AIRPORT (FERIHEGY – HUNGARY) AIR QUALITY ANALYSIS USING THE EDMS MODELLING SYSTEM

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INTRODUCTION

Air quality at airports has received substantial attention in recent years. As the contribution to urban air pollution from road emissions is steadily reducing in cities of European countries, other emission sources are becoming comparatively more relevant. The contribution to air pollution levels from emissions produced by the operation of airports located close to cities is one example in this respect. This phenomenon is accentuated due to urban settlement dynamics resulting in increases in the number of people exposed either living or working around these facilities and expansion wishes of airport operators to cope with forecasted increases in air traffic demand.

Budapest Ferihegy Airport does not belong to the internationally registered busiest airports, but the volume expanding of its traffic require to be aware of air quality impact statement. By the recommendation of EEA (European Environment Agency), in case of an airport has more than 100 thousands LTO cycles (landing, take-off and taxi) per year, the airport become an important air pollution source in the national balance. Our airport exceeds this limit, partly owing to the summer period, when a large number of charter flights can increase the traffic significantly.

EDMS MODELLING SYSTEM

The EDMS (Emissions and Dispersion Modelling System) has been considered a preferred model for airport air quality analysis. The modelling system EDMS was developed in the mid-1980s as a complex source microcomputer model designed to assess the air quality impacts of proposed airport development projects. EDMS is a combined emissions and dispersion model (AERMOD) for assessing air quality at the airports. The model is used to produce an inventory of emissions generated by sources on and around the airport or air base, and to calculate pollutant concentrations in these environments. The policy statement is intended to ensure consistency and quality of analysis performed to assess the air quality impacts of airport emission sources for purposes of complying with the National Environmental Policy Act.

The previous version of EDMS (Version 3.23) used CALINE3 and PAL2 for atmospheric dispersion. In the first quarter of 2001, CALINE3 and PAL2 were replaced by AERMOD and its supporting weather and terrain processors, AERMET and AERMAP in Version 4.0 of EDMS. AERMOD has better characterization of the planetary boundary layer and allows dispersion to be accomplished using continuous functions rather than with discrete stability classes that do not change with height. Instead of a Gaussian distribution for both the horizontal and vertical directions, AERMOD uses a bi-Gauassian probability density function (PDF) to characterize the dispersion in the vertical direction. AERMOD also incorporates a new, simple method to model flow and dispersion in complex terrain. The EDMS version used for this study is EDMS Version 4.5.

The emissions for pollutants: CO, NOx, SOx, Total Hydrocarbons (THC), Non-Methane Hydrocarbons (NMHC), Volatile Organic Compounds (VOC), $PM_{2.5}$ and PM_{10} are provided.

At the Hungarian Meteorological Service (HMS) the AERMOD model system was adapted first. Because of the input data file formats required for AERMET and AERMAP are not available at HMS, new pre-processors were developed instead of AERMET and AERMAP for preparing the input files for the dispersion model. The MM5 numerical weather prediction model analysis files are used as meteorological input of AERMOD. After successful setting up of AERMOD, the adaptation of EDMS was not too difficult work. *Figure 1* shows the architecture of the EDMS modelling system.

