

ALAQS Project:

Chopin Airport Case Study

Part 1: Emission Inventory

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EXECUTIVE SUMMARY

This report presents the results of phase 1 of the ALAQS case study at Warsaw F. Chopin airport. Phase 1 of the study comprises an emission inventory for Chopin Airport for the year 2004. This emission inventory constitutes the first step of Chopin Airport ALAQS case study which is expected to continue with the modelling of the subsequent dispersion. Data collection issues are highlighted to ensure that the final dispersion results will be valid. Various methodologies are compared for the emissions sources present in the table below.

The objective of the ALAQS emissions inventory studies is to try to use detailed local data wherever possible. The report covers the data collected and its use in the inventory and highlights the benefits and problems encountered using the different inventory methods available in the ALAQS-AV toolset.

The results from this case study should be considered for experimental purposes only and the results should be used with caution. Although the results of the inventory are considered to be reliable, they should not be used in the context of a formal environmental impact assessment but should serve as a reference for future emissions inventories.

As one could have expected, generally the more exhaustive is the input data collection and the more precise will be the emission figures. This was verified for aircraft emissions and for ground handling emissions using different methods, leading to significantly different results especially in the case of aircraft emissions (hundreds of tons). Emphasis was put on the importance of using region specific parameters in the case of Ground aircraft handling equipment to ensure realistic figures.

Road vehicle emissions were not fully calculated due to difficulties with road traffic data collection. This problem was encountered in a previous ALAQS case study at Bucharest airport. The report suggests a possible method to work around limited data based on published aircraft movement and passenger data. The method aims at allowing road traffic emissions and parameters to be estimated (based on airport known statistics, such as freight and passengers transported). The French CITEPA [Ref. 1] and UK department of Transport, [Ref. 1] amongst others, have well established methods that may serve as a starting point.

Stationary source emissions were not calculated because of insufficient input data. However, stationary source emissions usually form less of 10% of total airport emissions and in the case of Warsaw this percentage would be even lower since electric generation is off-site.

The present F. Chopin airport emissions inventory will be used as input to the dispersion analysis modelling in the second phase of the study. The emissions inventory of aircraft and ground handling equipment are considered to be accurate enough to use as input to the dispersion calculations. However, the calculations of road vehicle and stationary source emissions require further work before the results can be used for dispersion analysis, e.g. Stationary sources need the annual consumption figures.

Table: summary of emission sources considered in the Frederic Chopin case study

Source	Sub-source	ALAQS-AV Chopin 2004	Emission Indices source
Air traffic	Commercial	yes	n/a
	Cargo	yes	n/a
	Military	No	n/a
	Helicopters	no	n/a
Aircraft	Taxiways	yes	ICAO
	Runway roll (landing and take-off)	yes	ICAO
	Emissions up to 3000 ft.	ALAQS (INM 6.1)	FAA
Aircraft at the gates	Engine start	yes	LASPORT 1.5
	APU	yes	EDMS 4.1 LASPORT
Gates	GPU	yes	CITEPA EDMS 4.1 LASPORT 1.5
	GSE	yes	CITEPA EDMS 4.1 LASPORT 1.5
Stationary sources	Power / Heat plants	No	EDMS 4.1
	Fuel tanks	No	EDMS 4.1
Roadways	Airside	No	Various (EU, UN...)
	Landside	No	Various (EU, UN...)
	Parking	no	Various (EU, UN...)

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ABBREVIATIONS

Acronym	Definition
IoA	Institute of Aviation of Poland
PPL	Polish Airports State Enterprise
AC	AirCraFt
ACARE	Advisory Council for Aviation Research in Europe
ALAQS	Airport Local Air Quality Studies
ALAQS-AV	ALAQS-ArcView tool
ANCAT	Abatement of Nuisances Caused by Air Transport
ANTLE	Affordable Near Term Low Emissions
AP	AirPort
APU	Auxiliary Power Unit
ASU	Air Start Unit
AV	Arc View
BUC1	First model designed at Henri Coanda Airport
BUC2	Second model designed at Henri Coanda Airport
CAEP	Committee on Aviation Environmental Protection
CLEAN	Component vaLidator for Environmentally friendly Aero eNginE
CNG	Compressed Natural Gas
COPERT	Computer Program to calculate Emissions from Road Transport
DfT	UK Department for Transport
ECAC	European Civil Aviation Conference
EDMS	Emission and Dispersion Modeling Software (US FAA)
EEA	European Environmental Agency
EEC	EUROCONTROL Experimental Centre
EEFAE	Efficient & Environmentally Friendly Aero-Engines
EPA	US Environmental Protection Agency
FAA	Federal Aviation Administration
GIS	Geographical Information System
GPU	Ground Power Unit
GSE	Ground Support Equipment
HDV	Heavy Duty Vehicle
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
INM	Integrated Noise Model
JB	Jet Business (ALAQS AC grouping)
JL	Jet Large (ALAQS AC grouping)
JM	Jet Medium (ALAQS AC grouping)
JR	Jet Regional (ALAQS AC grouping)
JS	Jet Small (ALAQS AC grouping)
LAQ	Local Air Quality
LDV	Light Duty Vehicle
LPG	Liquefied Petroleum Gas
LTO	ICAO Landing and Take Off cycle
MTOW	Maximum Take Off Weight
NMVOc	Non-Methane Volatile Organic Carbon
PC	Passenger Car
SEE	Social, Economic and Environment
STATFOR	EEC STATistics and FORecast services
TIM	Time In Modes
TP	Turbo Propeller (ALAQS AC grouping)

1. INTRODUCTION

1.1 Current European legislation on Air Quality

The strategy of the European Union concerning ambient air quality is laid in the Framework Directive 96/62/EC of the 27th of September 1996. It defines objectives to avoid, prevent or reduce harmful effects on human health and the environment. Several thresholds are described: limit values (which should not be exceeded), target values (which will avoid impact on human health) and alert thresholds (which when exceeded require action by Member States). Common methods are also characterized to ensure harmonised Air quality measurements. Based on this framework, three daughter directives have been published which set explicit values for the thresholds of specific pollutants (Table 1).

Table 1: EU Ambient Air Quality Directives

Publication Date	Directive	Pollutants considered
April 1999	1999/3/EC	SO ₂ , NO ₂ , NO _x , particulate matter (PM ₁₀), lead (Pb)
November 2000	2000/69/EC	Benzene, CO
February 2002	2002/3/EC	Ozone
December 2004	2004/107/EC	Heavy Metals and Polycyclic Aromatic Hydrocarbons

Targets for national emission ceilings for certain atmospheric pollutants (SO₂, NO_x, VOC and NH₃) in 2010 are also defined in the Directive 2001/81/EC (23 October 2001).

Finally every Member State has also an obligation of reporting the implementation of ambient air quality legislation to both the public and the European institution (Dir. 91/692/EEC).

1.2 Background of the Study

With the continuous growth in air traffic, environmental issues around airports are causing greater concern to the general public and to airport operations. There are two main areas of interest when dealing with airport environmental issues: noise and Local Air Quality (LAQ). People living near airports feel more and more concerned about those issues. Combining this pressure from the local population with that of the European Community, there is an increasing demand for environmental reporting (section 1.1). This is particularly true for the airports wishing to expand (e.g. Heathrow fifth terminal and third runway) for which such reports are vital to inform and to get the support of the local authorities and populations. The present report focuses on LAQ issues for Frederic Chopin Airport (Warsaw, Poland).

