - 5.45	1,000					
5.45 - 6.00	1,120					
6.00 - 6.15	1,100	1,130	**6.00 - 700**	4,435	4,520	0.981
6.15 - 6.30	1,130					
6.30 - 6.45	1,125					
6.45 - 7.00	1,080					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Monday 5 July, 2010 **Counted By:** Mohamed Al Imam
Point No: P12
Name of Street: Lotifi Al Said St. between Abasia and Ghamrah (One Way to Ramses Square)
Direction: To Ramses Square

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	598	1,049	**7.00 - 8.00**	3,544	4,196	0.845
7:15 - 7:30	900					
7:30 - 7:45	997					
7:45 - 8:00	1,049					
8:00 - 8:15	1,249	1,289	**8.00 - 9.00**	4,604	5,156	0.893
8:15 - 8:30	1,289					
8:30 - 8:45	1,033					
8:45 - 9:00	1,033					
9:00 - 9:15	882	1,035	**9.00 - 10.00**	3,593	4,140	0.868
9:15 - 9:30	1,035					
9:30 - 9:45	872					
9:45 - 10;00	804					
10:00 - 10:15	1,205	1,348	**10.00 - 11.00**	4,631	5,392	0.859
10.15 - 10.30	1,084					
10.30 - 10.45	994					
10.45 - 11.00	1,348					
3.00 - 3.15	1,329	1,329	**3.00 - 4.00**	4,419	5,316	0.831
3.15 - 3.30	946					
3.30 - 3.45	1,197					
3.45 - 4.00	947					
4.00 - 4.15	804	1,183	**4.00 - 5.00**	3,926	4,732	0.830
4.15 - 4.30	1,061					
4.30 - 4.45	1,183					
4.45 - 5.00	878					
5.00 - 5.15	1,020	1,082	**5.00 - 6.00**	3,946	4,328	0.912
5.15 - 5.30	825					
5.30 - 5.45	1,082					
5.45 - 6.00	1,019					
6.00 - 6.15	1,040	1,143	**6.00 - 700**	4,151	4,572	0.908
6.15 - 6.30	1,059					
6.30 - 6.45	1,143					
6.45 - 7.00	909					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Tuesday 6 July, 2010 **Counted By:** Mohasn El Imam
Point No: P14
Name of Street: Cornish El-Nil /Between 15th May & El-Sahel Bridge
Direction: To Shobra

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	406	449	**7.00 - 8.00**	1,699	1,796	0.946
7:15 - 7:30	425					
7:30 - 7:45	419					
7:45 - 8:00	449					
8:00 - 8:15	619	619	**8.00 - 9.00**	2,389	2,476	0.965
8:15 - 8:30	599					
8:30 - 8:45	565					
8:45 - 9:00	606					
9:00 - 9:15	717	853	**9.00 - 10.00**	3,034	3,412	0.889
9:15 - 9:30	853					
9:30 - 9:45	818					
9:45 - 10;00	646					
10:00 - 10:15	636	863	**10.00 - 11.00**	3,019	3,452	0.875
10.15 - 10.30	743					
10.30 - 10.45	777					
10.45 - 11.00	863					
3.00 - 3.15	703	809	**3.00 - 4.00**	2,921	3,236	0.903
3.15 - 3.30	699					
3.30 - 3.45	710					
3.45 - 4.00	809					
4.00 - 4.15	721	880	**4.00 - 5.00**	2,934	3,520	0.834
4.15 - 4.30	670					
4.30 - 4.45	880					
4.45 - 5.00	663					
5.00 - 5.15	862	954	**5.00 - 6.00**	3,553	3,816	0.931
5.15 - 5.30	815					
5.30 - 5.45	954					
5.45 - 6.00	922					
6.00 - 6.15	905	1,333	**6.00 - 700**	4,431	5,332	0.831
6.15 - 6.30	1,333					
6.30 - 6.45	1,027					
6.45 - 7.00	1,166					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Tuesday 6 July, 2010 **Counted By:** Mohamed El Imam
Point No: P14
Name of Street: Cornish El-Nil /Between 15th May & El-Sahel Bridge
Direction: To Al Tahrir

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	906	906	**7.00 - 8.00**	3,346	3,624	0.923
7:15 - 7:30	816					
7:30 - 7:45	890					
7:45 - 8:00	734					
8:00 - 8:15	662	1,347	**8.00 - 9.00**	4,289	5,388	0.796
8:15 - 8:30	1,113					
8:30 - 8:45	1,347					
8:45 - 9:00	1,167					
9:00 - 9:15	1,205	1,205	**9.00 - 10.00**	4,473	4,820	0.928
9:15 - 9:30	1,033					
9:30 - 9:45	1,031					
9:45 - 10;00	1,204					
10:00 - 10:15	1,066	1,066	**10.00 - 11.00**	3,956	4,264	0.928
10.15 - 10.30	1,018					
10.30 - 10.45	969					
10.45 - 11.00	903					
3.00 - 3.15	705	825	**3.00 - 4.00**	2,881	3,300	0.873
3.15 - 3.30	647					
3.30 - 3.45	825					
3.45 - 4.00	704					
4.00 - 4.15	698	754	**4.00 - 5.00**	2,849	3,016	0.945
4.15 - 4.30	774					
4.30 - 4.45	754					
4.45 - 5.00	623					
5.00 - 5.15	745	899	**5.00 - 6.00**	3,158	3,596	0.878
5.15 - 5.30	684					
5.30 - 5.45	830					
5.45 - 6.00	899					
6.00 - 6.15	970	1,069	**6.00 - 700**	4,106	4,276	0.960
6.15 - 6.30	1,004					
6.30 - 6.45	1,063					
6.45 - 7.00	1,069					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Tuesday 6 July, 2010 **Counted By:** Ramadan Ghanam
Point No: P15
Name of Street: Gamal Abd El-Naser (El-Nile St.)/Kornish al Agouza
Direction: To Giza

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	730	1,348	**7.00 - 8.00**	3,721	5,392	0.690
7:15 - 7:30	767					
7:30 - 7:45	876					
7:45 - 8:00	1,348					
8:00 - 8:15	1,433	1,455	**8.00 - 9.00**	5,399	5,820	0.928
8:15 - 8:30	1,436					
8:30 - 8:45	1,075					
8:45 - 9:00	1,455					
9:00 - 9:15	795	1,210	**9.00 - 10.00**	3,390	4,840	0.700
9:15 - 9:30	785					
9:30 - 9:45	600					
9:45 - 10;00	1,210					
10:00 - 10:15	980	1,050	**10.00 - 11.00**	3,720	4,200	0.886
10.15 - 10.30	875					
10.30 - 10.45	1,050					
10.45 - 11.00	815					
3.00 - 3.15	805	1,110	**3.00 - 4.00**	3,945	4,440	0.889
3.15 - 3.30	970					
3.30 - 3.45	1,060					
3.45 - 4.00	1,110					
4.00 - 4.15	1,055	1,055	**4.00 - 5.00**	3,260	4,220	0.773
4.15 - 4.30	960					
4.30 - 4.45	535					
4.45 - 5.00	710					
5.00 - 5.15	810	825	**5.00 - 6.00**	3,140	3,300	0.952
5.15 - 5.30	800					
5.30 - 5.45	705					
5.45 - 6.00	825					
6.00 - 6.15	885	1,030	**6.00 - 700**	3,705	4,120	0.899
6.15 - 6.30	1,030					
6.30 - 6.45	880					
6.45 - 7.00	910					

Survey Summary Sheet for Non-Classified Vehicle Counts

Date: Tuesday 6 July, 2010 **Counted By:** Magdi Mobark
Point No: P15
Name of Street: Gamal Abd El-Naser (El-Nile St.)/Kornish al Agouza
Direction: To Imbaba

Time Per 15 Min	Volume per 15 min	Highest 15 Min	Time Per Hour	Volume per Hour	Flow Rate per Hour	PHF
7:00 - 7.15	425	690	**7.00 - 8.00**	2,150	2,760	0.779
7:15 - 7:30	445					
7:30 - 7:45	590					
7:45 - 8:00	690					
8:00 - 8:15	730	870	**8.00 - 9.00**	3,220	3,480	0.925
8:15 - 8:30	750					
8:30 - 8:45	870					
8:45 - 9:00	870					
9:00 - 9:15	920	920	**9.00 - 10.00**	3,390	3,680	0.921
9:15 - 9:30	910					
9:30 - 9:45	660					
9:45 - 10;00	900					
10:00 - 10:15	790	830	**10.00 - 11.00**	3,240	3,320	0.976
10.15 - 10.30	810					
10.30 - 10.45	810					
10.45 - 11.00	830					
3.00 - 3.15	910	1,355	**3.00 - 4.00**	4,506	5,420	0.831
3.15 - 3.30	1,040					
3.30 - 3.45	1,355					
3.45 - 4.00	1,201					
4.00 - 4.15	1,200	1,200	**4.00 - 5.00**	4,275	4,800	0.891
4.15 - 4.30	1,035					
4.30 - 4.45	920					
4.45 - 5.00	1,120					
5.00 - 5.15	1,090	1,110	**5.00 - 6.00**	4,250	4,440	0.957
5.15 - 5.30	1,060					
5.30 - 5.45	1,110					
5.45 - 6.00	990					
6.00 - 6.15	940	1,075	**6.00 - 700**	3,735	4,300	0.869
6.15 - 6.30	830					
6.30 - 6.45	1,075					
6.45 - 7.00	890					

Annex 7: Classified Vehicle Counts

[separate pdf file]

ANNEX 7

Classified Vehicle Counts

Survey Summary Sheet for Classified Vehicle Counts

Date: Tuesday 6 July 2010
Location No: P3-1
Road Name: Suez Desert Road / Between KM 4.5 and Ring Road
Direction: To Cairo

Time From - To	Private Car	Taxi	Microbus and Minibus	Big Bus	Small Truck	Heavy Truck	Total
7:00 - 7:15	285	2	26	10	12	11	346
7:15 - 7:30	518	1	60	9	38	34	660
7:30 - 7:45	701	3	41	6	36	26	813
7:45 - 8:00	626	7	65	12	37	26	773
7:00 - 8:00	2,130	13	192	37	123	97	2,592
8:00 - 8:15	385	6	25	15	51	16	498
8:15 - 8:30	598	11	50	13	53	24	749
8:30 - 8:45	591	4	118	5	139	22	879
8:45 - 9:00	855	9	137	6	115	20	1,142
8:00 - 9:00	2,429	30	330	39	358	82	3,268
9:00 - 9:15	848	15	109	4	85	20	1,081
9:15 - 9:30	566	20	111	6	80	24	807
9:30 - 9:45	693	21	106	5	108	25	958
9:45 - 10;00	545	23	101	6	91	23	789
9:00 - 10:00	2,652	79	427	21	364	92	3,635

Survey Summary Sheet for Classified Vehicle Counts, P3-1 *(continued)*

10:00 - 10:15	783	28	48	2	81	33	975
10:15 - 10:30	244	20	66	4	101	34	469
10:30 - 10:45	270	30	113	1	151	43	608
10:45 - 11:00	378	28	93	3	128	28	658
10:00 - 11:00	***1,675***	***106***	***320***	***10***	***461***	***138***	***2,710***
3:00 - 3:15	810	20	68	9	130	20	1,057
3:15 - 3:30	774	28	58	13	112	34	1,019
3;30-3:45	719	34	75	5	156	34	1,023
3:45-4:00	763	16	80	10	106	31	1,006
3:00 - 4:00	***3,066***	***98***	***281***	***37***	***504***	***119***	***4,105***
4:00-4:15	757	25	105	7	125	37	1,056
4:15-4:30	760	27	75	9	132	23	1,026
4:30-4:45	766	33	130	11	128	31	1,099
4:45-5:00	654	18	111	24	94	29	930
4:00 - 5:00	***2,937***	***103***	***421***	***51***	***479***	***120***	***4,111***
5:00-5:15	674	23	151	12	116	28	1,004
5:15-5:30	470	20	113	7	104	31	745
5:30-5:45	675	32	148	10	100	36	1,001
5:45-6:00	594	19	187	13	137	27	977
5:00 - 6:00	***2,413***	***94***	***599***	***42***	***457***	***122***	***3,727***
6:00-6:15	851	29	176	8	125	24	1,213
6:15-6;30	650	20	166	13	126	40	1,015
6:30-6;45	605	20	179	18	130	30	982
6:45-7:00	465	22	188	12	110	35	832
6:00 - 7:00	***2,571***	***91***	***709***	***51***	***491***	***129***	***4,042***

Survey Summary Sheet for Classified Vehicle Counts

Date: Tuesday 6 July 2010
Location No: P3-2
Road Name: Suez Desert Road / Between KM 4.5 and Ring Road
Direction: To Suez

Time From - To	Private Car	Taxi	Microbus and Minibus	Big Bus	Small Truck	Heavy Truck	Total
7:00 - 7:15	156	4		7		10	177
7:15 - 7:30	219	0		6		28	253
7:30 - 7:45	260	6		10		25	301
7:45 - 8:00	289	8		13		26	336
7:00 - 8:00	924	18	0	36	0	89	1,067
8:00 - 8:15	353	5	150	12	88	24	632
8:15 - 8:30	438	14	76	18	76	22	644
8:30 - 8:45	348	9	82	29	76	33	577
8:45 - 9:00	352	10	83	8	63	20	536
8:00 - 9:00	1,491	38	391	67	303	99	2,389
9:00 - 9:15	351	8	59	8	66	17	509
9:15 - 9:30	384	16	46	7	66	22	541
9:30 - 9:45	400	17	44	6	60	27	554
9:45 - 10;00	375	11	46	9	65	28	534
9:00 - 10:00	1,510	52	195	30	257	94	2,138

Survey Summary Sheet for Classified Vehicle Counts, P3-2 *(continued)*

10:00 - 10:15	340	20	40	3	86	18	507
10:15 - 10:30	374	15	28	6	75	21	519
10:30 - 10:45	321	17	29	4	73	32	476
10:45 - 11:00	309	19	26	3	76	29	462
10:00 - 11:00	***1,344***	***71***	***123***	***16***	***310***	***100***	***1,964***
3:00 - 3:15	340	10	32	6	59	35	482
3:15 - 3:30	378	13	52	4	62	34	543
3;30-3:45	357	17	47	9	64	35	529
3:45-4:00	332	28	35	14	60	42	511
3:00 - 4:00	***1,407***	***68***	***166***	***33***	***245***	***146***	***2,065***
4:00-4:15	424	12	37	6	55	25	559
4:15-4:30	374	10	36	8	57	17	502
4:30-4:45	391	14	38	4	50	23	520
4:45-5:00	362	23	26	8	57	27	503
4:00 - 5:00	***1,551***	***59***	***137***	***26***	***219***	***92***	***2,084***
5:00-5:15	339	13	30	7	58	21	468
5:15-5:30	329	11	26	4	32	19	421
5:30-5:45	448	18	29	4	51	20	570
5:45-6:00	422	18	28	3	39	27	537
5:00 - 6:00	***1,538***	***60***	***113***	***18***	***180***	***87***	***1,996***
6:00-6:15	390	16	19	7	37	21	490
6:15-6;30	365	14	23	10	46	29	487
6:30-6;45	360	19	22	4	29	35	469
6:45-7:00	329	21	17	6	43	29	445
6:00 - 7:00	***1,444***	***70***	***81***	***27***	***155***	***114***	***1,891***

Survey Summary Sheet for Classified Vehicle Counts

Date: Wed. 7 July 2010
Location No: P13-1
Road Name: Salah Salem Str./Between Elfangary and Abbasey
Direction: To Abasiah

Time From - To	Private Car	Taxi	Microbus and Minibus	Big Bus	Small Truck	Heavy Truck	Total
7:00 - 7:15	390	55	66	15	15	0	541
7:15 - 7:30	693	79	63	22	17	3	877
7:30 - 7:45	819	125	88	18	15	0	1,065
7:45 - 8:00	695	117	78	22	15	3	930
7:00 - 8:00	2,597	376	295	77	62	6	3,413
8:00 - 8:15	733	169	42	14	21	1	980
8:15 - 8:30	890	143	56	13	17	0	1,119
8:30 - 8:45	874	125	43	13	16	0	1,071
8:45 - 9:00	782	190	52	11	19	2	1,056
8:00 - 9:00	3,279	627	193	51	73	3	4,226
9:00 - 9:15	695	160	51	9	15	2	932
9:15 - 9:30	745	180	59	7	25	2	1,018
9:30 - 9:45	624	120	44	12	13	2	815
9:45 - 10;00	864	202	40	13	5	1	1,125
9:00 - 10:00	2,928	662	194	41	58	7	3,890

Survey Summary Sheet for Classified Vehicle Counts, P13-1 *(continued)*

10:00 - 10:15	788	232	51	13	7	1	1,092
10:15 - 10:30	790	185	42	16	9	0	1,042
10:30 - 10:45	699	145	36	9	9	0	898
10:45 - 11:00	693	180	35	14	6	1	929
10:00 - 11:00	***2,970***	***742***	***164***	***52***	***31***	***2***	***3,961***
3:00 - 3:15	943	265	89	33	25	4	1,359
3:15 - 3:30	568	180	102	31	13	0	894
3;30-3:45	634	240	74	24	30	2	1,004
3:45-4:00	556	220	73	53	17	2	921
3:00 - 4:00	***2,701***	***905***	***338***	***141***	***85***	***8***	***4,178***
4:00-4:15	622	270	83	19	18	2	1,014
4:15-4:30	515	213	70	22	30	2	852
4:30-4:45	606	240	82	20	18	0	966
4:45-5:00	494	234	58	24	10	1	821
4:00 - 5:00	***2,237***	***957***	***293***	***85***	***76***	***5***	***3,653***
5:00-5:15	415	420	41	11	10	5	902
5:15-5:30	616	225	72	13	7	0	933
5:30-5:45	553	210	51	10	11	3	838
5:45-6:00	581	300	70	18	12	1	982
5:00 - 6:00	***2,165***	***1,155***	***234***	***52***	***40***	***9***	***3,655***
6:00-6:15	537	230	61	13	11	3	855
6:15-6;30	672	250	70	18	16	3	1,029
6:30-6;45	589	220	49	16	11	4	889
6:45-7:00	549	200	53	17	10	4	833
6:00 - 7:00	***2,347***	***900***	***233***	***64***	***48***	***14***	***3,606***

