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Air Quality Impact Assessment

Cairo International Airport, Terminal 3 with New Runway

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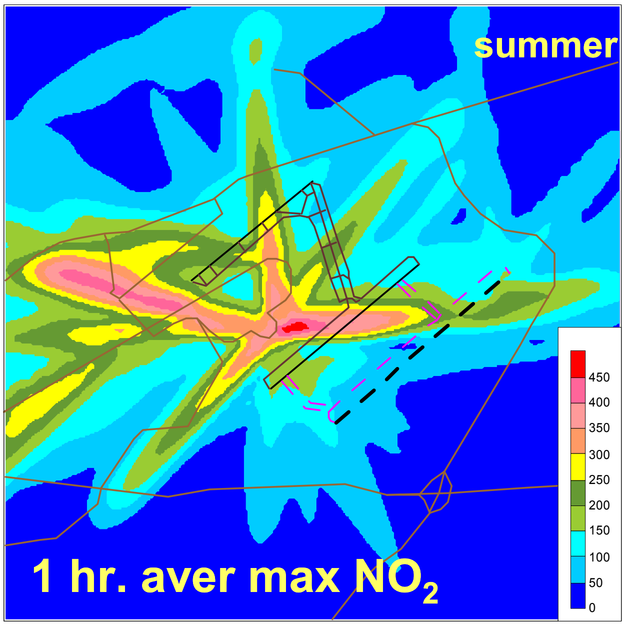

Ministry of State for Environmental Affairs

Norwegian Institute for Air Research

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Summary

The Norwegian Institute for Air Research (NILU) together with the Egyptian Environmental Affairs Agency (EEAA) has been requested by the Ministry of Civil Aviation to undertake an Environmental Impact Assessment (EIA) related to air pollution emitted from the different sources at a new air terminal at the Cairo Airport.

The first part of the study presented some of the baseline data, which have been collected for describing the present situation in the airport area. This report has concentrated on the future situation after opening of Terminal 3 and a prognosis for air and surface traffic up to year 2020. The results have been mainly based upon modelling of emissions and atmospheric dispersion.

The presentation of background air quality was based upon measurement data on meteorology and air quality collected by the EIMP programme administrated by the Egypt Environmental Affairs Agency (EEAA). A special designed local field measurement programme was started in June 2003.

For the model estimates it is important to be able to simulate the situation at the airport as of 2003. The reason is that we wanted to verify the models against measured ground level concentrations. In these comparisons we have to be aware of the fact that other sources than the airport traffic is influencing the concentrations measured in the airport area. This is especially the case for PM_{10}, which has a background concentration due to naturally occurring dust, which is much higher than the maximum impact from airport activities.

The main air pollution problem in Cairo is suspended particulate matter originating from traffic, open air burning and natural wind blown dust. From measurements it is seen that the ozone concentrations may during specific periods in the summer season exceed the limit values given in Law no. 4 of Egypt. The emissions of hydrocarbons and nitrogen oxides from airport activities may increase the ozone formation on a regional scale and also lead to the formation of NO_2 due to NO_x emissions.

The results of model calculations of emissions and concentrations of NO_X, CO, and HC (VOC) around the airport have indicated that the contribution from the airport on a local and regional scale is small.

Close to the roads and in the terminal areas, however, maximum concentrations of NO_2 and CO may reach national and international limit values. The emissions from the airport activities alone will only in very limited areas and for some very specific peak hour cases approach adverse levels. Adding the contributions from other sources in the north-eastern Cairo area may lead to impacts that can influence on the population’s exposure and well being to give undesired effects.

The simplest mitigation actions may be to improve the automobile quality to introduce catalytic converters, to redirect traffic and to assure that the idling time in the terminal areas are reduced to a minimum.

Concerning the emissions of SO_2 and the impact assessment for SO_2 this has not been based on the same detailed emission inventories and modelling procedures as for the compounds above. The reason being that the emission rates for SO_2 from aircraft operations is normally only 5 to 10% of the NO_x emission rates dependent upon the fuel quality. The levels of SO_2 due to airport activities will be much lower than any international or national limit value. It has also been stated that the total emissions from aviation normally do not contribute much to national total emissions.

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1 Introduction

The Norwegian Institute for Air Research (NILU) together with the Egyptian Environmental Affairs Agency (EEAA) has been requested by the Ministry of Civil Aviation to undertake an Environmental Impact Assessment (EIA) related to air pollution emitted from the different sources at a new air terminal at the Cairo Airport. In a meeting with the Minister of Civil Aviation on 4 June 2003 representatives from EEAA and NILU were briefly informed about the plans for the new Terminal.

The first report (NILU OR 62/2003) presented the status at the existing Cairo Airport based on measurement data and modelling. This report has concentrated on the future situation after opening of Terminal 3 and a prognosis for air and surface traffic up to year 2020. The results have been mainly based upon modelling of emissions and atmospheric dispersion.

1.1 Objectives and deadlines

The objectives of the study outlined below have been to collect the necessary input data, perform dispersion modelling and present the future air quality as a result of the Cairo Airport New Terminal and Runway. Results of the baseline studies and field measurements was present on 11 August 2003.

1.2 Scope of work

The scope of work has included several tasks, which had to be undertaken with very short deadlines. These tasks were:

1. Collect maps and GIS information
2. Emission data, background information
3. Meteorological data, from EIMP and Supplementary local measurements
4. Background air quality Cairo, EIMP
5. Baseline measurements
6. Emission modelling and complete inventory
7. Dispersion modelling
8. Air quality assessment and reporting
9. Workshop, presentation and training

2 New Terminal, Airport location and Sources

2.1 The new Terminal

A new terminal complex (TB3) has been designed for the Cairo International Airport. Functionally it has been integrated with the existing terminal building TB2. The combined terminals are dimensioned to accommodate a capacity of 6 million international and 5 million domestic passengers per annum. Reservations are made for the ultimate capacity of 50 million. Included in the project are the related aprons, taxiways, access roads, elevated roads, fuel supply system, loading bridges, drainage, airfield lighting and all other systems.

Figure 1: The Terminal 3 layout for the new Cairo Airport.

A link is planned between the new Main Terminal TB3 and the existing TB2, consisting of international passenger arrival level, public walkways and international passenger departure level. TB2 and TB3 will be fully integrated once work is completed, with TB1 continuing to receive domestic regional flights.

2.2 Location and prevailing winds

The Airport location northeast of Greater Cairo area is considered good location from the air quality point of view. The prevailing wind direction over the greater Cairo area is from around north. At the airport area north-north-westerly winds are totally dominating in the summer season, while southerly and westerly winds are also present in the winter, bringing pollution from the airport away from the city (see Appendix B). Most often the airport area up will be upwind from the major air pollution sources in Cairo. The area will thus be fairly clean compared to the high concentrations frequently observed in Cairo.

2.3 Sources and compounds

The main sources of air pollution will come from aircraft engines, surface vehicles of all kinds, ground support systems, power plants, fuel tank areas, fire training activities and refuelling activities. The main air pollutant compounds acting as the most important indicators for air pollution in the surrounding areas will be:

Nitrogen oxides (NO_x, and especially nitrogen dioxide NO_2), are mainly emitted from road traffic, aircrafts and power production. Most of the emissions from cars will be as NO, while 5 to 20 % may be emitted as NO_2. The ratio NO/NO_2 from aircrafts is not easily available. However, NO will be oxidised to NO_2 by the presence of ozone. It is thus necessary to have some information about background ozone concentrations.
$NO + O_3 \rightarrow NO_2 + O_2$

Sulphur dioxide (SO_2), from power plants, waste burning, fires and diesel vehicles. SO_2 is assumed to represent a insignificant problem in the airport area. Only limited estimates have been undertaken.

Hydrocarbons (HCs) consisting of different subgroups of different compounds such as benzene, toluene and xylene (BTX) and volatile organic compound (VOC). Measurements are often undertaken as NMHC (non-methane hydrocarbons). The HC pollutants are normally a complex mix of gases and aerosols from evaporation areas and releases of unburned fuels from air craft engines (parafines), or car engines (mostly diesel). These emissions as well as releases from fuel storage areas and fuelling areas may be a source of odours. The largest emissions will occur in the taxing areas and at the terminal buildings.

Particulate matter (indicator PM_{10}, particles with diameter < 10 μm), from diesel vehicles and general activities, burning and transport. Suspended particles is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. Particles can be suspended in the air for long periods of time. Some particles are large or dark enough to be seen as soot or smoke. Others are so small that individually they can only be detected with an electron microscope.

Some particles are directly emitted into the air. They come from a variety of sources such as cars, trucks, buses, factories, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood.

Combustion in air craft and car engines normally creates fine particles less than 10 μm in diameter (PM_{10}) or less than 2,5 μm ($PM_{2,5}$). These small particles may cause health impacts. At take off we often see a black cloud of unburned hydrocarbons, creating small particles; soot or black smoke. For some engines the ICAO standards give a “smoke number”. However this can hardly be related to emission rates in kg/h.

Carbon Monoxide (CO) is a colourless, odourless gas that is formed when carbon in fuel is not burned completely. It is a component of motor vehicle exhaust, which contributes about 56 percent of all CO emissions nationwide. CO is also emitted from aircrafts during taxing and idling. Traffic emissions of CO will increase in the terminal area as a result of low speeds and long periods of idling.

Carbon Dioxide (CO_2), from all burning of fossil fuels, only a global problem.

3 Baseline studies

3.1 Databases

Data on meteorology and air quality have been collected from several sources. This information has been important to classify the present situation at the airport as well as providing valuable input to estimating future impact. A report presenting the results of these data was presented on 11 August 2003.

General information about background air quality in the Greater Cairo area has been based on data collected from the EEAA air quality networks. EIMP (Environmental Information Monitoring Program) has been operating air quality measurements since 1998. The measurements are operated by EEAA in co-operation with Cairo University (CEHM) as a sub-contractor. The other network is mainly based on measurements of suspended particulate matter (PM_{10} and $PM_{2.5}$). This CAIP (Cairo Air Improvement Project) network is also operated under the supervision of EEAA.

The mobile laboratory was located at 4 different locations in the airport area to measure in a continuous basis the concentrations of:

- Nitrogen oxide (NO_2, NO_x) (1 hour resolution)
- Sulphur dioxide (SO_2) (1 hour resolution)
- Carbon monoxide (CO) (1 hour resolution)
- Ozone (O_3) (1 hour resolution)
- Hydrocarbon (NMHC) (1 hour resolution)
- Particles < 10 µm (PM_{10}) (24 hour average)

Data collected from 1 July to 18 July was included in the Baseline report.

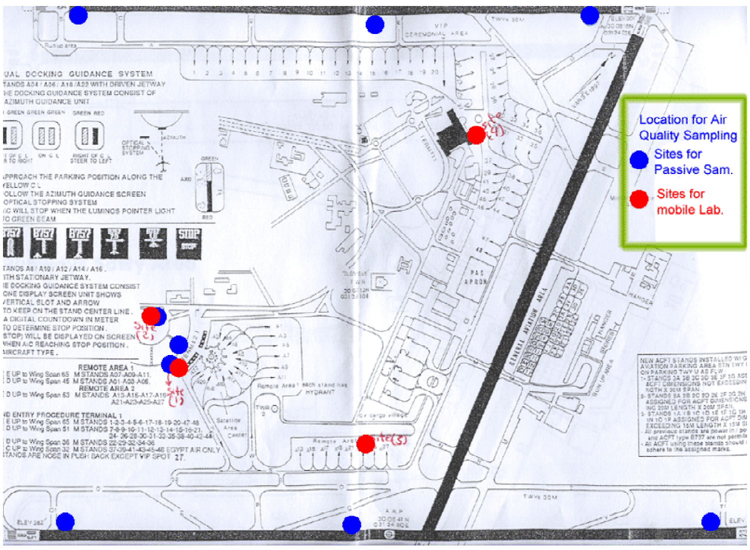


Figure 2: Location of the mobile laboratory for air quality monitoring at the airport, July-August 2003.

3.2 Air quality in the surrounding area of the Cairo airport

Suspended particles in air are the most important air pollution problem in greater Cairo. The average PM_{10} concentrations at Abbaseya ranged typically between 100 and 300 $\mu g/m^3$. (Sivertsen and Dreiem, 2003). The results of studies performed in the EIMP programme indicate that the typical average background concentration of PM_{10} seems to be around 70 to 80 $\mu g/m^3$. A level of 70 $\mu g/m^3$ is equivalent to the Air Quality Limit value for 24-hour average PM_{10} concentrations as given by the Law no. 4 of Egypt.

Also during measurements of PM_{10} in July 2003 at the airport area typical daily average concentrations ranged between 100 and 180 $\mu g/m^3$.

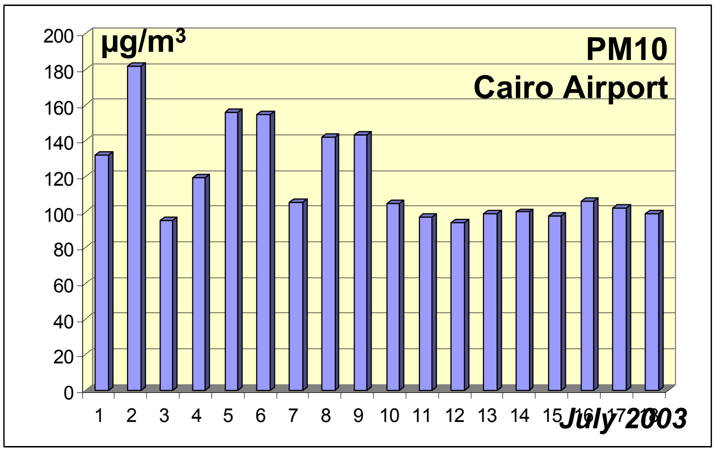


Figure 3: Daily average concentrations of PM_{10} measured at the Airport Terminal 2 (location 1 and 2) from 1 to 18 July 2003

Concentrations of suspended dust measured as PM_{10} are exceeding national and international air quality limit values almost in all sites measured in greater Cairo area.

The **SO_2 concentrations** measured at both sites (Abbaseya & Nasr City) rarely exceed the AQL values as given by Law no. 4. During three years of measurements (from 2000 to 2002) the daily average-air quality limit value has been exceeded only one time at Abbaseya station while at Nasr City there were no exceedances at all.

The median **concentration of NO_2** measured in the city centre of Cairo was 80 $\mu g/m^3$ while the hourly maximum concentration was measured at 162 $\mu g/m^3$. From the field study using passive samplers (Sivertsen, 2001b) it was shown that typical NO_2 concentrations in the greater Cairo area ranged between 40 and 90 $\mu g/m^3$ as weekly average concentrations. The one-hour average limit value of 400 $\mu g/m^3$ was not exceeded in 2002. However, the 24-hour average limit value of 150 $\mu g/m^3$ was exceeded during one to five days in the streets of Cairo.

CO concentrations in the busy streets of Cairo are occasionally exceeding limit values given by Law no. 4 of Egypt. Traffic jam and traffic congestion in the busiest streets is probably the main reasons for these relatively high CO concentrations. In the airport area we never measured more than 5 mg/m³ in July 2003, which is 50% of the limit value.

High concentrations of **surface ozone** have been observed as a result of regionally produced secondary pollutants in the Cairo region. The urban area of Cairo experiences occasionally very high air pollution levels due to emissions at ground level of pre-cursors such as NO_x and HC and limited dispersion conditions during adverse meteorological situations (low wind inversion conditions). Afternoon average concentrations of ozone at Abbaseya were 100 µg/m^3.

During the measurements undertaken at the airport in July 2003 the hourly ozone concentrations ranged from 5 to 84 µg/m^3. A very clear diurnal pattern can be seen in the data, with a maximum from midday till late afternoon. This was the same case for the NO_2 concentrations, but less pronounced than for ozone.

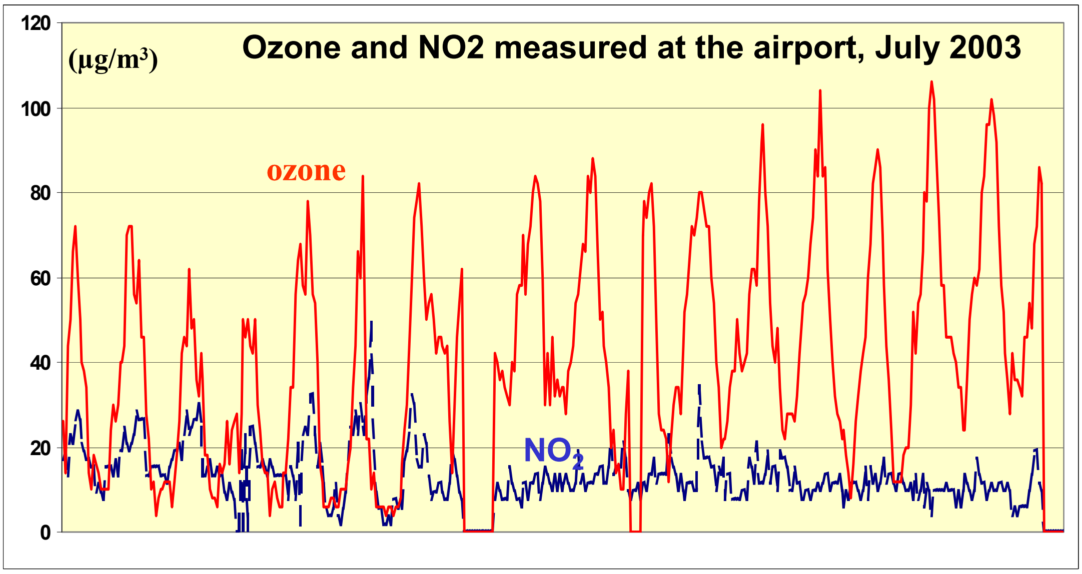


Figure 4: Hourly concentrations of NO_2 and ozone measured at the airport terminal 2 from 1 to 18 July 2003.

VOC measurements around the new terminal during the first week shows that there is high concentrations of carbon emissions in the area since the concentrations of C1-C4 was 316.2 µg/m^3 while the concentrations of the other volatile compounds were at the normal level since the concentrations of n-Butane, Iso-Butane and n-Pentane were 2.2, 6.2 and 16.4 µg/m^3 respectively

3.3 "Background" air quality at the airport, a summary

Background concentrations have been evaluated based on measurements performed by the EIMP/EEAA programme as well as from the short-term measurements performed at the airport during July 2003. (Ahmed, 2003) (Sivertsen et al., 2001)

The data have been presented above and a summary of average background concentrations is given in the following table.

Table 1: Average background concentrations of some air pollutants in the Cairo Airport area.

Compound	**Annual average ($\mu g/m^3$)**	**Max. daily ($\mu g/m^3$)**	**Max. hourly ($\mu g/m^3$)**
NO_2	40 - 60	100	240
SO_2	45	130	250 (400*)
PM_{10}	170	700	2000
CO	-	5	30
Ozone	60	130	150

*) Maximum concentration during an air pollution episode

Suspended dust (measured as PM_{10} and TSP) is the major air pollution problem in Egypt. Annual average concentrations of PM_{10} range between 100 and 200 $\mu g/m^3$ in urban and residential areas and between 200 and 500 $\mu g/m^3$ near industrial areas. Daily average concentrations of more than 6 times the Air Quality Limit value for Egypt are being recorded occasionally in the urban areas of Cairo. The natural background concentration of PM_{10} in Egypt has been evaluated to represent levels close to or around the Air Quality Limit value of 70 $\mu g/m^3$ as a daily average. (Sivertsen and Dreiem, 2003)

High concentrations of NO_2 are most often observed in the busiest streets of Cairo and near major roads. Average concentrations of NO_2 measured at the airport in July 2003 were about 30 $\mu g/m^3$, while hourly maximum concentrations are expected to reach more than 200 $\mu g/m^3$ at the most busy hour of the year. Based on NO_2 measurements undertaken in Cairo city there are reasons to believe that the annual average NO_2 concentrations may be 40 to 60 $\mu g/m^3$ in the airport area.