A common approach to evaluate the air quality around airports relies firstly on a thorough inventory of the pollution sources. The main sources are generally the aircraft, the Ground Support Equipment (GSE), and the transportation to and from the airport. Other emission sources to be considered include heating plants and generators. The objective of an emission inventory is to allow the

calculation and spatial allocation of the pollution released by a particular airport source during a specified period of time. Emission inventories are the initial step before conducting the dispersion modelling of the pollution around the airport. Dispersion will be the focus of the second phase of the Chopin Airport case study.

Emission inventories must be performed in a controlled manner in order to ensure the reliability of the results and of the subsequent estimation of the dispersion and concentrations.

1.3 The ALAQS Project

The ALAQS project started in 2003 under the impulse of the EUROCONTROL Social Economic and Environmental (SEE) business area. Initially the project aimed at producing an emission inventory tool (ALAQS-AV) as a mean of demonstrating and testing different emissions inventory and dispersion methods and parameters. Proceeding in such a way was expected to provide extensive knowledge in the production of emission inventories, which will form the basis of guidelines defining the best practice for LAQ assessment at airports.

The Airport Local Air Quality Studies (ALAQS) project was also intended to fill a gap in creating a pan-European harmonised methodology.

The first operational version of the ALAQS-AV tool was finalised in 2004. Earlier case studies were made at Lyon Saint Exupery (France), Zurich (Switzerland) and Bucharest Henri Coanda (Romania). The outcome of the Lyon case study highlighted the importance of using airport-specific data in order to obtain reliable results. The second case study, using Zurich airport's experience in producing emission inventories, allowed the collection of a complete set of airport-specific data and the comparison of three different models. The results for aircraft related emissions were comparable between the three methodologies which validated the ALAQS-AV method for aircraft emissions. However, the differences in vehicle related emissions highlighted the importance of using local operational data instead of the default emission factors and fleet mixes. The Bucharest case study highlighted the difficulties of obtaining realistic operational data for gate equipment especially, as well as considering the road traffic both on the landside and the airside of the airport.

1.4 Objectives of the ALAQS Case Studies

The Frederic Chopin Airport study is one of the case studies performed as part of the ALAQS project.

These ALAQS case studies have several general objectives:

- Determine the best practice method for an emissions inventory with the best data available at the site.
- Provide feedback on the task of collecting the necessary data for study with recommendations on the best practice.

- Give an opportunity to airport operators to gain experience with a detailed four dimensional (4D) emission inventory (i.e. the geo-spatial vertical and temporal distribution of emissions).
- Evaluate ALAQS-AV functionality by airport environmental practitioners.

4D emission inventories need to consider all airport pollution sources and will also be used for the analyses of the results of the future scenarios.

The ALAQS-AV toolset was given to the Polish Institute of Aviation (IoA) and the airport teams to allow the airport specialists to use ALAQS-AV in-house and to run the simulation on-site using the data they had collected.

In summary, the objectives of the ALAQS Frederic Chopin case study are to:

- Identify gaps in the data collection at the airport.
- Find ways to further facilitate the data collection for running an ALAQS-AV study.
- Try different inventory methods as a function of available input data
- Evaluate the ease of properly using the ALAQS-AV emission inventory tool (i.e. the level of support required to run a study).
- Find a suitable method to forecast future emissions through the definition of future scenarios in ALAQS-AV.
- Define actions to solve issues before dispersion modelling.

The case study at Frederic Chopin was carried out with the full and enthusiastic cooperation of the Chopin Airport Environmental Department and the Institute of Aviation of Poland (IoA) which were keen to augment their already established knowledge of airport environment issues.

1.5 Structure of the Document

The first part of this report gives general information about Warsaw F. Chopin airport such as its traffic and layout. Explanations about the scope of the LAQ study undertaken are also provided together with considerations about the definition of future scenarios.

In the following sections of the report, each group of pollution sources are analysed separately: aircraft, gates (handling equipment), roadways and finally stationary sources (heating plants, generators, etc). For each group, the method used is explained first, then some information about the data collection is provided, and the emission results are analysed. Each section ends with comments about best practice.

In conclusion, recommendations are given concerning inventory methodology and data collection. Issues are also presented together with the actions necessary to enhance the validity of the dispersion modelling results (phase two of this case study).

2. FREDERIC CHOPIN AIRPORT

2.1 Overview of Warsaw Frederic Chopin Airport

Situated in the South West of Warsaw, Poland, Frederic Chopin Airport is a civil airport with dual crossing runways. The airport is adjacent to a national road and some urban areas north and east of the airport perimeter (see Figure 1 below). Its layout is depicted in Figure 2.

The air traffic is mainly civil handling domestic (8 destinations) and international (around 80 destinations). Air traffic average annual growth has been around 5% for the last ten years. In 1994 the airport recorded nearly 43 000 aircraft movements compared to more than 108 000 in 2004.

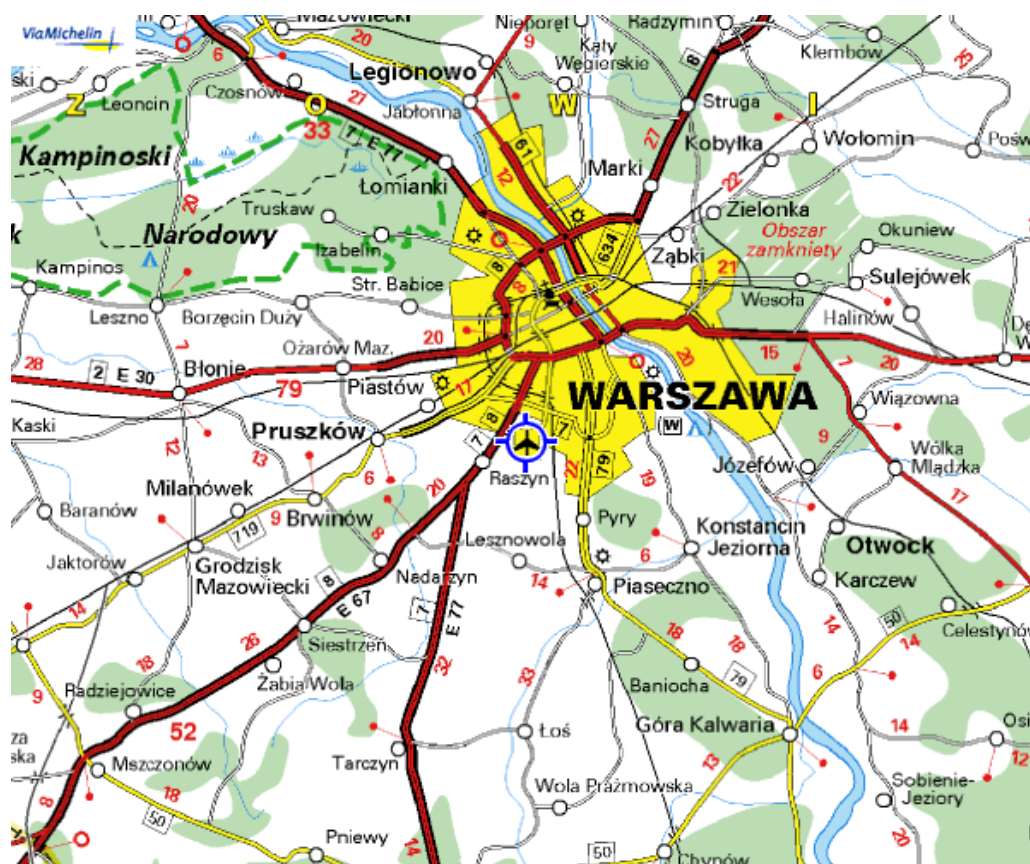


Figure 1: Location map: Frederic Chopin Airport

2.2 Scope of the ALAQS-AV Study

2.2.1 Geographical Scope

The definition of the geographical scope of the LAQ study is critical for a Local Air Quality Study.