Survey Summary Sheet for Classified Vehicle Counts

Date: Wed. 7 July 2010
Location No: P13-2
Road Name: Salah Salem Str./Between Elfangary and Abbasey
Direction: To Cairo Airport

Time From - To	Private Car	Taxi	Microbus and Minibus	Big Bus	Small Truck	Heavy Truck	Total
7:00 - 7:15	359	37	60	30	13	5	504
7:15 - 7:30	450	86	98	28	27	3	692
7:30 - 7:45	430	123	82	31	20	5	691
7:45 - 8:00	395	123	104	36	27	0	685
7:00 - 8:00	1,634	369	344	125	87	13	2,572
8:00 - 8:15	443	144	69	19	16	0	691
8:15 - 8:30	520	160	47	28	21	6	782
8:30 - 8:45	615	200	34	16	18	2	885
8:45 - 9:00	580	175	31	14	14	1	815
8:00 - 9:00	2,158	679	181	77	69	9	3,173
9:00 - 9:15	600	216	21	19	14	3	873
9:15 - 9:30	500	220	18	16	19	6	779
9:30 - 9:45	715	314	33	10	26	8	1,106
9:45 - 10;00	700	281	38	15	20	18	1,072
9:00 - 10:00	2,515	1,031	110	60	79	35	3,830

Survey Summary Sheet for Classified Vehicle Counts, P13-2 *(continued)*

10:00 - 10:15	685	377	38	17	24	15	1,156
10:15 - 10:30	595	415	25	16	42	15	1,108
10:30 - 10:45	800	475	21	5	28	13	1,342
10:45 - 11:00	775	378	24	9	27	5	1,218
10:00 - 11:00	***2,855***	***1,645***	***108***	***47***	***121***	***48***	***4,824***
3:00 - 3:15	960	192	52	8	19	6	1,237
3:15 - 3:30	1,000	226	63	13	16	4	1,322
3;30-3:45	970	358	50	22	24	3	1,427
3:45-4:00	950	346	59	17	18	4	1,394
3:00 - 4:00	***3,880***	***1,122***	***224***	***60***	***77***	***17***	***5,380***
4:00-4:15	1,010	292	52	19	19	3	1,395
4:15-4:30	1,000	327	49	20	15	5	1,416
4:30-4:45	950	317	38	14	13	7	1,339
4:45-5:00	975	242	59	15	18	3	1,312
4:00 - 5:00	***3,935***	***1,178***	***198***	***68***	***65***	***18***	***5,462***
5:00-5:15	1,075	226	54	12	18	2	1,387
5:15-5:30	980	285	49	28	28	7	1,377
5:30-5:45	940	248	57	9	21	5	1,280
5:45-6:00	1,010	304	37	11	14	14	1,390
5:00 - 6:00	***4,005***	***1,063***	***197***	***60***	***81***	***28***	***5,434***
6:00-6:15	970	362	44	9	11	6	1,402
6:15-6;30	850	428	28	12	10	5	1,333
6:30-6;45	900	450	34	11	17	3	1,415
6:45-7:00	950	403	16	13	9	0	1,391
6:00 - 7:00	***3,670***	***1,643***	***122***	***45***	***47***	***14***	***5,541***

Annex 8: June 6th Workshop: List of Participants, Invitation, Objectives and Program

[separate pdf file]

ANNEX 8

June 6th Workshop: List of Participants, Invitation, Objectives and Program

List of Participants of the June 6th Workshop

Name	Position	Affiliation
Dr. Rashad Elmitiny	professor of highway and traffic engineering	Cairo University
Dr. Layla Radwan	professor of highway and traffic engineering	Cairo University
Dr. Moustafa Sabry	professor of transport and traffic engineering	Ain Shams University
Dr. Hatem Abdel-Lateef	professor of transport and traffic engineering	Ain Shams University
Dr. Ahmed Al-Hakeem	professor of transport and traffic engineering	Al-Azhar University
Eng. Khaled Al-Manhawy	Senior consultant	ACE Consulting Engineers (Moharram-Bakhoum)
Dr. Hamed Mubarak	Senior consultant	Independent
Dr. Nabil Sehsah	Senior consultant	Independent
Eng. Fifi Mohamed	Head of Road Department	Transport Directorate, Cairo Governorate
Brigadier Safwat Kamel	Head of the Research and Planning Unit	Cairo Traffic Administration, Ministry of Interior
Dr. Essam Sharaf*	professor of highway and traffic engineering	Cairo University
Dr. Hoda Talaat*	assistant professor and director of ITS program	Nile University
Eng. Hossam Badrawy*	Assistant to Dr. Essam Sharaf	
Eng. Toka Muhammad*	research assistant	Nile University
Dr. Amer Shalaby*	Associate professor	University of Toronto

* Study team member

دعــوة

الاستاذ الدكتور / ....

بعد التحية........

نتشرف بدعوتكم إلى ورشة العمل الإستشارية بعنوان "أسباب الإزدحام المروري في القاهرة الكبرى" وذلك ضمن فعاليات الدراسة الحالية تحت عنوان " دراسة الإزدحام المروري في إقليم القاهرة الكبرى" والتى تهدف إلى تقييم الوضع الحالي والتكلفة الإقتصادية لهذا الإزدحام.

وسوف تقام ورشة العمل يوم الأحد الموافق 6-6-2010 فى تمام الساعة التاسعة صباحاً ، وتجدون مرفقاً مع هذه الدعوة ملخصاً حول أهداف ومنهجية وبرنامج الورشة، بالإضافة إلى مكان إنعقادها.

وحيث أن مشاركتكم في هذه الورشة ومساهمتكم في أعمالها لها أهمية خاصة ، فإننا نأمل قبولكم لهذه الدعوة ونأمل مشاركتكم فى هذه الورشة ، وسوف يتم تاكيد الحضور مع سيادتكم تليفونياً من خلال أحد مساعدى الاستاذ الدكتور / عصام شرف بصفته الخبير الوطنى فى هذه الدراسة وايضاً المضيف لهذه الورشة فى مكتبه بالاكاديمية العربية للعلوم والتكنولوجيا والنقل البحرى بشيراتون.

وتفضلوا بقبول فائق التحية.......

Title
Signature

ورشة عمل إستشارية
لمناقشة
أسباب الإزدحام المروري في القاهرة الكبرى

6 يونيو 2010

الخلفية والأهداف :

يتبنى البنك الدولي دراسة حالية تحت عنوان " دراسة الإزدحام المروري في إقليم القاهرة الكبرى" والتى تهدف إلى تقييم الوضع الحالي والتكلفة الإقتصادية لهذا الإزدحام ، وضمن فعاليات هذا المشروع سيتم تنظيم ورشة عمل إستشارية نسعى من خلالها إلى تحديد الأسباب الرئيسية للإزدحام المرورى في إقليم القاهرة الكبرى.

برنامج الورشة

ترحيب من قبل د. عصام شرف وتعارف المشاركين	9:00 – 9:15
خلفية وأهداف ورشة العمل- د.عامر شلبي	9:15 – 9:30
الجلسة الأولى عن الأسباب التشغيلية للإزدحام المرورى؟	9:30 – 10:45
إستراحة وقهوة	10:45 – 11:15
الجلسة الثانية عن الأسباب الإستراتيجية للإزدحام المرورى؟	11:15 – 12:30

المنهجية :

سيقوم فريق عمل الدراسة من خلال ورشة العمل الإستشارية بإستطلاع آراء مجموعة من الخبراء المميزين من خلال خبرتهم العملية والأكاديمية الواسعة لوضع تصور متكامل حول العوامل التي تؤدي إلى الإزدحام المروري في القاهرة الكبرى ، حيث أن المشاركين في هذه الورشة يمثلون مجموعات من المعنيين بهذا الأمر ولاسيما الأكاديميون والإستشاريون في مجال النقل والمرور بالإضافة إلى الجهات المختصة بشئون النقل والمرور.

وستتكون ورشة العمل من جلستين ، تعالج كل منهما عنصراً منفصلاً وهما:

1. ما هي الأسباب التشغيلية للإزدحام المروري؟
2. ما هي الأسباب الإستراتيجية والطويلة الأمد للإزدحام المروري؟

وفى إطار الإجابة على السؤالين أعلاه ، ستتم إدارة ورشة العمل من خلال " تقنية المجموعة الخاصة" والتي ستتبع الخطوات التالية:

- تولد الأفكار من خلال العصف الذهني الصامت من قبل كل مشارك
- تسجيل الأفكار- تجميع كل الأفكار، وتصنيفها، وعرضها للمشاركين
- مناقشة الأفكار- مناقشة كل فكرة من قبل كل المشاركين لتوضيحها وتحديد مدى أهميتها
- التصويت على الأفكار- يقوم المشاركون بالتصويت السري على الأفكار بهدف وضعها في ترتيب معين

<u>مكان إنعقاد الورشة</u>

الاكاديمية العربية للعلوم والتكنولوجيا والنقل البحرى.
مساكن شيراتون ، نهاية شارع المشير احمد إسماعيل – متفرع من صلاح سالم
مبنى الدراسات العليا - الدور الثالث - المركز العربى لدراسات النقل.

Annex 9: Measuring Congestion, Reliability Costs and Selection of Calculation Method Direct Costs

Congestion indicators

There are two general approaches for measuring congestion; an operational approach that has had the favour of those responsible for constructing and managing road networks and an economic-based approach that has generally been used to prioritise public expenditures for transport. The former is typically concerned with observable features of roadway performance (speed, flow, density, queue length and duration), whereas the latter has typically focused on extrapolating physical measures into monetary values that can then serve to guide policy through cost-benefit analysis.

In the former context, engineers have sought to deliver *technically "optimal" roadway performance* whereas economists have attempted to determine *economically "optimal" levels of congestion*. A review of national and regional practice among Working Group countries highlighted that the former approach – measuring physical and technical system performance – seems to be the overwhelmingly dominant approach.

Indicators that refer to time, service level or delay typically incorporate some arbitrary definition of the reference travel speed (e.g. free-flow as determined by design, legal operating speeds, or an arbitrary percentage of the free flow travel speed) that make no reference to what *users* may consider an economically optimal speed. Of course these indicators can be used as inputs to generalised cost calculations to derive economically optimal traffic levels. The use of such economically optimal traffic levels was surveyed as part of this study but most respondents confirmed that physical indicators and link flow maximisation were the main features of congestion measurement used in their experience. Furthermore, it seems that relatively few jurisdictions seem to track or otherwise monitor the *variability* of traffic performance via reliability indicators.

The manner in which these indicators are actually derived can be broken down into three broad approaches; those derived from point-related measurements (vehicle count, flow), temporal/speed indicators extrapolated or derived from the former (link travel time and delay) or spatial indicators (density, queue length, congested lane kilometres, etc). There is some evidence (see box), that point-related measurements of travel time (delay, speed, travel time and Level of Service) dominate the measurement of congestion. There also seems to be mixed views on the accuracy of these indicators, alone, to deliver an accurate understanding of congestion on the roadway network. The following table inventories a broad set of congestion indicators:

Table: Congestion Indicators: Inventory

Indicator	Description	Notes
1. Speed Based Indicator		
Average Traffic Speed	Average speed of vehicle trips for network	Does not adequately capture congestion effects
Peak Hour traffic speed	Average speeds of vehicle trips during peak hours	Can serve as a benchmark for reliability measures based on actual average or median speeds
2. Temporal/Delay-based indicators		
Annual Hours Of Delay	Hours of extra travel time due to congestion	All delay-based indicators depend on a baseline value for calculating the start of "delayed" travel – when this baseline is free-flow speed, the term "delay" becomes misleading since it is not at all clear that travellers on the network would ever be able to achieve delay-free speeds at peak hours.
Annual Delay Per Capita	Hours of extra travel time divided by area population	
Annual Delay Per Road User	Annual Delay Per Road User	
Average Commute Travel Time	Average commute trip time	
Estimated Travel Time	Estimated travel time on a roadway link (used in conjunction with variable message signs)	
Congested Time	Estimate of how long congested "rush hour" conditions exist	
Delay per road kilometre	Difference between reference travel time and congested travel time per network kilometre	
Travel Time In Congestion Index	Percentage of peak-period vehicle or person travel that occurs under congested conditions	The use of the travel time index and the travel time rate also depend on the identification of a baseline value for signalling the start of congested conditions – when this value is based on free flow speeds, the same reservation as noted for other "delay"-type indicators holds
Travel Time Index	The ratio of peak period to free-flow travel times, considering both reoccurring and incident delays (e.g., traffic crashes).	
Travel time Rate	The ratio of peak period to free-flow travel times, considering only reoccurring delays (normal congestion delays).	
3. Spatial Indicators		
Congested Lane Miles/kms	The number of peak-period lane miles/kms that have congested travel	Spatial indicators also depend on threshold values. These may be based on the median/average speeds typically achieved or on free-flow speeds (see note above).
Congested Road Miles/kms	Portion of roadway miles/kms that are congested during peak periods	
Network Connectivity Index	An index that accounts for the number of nodes and interchanges within a roadway network	This is an indicator of the potential for congestion to arise, whether or not this potential is realised depends on a number of other factors

4. Service level/capacity indicator		
Roadway Level Of Service (LOS)	Intensity of congestion delays on a particular roadway or at an intersection, rated from A (uncongested) to F (extremely congested).	These indicators have had the favour of roadway managers. They typically reference the design capacity of a roadway and are typically implicitly used to maximise throughput up to the design capacity of the roadway link in question.
Roadway Saturation Index	Ration of observed flow to design capacity of roadway	
5. Reliability Indicators		
Buffer time Index	See planning time index below	These indicators try to capture how road users typically make trip decisions on congested networks – they explicitly take into account the importance to many users of making trips "on time" rather than simply making trips at a high rate of speed.
Congestion Variability Index	An index relating the variability of travel speeds on the network	
Planning time index	An index that accounts for a time buffer that allows an on-time arrival for 95% of trips on a network	
Mean vs. variance travel times	Measure of the standard deviation of travel times on a link or on the network for a given period	
Distribution of travel times: Percentile - mean	Measure of the difference between the 80th or 90th percentile of the travel time distribution and the median or 50th percentile	
6. Economic cost/efficiency indicators		
Annual Congestion Costs	Hours of extra travel time (generated by travel below reference speed) multiplied by a travel time value, plus the value of additional fuel consumption. This is a monetised congestion cost.	As noted above, the selection of free-flow speeds when trying to account for "congestion costs" is highly problematic.
Current marginal external congestion costs	The additional external costs (not borne by users) of every additional vehicle/use entering the network	
Total deadweight loss	The sum total of the overall losses (costs benefits) incurred for a given level of use/traffic	
Average deadweight loss per vehicle/km	The dead weight loss divided by the number of vehicles/km giving rise to that loss.	
7. Other indicators		
Congestion Burden	The exposure of a population to congested road conditions (accounts for availability and use of alternatives)	
Excess Fuel Consumption	Total additional fuel consumption due to congestion.	Again, determining the point of reference for "additional" fuel consumption can be problematic if based on free-flow speeds
Excess Fuel Consumption Per Capita	Additional fuel consumption divided by area population	

Source: VTPI(2005) and COMPETE, (2006).

Among the multitude of available indicators, one can discern *three broad families of primary indicators and performance measurements* that could usefully transmit a more accurate picture of congestion and its burden. These primary indicators of congestion could be used to track both system performance as well as to derive the economic impacts of congestion. These indicators relate to system performance in relation to:

1. *Travel time* (and thus the average speeds experienced on the roadway at peak hours).
2. Travel quality (and primarily to trip reliability and predictability).
3. The exposure of urban peak-hour travellers to roadway congestion (e.g. roadway users travelling on congested roads vs. all urban travellers in peak hours*)*.

Travel Time Indicators

Of this indicator "families", the first is most developed and most widespread. These measures of system performance can either only reference average speeds or can go one step further and try to relate these average speeds to some benchmark figure – typically free-flow speeds. Free flow speeds are those speeds which drivers self-select on what are commonly considered "empty" roads – e.g. roads with so few vehicles on them that vehicles do not impede each others progress.

These speeds tend to gravitate around the maximum legal speeds posted for each road type although on urban roads these speeds might be less due to stops at intersections. The use of free-flow speeds as a benchmark is understandable since it can be seen as a replicable and readily useable "objective" figure. Problems arise, however, when the difference between free flow speeds and experienced speeds are labelled "delay". Delay is the technically correct term for the difference but is often semantically misconstrued as referring to an attainable target for peak hour travel – e.g. "zero-delay". It should be noted that, most dynamic cities cannot afford to deliver free-flow speeds at peak hours, nor would they want to live with a road network that could deliver these speeds at peak hours. Discourse based on delay as measured in reference to free-flow travel times can thus be biased towards an unattainable and likely undesirable congestion management goal (e.g. zero delay). In this case, the use of an outcome neutral indicators or indices is preferable.

Another way of side-stepping the issue of involuntarily biasing congestion management policies towards the delivery of free-flow travel speeds is to select speeds other than free-flow to serve as the benchmark value. These may be the legally posted speed or some manifestation of "normal" or "expected" travel speeds on the particular type of road. Such selected benchmarks can more realistically convey the deviation from expected travel speeds but make it difficult to compare different regions. Canada provides one example of how free-flow indicators can be nuanced for policy purposes.

The average travel speed for a given road link and for a given representative period may seem to be a natural candidate for such a benchmark – but average speeds can hide the impact of extraordinary non-recurring congestion-causing events. Therefore, it may make more sense to select the *median* speed as opposed to the *mean average* speed as a reasonable proxy for use as an "expected" or "normal" travel time performance benchmark.

Travel Quality / Travel Time Variability Indicators

By travel quality, we mean principally those elements that contribute to *smooth and predictable* travel conditions. Travel-time *variability* and its converse, travel time *predictability*, are at the heart of this family of indicators. These metrics are important in order to provide system managers, roadway users and policy-makers with a realistic assessment of how well traffic and congestion management policies are delivering consistent and therefore “plan-able” travel times. Success in delivering such dependable travel conditions is important since these can greatly contribute to reduced traveller stress – even in light of relatively slow *average* travel speeds.