The concentration of SO_2 is normally expected to be much lower than the limit values. However, during air pollution episodes over Cairo relatively high hourly concentration of more than 400 $\mu g/m^3$ has been observed. This was the case during an episode on 24 April 2003 (Sivertsen and Dreiem, 2003).

Background ozone concentrations are important for the formation of secondary pollutants such as NO_2. Typical daily average concentrations in the greater Cairo area ranges between 110 and 130 $\mu g/m^3$.

CO concentrations are probably most interesting in the near Terminal area where cars are idling (load/unload zone). The highest hourly average CO concentration measured in July 2003 was 5.6 mg/m^3. Close to the unloading zone it is expected that the concentrations during rush hours may reach up to 30 mg/m^3.

4 Modelling, methods and modelling area

4.1 Dispersion models

The NILU developed source oriented numerical dispersion model EPISODE calculates spatially distributed hourly concentrations from point, line and area sources. The NILU models ROADAIR and CONTILENK are used to estimate sub grid concentrations close to roads within the square grid. A puff-trajectory model, INPUF, is used to calculate the influence of point sources.

Similar estimates as the ones prepared for the Cairo International Airport have been performed for the Oslo Main Airport Gardermoen in Norway (Slørdal et al., 1999) and (Gram and Walker, 2002).

The concentrations may be given as grid distributed concentrations (field data set), concentrations along roads (line data set), and as concentrations in points (receptor point or building point data set).

The USEPA AERMOD model is also available in the NILU model library, and has been tested together with the NILU models. The NILU EPISODE model system is, however, a more flexible dispersion model, which has been proven excellent in international model comparison studies (see: www.nilu.no/aqm/models).

Another dynamic model, which is being used by NILU, is the TAPM model. This is a PC-based 3-D prognostic model for air pollution studies. This model predicts all meteorological parameters, which imply that no local data are needed. It also predicts pollution parameters directly (including photochemistry) on local, city or inter-regional scales (Physick et al., 2002)

The EPISODE model, which represents the core of NILU models, is described on the web as part of models database within the European Topic Centre on Air Quality (ETC-AQ) (www.etcaq.rivm). The Model Documentation System has been developed by the European Topic Centre on Air Quality (ETC-AQ) with the aim to provide guidance to model users in the selection of the most appropriate model for a specified application.

Spatial concentration distributions have been estimated for nitrogen oxides (NO_x), carbon monoxide (CO) and hydrocarbons (HC). Emission sources such as airplanes, road traffic and point sources were included in the estimates.

Most of the sources were treated as line sources, but also methods estimating the sources as a line of point sources has been tested and evaluated. Emission from single sources is treated in the models as point sources. A detailed description may be found in several NILU reports (Slørdal et al., 2003).

A number of concentration fields have been estimated for a variety of options and test cases. It will thus be impossible to present all of these in this report. The presentations presented are thus extracts of the results.

The principle of the model, which enables the results to be treated individually, to evaluate the importance of emissions from the airplanes relative to cars and other sources, is presented in Figure 5.

For each hour the hourly concentrations are estimated in a 100x100m grid or in a resolution given by the emission data (Gram and Walker, 2002).

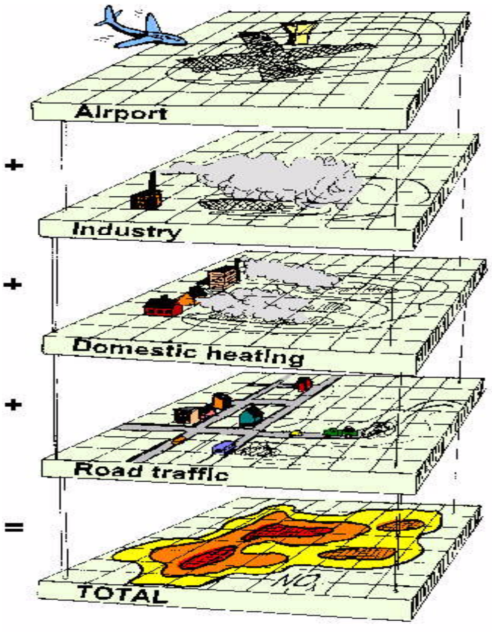


Figure 5: Dispersion models can be used to evaluate the relative importance of different sources.

4.2 Modelling area

Before starting the modelling process and the collection of emission data we have defined the modelling area. For this preliminary environmental impact assessment study we have selected a grid of 13 km x 13 km. The grid is presented with 500 m resolution in Figure 6.

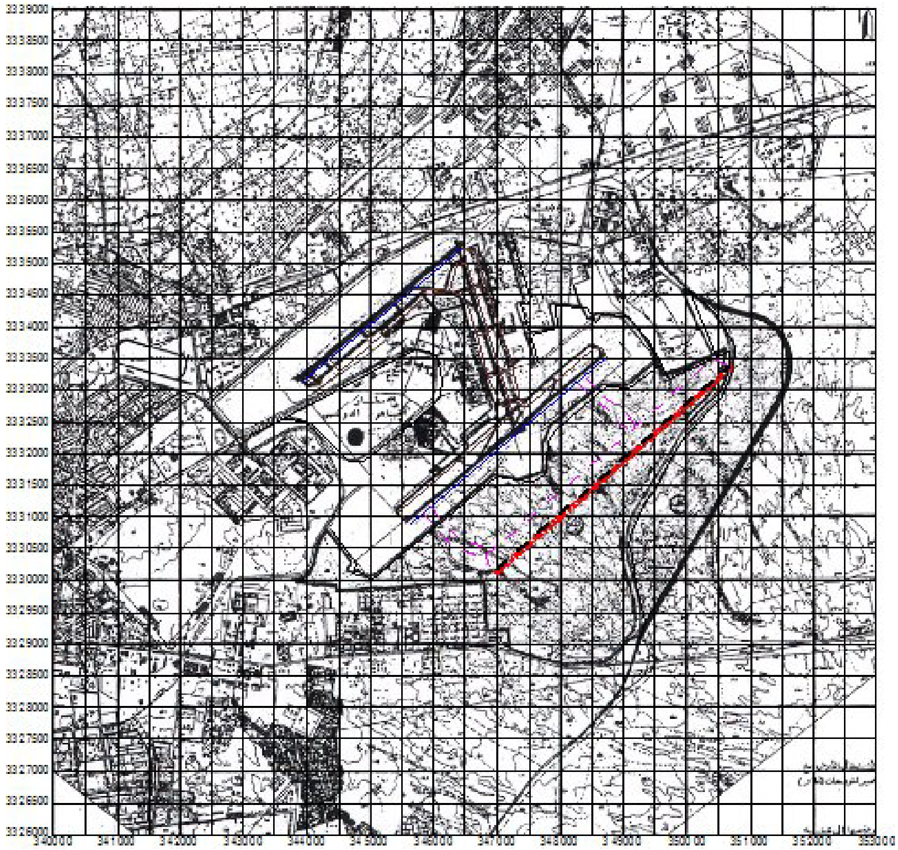


Figure 6: The modelling area and grids (500 m × 500 m) selected for the modelling of air pollution concentrations as a result of the airport activities. Models were operated in a 250 m × 250 m grid.

5 Input data for modelling

The following input data have been prepared for the modelling of air pollution impacts:

- Meteorological data; wind direction, wind speed, stability and turbulence,
- Background concentrations; observed air quality in the area,
- Emission data; air traffic, road traffic, point sources.

5.1 Meteorological data

Meteorological data have been based on measurements of winds performed by the EIMP/EEAA programme at Abbaseya. Stability and turbulence has been estimated using the NILU meteorological pre-processor (Bøhler, 1996).

Meteorological statistics has been presented in Appendix B. For modelling purposes hourly data for one winter month and one summer month has been prepared including all the necessary parameters. The input data have been verified to be representative for the typical winter and summer conditions at the airport area.

The dynamical meteorological forecast model, which is part of the TAPM model, has also produced meteorological data. These data are used directly as input to the model estimates performed with the TAPM model.

5.2 Background concentrations

Background concentrations have been presented in Chapter 3.3 and the concentrations presented in Table 1 has been used as input to the model results whenever necessary.

5.3 Emission data

For estimating the emissions of air pollutants we have used methods and approaches used in earlier impact assessment studies used at Oslo Airport Gardermoen (Gram and Walker, 2002).

Based on emission input data as developed in the following chapters emission models have been applied to develop an emission inventory for the airport area. This inventory is used as part of the input data to the dispersion models and has been divided into:

- Point sources (stacks and combustion sources)
- Line sources (road traffic and plane movement on apron, taxing lanes and landing – take-off)
- Area sources (diffusive emissions, storage areas etc.)

The estimates have included nitrogen oxides (NO_x, estimated as NO_2), carbon monoxide (CO), hydrocarbons (HC, or VOC, volatile organic compounds) and exhaust particles.

The TOR specified that the “required emission inventory for the airport site will be undertaken as a desk top assessment”. Data prepared by other institutions should have been used in preparing this inventory database. However, only limited amount of information has been available in the study so far. Information about emissions from surface traffic, air traffic, buildings and fuel storage areas have been estimated based on whatever information could be collected during the short period of this project.

Road traffic
The road traffic emission data have been compiled and estimated based on the following data:

- Traffic density numbers (to and from the terminal building)
- Composition of cars (taxi, private, trucks, buses)
- Idling time at terminal
- Emission factors for car fleet in Cairo (if available).

A very limited amount of traffic data had been made available for the model input estimates.

Air Traffic

For the air traffic activity we specified the need for:

- Number of flights per day (average and maximum)
- Weekly distribution and number of flights per hour if available
- Composition of the fleet
- Time consumption and location of idling, taxing and take off activities
- Emission factors (if available, otherwise collect from ICAO databank)

Buildings and ground activities
Information about all activities at ground level, which may produce air pollutants, had been requested. However, this information was not available when the modelling of the airport impacts was undertaken.

The location of possible power plant or other boilers using fossil fuels should have been specified. Consumption (annual or monthly) of fossil fuels is needed. Other activities such as waste burning must be indicated.

Fuel storage areas
Fuel storage area location and storage methods should be provided. If emission estimates have already been undertaken, these data will be valuable to the total assessment. Some VOC and HC measurements will be undertaken on the existing terminal area, but we don't believe that these data will provide adequate information concerning possible emissions from existing and future storage areas. For this purpose more detailed field investigations using tracer techniques will have to be undertaken in the future.

The diffuse emissions of jet fuel and un-burnt hydrocarbons from the aeroplanes is mainly an odour problem, and ventilation intakes for the terminal building should be located in such a way that smell in the terminal building is being avoided.

Other activities linked to fuels storage, filling, leakages, waste and transport may also represent valuable input.

5.3.1 Air traffic emissions

The emission from aircrafts has been estimated based on the data and procedures presented below.

The emissions from an aircraft can be divided into several steps:

- Approach, normally outside the modelling grid
- Landing, breaking of the aircraft
- Taxing to the terminal gate
- Taxing to the runway
- Take-off, on the runway and up to 100 m
- Climbing, normally outside the modelling grid

Together, these steps make an LTO-cycle (landing and take-off cycle).

An aircraft engine is constructed to give as much power as possible from the fuel when the aircraft is in the air. At the ground, the engine is used to move the aircraft around slowly, the combustion is bad and the emissions are high. About 98% of the CO-and HC-emissions and about 75% of the NO_x emissions normally comes from the taxing at the airport and along the runways. It is thus important to get good quality data for the taxing at the airport.

The different types of aircrafts are equipped with different engine types which release different amount of air pollutants. The emission factors for the specific aircrafts have been developed and used in the emission modelling procedures. The emission factors for different engines and aircrafts have been grouped in several classes according to the engine type, power etc. In this project information about aircraft type was not available in the traffic schedule. Instead we have used information about the distribution of different aircraft types to calculate average emission factors for Cairo Airport. (Tail number and call sign are additional information for the quality assurance of the input data.)

From Runway, Terminal gate and Destination the route of each aircraft is determined. The number of seconds an aircraft is spending at each location in the modelling grid (within 100 m x 100 m) has been estimated from the aircraft operations at the airport.

5.3.1.1 Air traffic data

The total number of flights from the Cairo airport in 2002 was 81340 bringing 8.4 million passengers. The daily traffic at Cairo airport is presently about 230 movements. The peak hour reaches 20 movements, with a different distribution according to the time of the day:

- About 15 departures by hour in the early morning
- About 15 arrivals by midday and at the end of the afternoon

These numbers represent about half of the traffic density at Oslo International airport Gardermoen. The number of passengers travelling from Oslo Airport was in June 2003 1.3 million. On an annual basis the number in Oslo are about 13 million passengers.

From a purely geographical point of view the main flows of flights at Cairo International airport come from or go to:

- North/West: International flights to/from Europe, domestic flight to north Egypt
- South/East: International flights Amman, Jeddah, FIR + domestic flights from south Egypt

The projected air traffic has been presented by the Cairo Airport Master plan based on forecasts from 1994 by NACO. The year 2020 figures were based on a total of 12 million flights in 2000, which indicates that the estimate may be an overestimate of the situation in the future. The following table shows the results of these estimates (year 2020).

Aircrafts in 2020	Total aircraft movements	Total passengers
International flights	113 700	21 011 000
Domestic flights	66 700	9 830 000
Non passenger aircrafts	12 600	
Total	193 000	30 841 000

The information given for 2020 was based on prognoses that were given by the NACO forecasts. The traffic assessment team re-evaluated these numbers as part of the impact assessment study. The numbers are basically the same as the NACO study, but were adjusted to suit the present situation. The final numbers of aircraft and passenger at Cairo International Airport is presented in Table 2.

Table 2: The number of passengers and aircrafts at Cairo International Airport from 2001 to 2020, finalised by the Traffic Assessment team.

Year	Aircraft Movements		Passenger Movements	
	With Project	Without Project	With Project	Without Project
2001	83,293		8,318,643	
2002	81,340		8,392,670	
2005	121,600	80,400	15,898,000	8,768,000
2010	146,600	92,600	20,649,000	10,772,000
2015	171,500	108,800	25,884,000	13,573,000
2020	193,000	125,900	30,841,000	16,784,000

In the air operation description it is specified that with the mix traffic defined with 65% of medium jets and 35% of heavy jets, the potential runway system capacity should be 70 to 80 movements (ARR and DEP) per hour. Assuming an initial total traffic at Cairo Airport of 100 000 movements, and that 50% of the traffic will use the new runway, with another 50% for take off, a figure of 25,000 departures can be taken as a basic design. The assumptions presented above have been used for estimating the total future emissions as a result of aircraft movements at the existing runway (05R-23L) and the new runway (05RR-23LL) runway. We assume that about 100 000 movements will occur at each of the runways.

The diurnal variation of traffic density is presented as weekly averages for the summer and winter season for Terminal 1 and Terminal 2 in Figure 7 based on actual data collected for the traffic in 2002.

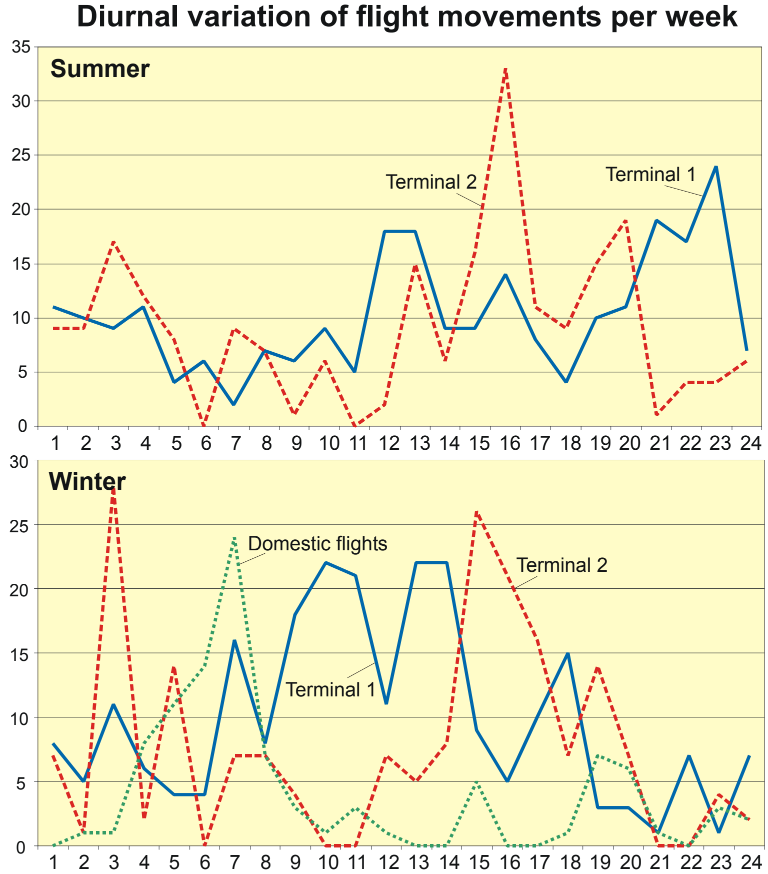


Figure 7: The diurnal variation of flight movements at Cairo Airport per week for a typical summer and winter season (2002).

At Terminal 2 in the winter season there is a clear peak in traffic at night and in the afternoon, while in the summer season there is only this peak in the afternoon. At Terminal 1 there is a more evenly distributed traffic over the whole day. In winter, however, most of the traffic is at daytime between early morning and late afternoon.

5.3.1.2 Type of aircrafts on new runway

Information concerning the type of aircrafts operating at Cairo Airport has been limited. Estimates have been based on the Consultancy Services Contract report for Terminal area no. 3 (NACO –ECG 1994) as well as from Task 1.3 Study and Recommendations (Arab Consulting Engineers, 2002). The traffic distribution considering typical aircrafts operating on the new runway at Cairo Airport has been estimated and presented in Table 3.

Table 3: Estimated distribution of aircraft types at the new runway at Cairo Airport 2000 and 2020.

Aircraft		Traffic on new runway (departures only)	
Class	**Reference aircraft**	**Percentage**	**2020**
E or F	B 747-400	20	10 000
D	B 767-300	15	7 500
C	A 320-200	50	25 000
Others	Fokker 100	15	7 500
		Total	**50 000**

In the dispersion estimates it will be assumed that O5L/23R will be used with restrictions because of environmental constraints. We have assumed no traffic at this runway.

From all the different observed movements we have performed the present day situation based on the following actual flight information:

Number of total movements: Winter season = 1047 movements per week
Summer season = 946 movements per week.

The total annual number of movements is thus about 52 000. This is in accordance to the estimated distribution of aircrafts in Table 3. This number is on the other hand only about half of the prognoses presented by NACO and ECG (NACO 1994). The annual grand total aircraft movements was at that time estimated to be 108 000 in 2005 (see Appendix C).

5.3.1.3 Time use pattern and traffic density used for modelling

The time use pattern is presented in Appendix E1. The pattern is different for different aircrafts, but as the information about the aircraft type was limited for Cairo Airport, we have based the estimates on a typical "average aircraft".

The emission calculations for the existing runway are based upon the assumption that the domestic flights are using Terminal 1, while the international flights are using Terminal 2. For the new runway it is assumed that domestic flights are using Terminal 2 and the old runway (23L/05R), while the international flights will be using Terminal 3 to the new runway (23LL/05RR). Table 4 shows the use in seconds for different movements at Cairo Airport. The more detailed time consumptions at the existing and the new runway is presented in Appendix E1.