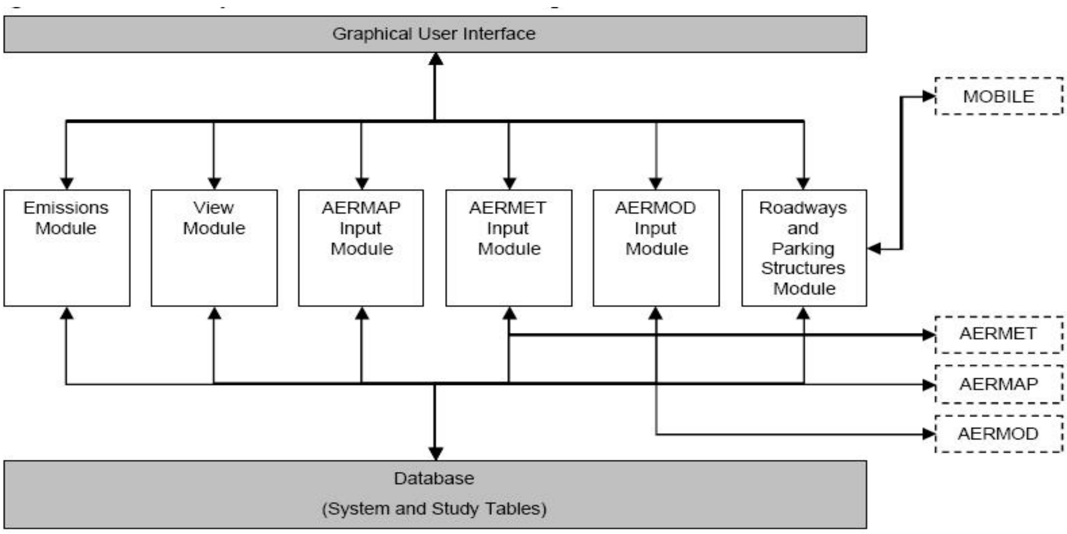

Fig. 1; EDMS system architecture and components.

EDMS INPUTS REQUIRED

EDMS generates input files for use with the AERMOD dispersion model. Since EDMS is a model specifically developed for use at airports, the inputs relate directly to the placement of aircraft and other source activity and movement on the airport. Data input includes:

1) Creation and specification of
   - runways,
   - queues,
   - taxiways,
   - buildings and
   - gates.
2) Emission data of
   - aircraft activity,
   - ground support equipment,
   - on-road vehicles,
   - parking facilities,
   - stationary sources and
   - training fires.

Aircraft activity is expressed in Landing-Takeoff (LTO) cycles. Each LTO consists of taxiing, queuing, takeoff, climb out, approach and landing. There is no provision to specify arrival numbers and departure numbers independently of each other. EDMS contains default aircraft-specific data relating to the emissions:

1) Times in mode (TIMs) are the durations per LTO cycle that an aircraft spends in each of the four modes of aircraft operation. Takeoff, climb out, approach and landing mode TIMs are aircraft-specific in EDMS.

2) Ground Support Equipments (GSE) are made to be based on aircraft type with an operating time associated with each aircraft LTO cycle.
3) Aircrafts are assigned to an unlimited number of taxiways and runways.
4) Engine emission factors are aircraft-specific.

FIRST RESULTS

The dispersion model calculates concentrations for 1-hour periods, and all source types can vary hour by hour in their activity or strength. Therefore, EDMS uses operational profiles which are based on the concept of peak activity. A peak hour, day or month is defined as that at which the most or maximum activity occurs. Peak activity is represented by a proportional factor of 1 (signifying maximum activity).

In our study three categories are defined for the aircrafts – light, medium, heavy - in accordance with the International Civil Aviation Organization (ICAO) scheme. Each category is represented by the aircraft-type most frequently operated at Ferihegy Airport (Socata Tampico - light, Boeing 737 – medium, Boeing 767 – heavy). All aircrafts are replaced by the appropriate defined aircraft with its default specific data. Hourly, daily and monthly operational profiles are also calculated for the three defined aircrafts.

B737 made 57594 LTO cycles during the year 2006, while Socata Tampico made 3769 LTO cycles and B767 made 2112 LTO cycles. 1/3 of all three aircraft types used the gates at Terminal 1 and the other 2/3 at Terminal 2. We calculated with a taxi time of 26 minutes (EPA default) for every aircraft.

Emissions are generated by ground support vehicles and auxiliary power units (APUs) while the aircraft is parked at the gate. GSE Emissions are obtained from EPA's NONROAD model and are dependent on the age, fuel, horsepower and load factor applied to the engine. APUs are most often on-board generators that provide electrical power to the aircraft while its engines are shut down. Like GSE, APU emissions generated per LTO cycle are the product of the emission factor and the operating time, and multiplied by the number of applicable aircraft LTO cycles. In case of B737 and B767 the default APUs were used. In case of the other aircrafts (light aircrafts) APUs were not used. The GSE was also set to the default values of the different aircraft types.