While travel times can vary according to departure time for different vehicles travelling at roughly the same time period on the same road (*vehicle-to-vehicle variability*), most travel-time variability indicators seek, rather, to capture the change in travel times for vehicles travelling during the same time periods on the same roads *but on different days*. While habitual roadway users are likely to make a rough heuristic determination as to how much time they should account for in order to make a reasonable percentage of their trips on time based on their past experiences, this is not true for the large minority of those who have not sufficient experience to make such judgements. Research into roadway traffic composition has underscored that up to 20-40% of roadway users during peak hours are not habitual travellers for any given road.

Congestion indicators that effectively relate the variability of travel times can allow non-habitual users to make realistic assessments of their travel time requirements (and the “time buffers” necessary to allow for in order to have a good chance of arriving on time) as well as provide more realistic assessments of habitual users’ travel and buffer time requirements.

Travel time variability can refer to the difference in travel time between *different* vehicles undertaking the *same trip with the same departure and arrival times*, the difference between the same trip undertaken at *different departure and arrival times* and/or the difference between the same trips undertaken at the same time on *different days*.
In this context, the measure of variability is related to the frequency distribution, and the standard deviation, of the same trips started at the same time, but on different days – that is the day-to-day variation in travel times. The distribution provides insight into what is hidden by average speed data – namely, if the average is composed of more uniform and predictable trips or by highly diverse and unpredictable trips.

Indicators of Exposure to Roadway Congestion

The final leg of congestion indicator families relates to how *roadway* congestion impacts *total* transport system performance. This is an underdeveloped indicator “family” and would ideally seek to provide a relative measure of how many urban travellers are affected by congestion. As noted earlier, roadway congestion is a still a temporal phenomenon and thus, ideally, policy-makers might seek to understand what percentage of travel takes place in congested conditions. For commuting travel, it seems obvious that the bulk of road travel will take place during the morning and evening peak periods. Less obvious, however, is the importance of peak period travel for other travel purposes. For instance, the United States Federal Highway Administration reports that “most motor carriers work aggressively to schedule and route their truck moves outside of peak periods and around known bottlenecks. Truck volumes typically peak during the midday, especially on urban Interstate highways, and are relatively high in the early morning and at night compared to automobile volumes". Thus, it might be surmised that truck travel is relatively less exposed than commuter traffic to congested travel conditions.

Another form of exposure to congestion relates to the number of travellers caught on congested roads versus the total number of travellers during daily peak periods. This type of indicator would seem to be potentially useful as it could guide policy interventions seeking to improve total transport system performance. Obviously, the policy importance of roadway congestion in a city where 98% of peak hour travel takes place upon the roads is different from that of a city where only 60% of peak hour travel takes place upon the road. For such an indicator to be helpful it must also seek to capture the relative quality of road vs. public transport. This necessarily would have to seek to compare travel times and travel predictability among the different modes – along with some measure of road vs. public transport accessibility to desired destinations. Much travel by public transport (non-separated tramway and bus travel) employs the same congested roads as cars and is therefore exposed to the same congestion as the latter.

While elements of such a composite indicator exist within various road and public transport administrations, operational holistic indicators of traffic congestion exposure across modes are still to be developed. This is an area where further innovation and research is required.

Commonly used performance measure(s) that reflects congestion levels on roads

In this section, a set of commonly used performance measures that reflect congestion levels on roads are briefly explained and their drawbacks are distinguished.

Roadway congestion index

This index allows for comparison across metropolitan areas by measuring the full range of system performance by focusing on the physical capacity of the roadway in terms of vehicles. The index measures congestion by focusing on daily vehicle miles traveled on both freeway and arterial roads.

Drawback(s): None

Travel rate index

This index computes the "amount of additional time that is required to make a trip because of congested conditions on the roadway." It examines how fast a trip can occur during the peak period by focusing on time rather than speed. It uses both freeway and arterial road travel rates.

Drawback(s): Measure can be difficult for public to understand

Travel time index

This index compares peak period travel and free flow travel while accounting for both recurring and incident conditions. It determines how long it takes to travel during a peak hour and uses both freeway and arterial travel rates.

Drawback(s): Requires separation of recurring and incident delay. Measure can be difficult for public to understand

Travel delay

Travel delay is the extra amount of time spent traveling because of congested conditions. The TTI study divided travel delay into two categories: recurring and incident.

Drawback(s): Requires separation of recurring and incident delay

Travel rate

Travel rate, expressed in minutes per mile, is how quickly a vehicle travels over a certain segment of roadway. It can be used for specific segments of roadway or averaged for an entire facility. Estimates of travel rate can be compared to a target value that represents unacceptable levels of congestion.

Remark: Included in many other calculations

Delay rate

The delay rate is "the rate of time loss for vehicles operating in congested conditions on a roadway segment or during a trip." This quantity can estimate system performance and compare actual and expected performance.

Remark: Included in many other calculations

Total delay

Total delay is the sum of time lost on a segment of roadway for all vehicles. This measure can show how improvements affect a transportation system, such as the effects on the entire transportation system of major improvements on one particular corridor.

Drawback(s): None.

Relative delay rate

The relative delay rate can be used to compare mobility levels on roadways or between different modes of transportation. This measure compares system operations to a standard or target. It can also be used to compare different parts of the transportation system and reflect differences in operation between transit and roadway modes.

Drawback(s): Measure may be difficult for public to understand because result is a number with no units.

Delay ratio

The delay ratio can be used to compare mobility levels on roadways or among different modes of transportation. It identifies the significance of the mobility problem in relation to actual conditions.

Drawback(s): Measure may be difficult for public to understand because result is a number with no units.

Congested travel

This measure concerns the amount and extent of congestion on roadways. Congested travel is a measure of the amount of travel that occurs during congestion in terms of vehicle-miles.

Drawback(s): Formula requires length of congested roadway segment

Congested roadway

This measure concerns the amount and extent of congestion that occurs on roadways. It describes the degree of congestion on the roadway.

Drawback(s): Formula requires length of congested roadway segment

Accessibility

Accessibility is a measure of the time to complete travel objectives at a particular location. Travel objectives are defined as trips to employment, shopping, home, or other destinations of interest. This measure is the sum of objective fulfillment opportunities where travel time is less than or equal to acceptable travel time. This measure can be used with any mode of transportation but is most often used when assessing the quality of transit services.

Drawback(s): Requires information on trip objective. Most often used with transit services.

Speed reduction index

This measure "represents the ratio of the decline in speeds from free flow conditions." It provides a way to compare the amount of congestion on different transportation facilities by using a continuous scale to differentiate between different levels of congestion. The index can be applied to entire routes, entire urban areas, or individual freeway segments for off-peak and peak conditions.

Drawback(s): Measure may be difficult for public to understand because result is a number with no units. Result is relative to free flow speed, which is difficult for motorists to comprehend.

Congestion severity index

This index is "a measure of freeway delay per million miles of travel." This measure estimates congestion using both freeway and arterial road delay and vehicle miles traveled.

Drawback(s): None

Lane-mile duration index

This index is a measure of recurring freeway congestion. This index measures congestion by summing the product of congested lane miles or kms and congestion duration for segments of roadway.

Drawback(s): Results would be poor since not all freeway segments in area collect traffic data.

Level of service (LOS)

LOS differs by facility type and is defined by characteristics such as vehicle density and volume to capacity ratio. Congested conditions often fall into a LOS F range, where demand exceeds capacity of the roadway. Volume to capacity ratios could be compared to LOS to reach conclusions about congested conditions; however, there is no distinction between different levels of congestion once congested conditions are reached.

Drawback(s): Is difficult to distinguish between levels of congestion once congested conditions are reached.

Queues

Queues or traffic back-ups best represent the public's view of congestion. Queues can be measured using aerial photography, which can often determine performance measures such as LOS and queued volume.

Drawback(s): Difficult to estimate queues using available traffic data. Can be measured by use of aerial photography but is costly and site specific.

Travel Time Reliability

In transport planning, reliability performance is generally expressed by the probability of realizing trips within a certain travel time. As travel times depend on many factors, the travel times in a given network have some randomness arising mainly from interaction between users and available network capacity as well as variations in road capacity due tom external factors.

There are numerous indicators used to express the reliability system performance. While the reliability of system performance of public transport is often expressed by the punctuality of arrivals and/ or departures at stops and stations, reliability of system performance in private transport is measured by a wide variety of temporal indicators.

Commonly used travel time reliability indictors

In this section, a range of suggested indicators are presented, taking into account some considerations regarding the situation for which they can best fit.

The Standard deviation

In situations where there is a need to look at the variability in travel times around an average value and it is expected that this variability is not much influenced by (a limited number of) extreme delays, the travel time distribution will be not very much skewed. In these cases, statistical range indicators can be considered useful. The standard deviation of travel times can be used to describe the extent of travel time dispersion. A further consideration to use the standard deviation as a reliability indicator is due to pragmatic reasons and applicability in the cost-benefit analyses.

The 95- percentile value

To overcome the eventual problem of not giving much specific attention to possible extreme, the 95-percentile value of the distribution can be used or added to the analyses; this indicator is very appropriate to focus on the width of the travel time distribution and can be very useful to analyze the development of high travel time values. However, as long as this indicator is not combined with information on average expected travel times or delays, the indicator does not directly represent reliability.

The Buffer time

The use of so-called “buffer time” related indicators is becoming more and more common. The buffer time can be explained as the extra percentage of travel time due to travel time variability on a trip that a traveler may take into account in order to have a high probability of arriving on time. Examples of buffer time related indicators are the Buffer Index and the Planning Time Index, used in the US Federal Highway Administration’s Urban Congestion Reports, aimed at monitoring traffic congestion and travel reliability on a national scale.

Buffer Index

The buffer index represents the reliability of travel rates associated with single vehicles. This measure may be beneficial to the public because it tells them how congestion will affect them as individuals.
The buffer index shows the effect of congestion on the reliability of travel rates along the roadway. The extra percentage of travel time a traveler should allow in order to be on time 95 percent of the time is represented by the buffer index as follows:

$$Buffer\ Time\ Index = \frac{TT95 - \overline{T}}{\overline{T}}$$

Where:

TT95: 95th percentile of travel time
$\overline{T}$: Average travel time

Planning Time Index
The Planning Time Index represents the extra time most travelers should add to a free flow travel time so as to be fairly confident of arriving at the destination by a certain time. The measure differs from the Buffer Index in that it includes recurring delay as well as nonrecurring delay. For example, a planning time index of 1.60 means that travelers plan for an additional 60% travel time above the free-flow travel time to ensure on time arrival most (95%) of the time.

$$Planning\ Time\ Index = \frac{TT95}{TTfreeflow}$$

To summarize, the consultant believes buffer time related indicators such as the Buffer Time Index and Planning Time Index are appropriate monitors to describe and communicate travel time reliability to planners as well as network users. Other more simple measures such as travel time percentiles, median travel times and the standard deviation of travel time may also serve as appropriate indicators, but they should be used with caution, as relevant characteristics of the travel time distributions could be easily overlooked. For instance, using the standard deviation of travel time as a utility component in route choice may results in biased outcomes.

Selection of Performance Measures for GCMA

To define a measure or measures of performance that reflect congestion levels along specific corridors, two performance measures are selected that focus on :
- travel time delay
- travel time reliability

Basically, the data needed to support these measures are available in Smart Traffic Centers (Texas Transportation Institute), therefore allowing most agencies to perform the necessary calculations to validate the measures' accuracy.

Total delay measure

Total delay was chosen as a performance measure because it relates to delay and the data needed to calculate this measure are readily available. The travel times can be derived by using speed and the length of a route. This measure will help transportation professionals determine the delay for all vehicles traveling over a segment of roadway during a specific time period and thus to assess the severity of the congestion. Total delay could also allow transportation professionals to estimate how improvements within a transportation system affect a particular corridor or the entire system.

Total delay may be useful to traffic managers because it represents delay for all vehicles. Time lost for all vehicles is more important for roads that have higher volumes because higher volumes mean that more travelers are affected by the time lost, which can mean more community money is wasted. A comparison of delay among different segments of roadway is also possible when using total delay. Total delay shows the effect of congestion in terms of the amount of lost travel time. The sum of time lost on a segment of roadway due to congestion for all vehicles is represented by total delay as follows:

Total delay (PCU-hr) = [Actual travel time (hr) – Acceptable travel time (hr)] x Traffic Volume (PCU)

The Buffer Index as the travel time reliability measure

A recent US national Cooperative Highway research Program report concludes that the Buffer Index appears to relate particularly well to the way in which travelers make their decisions (NCHRP 2008). The Buffer Index is useful in the user's assessment of how much extra time has to be allowed for uncertainty in travel conditions. It hence answers simple questions such as "how much time do I need to allow?" "When should I leave?"

In other words, the buffer index is chosen for the project as a performance measure because it relates to the reliability of an individual vehicle trip, and also is useful to both the public and transportation professionals. The travel rates used in this calculation can be derived from average speed readings and the length of a route. This measure will help transportation professionals determine the impact of congestion on one vehicle traveling on a segment of roadway during a specific time period. The buffer index could also be useful in alerting motorists of the anticipated changes in travel time on particular segments of roadway so trips could be planned accordingly.

In addition to the Buffer Time Index, the Planning Time Index represents the total travel time that should be planned when an adequate buffer time is included. In the NCHRP report both these indicators are advised as cost effective measures to monitor travel time variation and reliability.

Identification of Congested Locations

The goal of road administrators are focused on assessments and management of the road systems in urban areas in ways that *maximised* the ability of existing infrastructure to handle current and expected future traffic demand and *minimised* traffic delays and the associated personal, business and resource impacts including personal and productive time lost, fuel wasted and air quality degradation. Identification of existing and potential future congestion locations is the first step toward transport system management.

The approach typically involves:

- Measurement of traffic speeds and flows.
- Estimates of maximum achievable speeds and flows during uninterrupted traffic flow conditions (but taking into account speed limits and intersection capacity).
- Assessments of actual speeds and flows in relation to maximum achievable speeds and flows. These are often defined in terms of percent below posted speed (or below off-peak speeds at prevailing flows), roadway volume/capacity ratio, speed-flow charts and intersection levels of service.
- Identification of congested locations throughout the network based on overall Levels of Service (LOS) or another form of categorization.

Annex 10: Equations used for Direct Cost Calculation

In this section, the formulas that are used to estimate the direct economic costs of traffic congestion in the following themes are presented:

- Travel time delay
- Travel time reliability
- Excess gasoline consumption
- CO_2 emission

Travel Time Delay

In order to estimate delay from recurrent traffic congestion, determining the congestion threshold is essential. In order to determine the congestion threshold two different approaches have been applied as follows:

- Approach 1: Applying Principal Corridors Collective Assessment for corridors' speed plot
- Approach 2: Applying V/C based on traffic counts and useable road capacity

Delay Estimation Causing By Recurrent Congestion

Approach 1: Applying Principal Corridors Collective Assessment for corridors' speed plot

The consultant uses the speed indices plots to determine the corridors' level of service and thus the congestion level. The hours that the speed indices show the average speed below 0.6 is considered as congested hours.

Travel delay from recurrent traffic congestion is estimated by equations relating vehicle traffic volume per lane and traffic speed. The calculation proceeds through the following simplified steps based on the method proposed by Texas Transportation Institute (TTI Method):

1. Estimate the daily volume of vehicles per lane corresponding to congested peak hours
2. Calculate Daily Vehicle Kilometer of Travel (DVKT) for each roadway section as the average daily traffic (ADT) of a section of roadway multiplied by the length of that section of roadway. The Daily Vehicle-Kilometers of travel (DVKT) is the average daily traffic (ADT) of a section of roadway multiplied by the length (in Kilometers) of that section of roadway. This allows the daily volume of all urban facilities to be presented in terms that can be utilized in cost calculations. DVKT was estimated for the freeways and principal arterial streets located in each urbanized study area.
3. Determine average freeway speeds based on data collected from travel time and speed surveys in the region.

4. *Estimate Travel Delay:* The difference between the amount of time it takes to travel during the peak-period at the average speed and at free-flow speeds in a the segments is termed delay.
5. Calculate daily recurring vehicle-hour delay by using the following formula:

$$\frac{\text{Recurring vehicle hour delay}}{\text{Day}} = \frac{\text{Peak Period Congested DVKT}}{\text{Avg. Peak Period Speed}} - \frac{\text{Peak Period Congested DVKT}}{\text{Avg. Off Peak Period Speed}}$$

The amount of delay incurred in the peak period is the difference between the time to travel at the average speed and the travel time at the free-flow speed, multiplied by the distance traveled in the peak period.

Approach 2: Applying V/C based on traffic counts and useable road capacity

By this approach the consultant applied the following multistep method to identify congested peak hours and segments for the corridors:

1. Divide each corridor into segments based on the useable segment's capacity
2. Calculate V/C for each segment during peak hours
3. Identify congested segments when V/C >0.77.

The FHWA model used 0.77 V/C ratio as the threshold marker for traffic congestion. In fact, in 1991, the FHWA completed additional research in the area of quantifying congestion. The focus of this work was on recurring congestion on urban area freeways and the development of a congestion indicator combining both the duration and extent of congestion in a single measure (Cottrell, 1991), (Texas Transportation Institute, 1992), and (Epps et al. 1993). The only impact of congestion considered in this work was recurring congestion-induced delay expressed in terms of both its duration and physical extent by a newly developed indicator called the lane-mile duration index.

Given description above, the consultant applied the following steps to estimate the delay from recurrent congestion:

- Calculate capacity based on number of lanes, an adjustment factor for lane width, lateral clearance, the presence of trucks, and type of terrain, and a value of 2,200 vehicles per lane per hour for the basic lane capacity assuming a roadway design speed of at least 60 Km per hour (kph)
- Calculate volume-to-capacity ratio (V/C) for each hour of a typical day based on new counts
- Determine which hours of the day are to be classified as congested. A V/C ratio of 0.77 was used to indicate the onset of congested travel conditions (boundary between LOS C and LOS D).
- Calculate total annual congested vehicle Kms of travel (DVKT) based on AADT, roadway section length, and percentage of daily traffic experiencing congested conditions, which is the sum of the percentages of traffic occurring during those hours of the day with a V/C ratio greater than or equal to 0.77.
- *Estimate Travel Delay:* The difference between the amount of time it takes to travel the peak-period vehicle-Kilometers at the average speed and at free-flow speeds is termed delay.
- Calculate daily recurring vehicle-hour delay by the following formula:

$$\frac{Recurring\ vehicle\ hour\ delay}{Day} = \frac{Peak\ Period\ Congested\ DVKT}{Avg. Peak\ Period\ Speed} - \frac{Peak\ Period\ Congested\ DVKT}{Avg. Off\ Peak\ Speed}$$

Delay Estimation due to Nonrecurring Events

Another type of delay encountered by travelers is the delay that results from incidents, Security Checks, Vehicle Breakdowns, Random Minibus Stops, and finally Random Pedestrian Crossings. Incident delay is related to the frequency of crashes or vehicle breakdowns, how easily those incidents are removed from the traffic lanes and shoulders and the “normal” amount of recurring congestion. The basic procedure used to estimate incident delay in this study is to multiply the recurring delay by a ratio.
The process used to develop the delay factor ratio is a detailed examination of the freeway characteristics and volumes. In addition, a methodology developed by FHWA is used to model the effect of incidents based on the design characteristics and estimated volume patterns.