A formal emissions inventory would include all sources within the airport perimeter fence and a wider extent of public roads and local industry when the inventory results will be used as input to regional air quality analyses.

3. AIRCRAFT EMISSIONS

3.1 Method

3.1.1 Emissions above ground (airborne aircraft)

Aircraft emissions depend on two factors: (i) the engine(s) fitted to the aircraft and (ii) the mode of flight. There are different levels of complexity when calculating aircraft emissions as shown in Table 2.

Table 2: Various methods for aircraft emissions estimation

Method	Aircraft / engine fit	Operational profile	Emission Indices
Simple	Per aircraft group ⁽¹⁾	ICAO LTO Times In Mode	ICAO averaged per aircraft group ⁽¹⁾
Advanced	Per ICAO aircraft type	Per aircraft group	ICAO per movement
Sophisticated	Aircraft specific	Per aircraft type	ICAO per movement

⁽¹⁾ Jet Business, Jet Large, Jet Medium, Jet Regional, Jet Small, Piston, Turbo-Propeller

It is well known that the emission indices vary hugely from one engine to another, even though they can be used to fit the same type of aircraft. This is also true for engines of the same family (e.g. CFM56) [Ref. 6]. Therefore, it is expected that the modelled emissions will vary dramatically depending on the method used to assign an engine to an aircraft, which was verified in the Zurich case study: total pollutants emitted varied from 40% to 80% as a consequence of the engine assignment method [Ref. 7]. The best practice is to assign the engine type actually fitted to each aircraft (sophisticated method in Table 2) through the aircraft registration (tail number) and a commercial database.

In the F. Chopin study aircraft registration data was available for nearly all movements, which ensured reliable aircraft emissions calculation.

The vertical flight profiles for Landing and Take-off are stored in ALAQS-AV as flight profiles. Each aircraft type is assigned a departure profile and an arrival profile, depending on its maximum take off weight which is consistent with the sophisticated approach in Table 2. The profiles used in ALAQS-AV originate from the INM 6.1 software, the widely available aircraft noise modelling tool developed for the FAA.

3.1.2 Aircraft ground emissions

The method of calculating taxiing (and related manoeuvres) emissions is based on the time spent by the aircraft taxiing. As an example, the ICAO/EPA estimated a taxiing time of twenty six minutes that can be used for any airport LAQ. There are also other methods to estimate the taxiing time which rely on the taxiway length and the aircraft taxiing speed. Unfortunately, even though the taxi-route length for each movement may be readily available at an airport, the data concerning an aircraft taxiing speed is much more difficult to obtain.

Since the movement data provided by PPL included the exact times for touch-down/take-off (movement time) and On/off block time, the exact arrival and

departure taxi times could be calculated by subtracting block time from the movement time. Where the movement data did not include the movement type (arrival/departure) this could be calculated from the differences in movement and block times.

Note, although the precise taxi-times were known, the runway used was estimated from usual practice and observations made by PPL provided runway used from Noise monitoring system recordings. Consequently, we expect some discrepancies in the taxi emissions where the known taxi-time does not correspond with the assumed runway and taxi-route.

A mean to reduce emissions and fuel consumption commonly applied to aircraft ground movement is the use of single engine taxiing. Unfortunately this feature was not available in the ALAQS-AV tool at the moment of the study. Similarly, the modelling of reverse thrust is not implemented in the tool yet. However, thrust reverser induced emissions (and fuel flow) are shown to account for 2% to 3% of the emissions of all the LTO cycle only [Ref. 8] and therefore are not expected to significantly impact the results.

3.2 Data Collection

The Polish Airport State Enterprise (PPL) in collaboration with the Institute of Aviation of Poland (IoA) carried out data collection for the F. Chopin Airport emission inventory. In order to facilitate the data collection, the ALAQS-AV data requirement document [Ref. 10] was used as guidance. Table 3 below summarises the data collected at Chopin Airport in order to run the ALAQS-AV study. All the aircraft movement data was provided by PPL, including the aircraft registration number, block times (on and off) touch-down and airborne times for all movements.

The excellent level of detail permitted meant that the real taxiing times could be used in ALAQS-AV for calculating taxiways emissions.

In 2004 around 121 000 air movements were recorded at F. Chopin Airport, helicopters included. The repartition of the aircraft fleet in the different groups is shown in Figure 3 next page. Two categories constitute most of the traffic at F. Chopin Airport: small size jets and turbo-propellers aircraft. Together they represent around 60% of all movements, and more than 96% if regional and business jets are included.

Table 3: Summary data sources for aircraft emissions

Category	Parameter	Data Source: Airport or ALAQS default
Movements	Actual time and date of the movement	PPL
	Aircraft type	PPL
	Gate assigned	PPL ⁽¹⁾
	Runway assigned	PPL ⁽²⁾
	Departure/arrival code	PPL
	Off block time / On block time	PPL
	Aircraft registration number	PPL
Runways	Maximum hourly capacity	PPL
	Touchdown offset for landings	Default
	Maximum queue speed	Default
	Peak queue time	Default
Taxiways	Taxiing time.	Time data from PPL was available for all movements

⁽¹⁾ Assumption based on most used gate per aircraft group for 9% of all movements

⁽²⁾ Runway 33 assigned to departures and 29 to arrivals for 28% of all movements

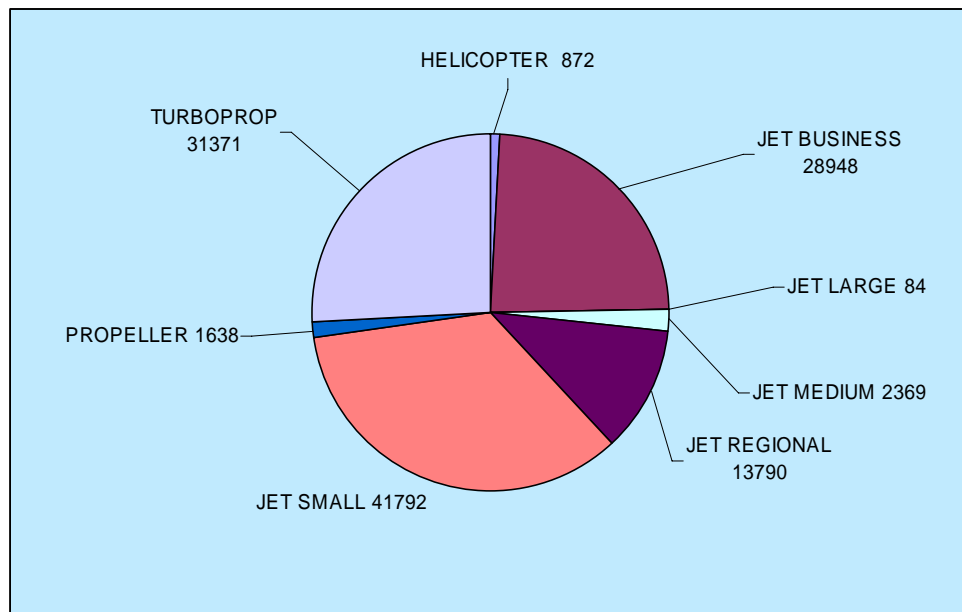


Figure 3: Distribution of F. Chopin Airport air traffic in 2004

3.3 Preparation of Aircraft Movement Data

Since the movement data provided by PPL included the exact times for touch-down/take-off (movement time) and On/off block time, the exact taxi times could be calculated by the difference between block time and movement time. Where the movement data did not include the movement type (arrival/departure) this could also be calculated from the differences in movement and block times.