In our work we used 2 parking facilities. The number of vehicles is 350,000 (yearly) using the parking facility at Terminal 2, and it is 300,000 at Terminal 1. The average speed of vehicles travelling in the parking facility is one of the parameters necessary to determine the emission factors for the movement of the vehicles using MOBILE5a, MOBILE5b or MOBILE6.2 models. The default fleet mix (types, fuels and ages of vehicles), the speed (10 mph) in the parking facility and the distance (250 m) travelled in lot were set to the default values. It is an estimate for the average distance a vehicle travels between entry and exit.

In order to take in account the motor vehicle activity on roadways at and near the airport, it is necessary to use as many traffic count results as possible. In our study we used 2 traffic count results at and near the airport. The first count was made near Terminal 2. The number of vehicles were counted on the road which links the two Terminals (2,350,000 vehicles per year) and on the road which connects Terminal 2 and road Nr. 4 (600,000 vehicles per year). The second count was made on road Nr. 4 near the airport (6,174,340 vehicles per year). The default fleet mix and the speed (35 mph) of the vehicles were set to the default values.

The general methodology for calculating emissions from stationary sources considers the amount of fuel or substance consumed. In the modelling we used the three main stationary sources (P1, P2, P16) at the airport. Each of these sources have a stack height of 40 meters and a stack inside diameter of 1.9 meters.

The locations at which concentrations are estimated are known as receptors. EDMS allows the placement of receptors in the Cartesian or Polar coordinate system with the ability to also specify the height of the receptors. In the modelling domain we used Cartesian receptor network with different resolution. Near the main emission sources we used a receptor network with higher resolution (100 m), elsewhere a receptor network with lower resolution (500 m).

We made two test runs with the EDMS modelling system. In the first run we calculated the yearly average NO_x concentration in the receptor points at a height of 1.8 m, in the second run the yearly average CO concentration was calculated the same way. *Figures 2* and *3* show the calculated concentrations for CO and NO_x, respectively. In the figures, black solid lines indicate the runways, black dashed lines are taxiways, white solid lines are the roads and white poligons indicate the two terminals. The numbers at the two axes present the distance in meters from the center of the figure. The whole area is about 9 x 8 km^2.

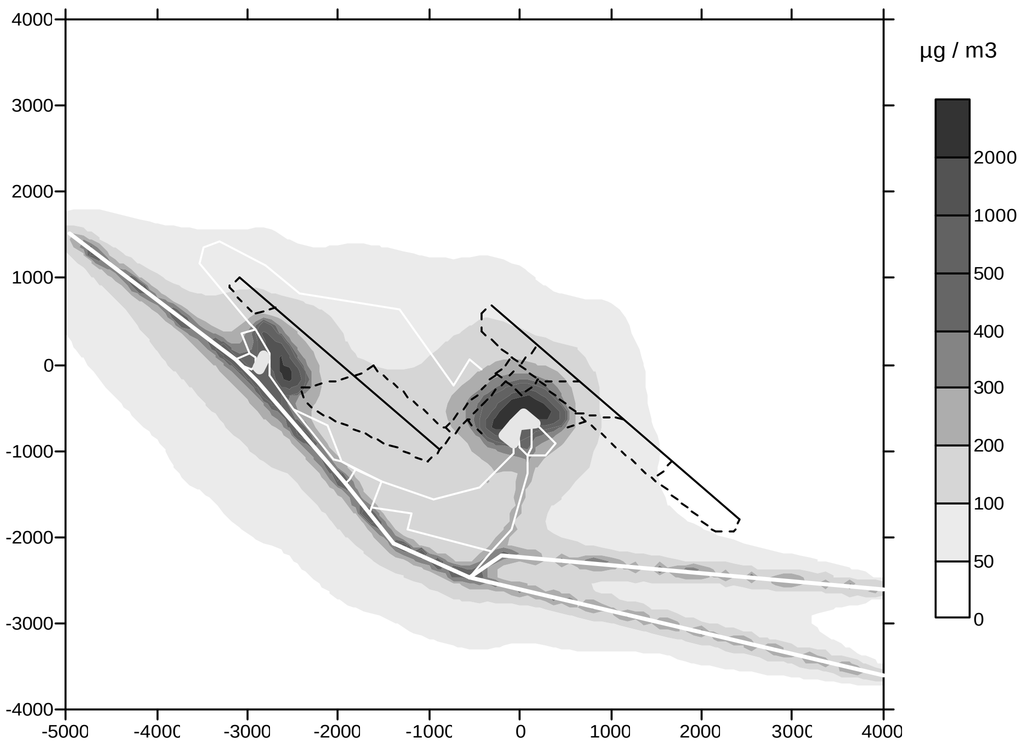

Fig. 2; Yearly average CO concentration at Ferihegy Airport.