Delay from non-recurring congestion-Summary Version:
Calculate vehicle hours of delay due to incidents by the following formula:

$$Daily\ Non\ Recurring\ VHD = Daily\ Recurring\ VHD \times \alpha$$

Where:
α: Road incident delay factor

Total VHD= Daily Recurring VHD+ Daily Nonrecurring VHD

The road incident delay factor is derived from the TTI Urban Mobility Report Methodology. The process used to develop the delay factor ratio is a detailed examination of the road characteristics and volumes. The consultant uses daily traffic influencing events in the car floating survey to estimate the incident delay factor.
Incident delay occurs in different ways on streets than freeways. While there are driveways that can be used to remove incidents, the crash rate is higher and the recurring delay is lower on streets. Arterial street designs are more consistent from city to city than freeway designs. For the purpose of this study, the road incident delay factor for arterial streets is ranges between 110 to 160 percent of arterial street recurring delay depending on:

- No. of accidents;
- Security checks;
- Vehicle breakdowns;
- Random Microbus stops;
- Random pedestrian crossings

Table A10.1 outlines the road incident delay factor for diverse US states provided by the Texas Transportation Institute and stated in the TTI Urban Mobility Report Methodology.

Table A10.1: TTI incident delay factor

Urban Area	Freeway Incident Delay Ratio	Arterial Street Incident Delay Ratio	Urban Area	Freeway Incident Delay Ratio	Arterial Street Incident Delay Ratio
Very Large			Medium		
Atlanta, GA	1.2	1.1	Akron, OH	1.4	1.1
Boston, MA-NH-RI	1.6	1.1	Albany-Schenectady, NY	2.3	1.1
Chicago, IL-IN	0.8	1.1	Albuquerque, NM	1.1	1.1
Dallas-Fort Worth-Arlington, TX	1.3	1.1	Allentown-Bethlehem, PA-NJ	1.6	1.1
Detroit, MI	1.2	1.1	Bakersfield, CA	1.8	1.1
Houston, TX	0.9	1.1	Birmingham, AL	2.0	1.1
Los Angeles-LBch-Santa Ana, CA	0.7	1.1	Bridgeport-Stamford, CT-NY	1.5	1.1
Miami, FL	1.0	1.1	Colorado Springs, CO	2.2	1.1
New York-Newark, NY-NJ-CT	2.5	1.1	Dayton, OH	1.4	1.1
Philadelphia, PA-NJ-DE-MD	2.2	1.1	El Paso, TX-NM	1.7	1.1
Phoenix, AZ	0.9	1.1	Fresno, CA	2.3	1.1
San Francisco-Oakland, CA	0.9	1.1	Grand Rapids, MI	2.1	1.1
Seattle, WA	1.2	1.1	Hartford, CT	2.1	1.1
Washington, DC-VA-MD	1.0	1.1	Honolulu, HI	1.3	1.1
			Indio-Cat. City-Palm Springs, CA	2.5	1.1
Large			Lancaster-Palmdale, CA	2.5	1.1
Austin, TX	1.6	1.1	Louisville, KY-IN	1.5	1.1
Baltimore, MD	1.3	1.1	Nashville-Davidson, TN	1.7	1.1
Buffalo, NY	2.1	1.1	New Haven, CT	1.4	1.1
Charlotte, NC-SC	1.2	1.1	Oklahoma City, OK	2.0	1.1
Cincinnati, OH-KY-IN	1.3	1.1	Omaha, NE-IA	2.3	1.1
Cleveland, OH	1.5	1.1	Oxnard-Ventura, CA	1.3	1.1
Columbus, OH	1.3	1.1	Poughkeepsie-Newburgh, NY	2.5	1.1
Denver-Aurora, CO	1.2	1.1	Richmond, VA	2.2	1.1
Indianapolis, IN	1.1	1.1	Rochester, NY	2.3	1.1
Jacksonville, FL	1.5	1.1	Salt Lake City, UT	1.3	1.1
Kansas City, MO-KS	2.5	1.1	Sarasota-Bradenton, FL	2.5	1.1
Las Vegas, NV	1.1	1.1	Springfield, MA-CT	1.9	1.1
Memphis, TN-MS-AR	1.6	1.1	Toledo, OH-MI	2.1	1.1
Milwaukee, WI	1.1	1.1	Tucson, AZ	1.5	1.1
Minneapolis-St. Paul, MN	1.4	1.1	Tulsa, OK	2.1	1.1
New Orleans, LA	1.4	1.1			
Orlando, FL	1.3	1.1	Small		
Pittsburgh, PA	2.5	1.1	Anchorage, AK	2.5	1.1
Portland, OR-WA	1.4	1.1	Beaumont, TX	2.5	1.1
Providence, RI-MA	2.2	1.1	Boulder, CO	2.5	1.1
Raleigh-Durham, NC	1.6	1.1	Brownsville, TX	2.5	1.1
Riverside-San Bernardino, CA	0.9	1.1	Cape Coral, FL	2.5	1.1
Sacramento, CA	1.0	1.1	Charleston-No. Charleston, SC	2.0	1.1
San Antonio, TX	1.2	1.1	Columbia, SC	1.9	1.1
San Diego, CA	0.9	1.1	Corpus Christi, TX	2.4	1.1
San Jose, CA	1.2	1.1	Eugene, OR	2.4	1.1
St. Louis, MO-IL	1.2	1.1	Knoxville, TX	2.3	1.1
Tampa-St. Petersburg, FL	1.5	1.1	Laredo, TX	2.5	1.1
Virginia Beach, VA	2.1	1.1	Little Rock, AR	1.6	1.1
			Pensacola, FL-AL	2.5	1.1
			Salem, OR	2.5	1.1
			Spokane, WA	2.4	1.1
			Wichita, KS	2.5	1.1

Based on engineering judgment most of the corridors are allocated the value of **1.1** as the incident delay ratio.

For corridor 1 with the following nonrecurring events, the value of **1.3** is considered as the incident delay ratio.

Corridor 1 Nonrecurring events:

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

For corridor 3 with the following nonrecurring events, the value of 1.6 is considered as the incident delay ratio

Corridor 3 Nonrecurring events:

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

For corridor 4 with the following nonrecurring events, the value of 1.2 is considered as the incident delay ratio

Corridor 4 Nonrecurring events:

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

Total delay estimation:

The annual recurring and nonrecurring delay costs for passenger car users, motorcyclists, taxi users ,transit users (buses and minibuses), freight transporters, and overall road users have been estimated given recurrent and nonrecurring delays that travelers face as follows:

$$DC_{pc} = N_{pc} \times O_{pc} \times (1+\alpha) \times L \times \left(\frac{1}{V_p\,pc} - \frac{1}{V_f\,pc}\right) \times VOT_{pc}$$

$$DC_m = N_m \times O_m \times (1+\alpha) \times L \times \left(\frac{1}{V_p\,m} - \frac{1}{V_f\,m}\right) \times VOT_m$$

$$DC_{tx} = N_{tx} \times O_{tx} \times (1+\alpha) \times L \times \left(\frac{1}{V_p\,tx} - \frac{1}{V_f\,tx}\right) \times VOT_{tx}$$

$$DC_{pt} = N_{pt} \times O_{pt} \times (1+\alpha) \times L \times \left(\frac{1}{V_p\,pt} - \frac{1}{V_f\,pt}\right) \times VOT_{pt}$$

$$DC_{fr} = N_{fr} \times O_{fr} \times (1+\alpha) \times L \times \left(\frac{1}{V_p\,fr} - \frac{1}{V_f\,fr}\right) \times VOT_{fr}$$

Where:

DC: The annual recurring and nonrecurring delay cost (LE per year)
N: Number of vehicle running during peak hours per year
O: Vehicle occupancy factor
α: Road incident delay factor
L: Congested corridor length (km)
V_p: Average speed during peak hours (km/hr)
V_f: Free flow speed (km/hr)
VOT: Value of time (LE/hr)

The indices *pc, m, tx, pt,* and *fr* express passenger cars, motorcycles, taxies, public transportation, and freight transportation respectively.

A wide variety of temporal indicators (e.g. STD, COV, 95th Percentile, Buffer time index) can be used to provide a range of perspectives of the reliability issue. The consultant applies *Coefficient of Variation of Travel time o*n the routes as the travel time reliability measure. The coefficient of variation of travel times is defined as standard deviation divided by mean travel time:

$$COV_i = \frac{STD_i}{\overline{T}_i}$$

Where:

i: corridor number

STD: The standard deviation of travel time

$\overline{T}$: The mean travel time

$$STD_v = standard\ deviation\ of\ speeds$$

$$STD_T = standard\ deviation\ of\ travel\ times = \frac{L}{STD_v}$$

$$T = \frac{L}{V}$$

Economic Cost of Unreliability

In general, reliability is highly valued by travelers and commercial vehicle operators reflecting the fact that a reliable transport network is a net benefit for society and that an unreliable network represents a net cost to society. A lot of work has been carried out in the Netherlands to monetize unreliability of travel time. Based on the research's outcomes (OECD 2010) and the local conditions, the consultant assumes the following rates for monetizing travel time unreliability:

Passenger cars and motorcycle:	1.0 minute travel time variation is equivalent to 0.9 minute travel time
Public Transport including taxi:	1.0 minute travel time variation is equivalent to 1.1 minute in vehicle travel time

Thus, the annual value of unreliability for passenger car users including driver are estimated as follows:

$$VOR_i^{pc} = 0.9 \times N_{pc} \times STD_i \times VOT_{pc}$$

Where:

i: Route number

VOR: Value of unreliability imposed to passenger car users (for both tails, early and late arrivals)

N_{pc}: Annual number of passenger car users who suffer from unreliability

STD_i: The average standard deviation of travel time in route *i*

VOT_{pc}: The Value of time of passenger car users

The coefficient of variation of travel time (COV) can not be monetized directly since it is unit less. The consultant monetizes the STD of travel time instead as the proxy for the COV accordingly.

Cost of Excess Fuel Consumption

In order to estimate excess fuel consumption due to traffic congestion the following steps are applied:

- Calculate average fuel efficiency
- Calculate total excess fuel (liters) used as a result of recurring and nonrecurring delay using the following formulas:

The average fuel economy calculation is used to estimate the fuel consumption of the vehicles running in the congested condition. The average fuel economy is formulated as follows:

$$\textit{Average Fuel Economy in Congestion} = 8.8 + 0.25\,\textit{(Average peak Period Congested System Speed)}$$

It should be noted that a metric conversion has to be applied to the equation above since it is originally formulated based on non metric Units (Miles per Gallon).

<u>Adjusting the fuel efficiency formula for Cairo</u>

The formula above has been already developed and calibrated for USA between 1985-1995 . However, the consultant believes it is more or less useable for Cairo as well. By looking at the car composition in US between 1985-1995, and due the fact that GM cars were dominant, the Fuel Efficiency for American cars such as Chevrolet is derived as follows:

Brand/Model	MPG (City)	MPG (HWY)
Chevrolet Celebrity (6 cyl)	18	24
Buick Century (6 cyl)	16	23
Cadillac (6 cyl)	16	22
Dodge Lancer (4 cyl)	20	30
Jeep Cherokee (6 cyl)	15	17
Pontiac 6000 (6 cyl)	18	24
Lincoln Continental (6 cyl)	20	26
Chevrolet Blazer (6 cyl)	16	23

Chevrolet Camaro (8 cyl)	16	24

Source: www.fueleconomy.gov

Given the fleet composition in the Cairo region stated in tables A 3-9 , A3-11, it seems the following car composition and corresponding fuel economy is dominant:

Brand	Age	MPG (City)	MPG (HWY)
Isuze	< 5	18	24
Daewoo	< 5	17	25
Chevrolet	< 5	18	27
Nissan	< 10	19	25
Mercedes	< 10	19	25
Peugeot	< 20	17	22

Of course for accurate estimation, further information on Brand model, engine type, AC system availability, and so on is required.

Based on engineering judgment the consultant believes that the average fleet age at GCR would be from 10 to 12 years (Figure A10-1). Also, the average fuel consumption is estimated around 10 litres/100 km (24 MPG) in the city based on speed of 60 Km/hr which corresponds with the American estimation in 80th decade. It should be noted that the engine size of most passenger cars in the GCR is 1600 cc (Figure A10-2).

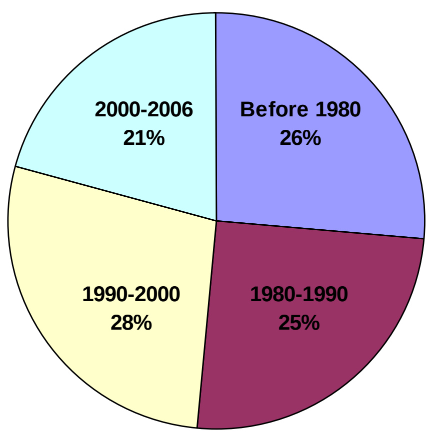


Figure A10.1Car's age distribution in Egypt

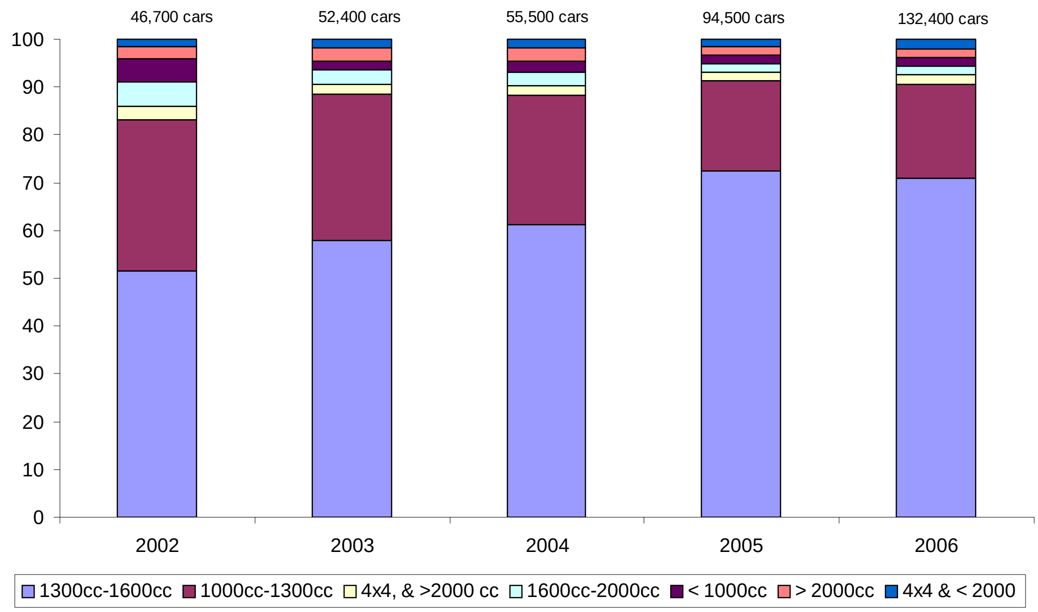


Figure A10.2Relative distribution of cars' engine size between 2002-2006 in Egypt

Source: AMIC Egypt

The fuel that is deemed "wasted due to congestion" is the difference between the amount consumed at peak speeds and free-flow speeds:

$$\begin{aligned}&\mathit{Annual\ Fuel\ Wasted\ in\ Congestion} = \mathit{Annual\ Fuel\ Consumed\ in\ Peak\ Conditions}\\ &- \mathit{Annual\ Fuel\ That\ Would\ be\ Consumed\ in\ Free\ Flow\ Condition}\end{aligned}$$

$$\mathit{Daily\ Fuel\ Wasted\ (Liter)} = \frac{\mathit{DVKT}}{\mathit{Free\ Flow\ Travel\ Speed}} \times \left(\frac{\mathit{Free\ flow\ speed}}{\mathit{Average\ fuel\ economy}} - \frac{\mathit{Peak\ period\ system\ congested\ speed}}{\mathit{Average\ fuel\ economy}}\right)$$

The formula above is applied for Gasoline cars and Diesel cars separately to derive the amount of excess gasoline consumption (EGW) and excess diesel consumption (EDW) separately.

To calculate the Excess gasoline cost, the consultant uses the following formulation:

$$EGC = EGW \times 1.8$$

Where:
EGC: Annual excess gasoline cost (LE)
EGW: Annual excess gasoline wasted (litre)

Likewise, to calculate the Excess diesel Cost, the consultant uses the following formulation:

$$EDC = EDW \times 1.0$$

Where:

EDC: Annual excess diesel cost (LE)

EDW: Annual excess diesel wasted (litre)

The total excess fuel cost is computed as follows:

EFC= EGC+EDC

Furthermore, the consultant computes the excess fuel subsidy imposed to the government due to traffic congestion:

Gasoline Subsidy:

$$EGS = EGW \times 2.2$$

Where:

EGS: Annual excess gasoline subsidy (LE)

EGW: Annual excess gasoline wasted (litre)

Diesel Subsidy:

$$EDS = EDW \times 1.1$$

Where:

EDS: Annual excess gasoline subsidy (LE)

EDW: Annual excess gasoline wasted (litre)

The total Fuel subsidy will be calculated as follows:

EFS= EGS+ EDS

Emission Cost

The consultant uses the following standard emission rates for diverse vehicular modes, to calculate the CO_2 emission due to congestion in Cairo. As shown, the standard rates below depend on only fuel type as well as the vehicle type and **not** engine type. For example, 1 liter consumed gasoline or diesel in passenger cars produces 2.40 kg CO_2.