Data provided by PPL gave the unique stand identifier for each aircraft movement. At F. Chopin there are 65 stands and 2 runways. In ALAQS-AV, taxi-routes must be derived for every stand and every runway exit point separately. Defining all combinations of taxi-route in ALAQS would therefore require 4 exit points per runway (2 in each direction) the number of taxi-routes to draw to model F. Chopin Airport would be 512 ($N_{\text{taxi-route}} = N_{\text{Runway}} \times N_{\text{Exit-point}} \times N_{\text{stands}}$). Using this number of taxi-routes in ALAQS would require considerable effort to define each route, check consistency and slow the processing significantly. To avoid these problems stands were grouped according to apron identifier given in the Poland AIP [Ref. 8]. With this method twelve gates were modelled reducing the number of taxi-routes to draw down to 96.

Movement data were provided from two sources – PPL data gave detailed times, and flight information but not the runway used. Runway used for each movement was retrieved from the Noise Monitoring system. Some data processing was necessary as the times in the movement table were expressed in UTC as opposed to local times in the Noise Monitoring System. Warsaw is UTC -1 hour which meant a difference of 1 hour in winter and 2 hours in summer due to daylight saving time.

Note, although the precise taxi-times were known for each movement not all movements had runway specified (e.g. the noise monitoring system may be out of service). Unknown values were estimated from usual practice and observations made by PPL - runway 33 for departures and runway 29 for arrivals. Consequently, we expect some discrepancies in the taxi emissions where the known taxi-time does not correspond with the assumed runway and taxi-route.

Movements that had missing gate values were assigned the gate most used by the corresponding aircraft group.

3.4 Models and Results

For the purpose of comparing aircraft emissions methods, the results presented in this section are based on two methodologies: the simple one and the sophisticated one (see Table 2). The simple method is based on ICAO and US EPA (Environment Protection Agency) times in modes (Table 4 and Table 5). That is because ICAO recommendations are valid for ICAO regulated

aircraft that is to say aircraft fitted with jet engines as opposed to turboprop and piston powered aircraft. For the last categories the US EPA suggested times in modes were used. Finally the aircraft group emission factors from the LASPORT tool (Table 7). Only CO and NO_x emissions are considered in the case of the simple methodology. Results are presented in Table 8.

Table 4: ICAO LTO time in (minutes)

ICAO mode	Time (minute)	Thrust (% of full thrust)
Approach	4.0	30%
Take Off	0.7	100%
Climb Out	2.2	85%
Taxiing	26	7%

Table 5: US EPA times in mode (minutes)

Mode	Business jet	Turboprop	Piston engine	Thrust
Approach	1.6	4.5	6.0	30%
Take Off	0.4	0.5	0.3	100%
Climb Out	0.5	2.5	5.0	85%
Taxiing	13	26	16	7%

Table 6: ALAQs-AV times in mode

Mode	Average time for all movements (minute)	Thrust
Approach	4.93	30%
Take Off	0.42	100%
Climb Out	1.42	85%
Taxiing	6.53	7%
Queuing	0.82	7%

Table 7: LASPORT aircraft emission factors

Name	Tracer	Unit	Take Off	Climb Out	Approach	Idle
Large	Fuel	kg/s	7.37	5.90	1.99	0.64
Large	NOX	g/kg	36.03	27.67	10.19	4.27
Large	CO	g/kg	0.67	0.66	2.55	31.87
Small	Fuel	kg/s	2.43	1.98	0.71	0.26
Small	NOX	g/kg	23.94	19.19	8.66	3.95
Small	CO	g/kg	0.95	1.39	5.84	24.26
Medium	Fuel	kg/s	4.98	4.02	1.37	0.45
Medium	NOX	g/kg	32.49	25.27	10.11	4.06
Medium	CO	g/kg	0.54	0.59	2.65	27.17
Business	Fuel	kg/s	0.45	0.37	0.14	0.05
Business	NOX	g/kg	19.15	16.02	6.92	3.72
Business	CO	g/kg	1.13	1.62	15.56	47.70
Regional	Fuel	kg/s	1.45	1.21	0.45	0.18
Regional	NOX	g/kg	17.45	14.56	7.08	3.83
Regional	CO	g/kg	0.53	0.62	4.42	33.37
Propeller	NOX	g/kg	2.71	4.32	3.77	1.91
Propeller	CO	g/kg	1082.00	960.80	995.10	592.20
Turboprop	Fuel	kg/s	0.35	0.29	0.16	0.09
Turboprop	NOX	g/kg	13.56	12.34	7.61	4.39
Turboprop	CO	g/kg	1.96	2.36	7.16	22.59

Table 8: Aircraft emissions at Chopin Airport in 2004

	Simple method	ALAQS-AV
Movements ⁽¹⁾	59 996 (LTO cycles)	119 992
CO (kg)	420 369	245 328
HC (kg)	n/a	31 963
NO _x (kg)	321 542	220 574
SO _x (kg) ⁽²⁾	n/a	21 553
PM ₁₀ (kg) ⁽²⁾	n/a	3 659

⁽¹⁾ Helicopters excluded

⁽²⁾ Indicative figures only - emission factors need further adjustments

Emissions from both methods are in the same order of magnitude (hundreds of tons) but show differences between 175 tons and 100 tons (for CO and NO_x respectively). Results from the simple method were higher than the ones from the sophisticated one. The origin of that variation is double: first the emission factors for engines which are handled in a much more detailed way in ALAQS-AV and second the different times in mode used. ALAQS-AV times in mode are presented in Table 6. They are obtained from the average of the time in modes from each movement occurring at the airport, knowing that each aircraft has a specific climb-out profile issued from the INM (Integrated Noise Model) FAA fully validated tool. Comparison of the time in mode tables show that the ICAO set up durations are generally longer than the ones used in ALAQS-AV (except for the approach mode). This is especially true for the

taxiing time, the ICAO based one (26 min) being four times the ALAQS modelled time (6.5 min).

Those results are consistent with the ones published by Unique (Zurich Airport Authority) in [Ref. 11] which show that ICAO LTO calculated emissions tend to overestimate operational emissions.

3.5 Special considerations

3.5.1 Aircraft Emissions

Ground track

Horizontal deviation for aircraft trajectories is not implemented yet in ALAQS-AV. This doesn't influence the airport emission inventory results in terms of global figure but it could influence the dispersion modelling as the location of the pollution emitted by aircraft would vary.

However, for the second step of F. Chopin case study, the influence on the dispersion results is not expected to be tremendous. Especially ALAQ considers aircraft emissions up to 3000 ft (914 m). At that height only small aircraft (piston or turboprop, less polluting than jets) turned to liberate the runway. The horizontal track of other aircraft is generally a straight line.

But in terms of best practice it would be worth to add this consideration in the ALAQS-AV tool.