We can see that in both cases the maximum concentrations are near the gates of Terminal 1 and 2. The maximum yearly NO_x concentrations are about 200 µg/m^3, the maximum yearly CO concentrations are about 3000 µg/m^3. For the maximum concentrations near the gates the GSE and the APUs are responsible. From the emission inventory table of the model it can be seen that GSE and APUs produce the highest CO emissions in the modelling domain. Although the total NO_x emission of the aircrafts and roadways is higher than the NO_x emission of GSE and APUs, aircrafts and vehicles emit the pollutants in a much bigger area. In *Figure 3* it is visible that in case of NO_x, the vehicles (road Nr. 4) and the moving aircrafts (especially near the starting points) have significant influence to the concentration distribution. This result is not surprising, because the NO_x emission of aircrafts is highest during takeoff mode.

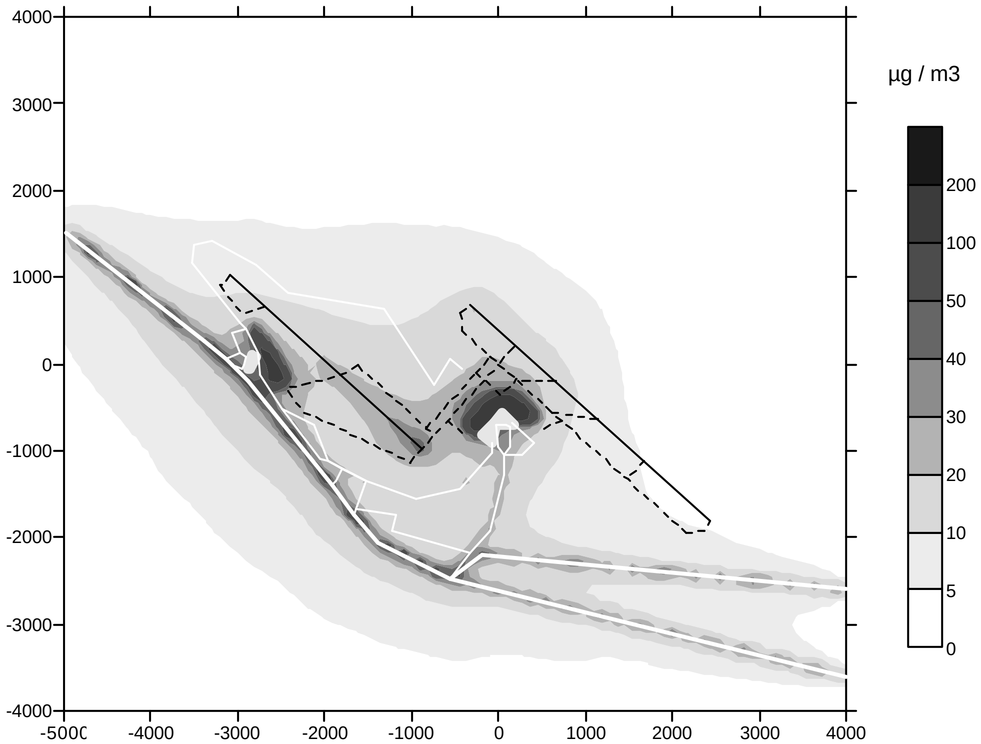

Fig. 3; Yearly average NO_x concentration at Ferihegy Airport.

In the future we would like to increase the accuracy of our modelling results. In case of the emission inputs we often used EDMS default values. Our goal is to use emission input values specific for Budapest Ferihegy Airport. To do that a lot of measuring work should be completed at and around the airport.

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