Table A10.2: The Emission rate for diverse vehicular modes

Emission rate	CO_2
Vehicular Mode	**kg/L**
Cars (diesel and gasoline)	2,40
Motorcycle	2,42
Taxi	2,40
Bus	2,41

BRT	2,24

The annual CO_2 emission weight (Kg) is estimated as follows:

$$W_{CO_2} = GW \times 2.40 + DW \times 2.41$$

Where:

GW: Annual weight of wasted gasoline (Kg)

DW: Annual weight of wasted Diesel (Kg)

The annual CO2 emission cost (LE) is formulated as follows:

$$C_{CO_2} = W_{CO_2} \times U_{C\,CO_2}$$

Where

$U_{C\,CO_2}$: Unit cost of CO2

The consultant assumes the unit cost of CO_2 as 57 LE per ton.

Annex 11: Detailed Direct Economic Cost of Traffic Congestion

In this section a series of analyses on direct economic costs of traffic congestion are presented. It consists of delay cost, unreliability cost, fuel cost and finally emission costs for both applied approaches for the 11 corridors in Cairo. Each component is estimated for both directions of the corridors. Then, a comparison between corridors is made.

A- Delay Cost

In this section total delay costs for each corridor and a comparison between corridors are presented for both approaches 1 and 2.

Approach 1:
Figures A11.1, A11.2, A11.3, A11.4, A11.5, and A11.6 illustrate the total delay cost for passenger car users, motorcyclists, taxi users, transit riders, freight transporters, and all road users respectively

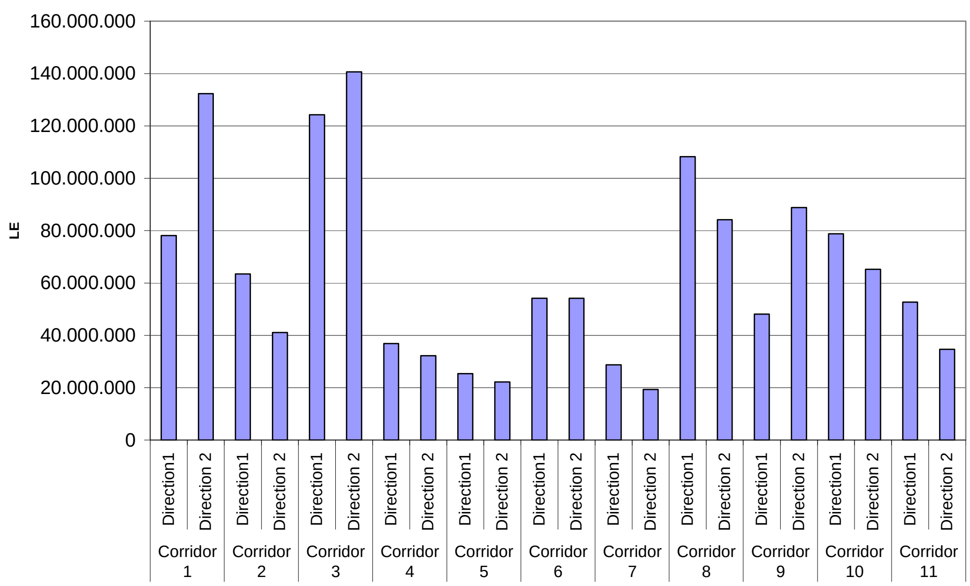


Figure A11.1 **Annual recurring and nonrecurring delay costs for passenger car users**

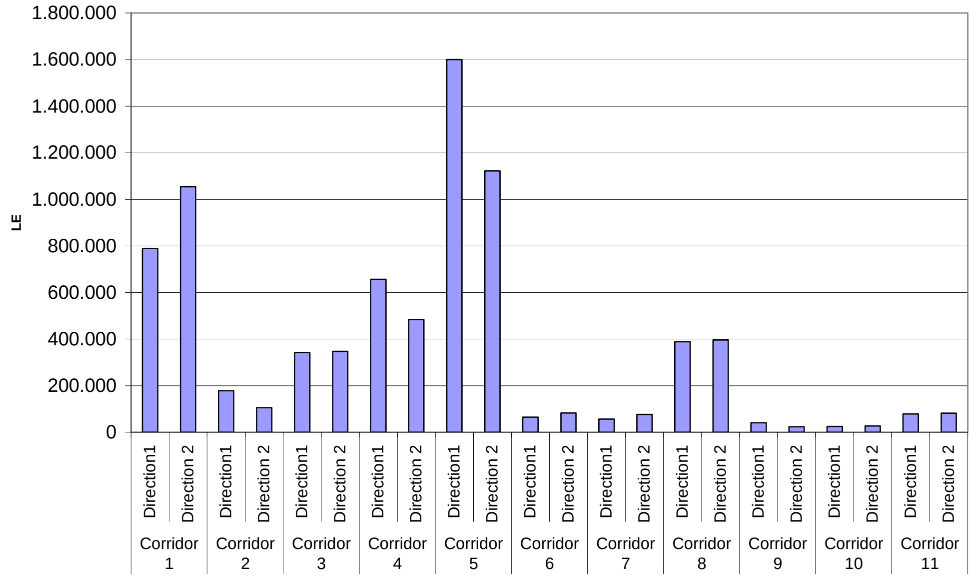


Figure A11.2 Annual recurring and nonrecurring delay costs for motorcyclists

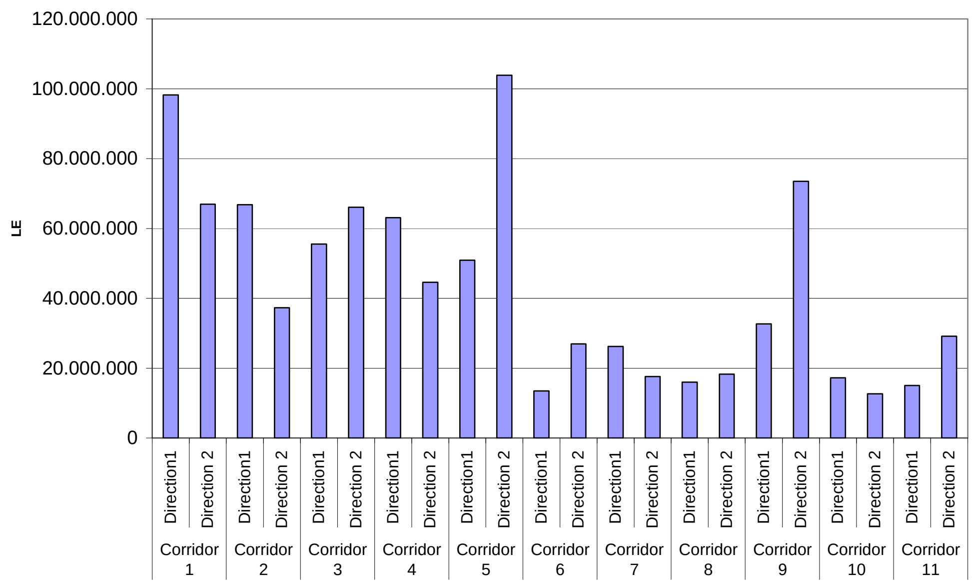


Figure A11.3 Annual recurring and nonrecurring delay costs for taxi users

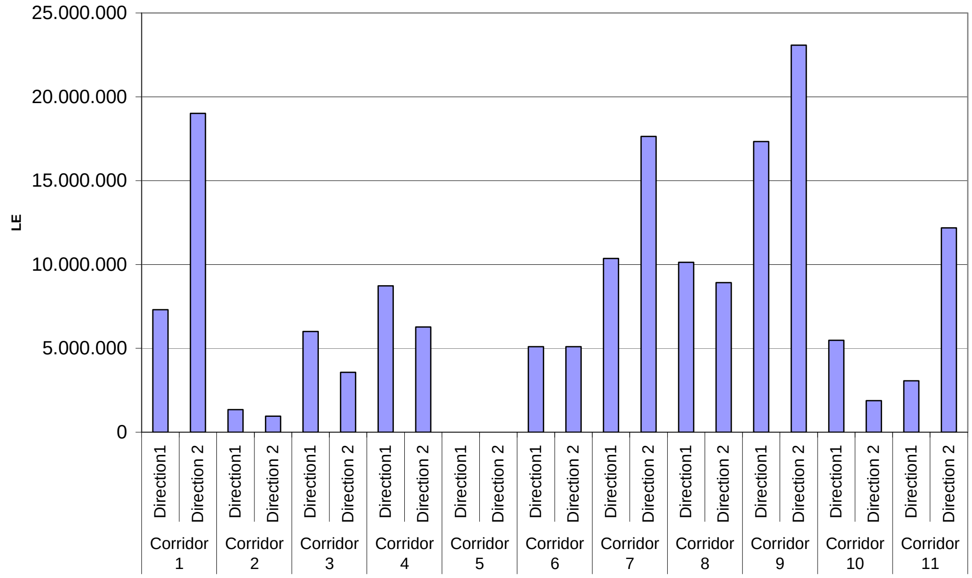


Figure A11.4 Annual recurring and nonrecurring delay costs for transit users

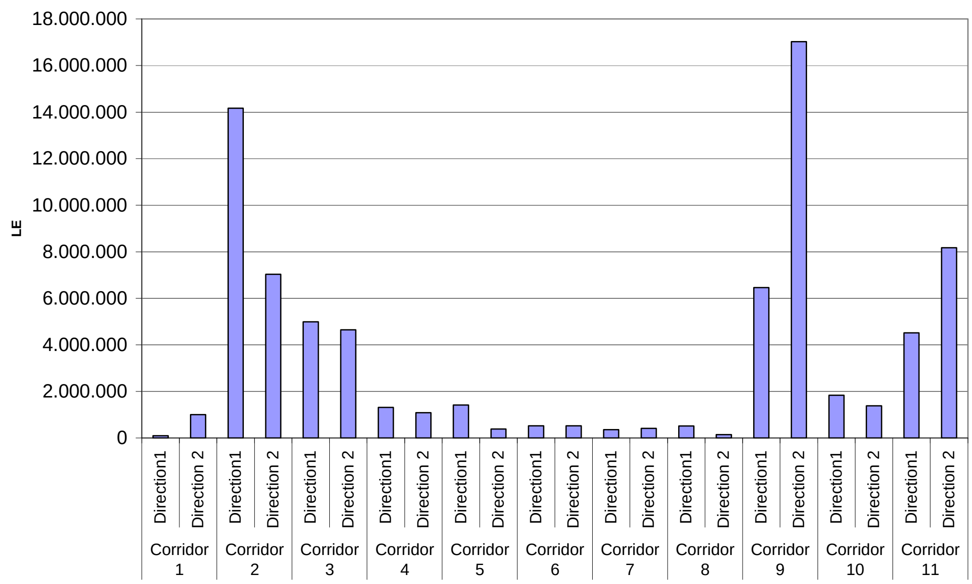


Figure A11.5 Annual recurring and nonrecurring delay costs for freight transportation

In the aggregate level figure A11.6 illustrates annual recurring and nonrecurring delay costs for all road users (passenger transport). The total delays cost is around 2.6 Billion LE per year for all road users.

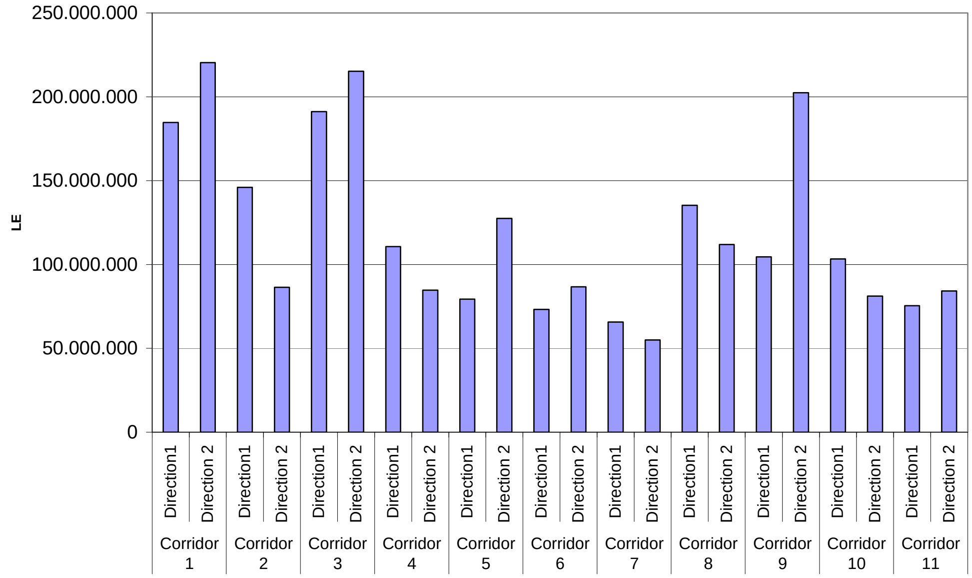


Figure A11.6 Annual recurring and nonrecurring delay costs for all road users

Approach 2:

Figures A11.7, A11.8, A11.9, A11.10, A11.11, and A11.12 illustrate the total delay cost for passenger car users, motorcyclists, taxi users, transit riders, freight transporters, and all road users respectively:

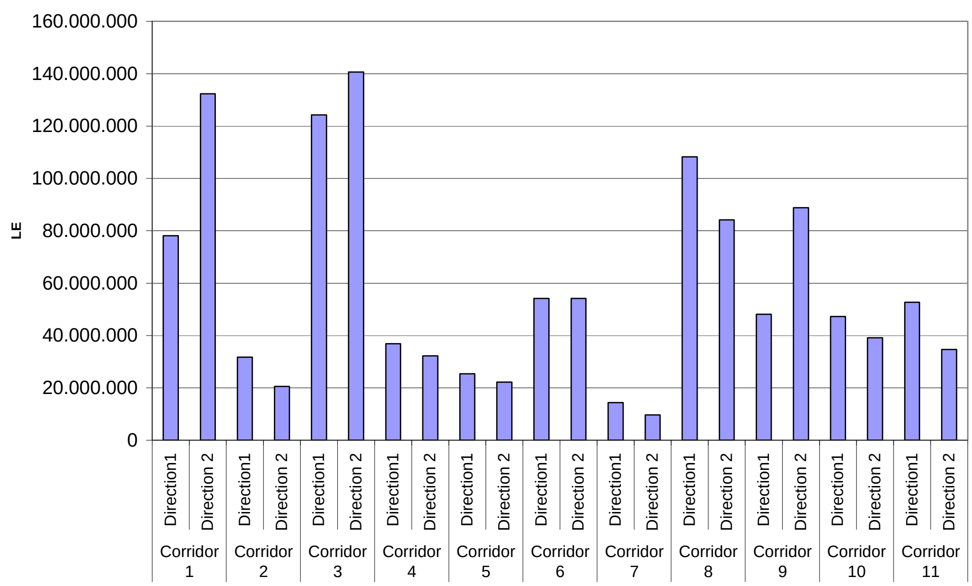


Figure A11.7 Annual recurring and nonrecurring delay costs for passenger car users