Table 4: Time use in seconds for different movements at Cairo Airport

Existing runway

	23 L				05 R			
	Term 1		Term 2		Term 1		Term 2	
	Cells	Time	Cells	Time	Cells	Time	Cells	Time
Arrival	20	107.3	20	107.3	20	107.3	20	107.3
Taxing	40	416	29	348	19	222	24	295
Taxing	37	423	38	457	44	530	20	252
Take-off	24	56.3	24	56.3	24	56.3	24	56.3

New runway

	23 LL				05 RR			
	Term 2		Term 3		Term 2		Term 3	
	Cells	Time	Cells	Time	Cells	Time	Cells	Time
Arrival	20	107.3	20	107.3	20	107.3	20	107.3
Taxing	55	651	49	588	48	588	69	835
Taxing	36	451	32	404	63	770	72	881
Take-off	24	56.3	24	56.3	24	56.3	24	56.3

The time use may seem to be too high, especially for the arrival and take-off. For the present-situation we have used the results of counting undertaken in 2002 as presented in Figure 7. The traffic density has been based on the observed traffic schedule for one week.

For the winter season there was a total of 1047 movements (arrivals or departures) during the week, and for the summer season there was 946 movements. Over a year, this gives a traffic density of about 52 000 movements. In addition to this, there is a lot of non-scheduled traffic that should be included in the calculations.

For the future situation in 2020 it is assumed a traffic density of about 200 000 movements. To reach this, the traffic schedule 2000 is used twice: first with the domestic traffic at Terminal 1 and international traffic at Terminal 2 with the existing runway, secondly with domestic flights at Terminal 2 and international flights at Terminal 3, using the new runway. Finally the emission fields are multiplied by 2 to correspond with the 200 000 movements.

5.3.1.4 Emission estimates

For each of the aircraft type the emissions can be estimated from the amount of fuel consumed in each of the movement mode. The emission may be estimated in kg/s for HC, CO and NO_X based on the factor given as g/kg of consumed fuel.

Typical emission factors are presented in Appendix D. The estimates apply for taxing, departure and landing. For the more recent aeroplanes the data are taken from "Jane's all the world's aircrafts" (Jane, 1996) and emission factors have been also estimated from ICAO (ICAO Engine Exhaust Emissions Data Bank, 1995 and

ICAOs Internet pages). New data are available for B737-600/700/800 and Airbus 321-B 757.

The emissions from an aircraft in the grid cell (I, J) are calculated as

$$Q (I, J, K, L) = Time (I, J) * CONS (K) * FACT (K,L),$$

where:

- K = the phase of the movement (landing, taxing or take-off),
- L = the compound (CO, HC or NOx),
- CONS(K) = the specific fuel consumption in phase K (g fuel /s) and
- FACT (K, L) = the emission factor for compound L in phase K in g/kg fuel.

To estimate the ground level concentrations of air pollutants the emission estimates are made for an aircraft in the lowest 50 meters of the atmosphere. Normally it will at this level already be outside the modelling area. This means that we in the calculations are normally not calculating the emissions from the total Approach phase and Climb phase. On the other side all emission occurring inside the modelling grids is taken into account.

The emissions for one week are calculated as presented in shown in Table 5.

Table 5: Emissions from scheduled air traffic at Cairo Airport 2000 and 2020. Unit: kg/week.

Season	Compound	Existing Runway, 2000	Existing + new Runway, 2020
Winter	CO	2138.8	10238.2
	HC	808.0	3890.1
	NOx	1203.8	4972.3
Summer	CO	1650.6	10325.8
	HC	619.5	3819.2
	NOx	1057.6	4550.2

The difference between winter and summer emissions is partly due to a different number of movements (1047 and 946), but also due to a different numbers of aircrafts in the runway directions (23/05). For year 2020 the traffic is four times the 2000-traffic, but the emissions are also much higher due to the longer taxing ways for the new runway. This especially influences the emissions of CO and HC, where the taxing emissions are highest. For NOx the highest emissions are from the take-off phase.

A summary of input information given for emission estimates is presented in Appendix E. The estimated emissions representative for the present traffic flow is presented in Figure 8.

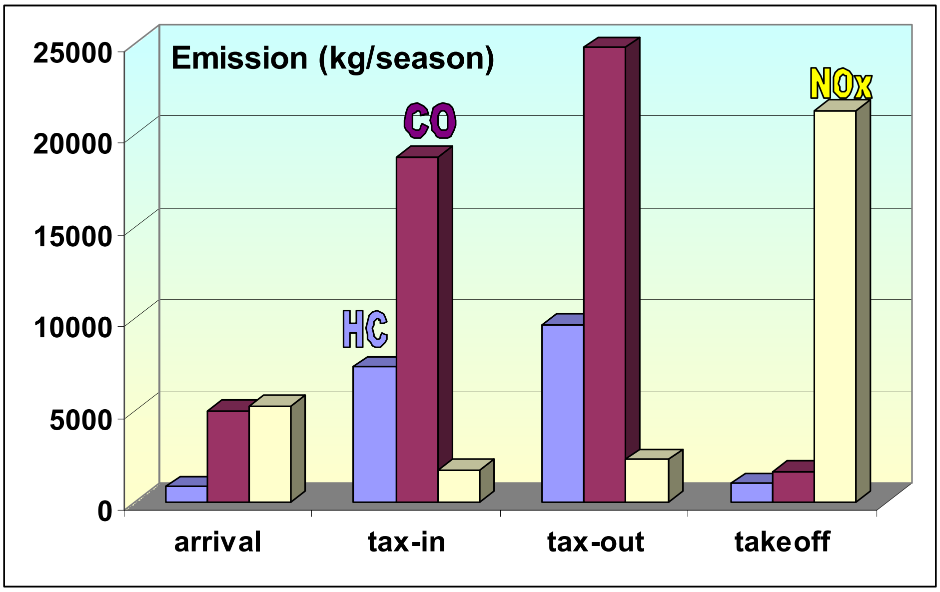


Figure 8: Emissions of HC, CO and NOx during arrival, taxing and takeoff at Cairo Airport 2002. The emission rates are given in kg per half year during the winter season.

As can be seen most of the NO_x is produced during take-off, while CO and HC emissions are most significant during taxing.

For the model estimates it is important to be able to simulate the situation at the airport as of 2003. The reason is that we want to verify the models against measured ground level concentrations. In these comparisons we are have to be aware of the fact that other sources than the airport traffic is influencing the concentrations measured in the airport area. This is especially the case for PM_{10}, which has a background concentration due to naturally occurring dust, which is much higher than the maximum impact from airport activities.

5.3.2 Road traffic, present situation

Traffic data to and from the airport have been collected from different sources. We have requested data for the main roads concerning traffic volume, speed and typical traffic composition (private cars, taxies, buses, lorries and motorcycles). To make a complete assessment for different time periods, data for the time variation of traffic density and traffic composition is needed. The analyses have included counting of typical days, average traffic density and peak traffic hours.

The main roads surrounding the Cairo Airport are presented in Figure 9.

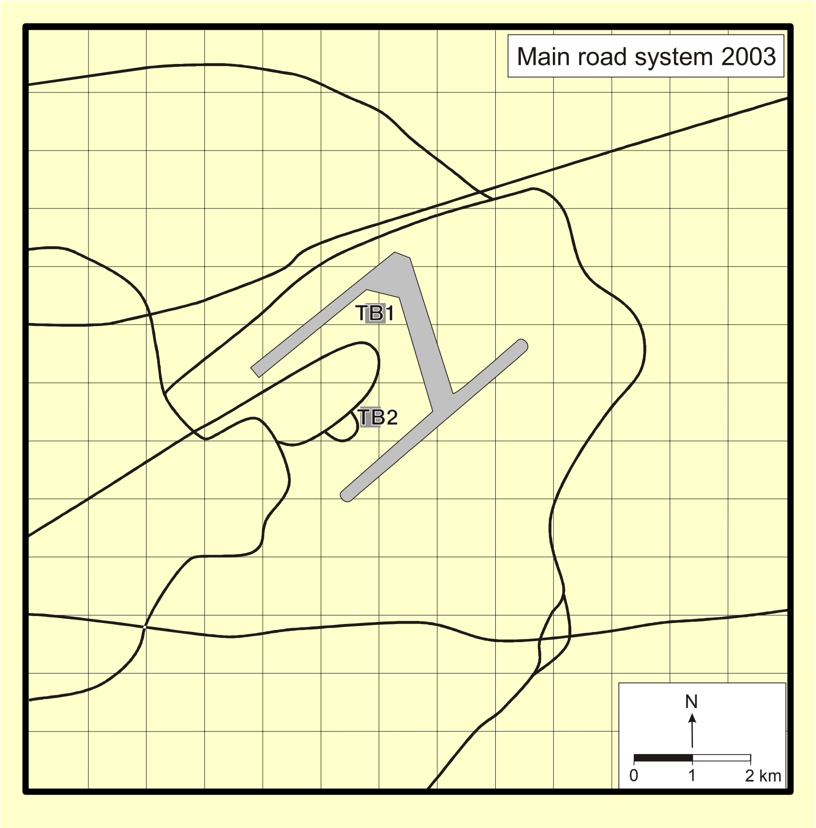


Figure 9: The main road system in the surroundings of the Cairo Airport.

Traffic flows and traffic densities on the roads other than the traffic to the airport was not available when these model estimates were performed. Model estimated emissions from land-based traffic have thus been related to the transport of passengers and goods to and from the airport. The concentrations estimated will thus be related to the impacts from the airport activities only.

The Cairo International Master plan report “Annex B, Landside traffic” presents data on the projection of road traffic to and from the airport in the future. On the basis of design traffic flow, typical requirements for the landside traffic related facilities have been designed.

It is assumed that terminal 2/3 will handle 14 million passengers at a time when the total airport will handle 20.7 million passengers. In the Master plan report the estimated capacity will reach 30 million in year 2010. Our estimates for the impact of emissions from the roads have been based on an estimated peak hour traffic including passengers, meeters and greeters at the ultimate development of the airport. An example is presented in Appendix C1 based on the Master Plan report. This table shows the number of passengers at peak hour traffic for the future ultimate development stage assuming that the total annual number of passengers in Terminal 1 and Terminal 2/3 is 70 million.

As part of the Environmental Impact Assessment Study of the Airport Developments, Dar El Handasah Consultants (Shair & Partners) entered into an agreement with Heikal Consultants (Prof. Dr. Ali Z. Heikal) in June 2003 in order to conduct a traffic survey at the Cairo International Airport area. The purpose of the study was to collect information on the present traffic magnitude and pattern associated with the airport area as well as the main access roads. The study was carried out during the period June-July 2003. The results of this study had only been made available in the last phase of this report.

The main results of these counting are presented in Appendix F3. The traffic study aimed at identifying the existing travel demand associated with the airport as well as the existing traffic volumes on the surrounding streets and intersections within the area of influence. The traffic entering Cairo International Airport during June 2003 was counted specifically.

The vehicle categories were divided into private cars and metered taxis, microbuses and pick-ups, buses and trucks. The average daily traffic was about 10,000 vehicles, varying from one weekday to another. The last week of the month recorded the highest flow. This is due to the summer season where tourism is high and the massive return of Egyptians working in the Gulf area for vacationing. These data are in accordance to the projected traffic flows used in the dispersion models.

For the emission estimates we have been searching for the peak hour traffic presented in some of the prognoses. In the model estimate for maximum impact we have used the numbers of passengers and cars presented in Table 6 (from Master Plan, Landside traffic, Annex B).

Table 6: Number of peak hour passengers at ultimate development stage for two separate terminals and for one terminal, traffic including passengers, meters and greeters.

	Two terminals		One terminal
	TB 2/3	TB4	TB all
International	8250	5100	13000
Domestic	4350	800	4300
Total	**12600**	5900	17300

To enable estimates of emissions using international emission factors, we have divided the traffic into different vehicle types. Transportation modes have been taken from the Master Plan Annex B report. The traffic composition is given by:

From Master plan	Emission classes (international)
Private cars	Light gasoline vehicles
Taxis	Light gasoline vehicles
Mini buses	Light-heavy vehicles
Large buses	Buses
Lorries	Heavy-heavy vehicles

Based on the Master plan we have evaluated the relative composition of cars to arrive at the airport road during peak hour. This is the hour when the combination of passengers, employees and others are at maximum. The input data for modelling emissions is presented in Table 7.

Table 7: Distribution of cars on the airport road during peak hour (based on data for Development stage 1) and emission factors used (based on an average speed of traffic of 50 km/h when moving).

Type of car	Fraction of type	Number passengers	Number of cars	Emission factors (g/km)			
	%		N/h	NO_x	PM	HC	CO
Private cars	24	1350	700	1.93	0.035	1.7	10.4
Taxis	40	2070	1000	1.93	0.035	1.7	10.4
Mini buses	15	860	140	6.45	0.45	0.9	5.4
Large buses	20	1080	60	13.5	0.9	1.1	4.2
Lorries	1	-	2	15.25	1.6	1.1	7.3
Total	**100**	**5360-**	**1902**				

The emission factors are sensitive to the final results of the model estimates. A different composition of traffic, older cars and a different average speed may alter the results. The study performed by Dar El Handasah Consultants during the summer 2003 indicated somewhat higher percentage of private cars and taxis. However, this will not influence significantly on the model results. The number of cars as well as other input parameters used in the model estimates is in accordance with the counting performed in June-July 2003.

The entry traffic flow counted for Mondays and Wednesdays were about 12000 cars per day, which is equivalent to about at total average of 1000 cars per hour (both ways). This is exactly the number of cars used as input to the present situation estimate.

Figure 10 illustrates the traffic fluctuation of vehicles entering the airport at the six entry gates during the surveys conducted on 10 July 2003. It can be seen that the highest entry flow occurred at 9:00 am with a total flow of 1889 vehicles/hour. This would be expected due to major inflow of airport employees.

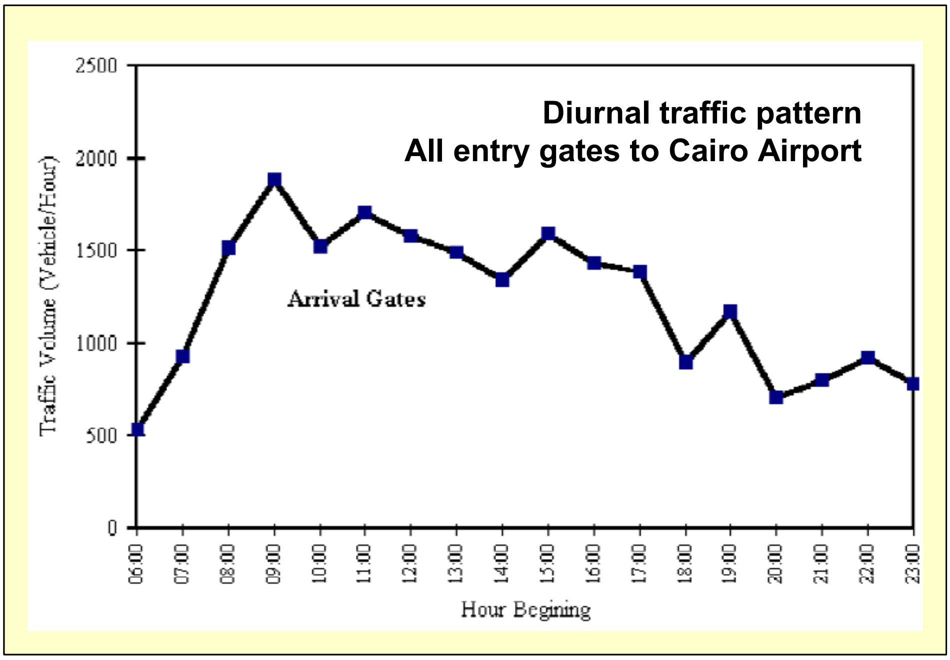


Figure 10: Diurnal variation of traffic at all gates leading to Cairo International Airport on10 July 2003.

Figure 11 show the traffic composition observed at the counting for all gates leading to Cairo International Airport on 10 July 2003. About 80 % of the traffic was private cars and taxis.

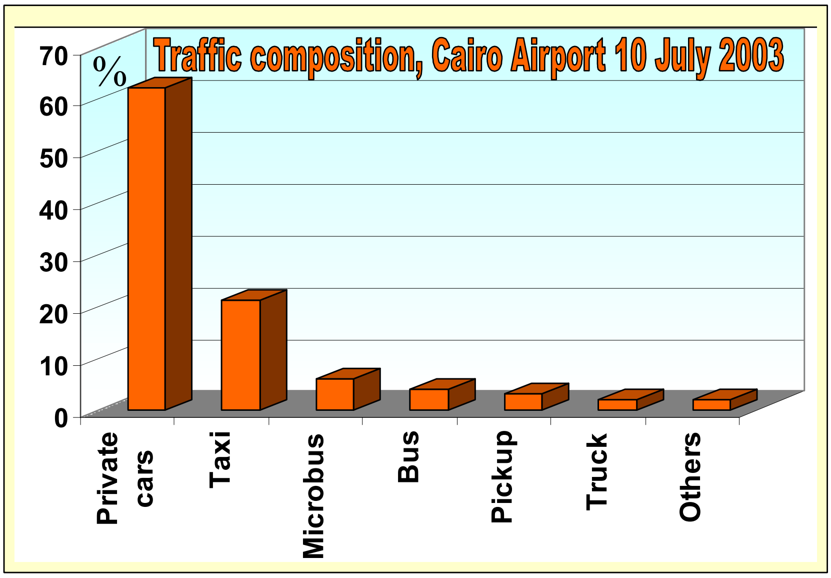


Figure 11: The traffic composition observed at all gates to Cairo International Airport on 10 July 2003.

5.3.2.1 Emission estimates for road traffic

To estimate the emissions of air pollutants on the roads leading to and from the airport we have used the following simple formula.

$$Q(tot) = \Sigma \{N(i) \times f(i) \times vel(i)\}$$

Where:

Q(tot) = total emission rate on the road (g/h)
i=type of vehicle
N(i) = number of vehicles per hour
vel (i) = average car speed on the road (km/h)
f(i) = emission factor for vehicle type i (g/km)

For estimates of emissions of pollutants in the unloading/loading area at the Terminal we have used the following formula:

$$Q(A) = \Sigma \{ N(i) \times f(i) \times t \}$$

Where:

Q(A) = emission rates per hour in the unloading/loading area A at the terminal
i = vehicle type
N(i) = number of vehicles of category i
f(i) = emission factor for idling for vehicle type i (g/s)
t = idling time during loading/unloading.

The data used for the estimates of emissions in the loading zone, when cars are idling, are given in Table 8.

Table 8: Emission factor for different type of vehicles at idling, "Summer conditions" (US-EPA, 1998).

Type of car	Number of cars	Idling time	Emission factor (g/h)			
	N/h	sec	NO_x	HC	CO	Exhaust particles
Private cars	700	60	4.72	16.1	229	2.62
Taxis	1000	60	4.72	16.1	229	2.62
Mini buses	140	100	5.71	24.1	339	2.57
Large buses	60	100	55.0	12.5	94	2.52
Lorries			25.0	8.0	50	2.59

The total emissions estimated from the traffic on the roads leading to and from the airport as well as the emissions generated while cars are idling in the loading and unloading zone at the Terminal are presented in Table 9 for the present situation at the airport.

Table 9: Estimated emissions for the present peak hour traffic leading to and from the Airport, as well as emissions from idling in the loading area at the Terminal building.

Present emissions (kg/h)				
	Nox	PM10	HC	CO
Driving at 50km/h	36,1	1,3	35,7	134,4
Load/unload idling	6,1	2,5	15,8	221,2
Total	42,2	3,8	51,4	355,6

Estimated emissions for the traffic leading to and from the airport Terminals 2/3 in the future has been presented in Appendix F4.

5.3.3 Future emissions from road traffic, Terminals 2/3

The traffic pattern inside the airport area will change after the building of Terminal 3. A sketch of the layout of roads is presented in Figure 12.