Aircraft Weight

A parameter that is not considered to calculate aircraft emissions is the operating weight of an aircraft. It is obvious that aircraft weight influences trajectories, which in turn alter aircraft emissions. But the impact on emissions of those changes in trajectories needs to be quantified. It is recommended that a study is run to investigate aircraft emissions sensitivity towards aircraft take off (and landing) weight variations.

Emission Factors Limitations

Moreover every aircraft emission estimation method is closely tied to ICAO recommendations, especially for aircraft operational parameters, i.e. emission factors, fuel flow and thrust. A number of sources, such as EC-NEPAIR [Ref. 12] and AEROCERT [Ref. 13] between others, have been raising limitations considering the ICAO certification schemes. Main restrictions reported are:

- it applies only to engine and does not consider airframe;
- it does not cover particulates nor CO₂;
- it is not aligned on actual operating practices anymore;
- it considers only four engine regimes to define fuel flow and emissions.

ICAO also raised that issue and a working group of CAEP is currently working on extrapolating emission factors and fuel flow on the basis of polynomial,

power law or log fittings depending on engine regime and pollutant [Ref. 14]. It is recommended to enhance collaboration with ICAO CAEP WG6 members so that new emission indices and fuel flow, more realistic, can be used to evaluate an airport air quality.

3.5.2 Helicopter Emissions

Even though helicopter movements were provided by F. Chopin airport authorities, it was not possible to handle calculations in ALAQS-AV. No specific flight profiles were available for helicopters.

4. GATE EMISSIONS (APU, GPU, ENGINE START AND GSE)

4.1 Method

Two main approaches are available to calculate GSE emissions: bottom up and top down. The bottom up approach relies on a detailed assessment of the handling equipment in use at the airport (fuel flow, emission indices, hours of operation...). On the contrary the bottom up necessitates long term fuel flow figures to calculate global emissions (without details about time or location of the emissions). Both approaches are complimentary as they should lead to comparable results, which would ensure of the reliability of both.

The following section gives details about those two approaches and especially lists of the necessary data are presented.

4.1.1 Bottom Up Approach

It is based on the equipment available at the airport and their operations. Therefore each airport needs to produce its own list of handling equipment together with information about how it is used. Various levels of grouping are possible. For example movements can be considered per aircraft group or per LTO cycle. Best practice consists in splitting arrival and departure. Similarly various methods exist for defining handling activities: scenario based or considering the actual GSE equipments used (Table 9).

Further details are available from the manual of the tools shown in the table.

Table 9: Various methods for handling emissions estimation

Method basis	Gate scenarios	Emission factors	Source of emission factors	Example
Gate scenario	Pier Remote	- per scenario - per aircraft group ⁽¹⁾ - per arrival / departure	- Zurich airport AQ monitoring	LASPORT 1.5 (see 0)
Equipment	No	- per GSE operated - per aircraft type - per LTO cycle	- User defined - EPA for GSE	EDMS 4.1 (see 0)
Combined	Pier Remote	- per scenario - per aircraft group ⁽¹⁾ - per arrival / departure	- Zurich airport	ALAQS-AV 2.0 (see 0)
	Cargo Other	- per GSE operated - per aircraft group ⁽¹⁾ - split arrival/departure	- User defined - EPA for GSE	

⁽¹⁾ Jet Business, Jet Large, Jet Medium, Jet Regional, Jet Small, Piston, Turbo-Propeller

It should be acknowledged that the assignment of GSE on an LTO basis induces an overestimation of the handling emissions [Ref. 16]. As a consequence this method should be applied with care.

Another method developed by CITEPA is detailed in [Ref. 1]. It calculates the difference between other the airport related emissions considering the engine power of the handling equipment. Default data for operating parameters

(duration, fuel flow, etc...) and emissions are provided on a basis of 1000 movements. Therefore it is sufficient to use the total number of air movements to derive handling emissions. The calculations can be refined if the exact distribution of airport handling equipment in terms of engine size or power and fuel type is known, which was the case for the present emission inventory.

4.1.2 Top Down Approach

There is another method that is also suitable for estimating aircraft handling emissions. It is based on real data, such as the annual fuel consumed by GSEs or the annual number of hours operated. This approach allows the calculation of the total emissions per year but is not suitable if dispersion is to be applied after the emission inventory. This is because the geographical and temporal repartitions of the pollution are unknown. However, best practice for handling emission validation will consist in applying both approaches (bottom up and top down) in order to ensure that the results are similar.

4.1.3 Considerations about APU, GPU and Engine Start Emissions

Depending on the gate allocated to an aircraft, APU or GPU power supply have to be used. This is linked to the gate scenarios as an aircraft at a remote stand will necessitate a GPU (principally diesel fuelled) as opposed to an aircraft linked to a terminal bridge. The assignment of an APU type to an aircraft group in ALAQS-AV is made following the observations made at Zurich Airport and related in the UNIQUE document [Ref. 17].

Engine start emissions are also considered in ALAQS-AV. Emission factors used are defined on an aircraft group basis and are similar with the ones of the LASPORT software.

4.2 Data Collection

4.2.1 Bottom Up approach

Table 10: Summary of the data collection for gate emissions (Bottom Up)

Category	Parameter	Source (default or APT)
Operation details	List of GSE equipment and duration of operations	APT
Gates scenarios (APU, GPU, Engine Start and GSE)	Height of emissions	Default
	Emission factors for APU	Default
	Emission factors for GPU	Default
	Emission factors for Engine start	Default
	Emission factors for GSE	Default
GSE (for each equipment if the population based method is chosen)	Emission class (APU, GPU or GSE)	APT
	Load factor	Default
	Population units	APT
	GSE type	APT

Category	Parameter	Source (default or APT)
	Brake horsepower	APT
	GSE engine fuel type	APT
	GSE engine coolant	Default

ALAQS-AV allows a user to define gate types that correspond to the functional parameters, including the aircraft type normally using a stand, Movement type (ARR/DEP), stand type (GSE equipment available).

4.2.2 Top Down approach

Table 11: Summary of the data collection for gate emissions (Top Down)

Category	Parameter (for each category)
- Personal car - Van, pick up, LDV - Truck, bus, HDV - Machinery - ASU - APU - GPU	Annual fuel burnt (diesel, essence, LPG, jet fuel, ...)
	Annual hours operated (or annual mileage)
	Repartition of vehicles per engine power
	Repartition of vehicles per fuel technology
	Total number of operations

A number of GSE companies are operating at F. Chopin Airport. Due to different monitoring strategies, the data collected from one company to another was not harmonised as shown in Table 12. As a consequence it was not straightforward to calculate F. Chopin Airport emissions. The number of aircraft handled for each GSE company was unknown, therefore it was not possible to use the data retrieved for comparing top down and bottom up approaches. Further data need to be collected to allow for such a comparison.

Table 12: GSE data collection at Chopin Airport

Company name	Number of equipment	Data for bottom up approach ⁽¹⁾	Data for top down approach
PPL WAW	264	Yes	No
LOT Ground Services	196	No	Yes
Warsaw Airport Services	58	Yes	No
LOT Catering	23	Yes	No
PETROLOT	17	Yes	No
LSP	8	Not available	Not available

4.3 Results

Emissions due to handling are evaluated using two methodologies:

- ALAQS-AV gate scenarios with emission factors from two different sources: EDMS and LASPORT

- CITEPA method which rely on the count aircraft movements only as default values are provided for the usage, fuel consumption and emission factors of handling equipments per thousand movements [Ref. 1].

Subsequent Results are presented in Table 13.