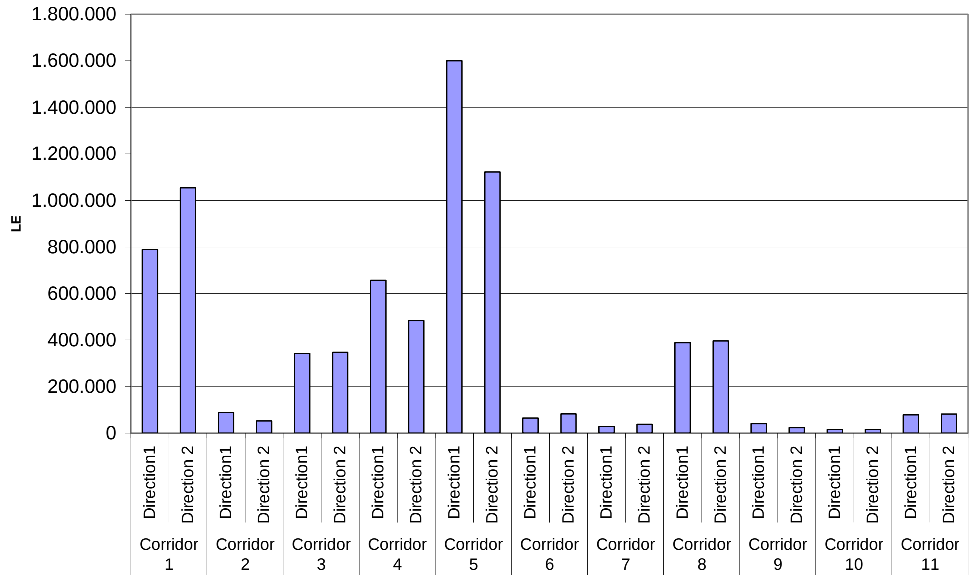


Figure A11.8 Annual recurring and nonrecurring delay costs for motorcyclists

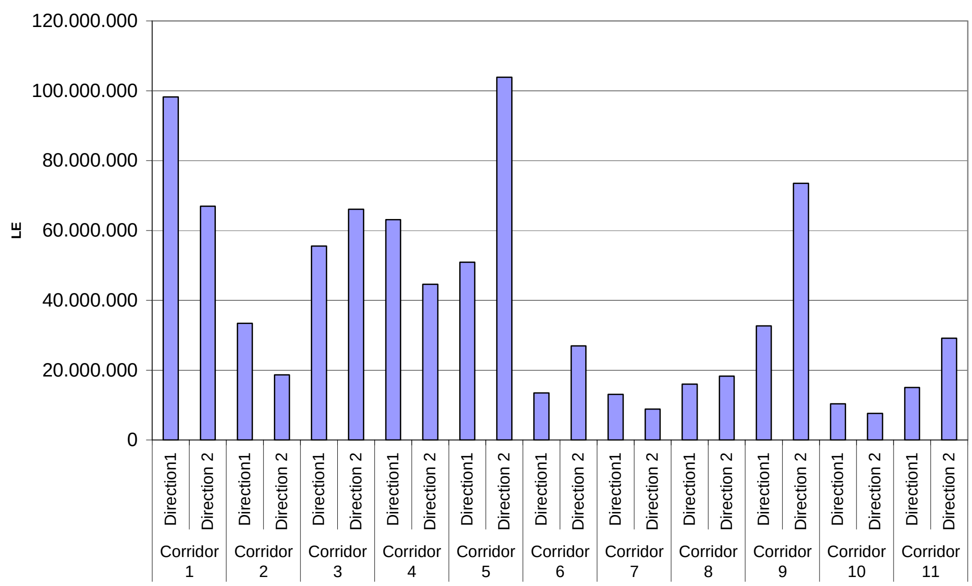


Figure A11.9 Annual recurring and nonrecurring delay costs for taxi users

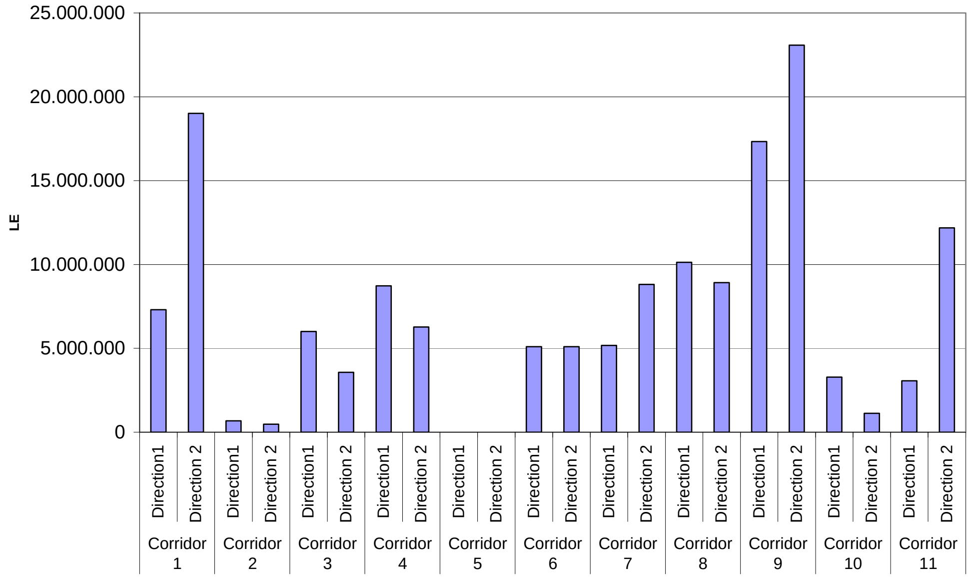


Figure A11.10 Annual recurring and nonrecurring delay costs for transit users

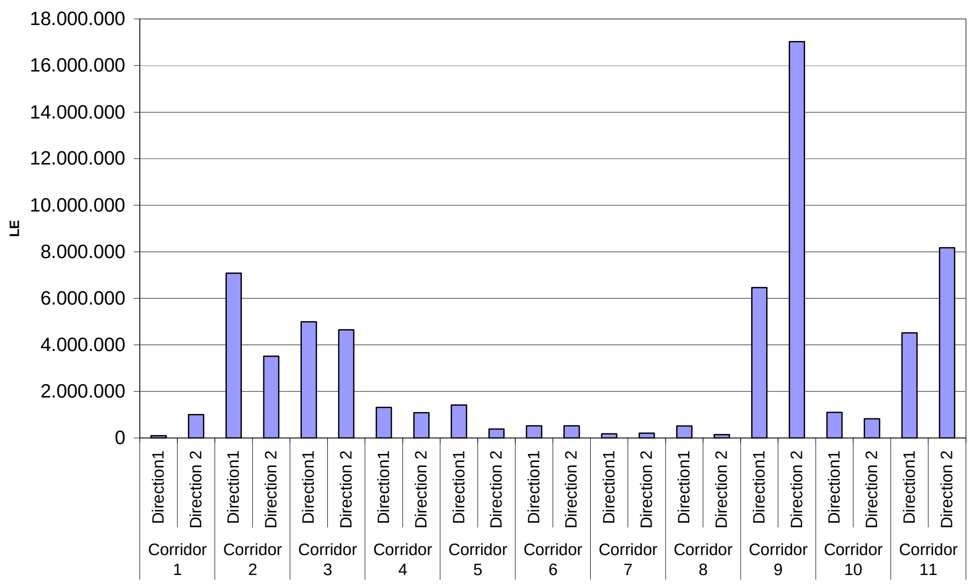


Figure A11.11 Annual recurring and nonrecurring delay costs for freight transportation

In the aggregate level figure A11.12 illustrates annual recurring and nonrecurring delay costs for all road users (passenger transport). The total delays cost for all road users is around 2.37 Billion LE per year.

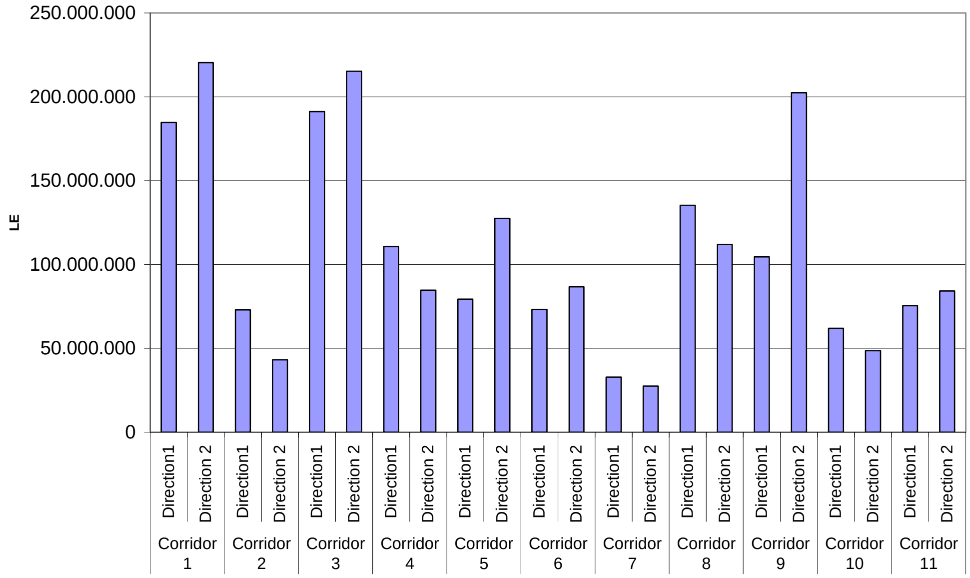


Figure A11.12 Annual recurring and nonrecurring delay costs for all road users

Results Outline

The analysis of annual recurring and nonrecurring delay costs due to traffic congestion in Cairo using 2 approaches yields the following results:

- Passenger car users suffer from the larger amount of delay due to traffic congestion in the 26th of July/15th of May Travel Corridor Particularly (Lebanon Square, Zamalek and Elesaaf) , and the Ring Road (Southern segment - at some major interchanges including the Autostrad, and Maryouteya). In the Ring Road the annual cost of delay reaches roughly 264 Million LE.
- Taxi users suffer from the larger amount of delay cost due to traffic congestion in corridors 26th of July/15th of May Travel Corridor Particularly (Lebanon Square, Zamalek and Elesaaf), Ring Road (Southern segment - at some major interchanges including the Autostrad, and Maryouteya), El Cornich- East/ El Matereya Sq. and Rod El Farag/El-Remaya (Particularly at KitKat Square, Agouza exit , El-Giza tunnel into 2 lanes heading to El-Giza Bridge). In Rod El Farag/El-Remaya corridor the annual cost of delay exceeds 155 Million LE.
- Transit users suffer from the larger amount of delay cost due to traffic congestion in 26th of July/15th of May Travel, Auto Strade/ Giza, and Cairo /Ismailia Qubba Corridors. This is due to larger number of transit demand in this corridor, and larger recurrent and nonrecurrent delays may occur.
- Freight transporters suffer from the larger amount of delay cost due to traffic congestion in the Ring Road (Both Northern and Southern), and Cairo-Ismaillia/El-Qubba,. In the ring Road Northern Segment the annual cost of delay reaches to 23.5 Million LE.

B- Unreliability Cost

In this section unreliability costs for the corridors and a comparison between them are presented.

Figures A11.13, A11.14, A11.15, A11.16, A11.17, A11.18 illustrate the total unreliability costs for passenger car users, motorcyclists, taxi users, transit riders, and all road users respectively.
It should be noted that unreliability costs for freight transportation is not included in this study due to lack of enough observation and data.

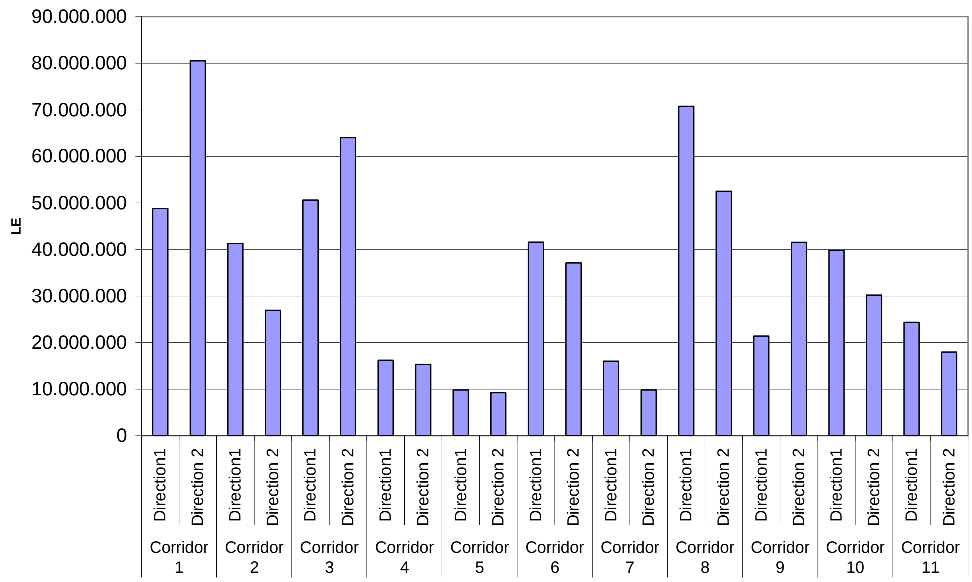


Figure A11.13 Annual unreliability associated costs for passenger car users

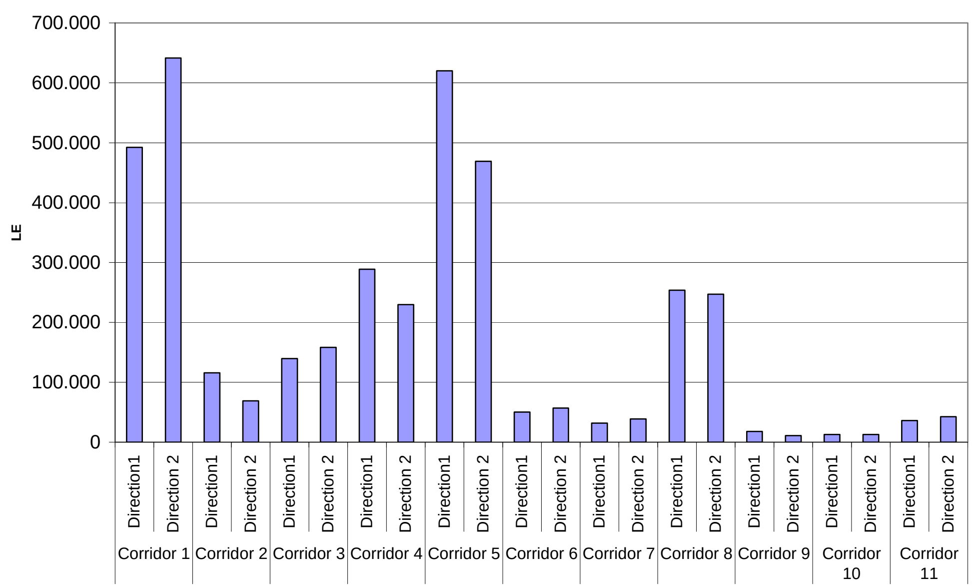


Figure A11.14 Annual unreliability associated costs for motorcyclists

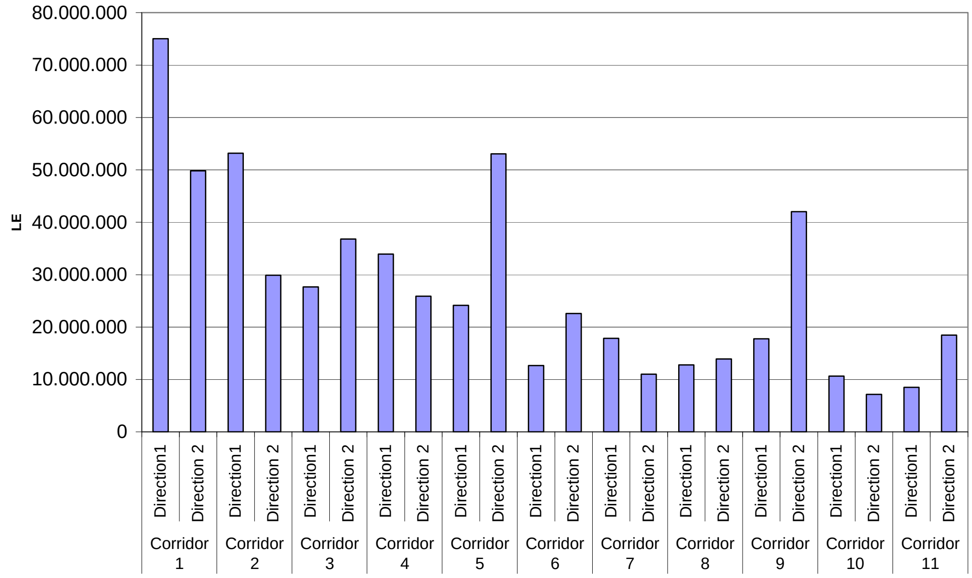


Figure A11.15 Annual unreliability associated costs for taxi and shared taxi Users

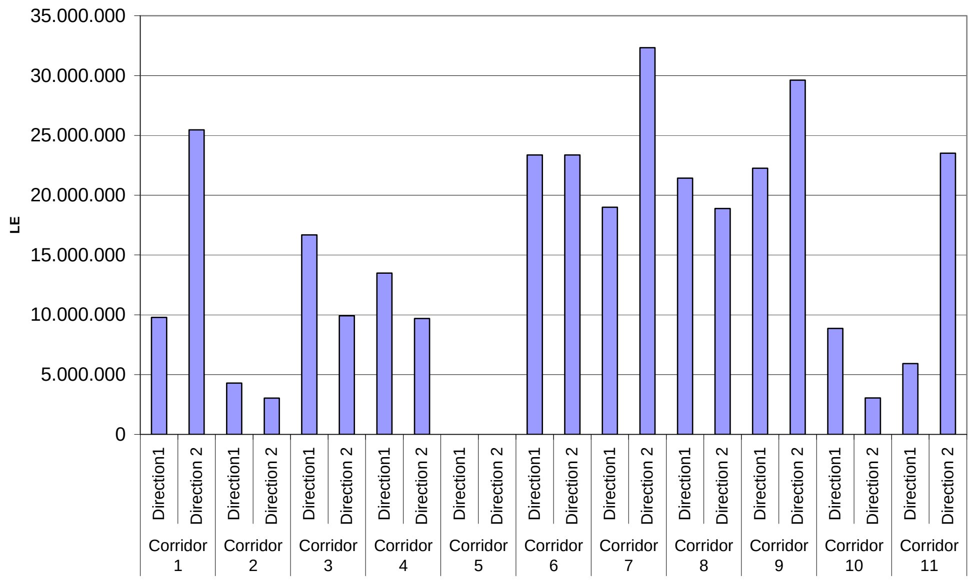


Figure A11.16 Annual unreliability associated costs for transit Users

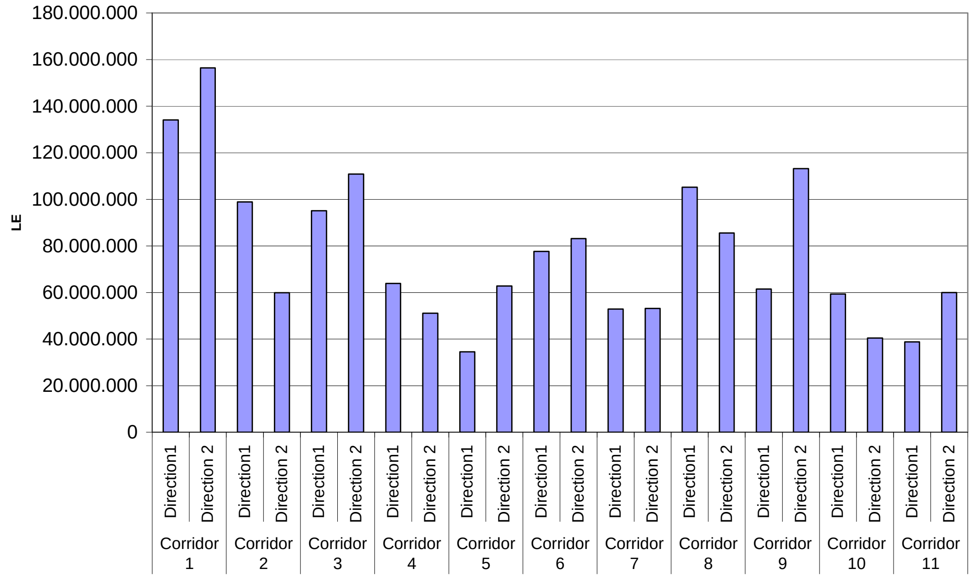


Figure A11.17 Annual unreliability associated costs for all road users (Excluding freight transporters)

Results Outline

The analysis of annual recurring and nonrecurring unreliability costs due to traffic congestion in Cairo yields the following hints:

- Passenger car users suffer from the larger unreliability costs due to traffic congestion in the 26th of July/15th of May Travel Corridor, the Ring Road (Southern segment), and the El-Orouba/6th of October Bridge. In corridor (El-Orouba/ 6th of October Bridge) the annual unreliability cost reaches to 122 Million LE.
- Taxi users suffer from the larger unreliability costs due to traffic congestion in the 26th of July/15th of May Travel Corridor, Rod El Farag/El-Remaya, and Cairo-Ismaillia/El-Qubba. In the 26th of July/15th of May Travel Corridor the annual unreliability cost reaches to 125 Million LE.
- Transit users suffer from the larger unreliability costs due to traffic congestion in the 26th of July/15th of May Travel Corridor, Cairo-Suez Desert Road/El-Qalaa, Autostrad/Giza Square, and Cairo-Ismaillia/El-Qubba. In the Cairo-Ismaillia/El-Qubba corridor the annual unreliability cost reaches approximately 51 Million LE.
- In the aggregate level, all road users suffer from the larger amount of unreliability associated costs due to traffic congestion in the 26th of July/15th of May Travel Corridor, Ring Road (Southern segment), El-Orouba/6th of October Bridge, and Cairo-Ismaillia/El-Qubba. In the 26th of July/15th of May Travel Corridor the annual cost of unreliability exceeds 290 Million LE.