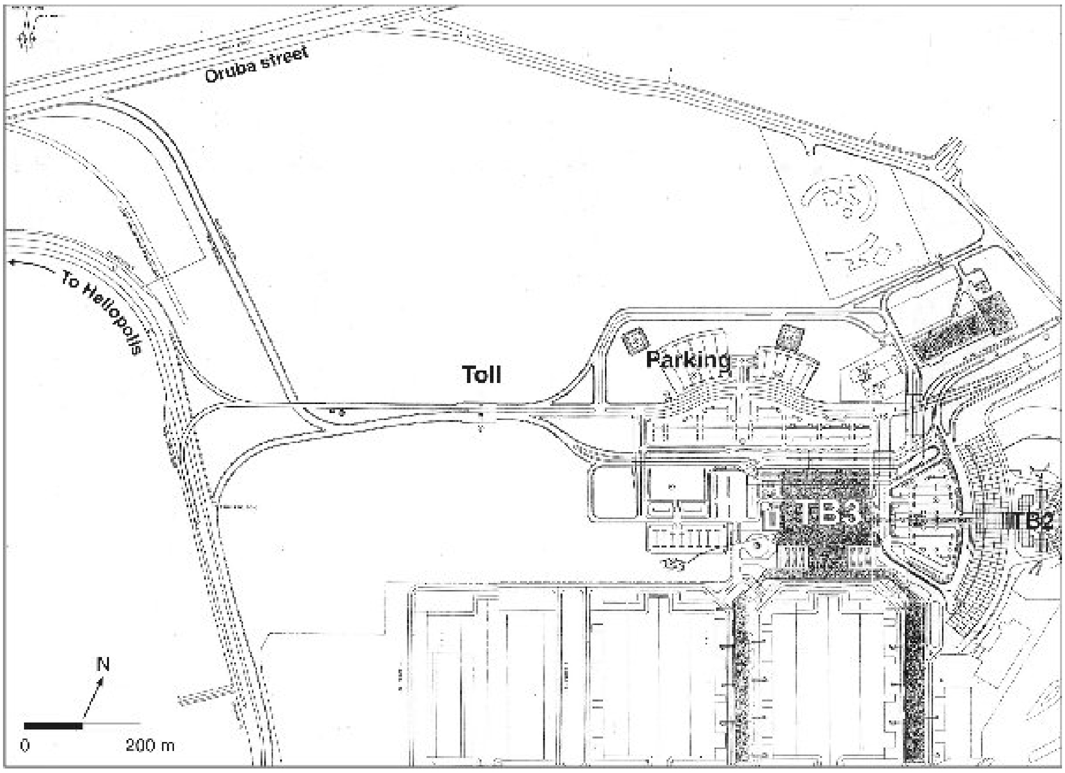


Figure 12: The layout of roads after the building of Terminal 3.

Traffic flows are based on the same references as used above. Road traffic information is taken from the Master Plan, while air craft movements have been based on the prognoses for future traffic at the Cairo Airport. The situation to day as presented above has been used as a starting point and adjusted to the prognoses given in the Master Plan.

The road traffic flows, which have been used to estimate the impact of traffic to and from the airport was based on the Master Plan estimates for a ultimate development stage with two separate terminal complexes and a total of 50 million passengers at Terminal 2/3 (20 million passengers at terminal 4).

We have further assumed that all traffic is approaching Terminal 2/3 via Orouba Street. From the last documents received we have seen from the counting that the traffic is divided in several roads, and there is a clear split in traffic at Orouba road, to Hayksteb road and to Ismailia road. It has been difficult to specify exactly on which roads the different part of the traffic will approach Terminal 2/3 in the future. Our assumptions will lead to a conservative (too high) estimate of the maximum ground level concentrations.

The total estimated emissions of NOx , PM_{10}, HC and CO from the road traffic leading to and from the new Terminal 2/3 is presented in Table 10.

Table 10: Traffic emissions (g/s) from vehicles moving to and from the airport estimated for the peak hour traffic. Total emissions are given in kg/h.

Road coordinates				Lenght(m)	Emissions (g/s)			
x0	y0	x1	y1		NOx(g/s)	PM10(g/s)	HC(g/s)	CO(g/s)
340004	3330423	342990	3332172	3460	9,7	0,35	9,5	35,9
342990	3332172	343715	3332534	811	1,1	0,04	1,1	4,2
343715	3332534	344099	3332364	420	0,6	0,02	0,6	2,2
344099	3332364	344738	3331873	806	1,1	0,04	1,1	4,2
344738	3331873	345207	3332087	515	0,7	0,03	0,7	2,7
345207	3332087	345527	3331916	363	0,5	0,02	0,5	1,9
345527	3331916	345783	3332193	377	3,9	1,40	9,3	124,9
345783	3332193	345591	3332492	355	0,5	0,02	0,5	1,8
345591	3332492	345996	3332876	558	0,8	0,03	0,8	2,9
345996	3332876	345975	3333558	683	1,0	0,03	0,9	3,5
345975	3333558	345570	3333622	410	0,6	0,02	0,6	2,1
345570	3333622	343715	3332534	2151	3,0	0,11	3,0	11,2
Total emissions from road traffic (kg/h)				**10908**	**84**	**7,55**	**103**	**711**

The emissions above are presented for each road segment used in the model. The road coordinates are specified by UTM co-ordinates in the table given at the end point of each segment.

One of the road segments (377 m long) includes the loading and unloading zone where cars are idling for an average time of one minute. We see that about 60 % of the CO emissions are coming from the relatively small area at the loading/ unloading zone at the Terminal building. This is a result of a large percentage of gasoline cars idling, which creates CO emissions.

5.3.4 Point sources, energy sources

Emissions from stationary sources in the airport area have not been estimated as data for fuel consumption and production numbers have not been made available.

The energy supply system mainly consists of electrical energy supply. Power is supplied to Cairo Airport (current situation) from the national grid operated by the Egyptian Electricity Transmission Company. One electrical power plant, including substations for step-down and electricity distribution, as well as an emergency power supply system with diesel generators has been planned.

Substations are located at Terminal 2 and a power plant is located within the TB2 area. The main station has 4 units with 25 MVA capacities. The current installed peak load at the airport is 40 MWA. The emission of air pollutants from the power plant will be dependent on what kind of fuel is being used. It is assumed to have limited adverse impact on the environment. However, the design of stacks and stack heights as well as any mitigation measures will have to be investigated.

5.3.5 Area sources, diffusive emissions

Handling of aviation fuels is a source of VOC emissions in the airport area. Leakages of hydrocarbons from storage tanks and parking areas could be a problem as the storage of aviation fuel, which is relatively volatile, could be subject to evaporation causing emissions to the atmosphere.

The present aviation fuel tank farm is situated near the cargo village. The storage capacity for the Jet A-1 6 fuel tanks is 12000 tons. There are two sources of fuel supply, one from Suez refinery by pipeline, the second one from Alexandria refinery by trucks.

We have assumed that closed tanks and modern handling and filling methods will reduce the emissions of VOC so that any impacts to the environment will be insignificant. HC emissions due to transport and handling could also cause some odour problems in the vicinity of the handling areas. However, these impacts would not be detectable outside the borders of the working atmosphere.

5.3.6 Total future emissions

The total emissions of air pollutants from the new Cairo Airport are summarised in the following table including emissions from roads, loading/unloading zones at Terminals 2/3 and the new runways.

We see from Table 11 that the emissions from road traffic leading to and from the airport will dominate the average emissions. This is due to the fact that these numbers represent the typical long-term average emissions (for each season or for a year). If we look at the emissions from aircraft during the hour when there is peak air traffic, we see that the emission rates from aircrafts totally are in the same order of magnitude as the road traffic. The three highest hours of emissions from aircrafts are also presented in Appendix E2, Table E6.

Table 11: Emissions of NOx, HC and CO from the future Cairo International Airport, roads, terminal loading and parking as well as all runways included.

	Future emissions (kg/h)			
	NO_x	PM_{10}	HC	CO
Road, 50km/h speed	72,1	2,6	71,3	268,4
Load/unload idling	12,2	5,0	31,6	442,7
Aircrafts, seasonal average	29,6	n.a.	23,2	60,9
Aircrafts, maximum hour	*75,0*	*n.a.*	*54,9*	*142,2*
Total average emissions	113,9	7,5	126,0	772,1

The road traffic emissions in this case represent a road length of about 10 km approaching the airport. At peak traffic hour for aircraft movements the emissions of NO_x and HC is comparable to the road traffic emissions, while the emissions of CO especially in the Terminal area with loading, unloading and parking is much higher.

Concerning the emissions of SO_2 and the impact assessment for SO_2 this has not been based on the same detailed emission inventories and modelling procedures as for the compounds presented above. The reason being that the emission rates for SO_2 from aircraft operations is normally only 5 to 10% of the NOx emission rates. (Rypdal, 2000) (EEA, 2000). This will to a certain degree depend of the fuel quality. The sulphur content in jet fuel is normally as low as about 0.02 % S. It has also been stated (Rypdal, 2000) that the total emissions from aviation normally do not contribute much to national total emissions.

6 Model results

The results from air pollution modelling are presented as spatial concentration distributions in the following chapters. The most important air pollutants originating from the airport activities are nitrogen oxides, hydrocarbons and carbon monoxide. Particles may also be emitted from the airport activities. However, the contribution of e.g. PM_{10} from airport activities compared to the "natural" background concentration in the area is completely insignificant. We have thus not concentrated much effort on presenting the PM_{10} concentration distributions. The same applies for SO_2 emissions as mentioned in Chapter 5.3.6 above.

6.1 Present situation, model results

The present situation as described above has been estimated by the dispersion models to verify the relative importance of emissions from aircrafts and cars bringing passengers back and forth to the airport.

Table 12: Model estimated concentrations of NOx (NO_2), CO and HC during winter conditions at the existing Cairo International Airport.

		Winter concentrations (µg/m^3)		
Average	**Contribution from**	**NOx (NO_2)**	**CO**	**HC**
Monthly/ seasonal	Traffic along road	18	100	20
	At Terminal building	35	800	64
	At end of runway	14	100	8
1 hour maximum	Traffic along road	320	3000	300
	At Terminal building	250	6400	520
	At end of runway	200	1000	200

Measurements of NO_2 undertaken as weekly average concentrations by passive samplers near the roads and at the parking area has shown total concentrations between about 30 and 50 µg/m^3. Continuous measurements of NO_2 at the airport area have indicated NO_2 concentrations varying between 10 and 30 µg/m^3. We may conclude that the estimated contribution from the airport activities alone confirms these levels. The worst hour, which may occur during low-wind winter conditions, is in accordance with the expected hourly maximum concentrations in the area.

CO concentrations are probably most interesting near the Terminal area where cars are idling (load/unload zone). The highest hourly average CO concentration measured in July 2003 was 5.6 mg/m^3. The model estimated contribution from the traffic to the airport has been estimated to reach up to 6,4 mg/m^3. Along the road leading the Terminal 2 buildings may reach 3 mg/m^3 as an absolute maximum. On the average the CO concentrations will be in the order of 0,1 to 0,8 mg/m^3, which is in accordance with what was measured during the summer 2003. Also the HC concentration estimates seem to be in accordance with typical measured VOC concentration levels at the airport during the summer 2003.

6.2 Air quality due to the future Cairo Airport

Model estimated concentration distributions for NO_x, CO and HC are presented below. The concentrations represent the seasonal average and peak hour maximum in the Cairo Airport area. Additional impact from pollution generated by other sources in the greater Cairo area included traffic emissions on roads, which are not linked to airport traffic will have to be added based on general measurements in areas outside the airport area.

6.2.1 Nitrogen dioxide (NO_2) concentrations

In the estimates of NO_2 concentrations as a result of emissions from road traffic and aircraft operations we have assumed that the ozone concentrations occurring in the area is high enough to transform all NOx to NO_2.

6.2.1.1 Average NO_2 concentrations

Figure 13 show the average concentration pattern for a typical winter- and summer season at the new Cairo airport.

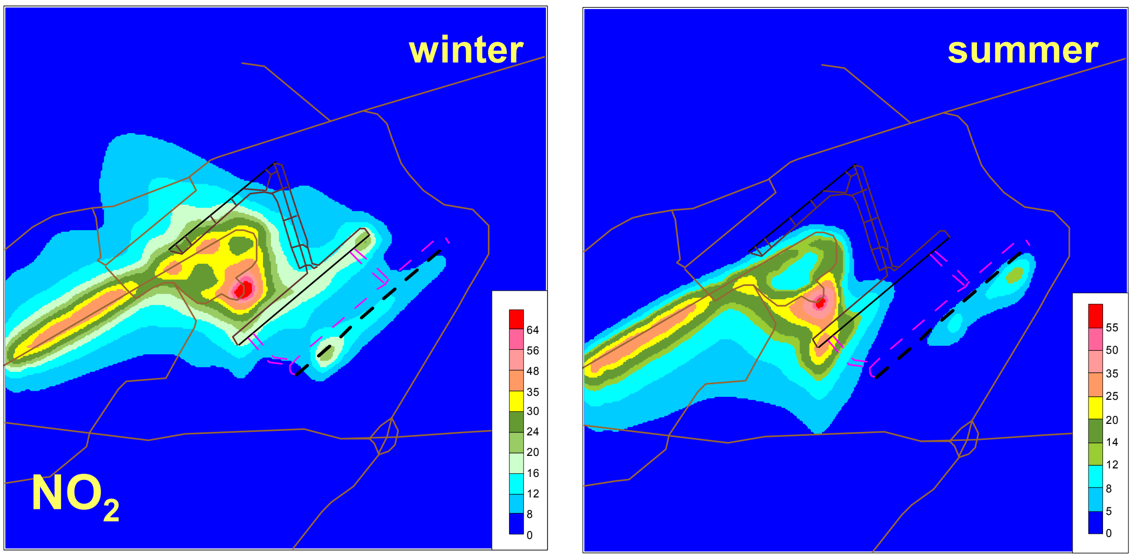


Figure 13; Seasonal average NO_2 concentration distributions estimated in the airport area as a result of emissions from airport activities such as planes and cars.

The concentrations in the maximum impact area resulting from all sources linked to the future airport are estimated to about 65 µg/m^3. The highest concentrations will occur along the road system and close to the terminal buildings. At the end of the runways the average concentrations of NO_2 may reach 30 μg/m^3 but these concentrations will be reduced very quickly only a few hundred metres away from the runways.

6.2.1.2 Maximum hourly concentrations of NO_2

The maximum NO_2 concentration has been estimated in all grid cells of the model area without considering which meteorological conditions are causing these maximum values. The picture in
Figure 14 therefore look rather complicated.

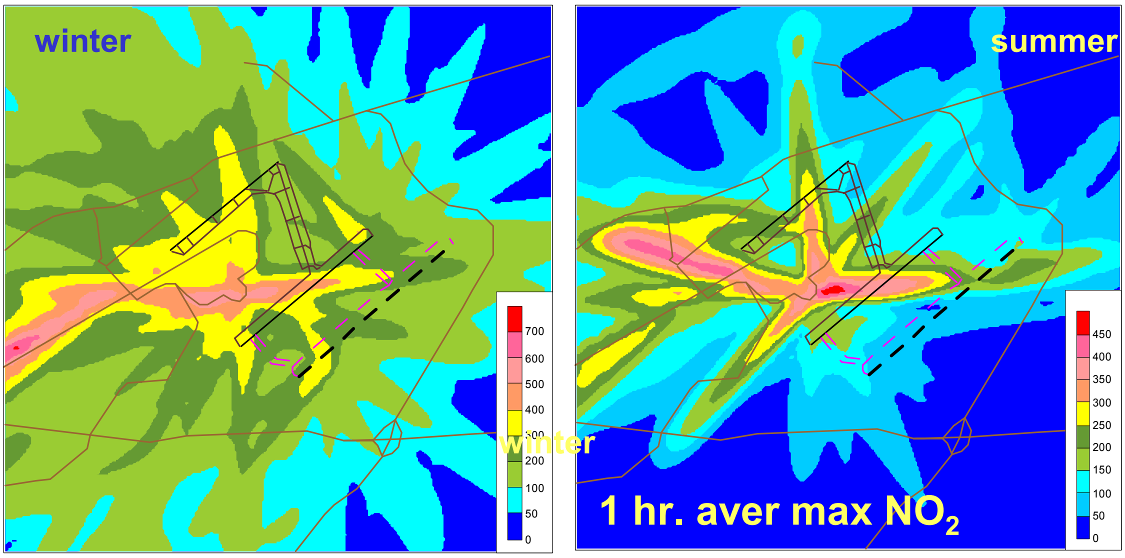


Figure 14: One hour average maximum NO_2 concentration distributions estimated in the airport area as a result of emissions from airport activities such as planes and cars

The highest NO_2 concentrations in winter will occur along the main road leading to the airport. Concentrations may in a small area around the road reach 600 μg/m^3. We should keep in mind that we have lead traffic to the airport along the Ourouba road. When distributing the traffic on several roads the concentrations may have been reduced somewhat. Also we will have to remember that this is actually the NOx concentration. At these levels it is doubtful that all NOx will occur as NO_2 due to background ozone levels. Concentration of more than 500 μg/m^3 NOx may also occur in the Terminal area.

During the summer season the highest NO_2 concentrations will reach about 450 μg/m^3 close to the terminal areas. The highest concentrations at the end of the runways will be about 200 μg/m^3.

6.2.2 Carbon monoxide (CO) concentrations

The highest CO concentrations seem to occur in the loading/unloading zone at Terminal 2/3 due to emissions when gasoline cars are idling. We have assumed an average idling time of one minute using the traffic flow presented above.

6.2.2.1 Seasonal average CO

Figure 15 indicate a average maximum area of CO concentrations at about 1,6 mg/m3 in the winter and 1,4 mg/m^3 in the summer season. In the aircraft taxing zones as well as along the road system leading to the airport the average CO concentrations will be less than 0,2 mg/m^3.

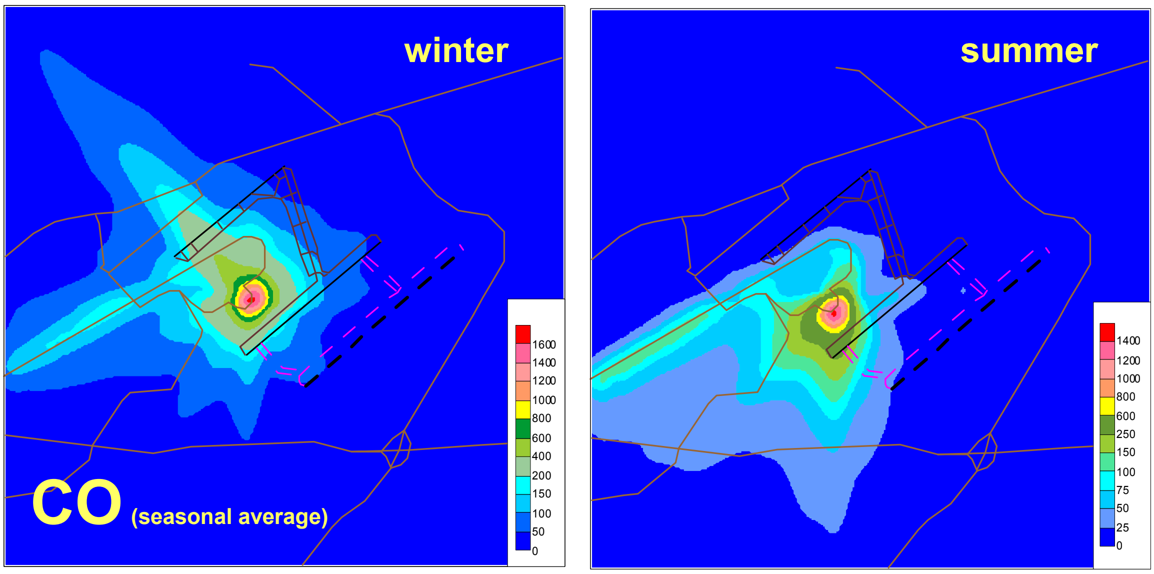


Figure 15: Seasonal average CO concentration distributions estimated in the airport area as a result of emissions from airport activities such as planes and cars.

More interesting when CO concentrations are concerned is to look at the short-term concentrations during peak hour traffic.

6.2.2.2 Hourly CO concentration during peak hour traffic

At peak hour, based at the time when the international flight activity is at its highest and the road traffic is peaking the CO concentrations inside the loading zone as well as between the terminal building and the taxing areas for aircrafts will reach levels close to or above international limit values.