Table 13: GSE emissions at Chopin Airport in 2004

	Bottom up Approaches		
	ALAQS-AV Gate scenarios		CITEPA ⁽¹⁾
Source for emission factors	LASPORT	ALAQS default (from EDMS)	[Ref. 1]
CO (kg)	5 615	21 840	6 577
HC (kg)	1 436	19 646	2 033 (NMVOC)
NO _x (kg)	18 587	21 803	15 455
SO _x (kg)	n/a	4 254	202 (SO ₂)
PM ₁₀ (kg)	1 032	1 512	n/a

⁽¹⁾ For comparison purposes, emissions from airport and aircraft maintenance equipment (e.g. grass cutting equipment, etc) were not accounted for despite data availability.

It is worth noticing that the EDMS emission factors used in ALAQS-AV origin from the version 4.1 of the software. Latest version released in 4.3, therefore the ALAQS-AC default data should be updated.

Emissions from the ALAQS-AV gate scenarios using LASPORT gate emission factors and from the CITEPA methodology are close to each other even though the two methods rely on different sources for gate emission factors. LASPORT data originates from on-site measurements at a specific airport. On the contrary CITEPA data consider for each kind of handling equipment:

- The usual engine power/class
- The estimated functioning time per 1000 movements
- The fuel type

The precise GSE data provided by PPL (including engine class and fuel type for all GSE in use at the airport) allowed a thorough inventory.

Note that LASPORT emission factors for gate scenarios and CITEPA method produced comparable results.

Handling emissions calculated using EDMS emission factors showed large differences in CO and HC especially. This was expected as it was related in previous reports [Ref. 7] and [Ref. 15]. The reason explaining such variation is that EDMS emission factors are computed for US airports and equipments, therefore the emission factors and operating times can be quite different as highlighted in Table 14. The regional specificity of handling equipments should be considered when an airport LAQ is run especially the location of the airport (i.e. European / US situations).

Unfortunately the ALAQS-AV equipment based approach could not be applied despite IoA and PPL extensive data collection. However this task is expected to be completed for the second phase of Chopin Airport case study.

Table 14: Example of difference in handling equipment parameters (from [Ref. 7])

GSE Example	Parameters	Europe	EDMS 4.12
Belt Loader	Engine	33 kW	71 hp (52.3 kW)
	Load Factor	25%	25%
	NOx (g/hr)	68.31	107.69
	HC (g/hr)	5.36	12.19
	CO (g/hr)	26.81	51.92
	Emission Factors	EC EUNRMM Stage1 ⁽¹⁾	EDMS Default

⁽¹⁾ EU Nonroad Mobile Machinery (EC Directive 97/68/EG) plus correction factors SAEFL.

4.4 Special considerations

An aspect of GSE activities that is not considered in any of the methods referenced here is their dependency with aircraft load. The more loaded an aircraft and the more gate equipment are required for its handling.

It is proposed to undertake a sensitivity analysis focused on the impact of aircraft load factor on GSE activities in order to estimate what could be the impact in terms of emission reduction.

5. ROAD VEHICLE EMISSIONS

Four different methods are available in ALAQS-AV to calculate roadways emissions:

- ALAQS (COPERT III adapted to airports) REF
- CITEPA REF
- COPERT III REF
- MOBILE 5.2 (EDMS 4.1) REF

Each method relies on different vehicle categories, engine technologies, and driving conditions which originate from various institutions. The main sources of information were the US EPA, the UK Department for Transport DfT and the EEA. However, those four ways to estimate roadway emissions rely on detailed traffic data (number of vehicles and fleet distribution). This kind of data was not available for F. Chopin airport at the time of this study.

It is not the first time that difficulties are encountered to estimate road traffic in the course of an ALAQS case study. As a consequence a methodology to estimate road traffic from well known air statistics (such as passenger and freight transported) should be developed. This section attempts to achieve this objective.

5.1 Data collection

As noted previously there was no global traffic estimation of the road network traffic around F. Chopin airport. However, some parking statistics were retrieved for all the airport parking lots. They consist in averages of movements per 24 hours from which it is feasible to extract (partial) yearly traffic figures for airport roads.

Also, F. Chopin provided some road traffic estimates (drive-ins per 24h) for taxi, city buses and private buses. Combining this with parking data should give an idea of the road traffic distribution on the main public access roads to the airport.

Nevertheless, additional figures are needed to capture the road traffic inventory for the whole study area. Especially drop-off / pick up and freight related movements should be accounted for. The use of airport freight and passenger data is expected to help in deriving such information.

5.2 Method

The road traffic around airport consists in two different types of flow. One is directly generated by the airport activities, and includes of course passenger and freight to and from the airport but also the personal of the airport for example. It can thus be derived from airport statistics. The other type of flow is due to the population living nearby the airport. As a consequence, there is a

need for two different estimation methods to derive traffic around airport. They are reported in the following sub-sections.

5.2.1 Airport induced traffic

In order to convert airport statistical figures to vehicle traffic, either monitoring or occupancy figures (for passengers and freight) are necessary for the following categories:

- Passenger Car (in passengers per vehicle)
- Light Duty vehicle (both passengers per vehicle and tons per vehicle)
- Heavy Duty Vehicle (in tons per vehicle)

Then a number of sources can be used to derive the traffic, using the following airport figures (from PPL website):

- Passengers 2004 6 085 811 persons
- Freight 2004 40 541,0 tons
- Mail 2004 6 717,5 tons

If the number of passenger (or tons) transported per vehicle is known, that is to say the vehicle occupancy, the traffic can be derived by a simple division. But this data was not available at the time of the study.

Another method, less detailed, is based on the efficiency rates of vehicles expressed in grams of CO₂ per passenger-kilometre or tons-kilometre. The number of tons and the passengers handled at the airport for a year is known, and the length of their trip can be derived from the airport map (Figure 4):

- Passenger trip: 4.97 km
- Freight trip: 8.49 km
- Non airport specific 8.05 km

Combining with the airport figures, we obtain the following global figures:

- Passengers: 30 246 480 passenger. kilometre
- Freight: 401 224 tons. kilometre

ABTS 2005 statistics (REF) allowed deriving the following fleet distribution for Poland. It is assumed that the traffic encountered around the airport has the same characteristics.

- Passenger Car 84%
- Light Duty Vehicle 1%
- Heavy Duty Vehicle 15%

Using the European averages for efficiency provided in Table 15, and the national polish fleet mix above the following CO₂ emissions can be derived:

- Passengers: 3 386.6 tons of CO₂
- Freight: 48.2 tons of CO₂

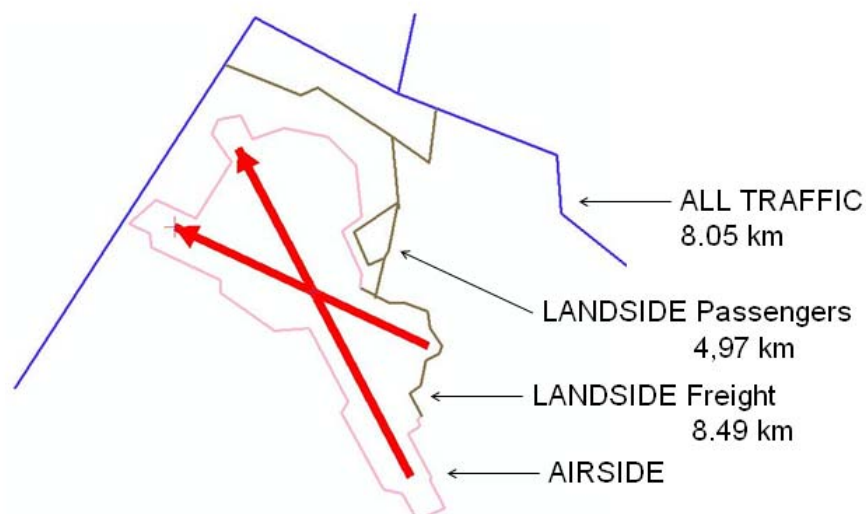


Figure 4: F. Chopin road network - categories

Table 15: Estimated CO₂ emissions per passenger kilometre and per tons kilometre in EU₁₅ (from