C- Excess Fuel consumption and Cost

In this section excess fuel consumption and cost due to traffic congestion in the Greater Cairo for each corridor and a comparison between corridors are presented.

Approach 1:

Figures A11.18 and A11.19 illustrate the excess gasoline and diesel consumption for 11 corridors using approach 1:

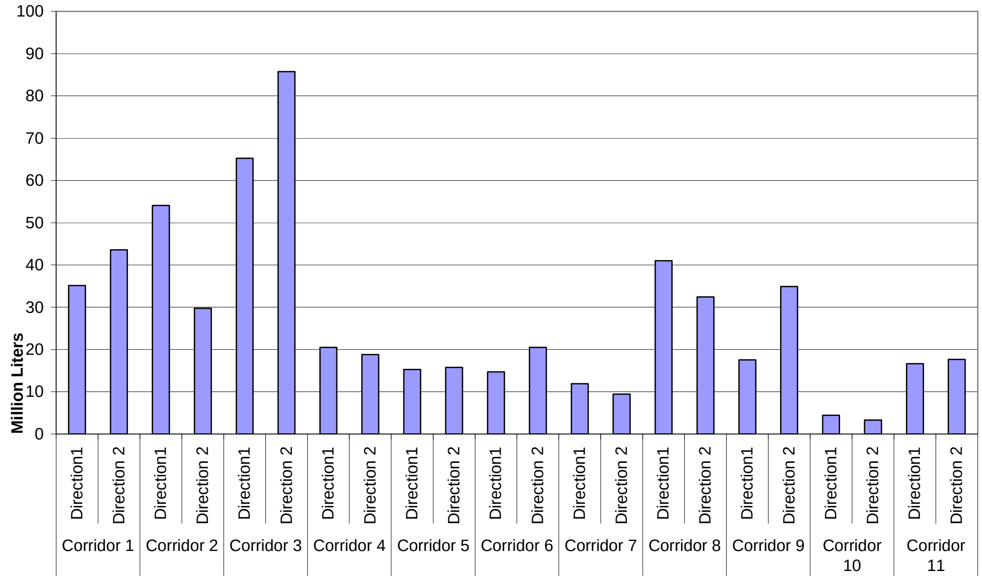


Figure A11.18 Annual excess gasoline consumption in the Greater Cairo (1st approach)

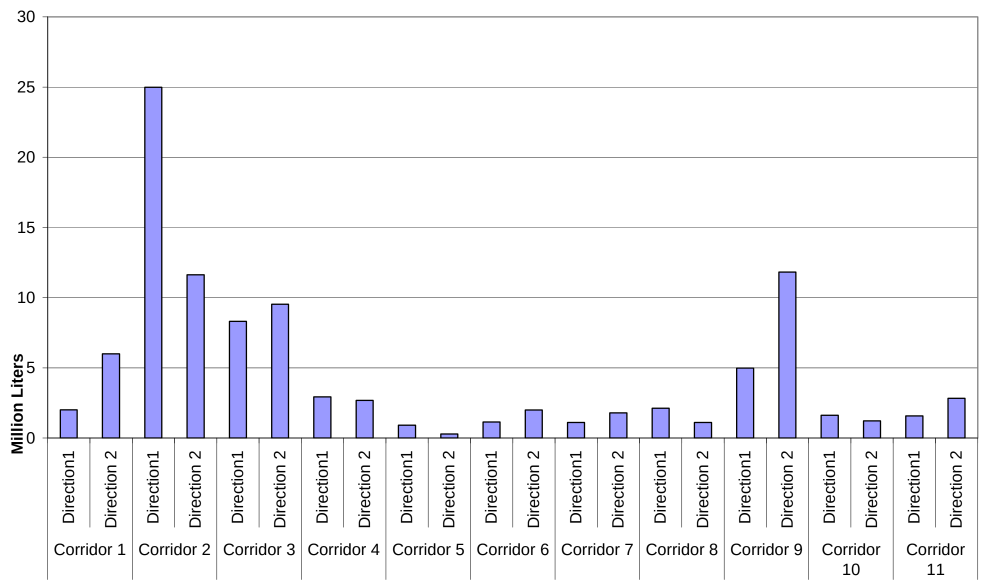


Figure A11.19 Annual excess Diesel consumption in the Greater Cairo (1st approach)

Summarizing the above results, traffic congestion wastes 608 Million Liters gasoline and 102 Million Liters Diesel annually in the 11 corridors in Cairo.

Given excess fuel consumption, figures A11.20 and A11.21 illustrate the annual excess gasoline and diesel cost in Cairo respectively.

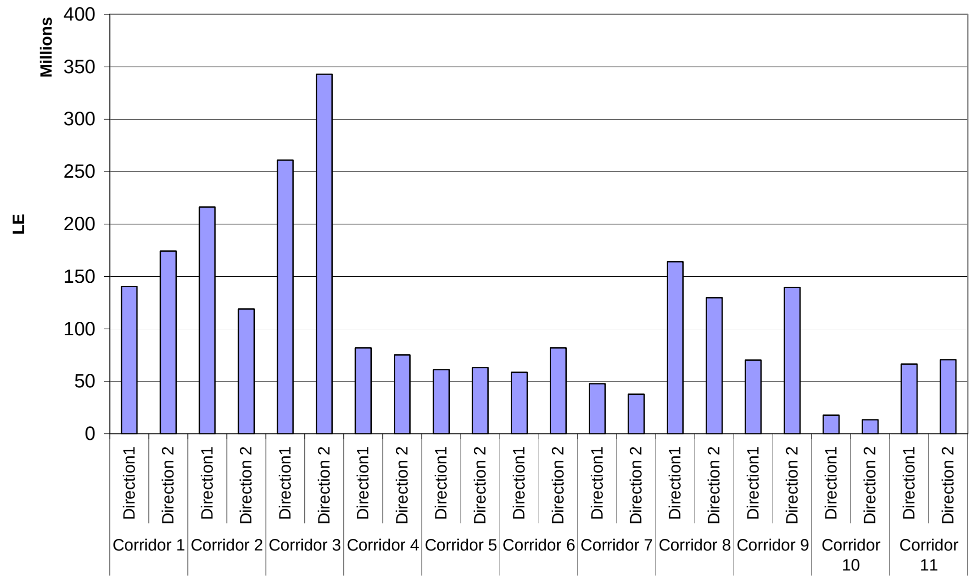


Figure A11.20 Annual excess gasoline costs as result of traffic congestion (1 st approach)

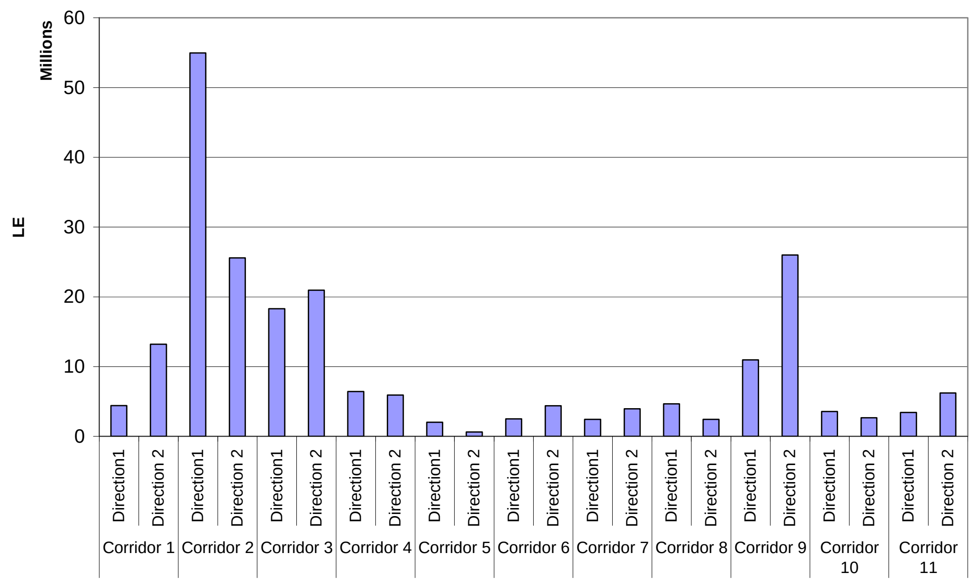


Figure A11.21 Annual excess diesel costs as result of traffic congestion (1 st approach)

Figure A11.22 illustrates total excess fuel costs per year as result of traffic congestion in Cairo for each corridor separately.

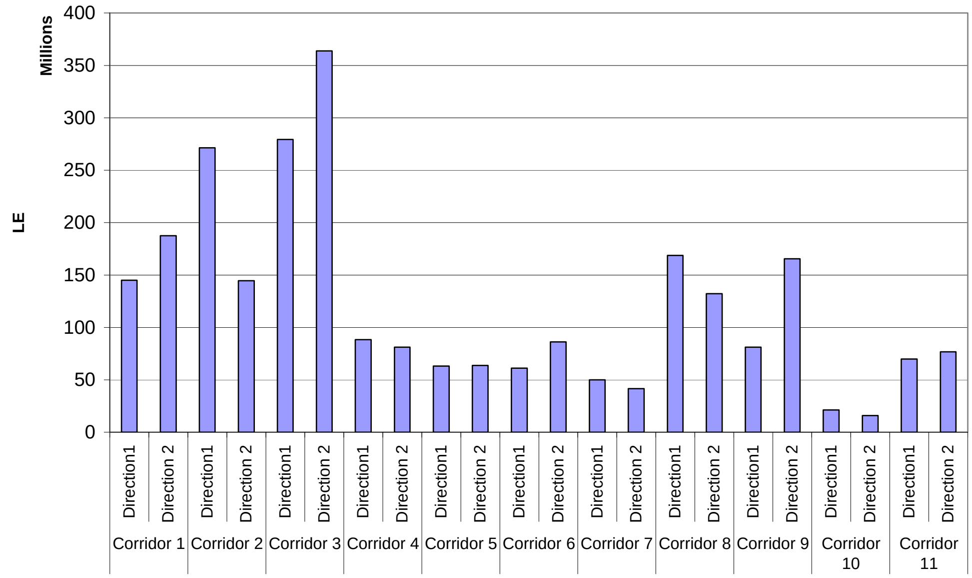


Figure A11.22 **Annual total excess fuel costs as result of traffic congestion**

Summarizing the above results, traffic congestion wastes 2.68 Billion LE annually fuel in the 11 corridors in Cairo (2.46 Billion LE gasoline, 0.22 Billion Diesel).

Approach 2:

Figures A11.23 and A11.24 illustrate the excess gasoline and diesel consumption for the 11 corridors using approach 2:

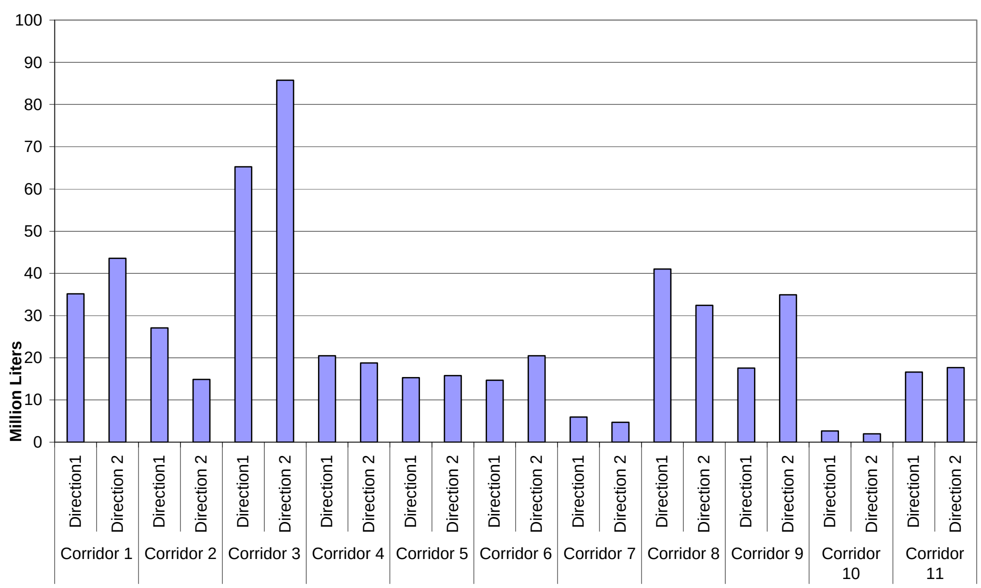


Figure A11.23 **Annual excess gasoline consumption in the Greater Cairo (2nd approach)**

Summarizing the above results, traffic congestion wastes 552 Million Liters gasoline and 81 Million Liters Diesel annually in the 11 corridors in Cairo.

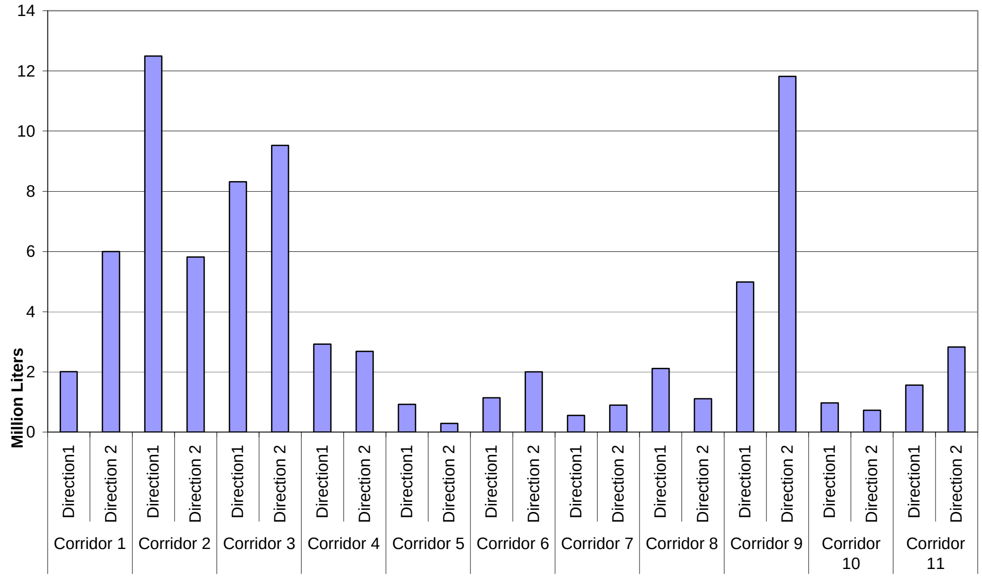


Figure A11.24 Annual excess Diesel consumption in the Greater Cairo (2nd approach)

Given excess fuel consumption, figures A11.25 and A11.26 illustrate the annual excess gasoline and diesel cost in Cairo respectively.

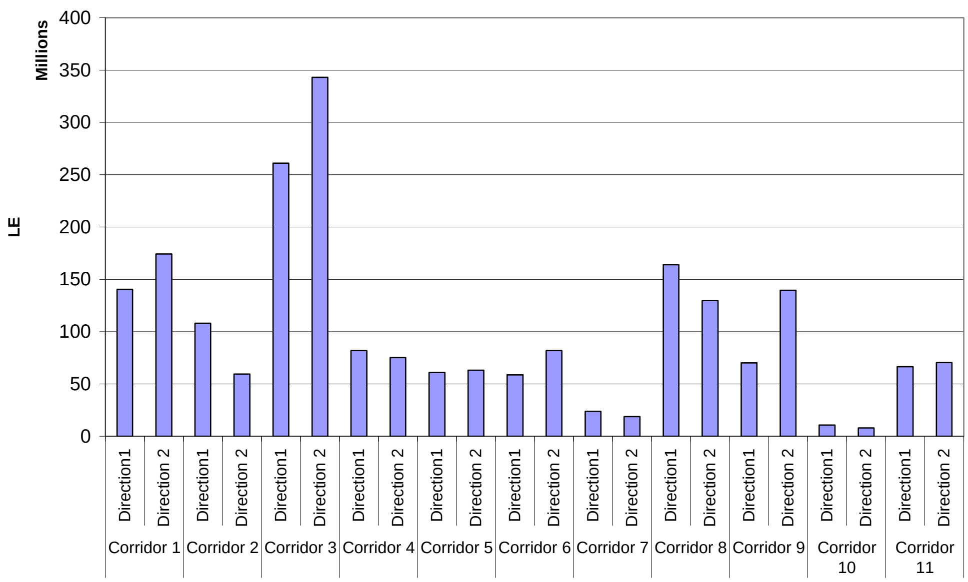


Figure A11.25 Annual excess gasoline costs as result of traffic congestion (2nd approach)

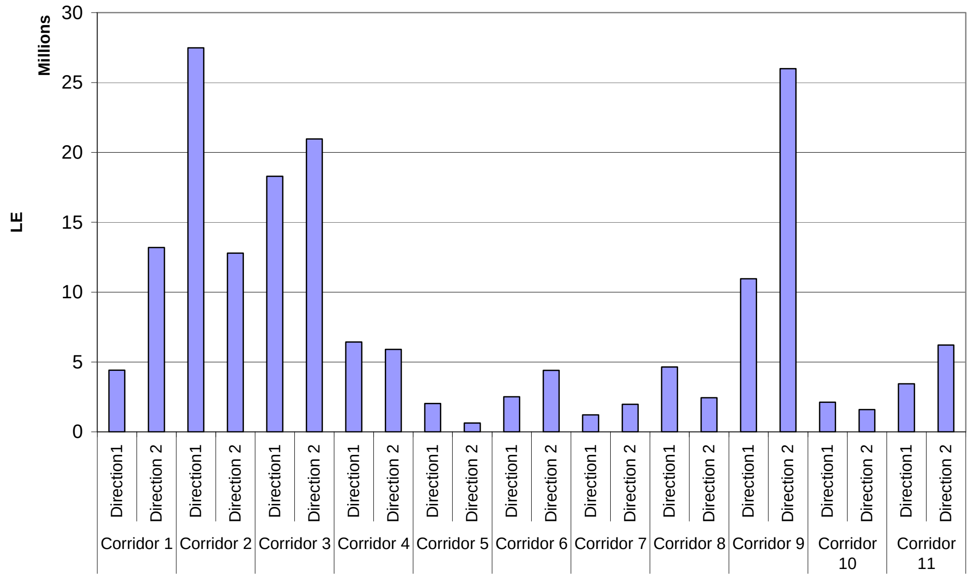


Figure A11.26 Annual excess diesel costs as result of traffic congestion (2nd approach)

Figure A11.27 illustrates the total excess fuel costs per year as result of traffic congestion in Cairo for each corridor separately.