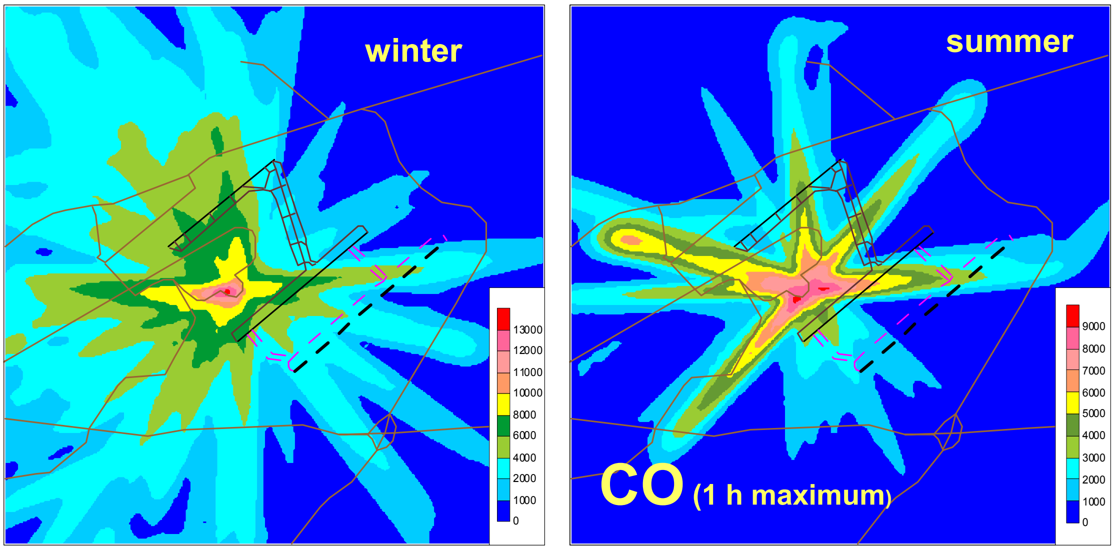


Figure 16; Maximum CO concentration distributions estimated in the airport area as a result of emissions from airport activities such as planes and cars

The highest CO concentration estimated as a one-hour average is presented in Figure 16 to be about 13 mg/m^3 in the winter season and about 9 mg/m^3 in the summer season. The international standards as well as the limit values given in the Egyptian law no. 4 are 30 mg/m^3 as a one-hour average. For the 8-h average concentrations the limit value is 10 mg/m^3.

None of these limit values will be exceeded due to the emissions from the airport activities alone. Already at a distance of about 3 km from the airport facilities (runways and terminal) the CO concentrations will be less than 2 mg/m^3 in the most impacted hour.

6.3 Concentrations of hydrocarbons

The highest concentrations of hydrocarbons will occur during the winter season. The emissions used for the model estimates only included the road traffic and the aircraft operations. Diffusive leakages of hydrocarbons from tank areas and storage facilities have not been included. However it is assumed that modern closed systems would not add significantly to the concentrations presented below.

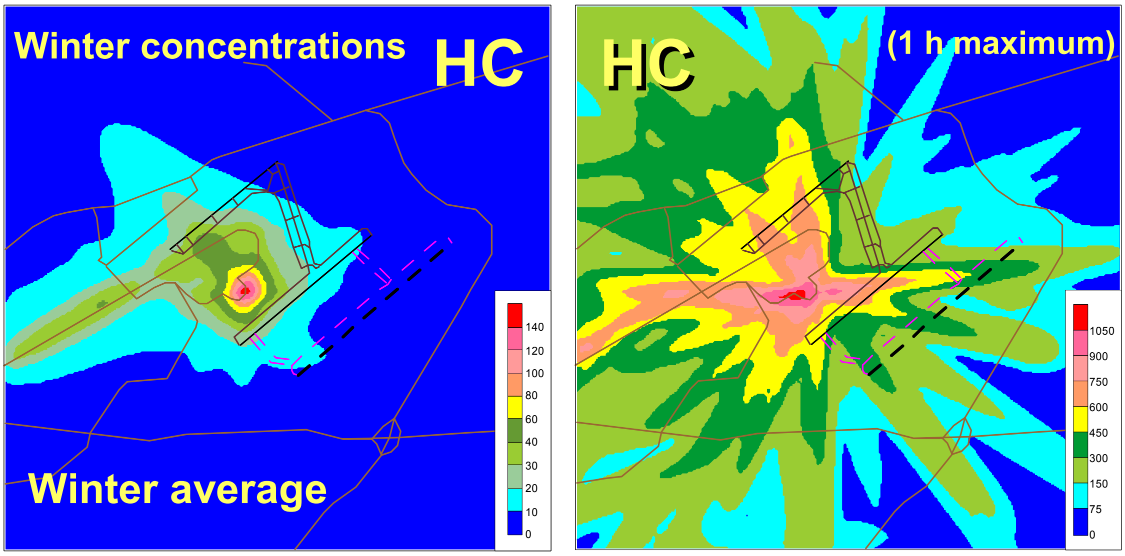


Figure 17: Winter average and maximum one-hour average concentrations of hydrocarbons (HC) estimated at the new Cairo Airport due to emissions from aircraft operations and road traffic.

The concentrations estimated for the winter season are higher than during the summer season.

therefore only shows the winter season averages and maximum concentrations.

The highest HC concentrations as a seasonal average are to be found near the terminal area. They are about 140 μg/m^3 and are due to cars and planes in the parking area and at idling mode. The highest short-term concentration of HC is estimated at about 1 mg/m^3 near the terminal area.

6.4 Estimated future concentrations, a summary

A summary of estimated future maximum concentrations as a result of the emissions from the new Cairo Airport activities is presented in Table 13.

Table 13: Model estimated concentrations of NOx (NO_2), CO and HC during winter conditions at the future Cairo International Airport

		Winter concentrations (μg/m^3)		
Average	**Contribution from**	**NOx (NO_2)**	**CO**	**HC**
Monthly/ seasonal	Traffic along road	40-50	200	40
	At Terminal building	64	1600	140
	At end of runway	20	200	30
1 hour maximum	Traffic along road	650	1000	600
	At Terminal building	500	13000	1050
	At end of runway	350	6000	600

The most critical concentrations compared to national and international standards and limit values are the short-term (1-hour average maximum) concentrations of nitrogen oxides that may occur along the road leading to the airport and around and close to the terminal buildings.

Also the maximum CO concentrations estimated at the terminal loading and unloading zone may approach the limit values during peak hour traffic if this coincides with adverse meteorological conditions.

The seasonal average concentrations of NO_x , along the road system may approach air quality limit values, but again this requires that all NO_x emitted from traffic is converted to NO_2 close to the road. This again requires that high ozone concentrations are present in the area.

The highest hydrocarbon concentrations are also estimated close to the terminal building. In this area we may experience concentrations at the same level as normally found inside streets and in urban areas. There are no standard values for HC or VOC. The only limit values are given by Italy as 200 $\mu g/m^3$ for 3 hour average of NMHC. Our estimates include methane and cannot be compared directly.

SO_2 concentrations are expected to be about 10 % or less than the NO_x concentrations estimated. This means that SO_2 concentrations generated by airport activities will be much less than the background concentrations generated by industries, open air burning and other sources in Cairo. During the measurements performed in the area in June-August 2003 we have detected hourly SO_2 concentrations ranging from 20 to 170 $\mu g/m^3$.

Also suspended particles will be insignificant from the airport activities compared to other sources (see discussion in Chapter 7).

7 Air Quality assessment

7.1 Suspended particle, a main problem in Cairo

The air quality generally observed and monitored in the north-eastern part of Cairo is dominated by sources other that those linked to the airport activities. The main air pollution problem in the area is the high concentrations of suspended dust in the air. The sources for this dust is natural windblown dust combined with emissions from traffic, open air waste burning and other sources. On the average the airport activities only contribute with a rather small portion of the total dust burden.

7.2 Nitrogen oxides, from traffic

Nitrogen oxide concentrations may reach relatively high levels close to the road systems and under the take-off flight pattern very close to the runways. In the close vicinity of the road system and in the terminal area the NO_2 concentrations, when added the regional background, may in the future exceed the limit values given by the Law no. 4 in Egypt.

The model estimated concentrations presented in this report have been based on total NOx emissions. The formation of NO_2 close to the roads and in the terminal area will depend upon the background ozone concentrations. During afternoon hours ozone levels have been measured at about 120 $\mu g/m^3$. This indicates that only during adverse meteorological conditions during peak hour traffic can we expect the NO_2 concentrations to exceed the limit values. Concentrations exceeding the Egypt limit of 400 $\mu g/m^3$ (or WHO guideline value:200 $\mu g/m^3$) is only probable very near the roads under the assumption that impacts from all other sources in the area is added.

The exposure to people living near to the airport will probably be limited. It is not expected that adverse health impact can be detected as a result of the airport activities alone. However, adding the background air pollution and nitrogen oxides originating from the high traffic registered on roads surrounding the airport area, a fair number of people might be exposed to air pollution exceeding the limit values given in Law no. 4.

These NO_2 levels combined with high concentrations of suspended particles and ozone may result in an undesired health impact in the area. More detailed studies of exposure based on predicted traffic in the area will have to be undertaken to draw exact and quantitative conclusions.

7.3 CO concentrations only at the terminal

High CO concentrations may occur close to the Terminal building due to idling of a number of vehicles. In the maximum hour scenario the ground level concentrations in the unloading/loading zone could reach 13 mg/m^3 as a one-hour average concentration. The limit value for this averaging time is 30 mg/m^3.

It is not probable that adverse health impacts will occur due to CO emissions. However in the worst hours, very close to the cars and in cases when there is traffic jam at the terminal, people may be annoyed by these high CO concentrations.

7.4 The total HC level compared to individual compounds

The estimated concentrations of hydrocarbons, especially around the terminal buildings, are due to a combination of road traffic and aircraft movements on the ground. The concentration levels of these “total HCs” are not extremely high.

However, the composition of hydrocarbons may lead to undesired levels of some individual compounds. Some of the compounds may cause unpleasant odour problems to people close to the sources.

Other hydrocarbons such as benzene (or BTEX) for which there are international standards, may exceed the required levels. Sources of benzene in ambient air include cigarette smoke, combustion and evaporation of benzene-containing petrol and combustion processes. Mean ambient air concentrations of benzene in rural and urban areas are about 1 $\mu g/m^3$ and 5–20 $\mu g/m^3$, respectively. In the WHO report (WHO, 2000) it is stated that benzene is carcinogenic to humans and no safe level of exposure can be recommended. In the European

The proposed limit value for benzene in Europe (CEC 1994) is 5 $\mu g/m^3$, as an annual mean, to be achieved by 1 January 2010. Specific estimates of these compounds have not been possible in this study.

8 Needs for Environmental Management Plan (EMO)

A project's environmental management plan (EMP) consists of the set of mitigation, monitoring, and institutional measures to be taken during implementation and operation to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels. The plan also includes the actions needed to implement these measures.

Based on the outcome of the EIA for a new Cairo International Airport and the discussions of air quality impacts and assessments there will probably not be an urgent need to start evaluation an optimal abatement plan for the airport activities at this point in time.

However, there are reasons to look at the impact from the road traffic bringing passengers to and from the airport. The NOx exposure predicted may be reduced considerably by implementing three-way catalytic converters. In our model estimates we have assumed the same emission factors for the traffic 2020 as during the present situation. Most modern cars are equipped with catalytic converters, which help to reduce carbon monoxide, VOCs and NO_x emissions. The converter uses two different types of catalysts, a reduction catalyst and oxidization catalyst. Introduction of catalytic converters will also reduce the general impact of nitrogen oxides in Cairo.

Reducing the traffic jam and redirecting the traffic so that the flow of traffic is improved may reduce the high CO concentrations estimated during peak hour traffic at the terminals.

Another important development, which may reduce road traffic impacts, is to further develop the metro system in Cairo to include the airport in a public transportation system.

For future planning and final impact assessments it will be necessary to finally estimate the total impact in Cairo and compare this with the relative impact from airport activities including possible options to reduce the impact. The tools for undertaking these kinds of optimal abatement strategy planning is available at NILU through the GIS based air quality management system AirQUIS. (Sivertsen and Bøhler, 2000), AirQUIS, 2003). The establishment of such systems has been proposed to EEAA as a continuation of the air quality monitoring programmes operated by EEAA.

9 Summary and conclusions

The present air quality situation at the Cairo International Airport has been evaluated based on measurements administrated and collected by the Egypt Environmental Affairs Agency (EEAA).

The main air pollution problem is suspended particulate matter originating from traffic, open air burning and natural wind blown dust. Ozone concentrations may also during specific periods in the summer season exceed the limit values given in Law no. 4 of Egypt. The emissions of hydrocarbons and nitrogen oxides from airport activities may increase the ozone formation on a regional scale. However, it has not been possible to complete this evaluation in this report.

Calculations of emissions and concentrations of NO_X, CO, and HC (VOC) around the airport have been performed for the present situation and for future developments. The results indicated that the contribution from the airport on a local and regional scale is small.

Close to the roads and in the terminal areas, however, maximum concentrations of NO_2 and CO may reach close to the national and international limit values. The emissions from the airport activities alone will only in very limited areas and for some very specific peak hour cases approach adverse levels. Adding the contributions from other sources in the north-eastern Cairo area may lead to impacts that can influence on the population's exposure and well being to give undesired effects.

The simplest mitigation actions may be to improve the automobile quality to introduce catalytic converters, to redirect traffic and to assure that the idling time in the terminal areas are reduced to a minimum. Also public transport system improvement to the airport area may reduce road traffic impacts.

10 References

AirQUIS (2003) The ultimate software for air quality management. URL: http://www.nilu.no/airquis/ (Accessed 2003-09-16).

Abdelhady, Y., El-Araby, T., El-Araby, H. (1999) Annual Report 1998. Air quality in Egypt based upon EIMP data. Cairo, Cairo University CEHM.

Abdelhady, Y., El-Araby, T., El-Araby, H. (2000) Annual Report 1999. Air quality in Egypt based upon EIMP data. Cairo, Cairo University CEHM.

Ahmed, H. (2003) Air Quality in Egypt, 2002. Cairo (Environmental Information and Monitoring Programme, EIMP report).

Arab Consulting Engineers (2002) Cairo International Airport, Third Runway Project. Task 1.3. Study and Recommendations. Revised version April 2002.

Bøhler, T. (1996) MEPDIM. The NILU meteorological processor for dispersion modelling. Version 1.0. Model description. Kjeller, Norwegian Institute for Air Research (NILU TR 7/96).

Dar El Handasah Consultants (2003) Traffic counting Cairo International Airport, June-July 2003. Cairo, (Draft report)

EU (1994) European Parliament and Council Directive on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminal to service stations (94/ 63/ EC), *Official Journal of the European Communities,* L 365, 31/12/1994, 24-30.

European Environment Agency (2000) UNECE/EMEP/EEA The emission inventory Guidebook. Snap codes 080501-04, Air Traffic. URL: http://reports.eea.eu.int/technical_report_2001_3/en.

Egypt (1994) Maximum limits for outdoor air pollutants, as given by Annex 5 of the Law number 4 for 1994, Law for the Environment, Egypt.

El-Raey, M. et al. (1999) Quarterly Report no. 1, 1999. Air quality in Egypt based upon EIMP data (Alexandria and Nile Delta). Alexandria, IGSR, University of Alexandria.

Gram, F. and Walker, S-E. (2002) Calculation of air quality around Oslo airport Gardermoen, 2001. Kjeller, Norwegian Institute for Air Research (NILU OR 33/2002). In Norwegian.

International Civil Aviation Organization (1995) ICAO engine exhaust emissions data bank. First edition. Montreal (ICAO Doc, 9646-AN/943).

International Civil Aviation Organization (2001) Aviation emission databank. URL: http://www.qinetiq.com/aviation_emissions_databank/index.asp (Accessed 2001-11-27).

Jane's Information Group. (1996) Jane's all the world's aircraft 1996-97. Coulsdon, UK, Jane's.

Netherlands Airport Consultants (NACO) and ECG Engineering (1994) Cairo Airport Authority, Consulting Services, Terminal Area no.3. Traffic forecast 1993 – 2020. Nasr City, Cairo (Draft report January 1994)

Physick, W.L., Hurley, P.J., Blockley, A., Rayner, K.N., and Mountford, P. (2002) Verification of the air quality models TAPM and DISPMOD in coastal regions. In: *Coastal environment: environmental problems in coastal regions IV*, *Rhodes, Greece*, ed. by: C.A. Brebbia. Southampton, WIT Press. (Environmental Studies vol. 8). pp. 425-434.

Rypdal, K. (2000) Aircraft emissions. Background papers – IPCC Expert meetings on Good practice guidance and uncertainty management in national greenhouse gas inventories.
URL: http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_5_Aircraft.pdf (Accessed 2003-09-16).

Sivertsen, B. (1999) DANIDA. Air Pollution in Egypt. Status after the first year of EEAA/EIMP measurements. Kjeller, Norwegian Institute for Air Research (NILU OR 33/99).

Sivertsen, B. (2001a) DANIDA. Environmental Information and Monitoring Programme (EIMP). Air quality monitoring component. Mission 19 report. Kjeller, Norwegian Institute for Air Research (NILU OR 7/2001).

Sivertsen, B. (2001 b) Passive sampling of SO_2 and NO_2 ambient air concentrations in Cairo, October 2000. Kjeller, Norwegian Institute for Air Research (NILU OR 16/2001).

Sivertsen B. and Bøhler T. (2000) On-line Air Quality Management System for Urban Areas in Norway. Presented at "The air of our cities – it's everybody's business". Paris 16-18 February 2000. Kjeller, Norwegian Institute for Air Research (NILU F 4/2000).

Sivertsen, B. and Dreiem, R. (2000) DANIDA. Environmental Information and Monitoring Programme (EIMP). Air quality monitoring component. Mission 18 report. Kjeller, Norwegian Institute for Air Research (NILU OR 38/2000).

Sivertsen, B. and Dreiem, R. (2003) DANIDA EIMP Phasing-out Phase, 2003-2004. End of Mission report, Air Quality Monitoring, Mission 02, May-June 2003. Kjeller, Norwegian Institute for Air Research (NILU OR 41/2003).

Sivertsen, B., El Seoud, A.A., Fathy, H. and Ahmed, H. (2001) Air Pollution in Egypt. Presented at the 12th World Clean Air & Environment Congress, 26-31 August 2001, Seoul, Korea. Kjeller, Norwegian Institute for Air Research (NILU F 02/2001).

Sivertsen, B., Mocioaca, G. and Gram, F. (2003) Air quality impact assessment. Cairo International Airport, Terminal 3. Baseline studies. Kjeller, Norwegian Institute for Air Research (NILU OR 62/2003).

Slørdal, L.H., Walker, S.-E. and Solberg, S. (2003) The urban air dispersion model EPISODE. Technical description. Kjeller, Norwegian Institute for Air Research (NILU TR in print).

United States Environmental Protection Agency (1998) Emission facts. Idling Vehicle emissions, Ann Arbor, EPA (EPA420-F-98-014)

World Health Organization (2000) Air quality guidelines for Europe, second edition. Copenhagen, WHO, Regional Office for Europe (WHO Regional Publications, European Series, No. 91)

Appendix A

Air Quality Limit Values

Air Quality Limit values for Egypt

Air Quality Limit values are given in the Executive Regulations of the Environmental Law no. 4 of Egypt (Egypt 1994). These Air Quality Limit values are presented in

Ambient Air Quality Limit values as given by Law no.4 for Egypt (1994) compared to the World Health Organisation (WHO) air quality guideline values.