Unit: grams per passenger-km (for passenger transport) or grams per tonne-km (for freight transport)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Passenger transport											
Air	185.1	181.1	177.2	173.4	169.7	166.1	146.6	146.3	144.6	143.5	141.6
Maritime	43.1	43.9	44.4	44.1	44.7	42.9	42.5	41.5	44.2	44.2	43.5
Rail	42.1	41.9	43.6	43.3	45.4	45.7	44.3	44.6	46.1	44.8	43.7
Road	121.5	121.0	120.6	120.9	120.6	120.4	119.9	119.4	119.1	118.7	118.4
Passenger cars	131.3	130.8	129.7	130.1	129.7	129.2	128.4	127.8	127.3	126.7	126.2
Two-wheelers	85.9	85.9	85.9	85.9	85.9	85.8	85.8	85.1	84.5	83.9	83.5
Buses	67.1	66.2	67.3	66.8	66.6	66.7	66.7	66.5	66.4	66.2	66.1
Coaches	34.9	34.5	34.9	34.6	34.5	34.5	34.6	34.5	34.4	34.4	34.3
Freight transport											
Inland	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	0.0	30.9
Maritime	13.5	13.5	13.7	13.7	13.7	13.7	13.8	13.8	7.9	5.9	13.9
Rail	24.0	22.6	22.6	23.2	23.1	23.0	22.7	22.7	0.0	22.9	22.8
Road	122.3	122.6	122.5	122.3	122.5	122.9	122.9	123.0	123.1	123.1	123.1
LDV	407.7	407.7	407.8	408.0	408.1	407.1	404.5	402.4	400.5	398.9	397.4
HDV	91.7	91.7	91.7	91.7	91.7	91.8	91.8	91.8	91.9	91.9	92.0

Source: Trends, 2003.

5.2.2 General Non Airport Traffic

General traffic data (number of vehicles, fleet distribution) can be obtained from urban data, that is to say inhabitants, car ownership projections or jobs as laid out in the model referenced hereby [Ref. 22]. The calculation of the emissions from non airport road traffic would help in calculating background concentrations, which is of special interest in the course of dispersion modelling. However, this is not achieved in the present report.

5.3 Activity profiles

Finally the temporal repartition of the airport road pollution in time could be performed using Figure 5 (Road diurnal profile for road traffic emissions). It is issued from airports emission inventories realised for the UK Department of Transport. As this figure is airport specific, it is assumed that the same profiles could be encountered at F. Chopin airport. Therefore an activity profile for roads was implemented in ALAQS-AV accordingly.

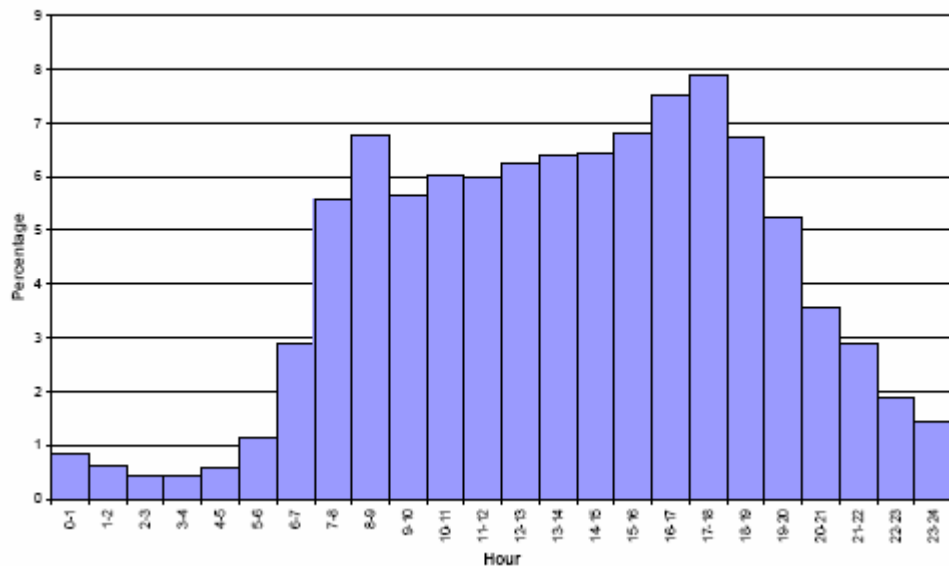


Figure 5: Representative diurnal profile for road traffic emissions (based on DfT Airport Emission Inventories [Ref. 21])

5.4 Special considerations

A common method to calculate airport road pollution considers roads in a larger perimeter than the area for ALAQ. For example, the rectangle including roads in the AQ study is 6km wider than the rectangle for airport AQ study in [Ref. 23]. This is expected to better estimate background concentrations, especially important for dispersion calculations.

Additionally, when airport road traffic is not monitored, it could be useful to use arrival and departure figures to authorize a better allocation of movements to roads providing that a specific road is defined for departures and another one for arrivals.

When traffic figures are not known, it is necessary to use vehicle occupancy figures to derive traffic figures and therefore use ALAQS-AV roadway inner methodologies. In case occupancies are unknown, environmental energy efficiency could be used to convert the airport statistics (passenger.km or tons.km) in quantities of emission released. In that case traffic itself is not considered then ALAQS-AV cannot be used and the pollutants estimated are limited. Considering environmental efficiency, data usually covers CO₂ exhausts which are expressed in grams of CO₂ per passenger.km (tons.km). Other pollutants are barely considered. Therefore it would be interesting to find ways to derive main pollutants figures (such as CO, HC, NO_x, PM...) from CO₂ emission estimations.

6. STATIONARY SOURCE EMISSIONS

6.1 Method

Two cases occur when estimating stationary sources emissions: either the emissions are continuously monitored (best practice) or they are not. Generally only large airports undertake such monitoring, in which case the measured values can be input in ALAQS-AV. It was not the case for Chopin Airport so default values had to be used.

The best practice methodology is based on the data collection of the following parameters for each source:

- Category (coal power plant, turbine heat plant, ...) and thermal power
- Type of fuel used (coal, diesel, ...) and characteristics
- Anti-pollution equipment (filters, low NO_x heaters, floating roof in the case of fuel tanks, ...)
- Quantities of energy used per equipment and per fuel type

Calculations are then based on a multiplication of the fuel consumption and the pollutant emission rate which are obtained from the equipment category and the fuel type. Default values for those parameters are available from the EDMS software. However whenever possible those default values should be replaced with airport specific or at least region specific data. Similarly parameters such as emission height, temperature and exhaust gas velocity should be user defined in order to allow for reliable dispersion calculations.

The activity profiles allow then to assign emissions for each hour, day and month of the year depending on the usage rate of the equipment. It is important to perform such a temporal distribution of the pollution as the subsequent dispersion will vary as a function of hourly dependent meteorological parameters such as wind speed and direction.