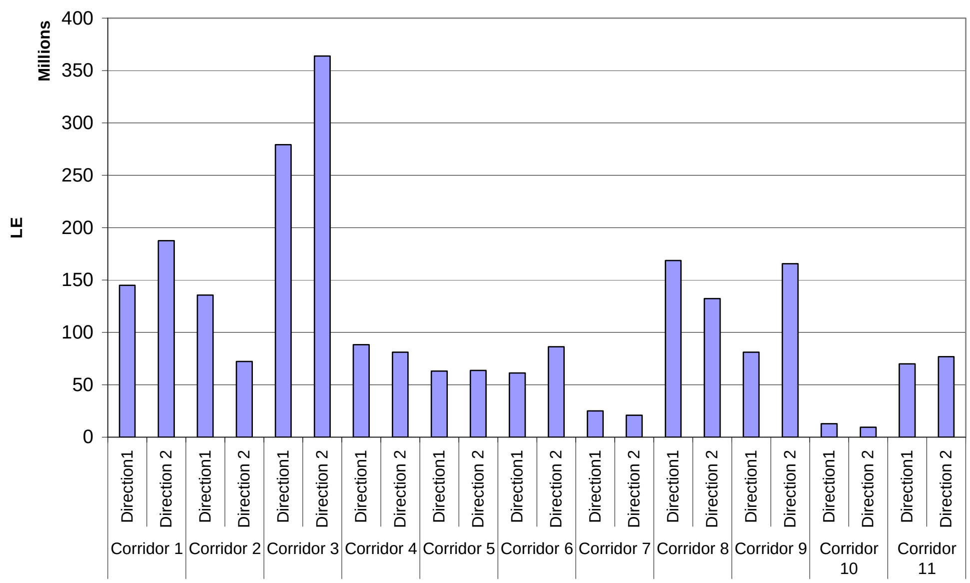


Figure A11.27 Annual total excess fuel costs as result of traffic congestion (2nd approach)

Summarizing the aforementioned results, traffic congestion wastes around 2.4 Billion LE annually in the 11 corridors in Cairo annually (2.2 Billion LE gasoline cost, 0.2 Billion LE Diesel cost).

Results outline

The analysis of annual excess fuel costs due to traffic congestion in Cairo yields the following hints:

- The excess gasoline as well as diesel consumption in the Ring Road corridor seems to be the highest (150 Million Liters (southern), and 36 Million Liters (northern) respectively). Thus, the gasoline and diesel cost are approximately estimated 604 and 80 Million LE for both directions of the aforementioned corridor.
- Besides Ring Road, the excess fuel cost is high in the 26th of July/15th of May Travel Corridor. The total excess fuel cost exceeds 332 Million LE per year.
- Comparing excess gasoline and diesel costs, the former is approximately 13 times as higher as the latter. This rate would decrease to 10, if the fuel subsidy was not taken into account.

D- Emission Cost

In this section excess the emission cost due to traffic congestion in the Greater Cairo for 11 corridors and a comparison between them are presented.

Approach 1:

Figures A11.28 and A11.29 illustrate the excess gasoline and diesel consumption for the 11 corridors using approach 1:

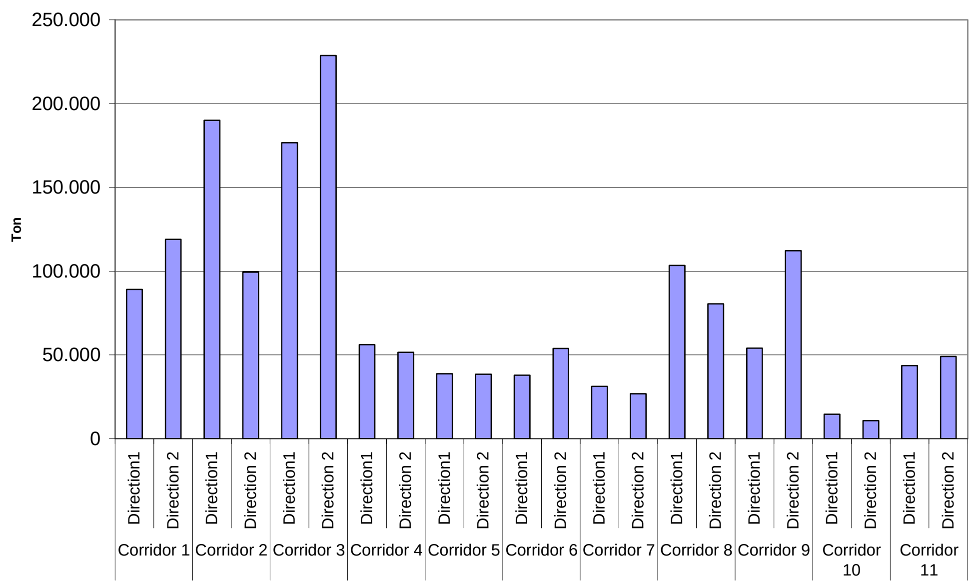


Figure A11.28 Annual total excess CO_2 emission weight due to traffic congestion (approach 1)

The total emission weight is estimated 1.7 Million ton per annum for 11 corridors in Cairo.The emission cost for each corridor is estimated by converting emission weights to costs. The consultant applied the conversion factor 57 (LE/Ton) based on the World Bank advice, Figure A11.29, illustrates the emission cost due to congestion for the corridors in Cairo using approach 1:

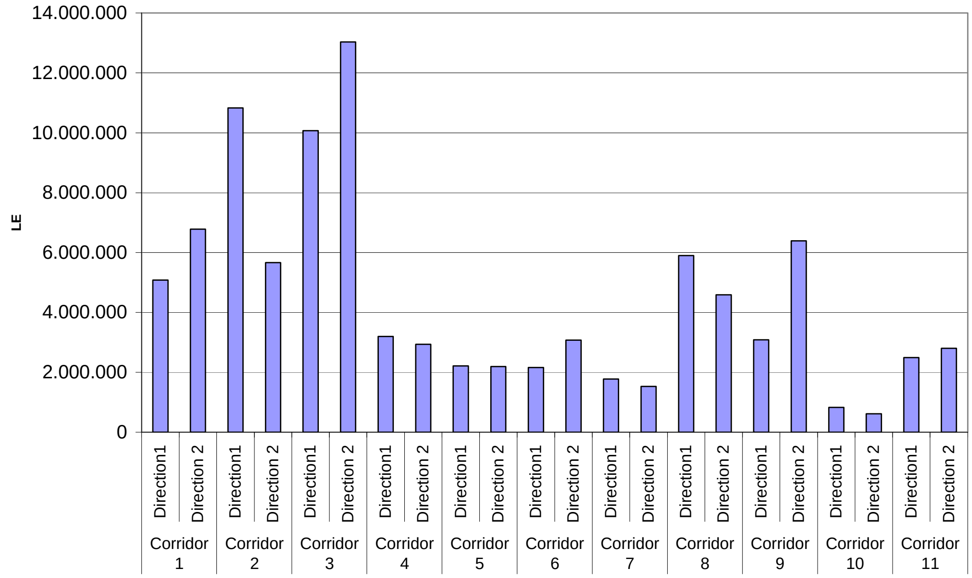


Figure A11.29 **Annual excess CO_2 emission costs due to traffic congestion (approach 1)**

The total emission costs due to traffic congestion for the 11 corridors in Cairo is estimated approximately 98 Million LE per annum.

Approach 2:

Figure A11.30 illustrates CO_2 emission weight for excess fuel consumption in Cairo per year by applying approach 2 in 11 corridors:

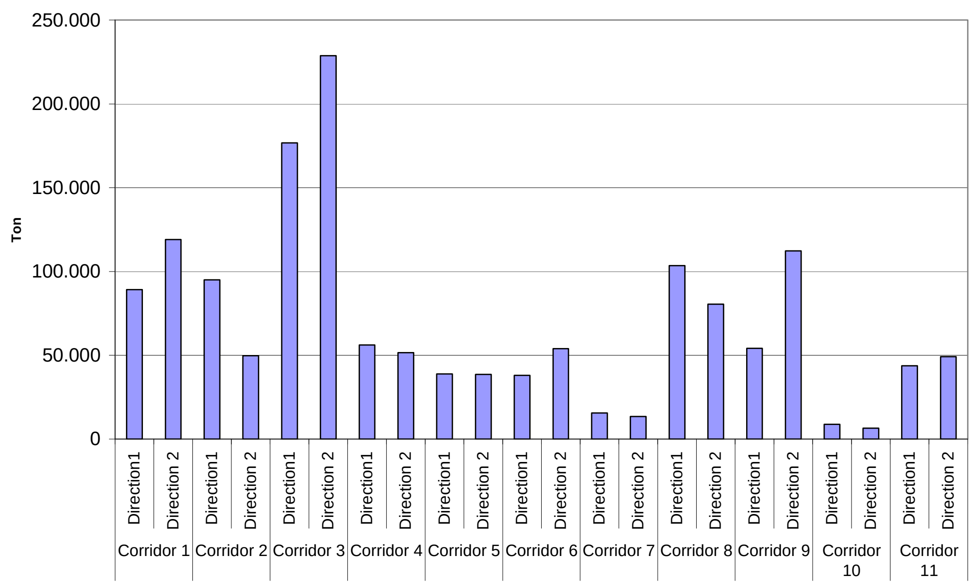


Figure A11.30 **Annual total excess CO_2 emission weight due to traffic congestion (approach 2)**

The total emission weight is estimated 1.52 Million ton per annum for 11 corridors in Cairo.The emission cost for each corridor is estimated by converting emission weights to costs. The consultant applied the conversion factor 57 (LE/Ton) based on the World Bank advice, Figure A 11.31 illustrates the emission cost due to congestion for the corridors in Cairo using approach 2:

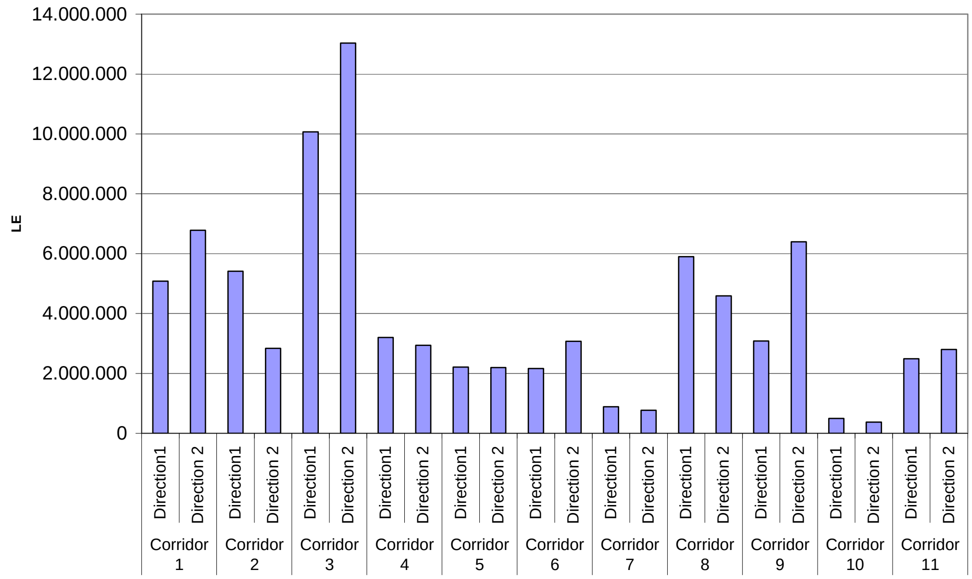


Figure A11.31 Annual excess CO_2 emission costs due to traffic congestion (approach 2)

Thus, the total emission cost due to traffic congestion for the 11 corridors in Cairo is estimated approximately 86 Million LE per annum.

Results outline

The analysis of annual excess emission cost due to traffic congestion in Cairo yields the following hints:

- The excess emission weight and consequent cost in the Ring Road Southern Segment Corridor is the highest in the region. The excess emission weight due to traffic congestion in the aforementioned corridor is estimated around 487000 tons per year . The excess emission cost in the Ring Road Southern Segment Corridor is approximately estimated 7.6 Million LE for both directions.
- Alongside the Ring Road Southern segment corridor, 26th of July/15th of May Travel Corridor suffers from higher air pollution. The excess emission weight due to traffic congestion in the aforementioned corridor is estimated around 220000 tons per year . The excess emission cost in the 26th of July/15th of May Travel Corridor is approximately estimated 3.5 Million LE.
- The minimum emission weight is observed in Cario-Alex Agr Road/ El-Qubba Bridge (11 000 tons per year).

Annex 12: Overview of Data Used for the Calculation of Direct Cost of Congestion

INPUT source: Car floating survey 2010

Free flow travel speed (km/hr)

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
80	80	90	90	90	90	60	60	60	60	50	50	60	60	60	60	70	70	60	60	80	80

INPUT source: Car floating survey 2010

Average travel speed (km/hr)

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
31	31	50	50	51	51	25	25	24	24	30	30	27	27	29	29	24	24	25	25	37	37

INPUT source: Car floating survey 2010

Peak hour travel speed (km/hr)

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
25	22	29	36	40	32	22	15	20	23	25	22	22	18	17	21	17	15	19	22	35	31

INPUT source: Car floating survey 2010

Corridor length (Km)

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
20	20	60	60	40	40	22.5	22.5	17.8	17.8	22	22	18	18	22	22	20	20	23.5	23.5	21	21

INPUT Source: Based on manual classified traffic count data on 23/5/2005 JICA Study and applying growth factor

Peak period No. of Vehicle (PCU) 2010

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
41402	52381	41999.82	24822	58445.26	65232.76	23918.58	18545.94	20478	21945	23795.2	30163.2	17991.1	14024.66	44516.4	38188.5	22348.3	44611.6	5769.4	4632.5	28190	29134

INPUT Source: Based on manual classified traffic count data on 23/5/2005 JICA Study and applying growth factor

Gasoline User %

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
94.6	87.9	68.4	71.9	88.7	90	87.5	87.5	94.3	98.2	92.8	91.1	91.5	84	95.1	96.7	77.9	74.7	73.4	73.1	91.4	86.2

INPUT Interview with fuel provider companies

Fuel cost (LE/LT)

Gasoline cost (LE/Lt)	Diesel cost (LE/Lt)
1.8	1.1

INPUT Source : Transportation Master Plan and Feasibility Study of Urban Transport Projects in Greater Cairo Region in the Arab Republic of Egypt, November 2002

Value of time (LE/hr, LE.Ton)

Passenger cars	Taxi users	transit users users	Freight Transport
13.80	5.45	3.5	4.2

INPUT source The strategic Development Master Plan Study for Sustainable Development of the Greater Cairo region in the Arab Republic of Egypt March 2008

Vehicle occupancy factor

Passenger cars	Taxi users	Motorcycle
1.50	2.50	1.00

For transit riders, the total number of passengers incl. minibuses have been estimated in Row 90

INPUT source: Car floating survey 2010

0.52380952

Coefficient of variation of travel time (AM)

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
0.68	0.81	0.51	0.43	0.42	0.27	0.43	0.47	0.38	0.54	0.46	0.41	0.5	0.44	0.57	0.53	0.45	0.43	0.52	0.54	0.44	0.52

INPUT source: Car floating survey 2010

Coefficient of variation travel time (PM)

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
0.85	0.73	0.56	0.62	0.4	0.58	0.55	0.59	0.47	0.42	0.65	0.58	0.62	0.58	0.67	0.65	0.61	0.67	0.57	0.48	0.48	0.52

INPUT source: Car floating survey 2010

Incident Delay ratio

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
1.3	1.3	1.1	1.1	1.6	1.6	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

INPUT Source: Based on manual classified traffic count data on 23/5/2005 JICA Study and applying growth factor

No. Of Cars and Pickups in peak hours

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
20774	35184	13694	8864	33988	38441	7717	6739	6560	5727	21224	21224	9018	6051	31792	24705	10102	18661	16535	13687	19873	13077

INPUT Source: Based on manual classified traffic count data on 23/5/2005 JICA Study and applying growth factor

No. Of Taxies and Share Taxies in peak hours (Each Share Taxi is equivalent to 5 taxies in terms of Capacity)

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
39661	27022	21887	12215	23061	27426	20023	14155	19996	40764	8022	16044	12483	8398	7126	8138	10414	23440	5496	4037	8625	16689

INPUT Source: Based on manual classified traffic count data on 23/5/2005 JICA Study and applying growth factor

No. Of Motorcycles in peak hours

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
1239	1657	227	134	554	562	812	598	2446	1716	152	193	106	142	675	687	50	30	31	34	175	183

INPUT Source: Based on manual classified traffic count data on 23/5/2005 JICA Study and applying growth factor

No. Of Transit riders in peak hours

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
15767	40997	3719	2634	22100	13145	15572	11191	0	0	33104	33104	29614	50388	29347	25870	27749	36928	9793	3372	10849	43043

INPUT Source: Based on manual classified traffic count data on 23/5/2005 JICA Study and applying growth factor

Freight Loads in peak hours (TON)

Corridor 1		Corridor 2		Corridor 3		Corridor 4		Corridor 5		Corridor 6		Corridor 7		Corridor 8		Corridor 9		Corridor 10		Corridor 11	
Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2	Direction1	Direction 2
182	1818	32703	16227	15433	14359	1960	1630	2548	698	2851	2851	862	997	1265	362	8692	22900	2760	2077	13400	24276

INPUT Source: Developing Harmonized European Approaches for Transport Costing and Project Assessment (HEATCO) , May 2006

Freight delay factor
4.164