Pollutant	Averaging time	Maximum Limit Value	
		WHO	Egypt
Sulphur dioxide (SO_2)	1 hour	500 (10 min)	350
	24 hours	125	150
	Year	50	60
Nitrogen dioxide (NO_2)	1 hour	200	400
	24 hours	-	150
	Year	40-50	
Ozone (O_3)	1 hour	150-200	200
	8 hours	120	120
Carbon monoxide (CO)	1 hour	30 000	30 000
	8 hours	10 000	10 000
Black Smoke (BS)	24 hours	50 *	150
	Year	-	60
Total Suspended Particles (TSP)	24 hours	-	230
	Year	-	90
Particles <10 µm (PM_{10})	24 hours	70 **	70
Lead (Pb)	Year	0.5-1,0	1

* Together with SO_2 ** Norwegian Air Quality Limit value

Dust fall (DF), which are measured as part of the programme, have no Air Quality Limit value. However, some countries normally state that when dust fall values exceed 10 g/m^2 per 30 days, the area may be considered unclean (polluted).

Appendix B

Meteorological data

A summary of meteorological condition at the airport area has been based on data collected at the airport and data from the EIMP/EEAA measurement station at Abbaseya (Abdelhady et al., 1999 and El-Raey et al., 1999).

Climatological data Airport

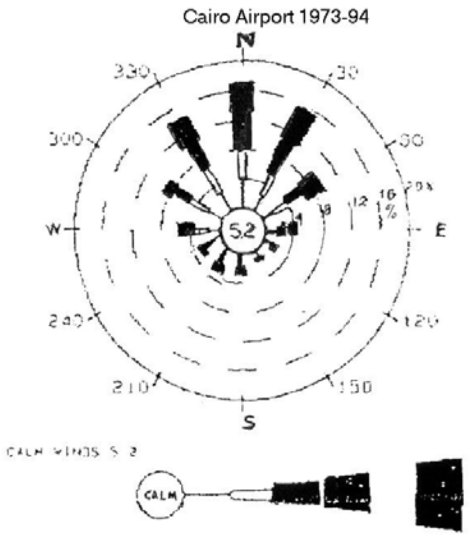
Air temperature

Temperature data have been collected at the airport during the period 1961-1990. Cairo Airport reference temperature is 35°C.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
18.8	20.6	23.7	28.5	32.1	34.7	34.4	34.0	32.7	29.7	24.7	20.3	**27.9**

Wind

The following wind frequency distribution (wind rose) has been based on measurements between 1973 and 1994.



A first analyses of the wind data from the airport indicates that:

- The predominant wind directions on an annual basis are from around North ± 45 degrees.
- Most wind speeds are ranging between 7 and 10 m/s. For flight conditions that correspond for code number 2 to a usability factor of 91% (which respects the minimum global usability factor of 80%) and for code numbers 3 and 4 to a usability factor of 100% (which respects the minimum global usability factor of 95%).

Sand storm and dust

Sand storm and dust corresponds to a yearly mean of 5.6 days per month. This lower visibility may lead to use the runway with precision approach conditions.

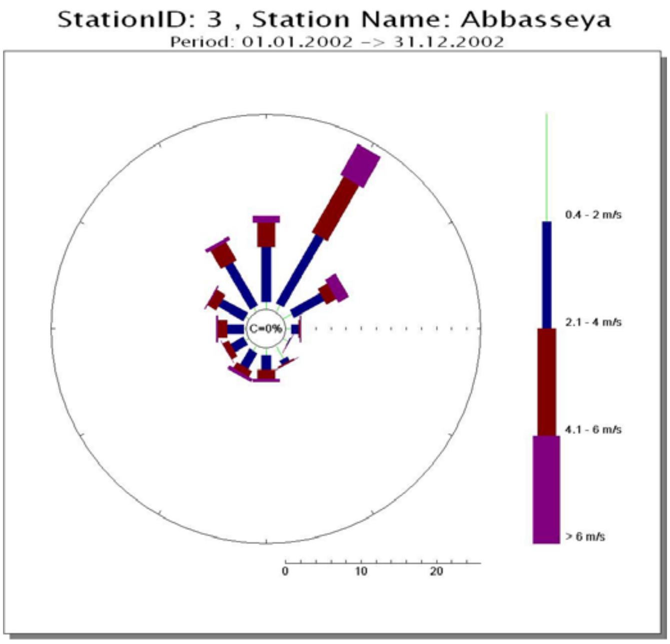
The monthly and annual mean number of days of occurrence of sand storm is presented in the following table:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0.4	0.8	1.0	1.0	0.4	0.1	0.0	0.1	0.1	0.1	0.2	0.4	**0.4**

The monthly and annual mean number of days of occurrence of dust is presented in the following:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
8.1	8.9	8.4	8.3	5.2	2.4	2.3	1.3	1.2	3.2	4.4	7.7	**5.2**

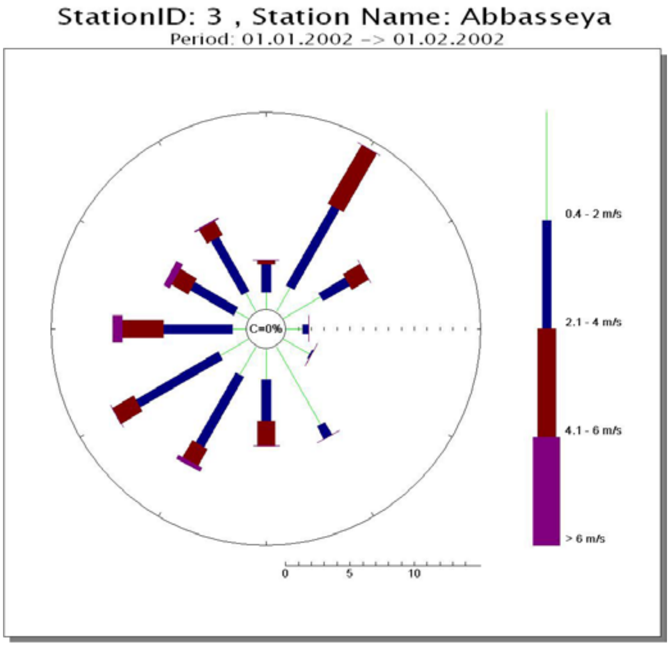
Wind at Abbaseya
The wind frequency distribution for Abbaseya for 2002 is presented in the following Figure.

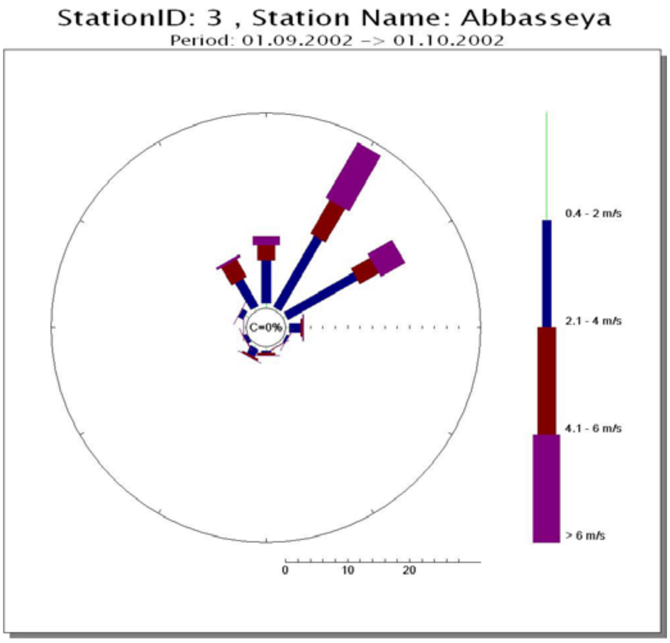


Compared to the 30 year average wind rose based on data fro the Airport there is a slight shift in wind directions at Abbaseya indicating that the wind is more canalised down the valley from around North-north-east.

This may be a realistic feature that indicates that emission released at the surface will be transported more along the valley than indicated by the measurements at the airport. We thus assume that the wind frequencies reported by the Abbaseya measurements will be representative for the low level emissions of air pollutants at the airport area.

The wind frequency distributions used in the model estimates have been selected for one winter month (January 2002) and one summer month (September 2002) as presented in the following Figures.





In the summer season the winds are almost always from northerly directions blowing air pollutants into the Cairo city centre, while during the winter months it is much more frequently blowing from around south and west blowing air pollutants emitted at the airport area away from Cairo city centre.

Appendix C

Number of passengers and aircraft movements

App C1: Estimated number of passengers at peak hour traffic.

DISTRIBUTION OF PEAK HOUR PASSENGERS/
MEETERS/GREETERS AT ULTIMATE DEVELOPMENT STAGE –
70 MILLION PAX IN TB1 AND TB2/3
(International Arrivals Peak)

	TB1 AND TB2/3		TB 2/3		TB 4	
Annual Pax (Airside)	70 000 000		50 000 000		20 000 000	
Peak Hour						
Total Pax - Airside	18 200		13 250		6 200	
Total Pax – Landside (95%) 5 % transit?	17 300		12 600		5 900	
Total Arrivals	10 400		7 550		3 550	
Total Departures	6 900		5 050		2 350	
International Total	13 000		8 250		5 100	
International Arrivals						
. Egyptians (40%)		3 100		1 980		1 220
. Foreign Tourists (30%)		2 350		1 485		915
. Business and Other Foreigners (30 %)		2 350		1 485		915
Total International Arrivals	7 800		4 950		3 050	
Meeters		9 725		6 188		3 813
International Departures						
. Egyptians (40%)		2 100		1 320		820
. Foreign Tourists (30%)		1 550		990		615
. Business and Other Foreigners (30 %)		1 550		990		615
Total International Departures	5 200		3 300		2 050	
Greeters		5 750		3 630		2 255
Domestic Total	4 300		4 350		800	
Domestic Arrivals						
. Egyptians (20%)		500		520		100
. Foreign Tourists (50%)		1 300		1 300		250
. Business and Other Foreigners (30 %)		800		780		150
Total Domestic Arrivals (60%)	2 600		2 600		500	
Meeters		2 450		2 470		475
Domestic Departures						
. Egyptians (20%)		350		350		60
. Foreign Tourists (50%)		850		875		150
. Business and Other Foreigners (30 %)		500		525		90
Total Domestic Departures	1 700		1 750		300	
Greeters		1 200		1 225		210

Appendix C2: Prognoses for Total Aircraft movements and annual passenger movements at Cairo Airport.

Cairo International Airport Traffic Forecast 1993-2020

Annual Total Aircraft Movements

	High scenario, Table 4.5					Low scenario, Table 4.12				
	Pax			Non-pax	Total Aircraf	Pax			Non-pax	Total Aircraft
	Int'l	Domestic	Total		Movements	Int'l	Domestic	Total		Movements
1983	53 896	14 002	67 898	0	67 898	53 896	14 002	67 898	0	67 898
1992	48 689	19 896	68 585	2 195	70 780	48 689	19 896	68 585	2 195	70 780
1995	51 600	26 100	77 700	5 400	83 100	50 700	24 400	75 100	5 300	80 400
2000	64 600	35 400	100 000	7 000	107 000	59 900	26 600	86 500	6 100	92 600
2005	81 500	46 200	127 700	8 900	136 600	70 000	31 700	101 700	7 100	108 800
2010	100 900	59 100	160 000	11 200	171 200	80 400	37 300	117 700	8 200	125 900
2015	121 400	73 500	194 900	13 600	208 500	90 200	42 000	132 200	9 300	141 500
2020	139 400	87 400	226 800	15 900	242 700	98 000	45 400	143 400	10 000	153 400

Annual Passenger Movements

	High scenario, Table 4.2 and 4.3					Low scenario, Table 4.9 and 4.10				
	Pax			Non-	Passenger	Pax			Non-	Passenger
	Int'l	Domestic	Total	scheduled	Movements	Int'l	Domestic	Total	scheduled	Movements
1983	5 397 997	1 068 543	6 466 540	620 954	7 087 494	5 397 997	1 068 543	6 466 540	620 954	7 087 494
1992	4 924 507	1 962 673	6 887 180	852 625	7 739 805	4 924 507	1 962 673	6 887 180	852 625	7 739 805
1995	5 626 000	2 472 000	8 098 000	993 000	9 091 000	5 466 000	2 338 000	7 804 000	964 000	8 768 000
2000	7 756 000	3 633 000	11 389 000	1 369 000	12 758 000	6 809 000	2 761 000	9 570 000	1 202 000	10 772 000
2005	10 634 000	5 264 000	15 898 000	1 877 000	17 775 000	8 499 000	3 574 000	12 073 000	1 500 000	13 573 000
2010	14 248 000	7 418 000	21 666 000	2 514 000	24 180 000	10 426 000	4 518 000	14 944 000	1 840 000	16 784 000
2015	18 415 000	10 068 000	28 483 000	3 250 000	31 733 000	12 467 000	5 497 000	17 964 000	2 200 000	20 164 000
2020	22 592 000	13 035 000	35 627 000	3 987 000	39 614 000	14 387 000	6 372 000	20 759 000	2 539 000	23 298 000

Appendix D

Emission factors for different types of aircrafts

Emission factors from aircrafts

It has been difficult to get an exact survey of the emissions from the different type of planes operating at Cairo Airport.

We have used data from the literature on similar type of planes, but different companies may use different engines and there have been recent changes due to the fact that many companies want to reduce the noise levels. In this study we have used data given by Jane (1996) as well as from the ICAO Engine Exhaust Emissions Data Bank (1995).

All types of planes are allocated to one of the emission classes 1-7, based on engine size and type. In addition there are data for GA-traffic (General Aviation).

For each of the emission class the consumption of fuel is given in g/s for departure, landing and taxing/idling. The following table presents the emission factors used in this study.

Table D.1: Fuel consumption and emission factors.

			Take-off				Approach				Idle			
		%	fuel	HC	CO	NOx	fuel	HC	CO	NOx	fuel	HC	CO	NOx
Code	Aircraft type	traffic	kg/s	g/kg	g/kg	g/kg	kg/s	g/kg	g/kg	g/kg	kg/s	g/kg	g/kg	g/kg
C	MD81-87,A320,o.l.	50	1,32	0,28	0,8	25,7	0,3833	1,6	4,17	9,1	0,1372	3,33	12,27	3,7
D	A330.B767.MD11.DC9	15	2,342	0,06	0,44	32,1	0,6584	0,13	2	11,6	0,208	9,92	41,86	3,98
E/F	B737-600/700/800	20	0,903	0,07	4,26	13,25	0,278	0,36	11,37	9,39	0,102	8,11	49,71	3,75
other	Turbo.DH8.EMB.F50	15	0,064	6,21	3,4	19,25	0,034	5	33,24	13,93	0,019	62,37	91,94	1,16
	Weighted factor	100	1,2015	1,0945	1,828	23,2025	0,35111	1,6415	9,645	10,2575	0,1231	14,131	36,147	3,371

For NO_x the highest emissions come from take-off, while for CO and HC the highest emissions comes from idling planes.

Appendix E

Aircraft emission estimates

E1: Time consumed in each of the modes; idling, taxing, take off

The time use at Cairo airport is based upon similar studies of time use at Gardermoen, Norway, together with information from aircraft personnel. There is defined a coordinate system with 100 m squares and with the vertical axis along the runways, with an origo so that the northeast end of the new runway has the grid coordinates (1,1). The y-axis is to the right of this, so that the runway of the existing runway 23L/05R has an x-coordinate of 16, corresponding to 1.6 km to the right of the new runway. In the model calculations the emissions that are calculated in this coordinate system are turned 130º and transformed into the modelling system, with 250 m grid cells.

For each aircraft arriving the airport a route from the end of the runway to a stop point at the middle of the terminal building is defined. For a landing aircraft the speed is reduced from about 250 km/h to 30 km/h. It is then entering a taxing mode to the terminal with about 30 km/h. When the aircraft changes the taxing direction its speed is reduced to 25 km/h, and in areas with heavy traffic of crossing taxing aircrafts some extra seconds are lost.

Before departure the aircraft is normally waiting some seconds with the engines idling before it can enter the taxing runway, and it moves towards the end of the runway. "You have no use of the runway behind you." The aircraft is standing at the end with full engines, and the speed is increased until the take-off. Some aircrafts, special smaller aircrafts will use "intersection take-off", both on landing and take-off, but we have no information to estimate this.

The time use may at the first glance seem to be very high, especially for the arrival and take-off, but this is based upon actual time recordings at several airports worldwide.

The time use pattern is different for different aircrafts. The information about the aircraft type at Cairo Airport was very limited. We thus had to make the calculations for an average aircraft. The emission calculations for the existing runway is based upon that domestic flight are using Terminal 1, while the international flights are using Terminal 2. For the new runway it is assumed that domestic flights are using Terminal 2 and the old runway (23L/05R), while the international flights will be using Terminal 3 to the new runway (23LL/05RR). Table 1 shows the use in seconds for different movements at Cairo Airport, and Table 2 and Table 3 shows the time use for the existing and for the new runway, respectively.

Table E1: Time use in seconds for different movements at Cairo Airport.

Existing runway

	23 L				05 R			
	Term 1		Term 2		Term 1		Term 2	
	Cells	Time	Cells	Time	Cells	Time	Cells	Time
Arrival	20	107.3	20	107.3	20	107.3	20	107.3
Taxing	40	416	29	348	19	222	24	295
Taxing	37	423	38	457	44	530	20	252
Take-off	24	56.3	24	56.3	24	56.3	24	56.3

New runway

	23 LL				05 RR			
	Term 2		Term 3		Term 2		Term 3	
	Cells	Time	Cells	Time	Cells	Time	Cells	Time
Arrival	20	107.3	20	107.3	20	107.3	20	107.3
Taxing	55	651	49	588	48	588	69	835
Taxing	36	451	32	404	63	770	72	881
Take-off	24	56.3	24	56.3	24	56.3	24	56.3

The time use may seem to be too high, especially for the arrival and take-off.

For the present-situation the traffic schedule obtained based on recorded flights 2002 for one week has been used. For the winter season there was a total of 1047 movements (arrivals or departures) during the week, and for the summer season there was 946 movements. Over a year, this gives a traffic density of about 52 000 movements. In addition to this, there is a lot of non-scheduled traffic that should be included in the calculations.

For the future situation in 2020 it is assumed a traffic density of about 200 000 movements. To reach this, the traffic schedule 2000 is used twice: first with the domestic traffic at Terminal 1 and international traffic at Terminal 2 with the existing runway, secondly with domestic flights at Terminal 2 and international flights at Terminal 3, using the new runway. Finally the emission fields are multiplied by 2 to correspond with the 200 000 movements.

A summary of time use applied as input to the emission models is presented in the following tables.

Table E2: Time use for existing runway from Terminal 1/2. Seconds in 100 m grid cells.