6.2 Data Collection

In the case of Chopin Airport, site-specific data was not available at the time of the study. Therefore the defaults stored in ALAQS-AV database are used. For each category and equipment type, the thermal power, fuel characteristics as well as the quantities of energy used are defined. It is assumed that no anti-pollution equipment is in use. The airport data collection consisted mainly on defining the category and type (i.e. sub-category) for each stationary source. Activity profiles were also missing, which will impact the second phase of this case study (dispersion).

Table 16: Summary of the data collection for stationary sources

Category	Parameter	Airport-specific data (APT) or ALAQS default
Stationary	Category	APT

sources	Type	APT
	Temperature of exhaust (°C)	Default
	Units emitted per year (kg or tons or m ³)	APT
	Diameter of the source output	Default
	Exhaust gas velocity (m/s)	Default
	Activity profile	None
	Average emission factors per source	Default
	Type of substance exhausted	Default
	Emission height	Default

It should be noted that the EDMS methodology evolved since it was implemented in ALAQS-AV. Especially in the latest version released (EDMS 4.3) there are five additional categories of stationary sources. Similarly emission factors might have been updated. For the next version of ALAQS-AV, it should be ensured that the latest default values and emission factors are used.

In the case of F. Chopin airport, the stationary sources consist in:

- Five fuel tanks (with one for military use)
- Two fuel powered heating stations
- Weekly training fires

It is noticeable that there is no electric generator at F. Chopin airport. Electricity is generated off-site. As a consequence the emissions from stationary sources are likely to represent a small proportion of the total pollution.

6.3 Results

Yearly fuel consumption figures were available for the two heating stations. In total it reached more than 220 m³ of fuel. Therefore the total pollution from heating plants could be retrieved. However, the only activity profiles available were on a four months basis which is too large for an accurate dispersion modelling. It was also the case for H. Coanda case study [Ref. 18]. It is anticipated that this kind of data would be difficult to obtain from any airport. Consequently, in the view of dispersion modelling, it could be worthwhile to develop a method deriving activity profiles from known statistics. For example average daily temperature and daily activity could be used. This will be investigated for the second phase of this case study where dispersion modelling will be dealt with.

Moreover, emissions due to wastes packaging, restaurants, grass cutting, runway sweeping... could not be estimated as they are not part of the EDMS methodology.

A new feature was implemented in the ALAQS-AV tool: the concept of area source. An emission rate per surface unit (m^2) could be derived knowing the operational conditions under which runway is cleaned or de-iced. But there is no default data available considering those. Possibility to derive such default should be investigated for the second phase of Chopin Airport case study.

6.4 Special Considerations

The inventory of F. Chopin Airport equipment revealed that the electrical power is generated off-site. It is used to aliment features such as runway lights as well as the terminals. Therefore the energy necessary to create and provide this electricity (and the subsequent pollution) is not accounted for in the emission inventory. The arising question asks whether we should consider it for airport air quality studies. The answer probably depends on the objective of such study. In the case of an environmental impact assessment it would be worth to consider it even though it does not impact directly the airport air quality.

A similar problem is encountered when dealing with access means to the airport and in particular with rail transport. Most trains are powered electrically which doesn't appear in the airport emission inventory. But a fair comparison of the environmental impact of access roads and access rails should consider the production of energy to propel trains.

In conclusion there is a need to define a method to account for electricity production even though it doesn't occur on the airport field. The eventual consideration of those in airports emission inventories should be discussed with experts.

About activity profiles, it could be feasible to derive those from know statistics. For example average daily temperature could be used to obtain heating plant daily activity. This would further enhance the dispersion modelling results.

Moreover, the new EDMS data (version 4.3) for stationary sources should be updated in ALAQS-AV to replace the previous ones (from EDMS 4.1).

7. CONCLUSIONS

7.1 Data collection issues for preparing the dispersion modelling

Chopin Airport Authorities made available all the data necessary to compute accurate aircraft emission calculations. No shortage in data collection was noticed. Comparison between a simple and a sophisticated method showed results of the same order of magnitude but varying by more than a hundred tons. Thus the importance of assigning emission factors on an engine basis rather than on an aircraft type or groups basis was emphasized.

Two approaches were considered to estimate handling emissions: top down and bottom up approaches. The top down approach consists of calculating total yearly emissions without geographic issues, from yearly fuel burn figures. Therefore the data collection needs to consider all the airport ground handling companies. Unfortunately the data retrieved was not harmonised so it was not feasible to apply this approach. On the contrary, it was possible to calculate emissions on a quite accurate way through the bottom up method.

Roadway traffic statistics were not available, neither for the landside nor the airside domain. Therefore we used an estimation method to calculate road traffic from passengers and freight statistics. Further adjustments are required, especially in terms of vehicle occupancy rates and environmental efficiency.

An accurate estimation of stationary sources emissions was not possible. ALAQS-AV default data should be updated with those of EDMS latest version. Activity profiles should be derived using known statistics.

7.2 Best practice recommendations

Aircraft emission are calculated in ALAQS-AV using accurate climb-out trajectories (between seven and 12 different reference points for each aircraft type) and moreover assigning to each aircraft the real engine fit (using each aircraft unique registration number). This is considered to be the best practice as previous case studies showed that assigning engine per aircraft type impacted greatly the results. Comparison of this sophisticated method with a simple one (based on ICAO times in mode and emission factors averaged per aircraft group) showed that the difference weight more than hundred(s) of tons.

Airport authorities provided an exhaustive list of the equipment in use at Chopin Airport. This allowed estimating emissions using gate scenarios method (i.e. assignment of emission factors per pollutant per gate type and per aircraft to each gate). Results obtained from two methods (LASPORT and CITEPA) were comparable even though the two methods were based on very different assumptions.

Shortage in data collection for roadways implied the use of national statistics and airport figures (freight and passengers) to derive road traffic. Only airport related traffic was considered. Further adjustments are required to provide better estimates.

The estimation of the pollution due to stationary sources could not be fully achieved. It is forecasted that the use in ALAQS-AV of default emission figures that are not region specific would imply non reliable emission figures. They should be update with the latest available data (EDMS 4.3) The best way to estimate emissions from fixed sources is to monitor on site their outputs for a specific period of time. The issue of considering electricity generation was raised, as no generator was operated at F. Chopin.

7.3 Action List to Prepare F. Chopin Case Studyphase 2 - Dispersion Modeling

1. Add default data in ALAQS-AV to account for helicopters movements.
2. Study the impact of ground track toward aircraft emissions geographical location.
3. Run sensitivity analysis of aircraft emissions about the impact of using operational weight dependent flight profiles (departures mainly).
4. Run sensitivity analysis of aircraft emissions about the impact of new emission factors and fuel flow when defined for any engine regime.
5. Use ALAQS-AV GSE allocation method to compare GSE emissions from various methods.
6. Feasibility of considering aircraft load factor to define the necessary gate handling equipment.
7. Implement EDMS 4.3 emission indices in ALAQS-AV for stationary sources and GSE emission calculations.
8. Define vehicle occupancy figures for Poland (or F. Chopin) to be able to derive road traffic estimation figures
9. Investigate the use of urban road model to estimate non airport generated road traffic around the airport (for calculating background concentrations).
10. Investigate the use of a new method for stationary source emissions: CITEPA methodology.
11. Implement activity profiles for stationary sources.

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