ARRIVAL

Arrival 23L	Term 2		Arrival 23L	Term 1		Arrival 05 R	Term 2		Arrival 05 R	Term 1	
	20	107.33		20	107.33		20	107.33		20	107.33
16	13	1.44	16	13	1.44	16	52	1.44	16	52	1.44
16	14	1.54	16	14	1.54	16	51	1.54	16	51	1.54
16	15	1.65	16	15	1.65	16	50	1.65	16	50	1.65
16	16	1.78	16	16	1.78	16	49	1.78	16	49	1.78
16	17	1.94	16	17	1.94	16	48	1.94	16	48	1.94
16	18	2.12	16	18	2.12	16	47	2.12	16	47	2.12
16	19	2.34	16	19	2.34	16	46	2.34	16	46	2.34
16	20	2.62	16	20	2.62	16	45	2.62	16	45	2.62
16	21	2.96	16	21	2.96	16	44	2.96	16	44	2.96
16	22	3.42	16	22	3.42	16	43	3.42	16	43	3.42
16	23	4.03	16	23	4.03	16	42	4.03	16	42	4.03
16	24	4.92	16	24	4.92	16	41	4.92	16	41	4.92
16	25	6.30	16	25	6.30	16	40	6.30	16	40	6.30
16	26	8.77	16	26	8.77	16	39	8.77	16	39	8.77
16	27	9.00	16	27	9.00	16	38	9.00	16	38	9.00
16	28	9.5	16	28	9.5	16	37	9.5	17	37	9.5
16	29	10	16	29	10	16	36	10	17	36	10
16	30	10.5	16	30	10.5	16	35	10.5	17	35	10.5
16	31	11	16	31	11	16	34	11	18	34	11
16	32	11.5	16	32	11.5	16	33	11.5	18	33	11.5

Taxing 23L	Term 2		Taxing 23L	Term 1		Taxing 05R	Term 2		Taxing 05R	Term 1	
	29	348		40	416		24	295		19	222
16	33	12	16	33	12	16	32	12	19	32	15
16	34	12	16	34	12	16	31	8	20	31	15
16	35	12	16	35	12	17	31	8	21	31	15
16	36	12	16	36	12	17	30	15	22	30	15
16	37	12	16	37	12	17	29	15	23	30	12
16	38	12	16	38	12	18	28	15	23	30	15
16	39	12	16	39	12	19	28	15	24	30	8
16	35	12	16	35	12	19	29	12	24	29	8
16	36	12	16	36	12	19	30	12	25	29	15
16	37	12	16	37	12	19	31	12	26	29	8
16	38	12	16	38	12	19	32	12	26	28	8
16	39	12	16	39	12	19	33	12	27	28	12
16	40	12	17	40	15	19	34	12	28	28	12
16	41	12	18	40	15	19	35	12	29	27	12
16	42	12	19	39	12	19	36	12	30	27	12
16	43	12	19	38	12	19	37	12	31	27	8
17	44	12	19	37	12	19	38	12	31	26	8
17	45	8	19	36	12	20	38	12	32	26	12
18	45	15	19	35	12	20	39	12	33	27	12
19	45	12	19	34	12	20	40	15			
19	44	12	19	33	12	21	40	12			
20	44	8	19	32	12	22	40	12			
20	43	12	20	31	15	23	40	12			
20	42	15	21	31	15	23	41	12			
20	41	8	22	31	8						
21	42	15	22	30	8						
22	42	12	23	30	12						
23	42	15	24	30	6						
23	41	12	24	29	6						
			25	29	12						
			26	29	8						
			26	28	8						
			27	28	12						
			28	28	12						
			29	27	12						
			30	27	12						
			31	27	8						
			31	26	8						
			32	26	12						
			33	27	12						

DEPARTURE

Taxing 23L		Term 2	Taxing 23L		Term 1	Taxing 05R		Term 2	Taxing 05R		Term 1
	38	457.00		37	423.00		20	252.00		44	530.00
23	41	20	33	27	20	23	41	20	33	27	20
23	42	15	32	26	12	23	42	15	32	26	12
22	42	12	32	25	12	22	42	12	32	25	12
21	42	15	31	24	8	21	42	15	31	24	8
20	41	8	30	25	12	20	41	8	30	25	12
20	40	12	29	25	12	20	42	15	29	25	12
20	39	12	28	25	8	20	43	12	28	25	8
20	38	12	28	26	10	20	44	8	28	26	10
20	37	12	27	26	8	19	44	12	27	26	8
20	36	12	26	27	8	19	45	12	26	27	8
20	35	12	25	27	15	19	46	15	25	27	15
20	34	12	24	27	15	19	47	12	24	27	15
20	33	12	23	28	15	19	48	12	23	28	15
20	32	12	22	28	15	19	49	12	22	28	15
19	32	12	21	29	12	19	50	12	21	29	12
19	31	12	21	28	6	19	51	12	21	28	6
19	30	12	20	28	12	19	52	12	20	28	15
19	29	12	19	28	8	18	53	12	19	29	15
19	28	12	19	27	8	17	53	12	19	30	12
19	27	12	19	26	12	16	52	12	19	31	12
19	26	12	19	25	12				19	32	12
19	25	12	19	24	12				19	33	12
19	24	12	19	23	12				19	34	12
19	23	12	19	22	12				19	35	12
19	22	12	19	21	12				19	36	12
19	21	12	19	20	12				19	37	12
19	20	12	19	19	12				19	38	12
19	19	12	19	18	12				19	39	12
19	18	12	19	17	12				19	40	12
19	17	12	19	16	12				19	41	12
19	16	12	19	15	12				19	42	12
19	15	12	19	14	12				19	43	12
19	14	12	19	13	5				19	44	12
19	13	5	18	13	10				19	45	12
18	13	10	18	12	12				19	46	12
18	12	12	17	12	12				19	47	12
17	12	12	16	13	12				19	48	12
16	13	12							19	49	12
									19	50	12
									19	51	12
									19	52	12
									18	53	12
									17	53	12
									16	52	12

Departure 23L		Term 2	Departure 23L		Term 1	Departure 05 R		Term 2	Departure 05 R		Term 1
	24	56.32		24	56.32		24	56.32		24	56.32
16	13	10.00	16	13	10.00	16	52	10.00	16	52	10.00
16	14	6.67	16	14	6.67	16	51	6.67	16	51	6.67
16	15	5.00	16	15	5.00	16	50	5.00	16	50	5.00
16	16	4.00	16	16	4.00	16	49	4.00	16	49	4.00
16	17	3.33	16	17	3.33	16	48	3.33	16	48	3.33
16	18	2.86	16	18	2.86	16	47	2.86	16	47	2.86
16	19	2.50	16	19	2.50	16	46	2.50	16	46	2.50
16	20	2.22	16	20	2.22	16	45	2.22	16	45	2.22
16	21	2.00	16	21	2.00	16	44	2.00	16	44	2.00
16	22	1.82	16	22	1.82	16	43	1.82	16	43	1.82
16	23	1.67	16	23	1.67	16	42	1.67	16	42	1.67
16	24	1.54	16	24	1.54	16	41	1.54	16	41	1.54
16	25	1.43	16	25	1.43	16	40	1.43	16	40	1.43
16	26	1.33	16	26	1.33	16	39	1.33	16	39	1.33
16	27	1.25	16	27	1.25	16	38	1.25	16	38	1.25
16	28	1.18	16	28	1.18	16	37	1.18	16	37	1.18
16	29	1.11	16	29	1.11	16	36	1.11	16	36	1.11
16	30	1.05	16	30	1.05	16	35	1.05	16	35	1.05
16	31	1.00	16	31	1.00	16	34	1.00	16	34	1.00
16	32	0.95	16	32	0.95	16	33	0.95	16	33	0.95
16	33	0.91	16	33	0.91	16	32	0.91	16	32	0.91
16	34	0.87	16	34	0.87	16	31	0.87	16	31	0.87
16	35	0.83	16	35	0.83	16	30	0.83	16	30	0.83
16	36	0.80	16	36	0.80	16	29	0.80	16	29	0.80

Table E3: Time use for the new runway from Terminal 2/3. Seconds in 100 m grid cells.

ARRIVAL

Arrival 23LL	T3		Arrival 23LL	T2		Arrival 05 RR	T3		Arrival 05 RR	T2	
	20	107.33		20	107.33		20	107.33		20	107.33
1	1	1.44	1	1	1.44	1	40	1.44	1	40	1.44
1	2	1.54	1	2	1.54	1	39	1.54	1	39	1.54
1	3	1.65	1	3	1.65	1	38	1.65	1	38	1.65
1	4	1.78	1	4	1.78	1	37	1.78	1	37	1.78
1	5	1.94	1	5	1.94	1	36	1.94	1	36	1.94
1	6	2.12	1	6	2.12	1	35	2.12	1	35	2.12
1	7	2.34	1	7	2.34	1	34	2.34	1	34	2.34
1	8	2.62	1	8	2.62	1	33	2.62	1	33	2.62
1	9	2.96	1	9	2.96	1	32	2.96	1	32	2.96
1	10	3.42	1	10	3.42	1	31	3.42	1	31	3.42
1	11	4.03	1	11	4.03	1	30	4.03	1	30	4.03
1	12	4.92	1	12	4.92	1	29	4.92	1	29	4.92
1	13	6.3	1	13	6.3	1	28	6.3	1	28	6.3
1	14	8.77	1	14	8.77	1	27	8.77	1	27	8.77
1	15	9	1	15	9	1	26	9	1	26	9
1	16	9.5	1	16	9.5	1	25	9.5	1	25	9.5
1	17	10	1	17	10	1	24	10	1	24	10
1	18	10.5	1	18	10.5	1	23	10.5	1	23	10.5
1	19	11	1	19	11	1	22	11	1	22	11
1	20	11.5	1	20	11.5	1	21	11.5	1	21	11.5

Taxing 23LL	T3		Taxing 23LL	T2		Taxing 05RR	T3		Taxing 05RR	T2	
	49	588		55	651		69	835		48	588
1	21	12	2	21	12	1	20	12	1	20	12
1	22	12	2	22	12	1	19	12	2	19	15
1	23	12	2	23	12	1	18	12	2	18	15
1	24	12	3	24	12	1	17	12	3	17	12
1	25	12	3	25	12	1	16	12	4	17	12
1	26	12	3	26	12	1	15	12	5	17	12
1	27	12	3	27	12	1	14	12	6	17	12
1	28	12	3	28	12	2	13	12	7	17	12
1	29	12	3	29	8	2	12	12	8	17	12
1	30	12	3	29	4	2	11	10	9	17	12
1	31	12	3	30	12	3	11	12	10	17	12
1	32	12	3	31	12	4	11	12	11	17	12
1	33	12	3	32	12	4	12	12	12	17	12
1	34	12	3	33	12	4	13	12	13	17	12
1	35	12	3	34	12	4	14	12	14	17	12
1	36	12	3	35	12	4	15	12	15	17	12
1	37	12	3	36	12	4	16	12	16	17	15
1	38	12	3	37	12	4	17	12	17	17	12
1	39	12	3	38	12	5	17	12	18	17	12
1	40	12	3	39	12	6	17	12	19	18	12
2	40	15	3	40	15	7	17	12	19	19	12
3	40	15	3	40	15	8	17	12	19	20	12
3	41	10	3	41	10	9	17	12	19	21	12
4	41	5	4	41	5	10	17	12	19	22	12
4	42	15	4	42	15	11	17	12	19	23	12
4	43	5	4	43	5	12	17	12	19	24	12
5	43	10	5	43	10	13	17	12	19	25	12
5	44	15	5	44	15	14	17	12	19	26	12
6	46	15	6	46	15	15	17	12	19	27	12
7	47	15	7	47	15	16	17	15	19	28	12
7	48	10	7	48	10	17	17	12	19	29	12
8	48	12	8	48	12	18	17	12	19	30	12
9	48	12	9	48	12	19	18	12	19	31	12
10	48	12	10	48	12	19	19	12	19	32	15
11	48	12	11	48	12	19	20	12	20	32	12
12	48	12	12	48	12	19	21	12	20	33	12
13	48	12	13	48	12	19	22	12	20	34	12
14	48	12	14	48	12	19	23	12	20	35	12
15	48	12	15	48	12	19	24	12	20	36	12
16	48	15	16	48	15	19	25	12	20	37	12
17	48	12	17	48	12	19	26	12	20	38	12
18	48	12	18	48	12	19	27	12	20	39	12
19	48	8	19	48	8	19	28	12	21	39	12
20	48	12	19	47	12	19	29	12	22	39	12
21	48	12	19	46	12	19	30	12	23	39	12
22	48	15	19	45	12	19	31	12	23	40	12
23	48	12	19	44	12	19	32	15	24	40	12
23	49	12	19	43	15	20	32	12	24	41	12
23	50	12	20	42	12	20	33	12			
			20	41	12	20	34	12			
			21	42	12	20	35	12			

			22	42	12	20	36	12			
			23	42	12	20	37	12			
			23	42	15	20	38	12			
			24	41	12	20	39	12			
						20	40	12			
						20	41	12			
						20	42	12			
						20	43	12			
						20	44	12			
						20	45	12			
						20	46	12			
						20	47	12			
						20	48	12			
						21	48	12			
						22	48	15			
						23	48	12			
						23	49	12			
						23	50	12			

TAKE-OFF

Taxing 23LL	T3		Taxing 23LL	T2		Taxing 05RR	T3		Taxing 05RR	T2	
	32	404		36	451		72	881		63	770
23	50	20	24	41	20	23	50	20	24	41	20
23	49	12	23	42	12	23	49	12	24	40	12
23	48	15	22	42	15	23	48	15	23	40	12
22	48	12	21	42	15	22	48	12	22	40	12
21	48	12	20	42	12	21	48	12	21	40	12
20	48	12	20	43	12	20	48	12	20	39	12
19	48	12	20	44	8	19	48	12	20	38	12
19	48	12	19	44	12	19	47	12	20	37	12
18	48	12	19	45	12	19	46	12	20	36	12
17	48	12	19	46	12	19	45	12	20	35	12
16	48	15	19	47	12	19	44	12	20	34	12
15	48	12	19	48	12	19	43	12	20	33	12
14	48	12	18	48	12	19	42	12	20	32	12
13	48	12	17	48	12	19	41	12	19	32	15
12	48	12	16	48	15	19	40	12	19	31	12
11	48	12	15	48	12	19	39	12	19	30	12
10	48	12	14	48	12	19	38	12	19	29	12
9	48	12	13	48	12	19	37	12	19	28	12
8	48	12	12	48	12	19	36	12	19	27	12
7	47	15	11	48	12	19	35	12	19	26	12
7	48	10	10	48	12	19	34	12	19	25	12
6	46	15	9	48	12	19	33	12	19	24	12
6	45	15	8	48	12	19	32	12	19	23	12
5	44	15	7	47	15	19	31	12	19	22	12
5	43	10	7	48	10	19	30	12	19	21	12
5	42	15	6	46	15	19	29	15	19	20	12
4	41	5	6	45	15	19	28	12	19	19	12
4	42	15	5	44	15	19	27	12	19	18	12
4	43	5	5	43	10	19	26	12	19	17	12
3	40	15	5	44	15	19	25	12	18	17	12
2	40	15	4	41	5	19	24	12	17	17	15
1	40	12	4	42	15	19	23	12	16	17	12
			4	43	5	19	22	12	15	17	12
			3	40	15	19	21	12	14	17	12
			2	40	15	19	20	12	13	17	12
			1	40	12	19	19	12	12	17	12
						19	18	12	11	17	12
						19	17	12	10	17	12
						18	17	12	9	17	12
						17	17	15	8	17	12
						16	17	12	7	17	12
						15	17	12	6	17	12
						14	17	12	5	17	12
						13	17	12	4	17	12
						12	17	12	3	17	12
						11	17	12	3	16	12
						10	17	12	3	15	12
						9	17	12	3	14	12
						8	17	12	3	13	12
						7	17	12	3	12	12
						6	17	12	3	11	12
						5	17	12	3	10	12
						4	17	12	3	9	12
						3	17	12	3	8	12
						3	16	12	3	7	12
						3	15	12	3	6	12
						3	14	12	3	5	12
						3	13	12	3	4	12

3	11	12	3	2	12
3	10	12	3	1	12
3	9	12	2	1	12
3	8	12	1	1	12
3	7	12			
3	6	12			
3	5	12			
3	4	12			
3	3	12			
3	2	12			
3	1	12			
2	1	12			
1	1	12			

Take-offT3			Take-offT2			Take-offT3			Take-offT2		
	24	56.32		24	56.32		24	56.32		24	56.32
1	40	10	1	40	10	1	1	10	1	1	10
1	39	6.67	1	39	6.67	1	2	6.67	1	2	6.67
1	38	5	1	38	5	1	3	5	1	3	5
1	37	4	1	37	4	1	4	4	1	4	4
1	36	3.33	1	36	3.33	1	5	3.33	1	5	3.33
1	35	2.86	1	35	2.86	1	6	2.86	1	6	2.86
1	34	2.5	1	34	2.5	1	7	2.5	1	7	2.5
1	33	2.22	1	33	2.22	1	8	2.22	1	8	2.22
1	32	2	1	32	2	1	9	2	1	9	2
1	31	1.82	1	31	1.82	1	10	1.82	1	10	1.82
1	30	1.67	1	30	1.67	1	11	1.67	1	11	1.67
1	29	1.54	1	29	1.54	1	12	1.54	1	12	1.54
1	28	1.43	1	28	1.43	1	13	1.43	1	13	1.43
1	27	1.33	1	27	1.33	1	14	1.33	1	14	1.33
1	26	1.25	1	26	1.25	1	15	1.25	1	15	1.25
1	25	1.18	1	25	1.18	1	16	1.18	1	16	1.18
1	24	1.11	1	24	1.11	1	17	1.11	1	17	1.11
1	23	1.05	1	23	1.05	1	18	1.05	1	18	1.05
1	22	1	1	22	1	1	19	1	1	19	1
1	21	0.95	1	21	0.95	1	20	0.95	1	20	0.95
1	20	0.91	1	20	0.91	1	21	0.91	1	21	0.91
1	19	0.87	1	19	0.87	1	22	0.87	1	22	0.87
1	18	0.83	1	18	0.83	1	23	0.83	1	23	0.83
1	17	0.8	1	17	0.8	1	24	0.8	1	24	0.8

The emissions from an aircraft in the grid cell (I, J) are calculated as

Q (I, J, K, L) = Time (I, J) * CONS (K) * FACT (K,L), where

K	is the phase of the movement (landing, taxing or take-off),
L	is the compound (CO, HC or NOx),
CONS(K)	is the specific fuel consumption in phase K (g fuel /s) and
FACT (K, L)	is the emission factor for compound L in phase K in g/kg fuel.

The emission calculations are made for an aircraft in the lowest 50 meters, normally it will on this stage be outside the calculation area. This means that we in the calculations are not calculating the emissions from the Approach phase, neither from the Climb phase (which are parts of a normal LTO-cycle).

The emissions for one week are calculated as shown in Table 4.

Table E4: Emissions from scheduled air traffic at Cairo Airport 2000 and 2020. Unit: kg/week.

Season	Compound	Existing runway, 2000	Existing + new runway, 2020
Winter	CO	2138.83	10238.18
	HC	808.04	3890.06
	NOx	1203.84	4972.28
Summer	CO	1650.56	10325.83
	HC	619.55	3819.22
	NOx	1057.57	4550.18

The difference between winter and summer emissions is partly due to a different number of movements (1047 and 946), but also due to a different numbers of aircrafts in the runway directions (23/05). For year 2020 the traffic is four times the 2000-traffic, but the emissions are also much higher due to the longer taxing ways for the new runway, specially for CO and HC, where the taxing emissions are highest. For NOx the highest emissions are from take-off, and are calculated as the same for the old and the new runway.

Table E5: Input data for estimating total emissions from aircrafts at the Cairo Airport in 2002.

	23L/2	23L/1	05R/2	05R/1	fuel	HC	CO	NOx
	seconds	seconds	seconds	seconds	kg/s	g/kg	g/kg	g/kg
Arrival	107,33	107,33	107,33	107,33	0,3511	1,6415	9,645	10,2575
Taxe	348	416	295	182	0,1231	14,131	36,147	3,371
Taxe	457	423	252	530	0,1231	14,131	36,147	3,371
T-O	56,32	56,32	56,32	56,32	1,2015	1,0945	1,828	23,2025

Emissions	23L/2				23L/1				05R/2				05R/1			
g/moveme	fuel	HC	CO	NOx	fuel	HC	CO	NOx	fuel	HC	CO	NOx	fuel	HC	CO	NOx
Arrival	37,68	61,86	363,47	386,55	37,68	176,18	1035,20	1100,94	37,68	176,18	1035,20	1100,94	37,68	176,18	1035,20	1100,94
Taxe	42,82	605,09	1547,87	144,35	51,19	5878,29	15037,15	1402,34	36,30	4168,50	10663,37	994,45	22,40	2571,75	6578,75	613,52
Taxe	56,23	794,61	2032,68	189,56	52,05	5977,20	15290,18	1425,93	31,01	3560,89	9109,04	849,49	65,22	7489,17	19157,91	1786,63
T-O	67,67	74,06	123,70	1570,08	67,67	61,64	102,95	1306,76	67,67	61,64	102,95	1306,76	67,67	61,64	102,95	1306,76

Assumption: 50-50 05 and 23

										Sum emissions 2002/2003, unit: kg/half year						
Emissions	Terminal 2				Terminal 1				winter	14,872	12,324		summer	11,336	13,234	
g/moveme	fuel	HC	CO	NOx	fuel	HC	CO	NOx	fuel	HC	CO	NOx	fuel	HC	CO	NOx
Arrival	37,68	61,86	363,47	386,55	37,68	61,86	363,47	386,55	512	841	4942	5256	463	760	4465	4749
Taxe	39,56	559,01	1430,00	133,36	36,79	519,89	1329,92	124,03	521	7360	18828	1756	468	6609	16905	1577
Taxe	43,62	616,39	1576,78	147,05	58,63	828,52	2119,42	197,65	686	9689	24785	2311	635	8976	22961	2141
T-O	67,67	74,06	123,70	1570,08	67,67	74,06	123,70	1570,08	920	1007	1682	21350	831	910	1520	19288

Arrival	37,68	61,86	363,47	386,55	37,68	61,86	363,47	386,55	37,68	61,86	363,47	386,55	37,68	61,86	363,47	386,55
Taxe	42,82	605,09	1547,87	144,35	51,19	723,32	1850,32	172,56	36,30	512,93	1312,13	122,37	22,40	316,45	809,52	75,49
Taxe	56,23	794,61	2032,68	189,56	52,05	735,49	1881,46	175,46	31,01	438,17	1120,87	104,53	65,22	921,54	2357,38	219,84
T-O	67,67	74,06	123,70	1570,08	67,67	74,06	123,70	1570,08	67,67	74,06	123,70	1570,08	67,67	74,06	123,70	1570,08
									fuel	HC	CO	NOx	fuel	HC	CO	NOx
								Arrival	975	1601	9408	10005	19	4	10	17
								Taxe	989	13969	35734	3332	20	39	37	6
								Taxe	1321	18665	47746	4453	26	52	50	8
								T-O	1751	1917	3202	40638	35	5	3	70
								sum,kg	5036	36152	96089	58429	100	100	100	100

Table E6: Estimated total emissions (g/h) during the most impacted hour at the Cairo Airport. The three highest hourly emissions are listed for the winter season. The weekday and hour is also indicated in the Table.

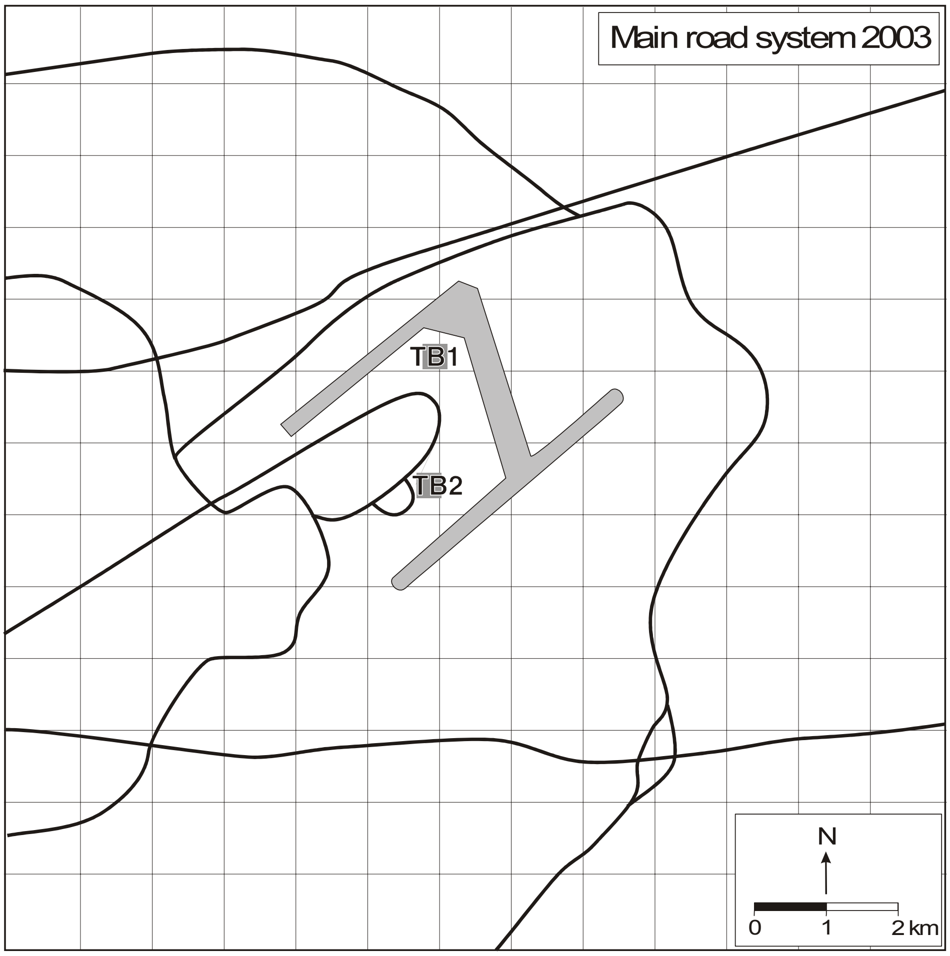
Max hour	Winter emissions (g/h)		
	CO	HC	NOx
Present emissions	25500	9868	15995
	Fri 22	Sun 07	Mon 13
	26800	10093	16343
	Thu 17	Fri 14	Mon 13
	26900	10167	18622
	Fri 14	Thu 17	Sun 07
Future emissions	CO	HC	NOx
	122690	46333	66094
	Fri 14	Fri 14	Mon 13
	140510	53723	70208
	Mon 15	Mon 15	Mon 03
	142420	54895	74976
	Mon 03	Mon 03	Sun 07

Appendix F

Road traffic

Car emission factors and emission estimates

Appendix F1 :
The road network in the surrounding areas of the airport as of 2003.



Appendix F2:

Idling Vehicle Emissions

Introduction

The following tables present idle emission factors, in grams per hour (g/hr) and grams per minute (g/min) of idle time, for volatile organic compounds (VOC), carbon monoxide (CO), and oxides of nitrogen (NO_x). Idle emissions of particulate matter (PM_{10}) are provided for heavy-duty diesel vehicles only; PM_{10} emissions from gasoline-fueled vehicles are negligible, especially when the elimination of lead in gasoline and reductions of sulphur content are accounted for. Emission factors are provided for both summer and winter conditions for VOC, CO, and NO_x. These idle emission factors are from the MOBILE5b highway vehicle emission factor model (VOC, CO, NO_x) and the PART5 model (PM_{10} for heavy-duty diesel vehicles only). These emission factors are national averages for all vehicles in the in-use fleet as of January 1, 1998 (winter) or July 1, 1998 (summer). PM_{10} idle emission factors for heavy-duty diesels are as of January 1, 1998.

Winter Conditions (30°F, 13.0 psi RVP gasoline)

Pollutant	Units	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
VOC	g/hr	21.1	30.7	44.6	3.63	4.79	12.6	20.1
	g/min	0.352	0.512	0.734	0.061	0.080	0.211	0.335
CO	g/hr	371	487	682	10.1	11.5	94.6	388
	g/min	6.19	8.12	11.4	0.168	0.191	1.58	6.47
NOx	g/hr	6.16	7.47	11.8	6.66	6.89	56.7	2.51
	g/min	0.103	0.125	0.196	0.111	0.115	0.945	0.042

Summer Conditions (75°F, 9.0 psi RVP Gasoline)

Pollutant	Units	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
VOC	g/hr	16.1	24.1	35.8	3.53	4.63	12.5	19.4
	g/min	0.269	0.401	0.597	0.059	0.077	0.208	0.324
CO	g/hr	229	339	738	9.97	11.2	94.0	435
	g/min	3.82	5.65	12.3	0.166	0.187	1.57	7.26
NOx	g/hr	4.72	5.71	10.2	6.50	6.67	55.0	1.69
	g/min	0.079	0.095	0.170	0.108	0.111	0.917	0.028

Particulate Matter Emissions

The only vehicle category for which EPA has idle PM_{10} emission factors is heavy-duty diesels. Particulate emissions are also observed to be relatively insensitive to temperature, and so "winter" and "summer" emission factors for idle PM_{10} are the same.

Engine Size	Emissions
Light/Medium HDDVs (8501-33,000 lb GVW)	2.62 g/hr (0.044 g/min)
Heavy HDDVs (33,001+ lb GVW)	2.57 g/hr (0.043 g/min)
HDD buses (all buses, urban and inter-city travel)	2.52 g/hr (0.042 g/min)
Average of all heavy-duty diesel engines	2.59 g/hr (0.043 g/min)

Emission factors given for different vehicles moving at about 50 km/h

Basic Emission Factors

ECVC ID	Fuel ID	Component	Basic Factors	Basic Factor Unit
Light gasoline vehicles	8	CO	10,4	g/km
Light diesel vehicles	19		0,8	g/km
Light-heavy vehicles	19		5,4	g/km
Medium heavy vehicles	19		6	g/km
Heavy-heavy vegicles	19		7,3	g/km
Buses	19		4,2	g/km
Light gasoline vehicles	8	Nox	1,93	g/km
Light diesel vehicles	19		0,85	g/km
Light-heavy vehicles	19		6,45	g/km
Medium heavy vehicles	19		13,75	g/km
Heavy-heavy vegicles	19		15,25	g/km
Buses	19		13,5	g/km
Light gasoline vehicles	8	Exhaust particles	0,035	g/km
Light diesel vehicles	19		0,2	g/km
Light-heavy vehicles	19		0,45	g/km
Medium heavy vehicles	19		0,9	g/km
Heavy-heavy vegicles	19		1,6	g/km
Buses	19		0,9	g/km

Appendix F3 :

Traffic survey June-July 2003

Dar El Handasah Consultants (Shair & Partners) entered into agreement with Heikal Consultants (Prof. Dr. Ali Z. Heikal) in June 2003 in order to conduct a traffic survey study at Cairo International Airport area as part of Environmental Impact Assessment Study of the Airport Developments. The purpose of the study is to collect information on the present traffic magnitude and pattern associated with the airport area as well as the main access roads. The study was carried out during the period June-July 2003.

The traffic study aimed at identifying the existing travel demand associated with the airport as well as the existing traffic volumes on the surrounding streets and intersections within the area of influence. The study scope of work includes the conduct of traffic surveys and interviews in order to determine the basic traffic and roadway conditions before the construction of the proposed airport development.

The traffic entering Cairo International Airport during June 2003 was counted specifically. These data were collected from the six entry gates of the airport. Data are classified into three categories (as per the entry charge) and for Terminals 1 and 2. The vehicle categories are: private cars and metered taxi, microbuses and pick-ups, Buses and trucks. It should be noted that these data do include vehicles that enter with passes (such as employees, buses, and limousines).

Table F1 illustrates the daily flow of all gates. The table clearly shows the average daily traffic is some 10,000 vehicles, and that the last week of the month recorded the highest flow. This is due to the summer season where tourism is high and the massive return of Egyptians working in the Gulf area for vacationing.

Further analysis is carried out for the trip purpose and travel pattern associated with the airport, with particular reference to parking. Previous analysis indicated that 66.8% of the airport traffic is associated with travellers, while the rest of trips is work related trips.

Traveller trips are classified to two groups: departing passengers, and arriving passengers. Trips are split between both groups by 43.6% and 56.4%, respectively, indicating a higher share of receiving travellers as shown before. As for the drivers pattern inside the airport and its need for parking, the data indicated that 60% of drivers drop or pick-up passengers without parking, while the remaining 40% do park their cars in the airport.

Table F1: Daily Entry Flow at Cairo International Airport During June 2003

Day	*Date*	*Private Car & Taxi*	*Microbus & Pick up*	*Buses & Trucks*	*Total*
Sunday	1	7786	834	754	9374
Monday	2	7755	652	919	9326
Tuesday	3	7640	748	695	9083
Wednesday	4	9511	870	835	11216
Thursday	5	9294	1513	935	11742
Friday	6	8284	509	733	9526
Saturday	7	7032	681	808	8521
Sunday	8	4482	641	793	5916
Monday	9	8364	735	750	9849
Tuesday	10	5687	1125	712	7524
Wednesday	11	10936	1143	736	12815
Thursday	12	9652	955	744	11351
Friday	13	8778	667	738	10183
Saturday	14	8845	795	872	10512
Sunday	15	8189	906	621	9716
Monday	16	7635	730	924	9289
Tuesday	17	5678	690	734	7102
Wednesday	18	7915	888	697	9500
Thursday	19	8419	912	736	10067
Friday	20	6211	643	546	7400
Saturday	21	7610	669	783	9062
Sunday	22	7400	778	775	8953
Monday	23	8049	818	916	9783
Tuesday	24	8570	1054	808	10432
Wednesday	25	10499	1205	874	12578
Thursday	26	10335	1213	918	12466
Friday	27	10064	836	836	11736
Saturday	28	9106	868	831	10805
Sunday	29	9448	883	817	11148
Monday	30	10529	1247	769	12545
Average		8323	874	787	9984

Traffic Counting on Ourouba Road South of Airport Bridge

15 July 2003

From Airport to Salem

Time	PC	Taxi	Limo	Van	M-Bus	Bus/Mini	Light Truck	Trucks	Trailers	Others	Total
06:00	477	164	31	11	188	134	63	38	4	9	1119
07:00	963	209	31	20	199	159	200	37	1	5	1824
08:00	1108	478	13	25	304	140	207	34	2	3	2314
09:00	1635	500	12	12	218	82	125	36	2	2	2624
10:00	1995	709	22	12	330	109	182	25	2	1	3387
11:00	1354	1454	1	5	567	54	193	35	4	2	3669
12:00	2138	614	26	33	437	73	204	24	5	3	3557
13:00	1983	478	10	12	455	47	110	35	5	5	3140
14:00	2543	982	9	7	198	70	110	25	5	3	3952
15:00	3167	499	57	36	151	158	253	8	0	8	4337
16:00	2361	425	40	32	77	238	266	52	0	17	3508
17:00	2605	446	36	11	62	271	357	67	1	13	3869
18:00	3757	530	49	24	86	135	255	46	1	37	4920
19:00	3609	539	30	30	77	121	187	11	2	32	4638
20:00	2938	300	36	17	49	166	211	42	1	11	3771
21:00	3816	548	22	29	97	105	129	13	0	28	4787
22:00	3716	481	18	40	87	178	138	15	0	8	4681
23:00	3456	419	13	44	115	114	119	21	2	13	4316
Sub-total	**43621**	**9775**	**456**	**400**	**3697**	**2354**	**3309**	**564**	**37**	**200**	**64413**

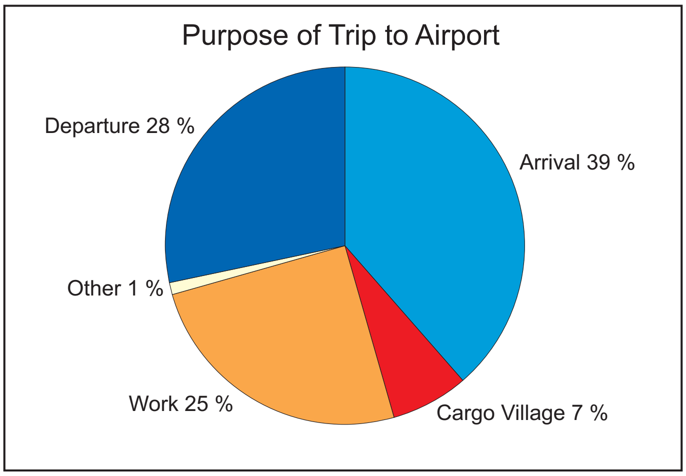
This means that 83% of the traffic is related to small private cars and taxis.

Traffic counting on 15 July 2003

From Salah Salem to Airport

Time	PC	Taxi	Limo	Van	M-Bus	Bus/Mini	Light Truck	Trucks	Trailers	Others	Total
06:00	511	179	8	0	85	134	171	78	3	3	1172
07:00	916	219	9	0	104	208	102	48	0	4	1610
08:00	2543	445	5	0	146	163	133	29	1	13	3478
09:00	1797	393	5	3	97	89	160	51	0	11	2606
10:00	2058	734	13	0	170	88	222	48	0	31	3364
11:00	1418	517	5	2	119	53	232	51	1	33	2431
12:00	1867	944	4	1	210	65	245	55	0	48	3439
13:00	1574	1468	6	0	694	60	136	55	0	24	4017
14:00	2055	2030	7	6	471	87	137	57	0	49	4899
15:00	2326	403	0	22	120	131	128	28	0	33	3191
16:00	2549	386	8	1	132	163	328	48	1	40	3656
17:00	2251	247	8	4	118	93	253	43	0	36	3053
18:00	2349	319	2	0	113	71	285	66	0	42	3247
19:00	2084	227	9	1	134	85	261	42	0	45	2888
20:00	2465	181	8	1	152	75	193	47	0	32	3154
21:00	2544	292	3	6	94	78	135	41	0	32	3225
22:00	2506	158	7	2	98	74	148	41	0	25	3059
23:00	2619	262	1	1	164	82	138	45	1	38	3351
Sub-total	**36432**	**9404**	**108**	**50**	**3221**	**1799**	**3407**	**873**	**7**	**539**	**55840**

Purpose for driving to airport



The roadside interview survey form included five purposes: departure, arrival (reception of travellers), cargo village, work and others. The data were tabulated and illustrated in the figure. 28 % of the traffic was related to departures, 38 % to arrivals, while 25% was transport of airport employees.

Appendix F4:

Traffic emissions (g/s) (total in kg/h) from vehicles moving to and from the airport estimated for the future peak hour traffic

Road coordinates				Lenght(m)	Emissions (g/s)			
x0	y0	x1	y1		NOx(g/s)	PM10(g/s)	HC(g/s)	CO(g/s)
340004	3330423	342990	3332172	3460	9,7	0,35	9,5	35,9
342990	3332172	343715	3332534	811	1,1	0,04	1,1	4,2
343715	3332534	344099	3332364	420	0,6	0,02	0,6	2,2
344099	3332364	344738	3331873	806	1,1	0,04	1,1	4,2
344738	3331873	345207	3332087	515	0,7	0,03	0,7	2,7
345207	3332087	345527	3331916	363	0,5	0,02	0,5	1,9
345527	3331916	345783	3332193	377	3,9	1,40	9,3	124,9
345783	3332193	345591	3332492	355	0,5	0,02	0,5	1,8
345591	3332492	345996	3332876	558	0,8	0,03	0,8	2,9
345996	3332876	345975	3333558	683	1,0	0,03	0,9	3,5
345975	3333558	345570	3333622	410	0,6	0,02	0,6	2,1
345570	3333622	343715	3332534	2151	3,0	0,11	3,0	11,2
Total emissions from road traffic (kg/				**10908**	**84**	**7,55**	**103**	**711**

The emissions above are presented for each road segment used in the model. The road coordinates are specified by UTM co-ordinates in the table given at the end point of each segment. One of the road segments (377 m long) includes the loading and unloading zone where cars are idling for an average time of one minute.

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ABSTRACT

The Environmental Impact Assessment for a new Cairo International Airport has been based on measurements and modelling of ground level concentrations due to emissions from road traffic and aircraft operations. The main air pollution problem in Cairo is suspended particulate matter originating from traffic, open air burning and natural wind blown dust.

The results of model calculations of emissions and concentrations of NO_X, CO, and HC (VOC) around the airport have indicated that the contribution from the airport on a local and regional scale is small. Close to the roads and in the terminal areas, however, maximum concentrations of NO_2 and CO may reach national and international limit values. The emissions from the airport activities alone will only in very limited areas and for some very specific peak hour cases approach adverse levels. Adding the contributions from other sources in the north-eastern Cairo area may lead to impacts that can influence on the population's exposure and well being to give undesired effects.

NORWEGIAN TITLE

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KEYWORDS		
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ABSTRACT

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