ESTIMATING EMISSIONS FROM SMALLER AIRPORTS

Summary

Base Year: 2008
Because of lack of recent activity datasets for the 2008 base year, estimate of airside emissions (provided by AEA Technology) for the 2008 base year (from the LAEI 2006) from minor Greater London airports and airfields (London City, Stapleford , Elstree , Northolt, Battersea , Kenley, Biggin Hill , Lippits Hill Heliport, Denham and Metro London Heliport), undertaken on behalf of the Greater London Authority (GLA) were used.

Projection Years: 2011 and 2015
Because of lack of recent, representative and reliable activity datasets, projection of atmospheric emissions from the smaller airports to 2011 and 2015 were not undertaken; instead projections of atmospheric emissions from the smaller airport to 2011 and 2015 were basically assumed to be the same as those in the LAEI 2006 (same as the 2010 projection).

2008 emission estimation methodology: (Same as the LAEI 2006 methodology)

This section describes the LAEI 2008 methodology, data used and results obtained from the calculation of airside emissions from minor Greater London airports and airfields (see Figure 8), undertaken by AEA Technology on behalf of the Greater London Authority (GLA). Airside emissions are those emissions that occur airside and include emissions from aircraft, airside vehicles and plant (i.e. those operating on the apron areas) and refuelling. The report summarises the methodology and present summarised result for each airport/airfield:

- London City
- Stapleford
- Elstree
- Northolt
- Battersea
- Kenley
- Biggin Hill
- Lippits Hill Heliport
- Denham
- Metro London Heliport

The historic data was only available for City Airport. The trends in aircrafts movement data from DfT statistics spreadsheet for Aircraft Movements 1998 – 2008 at City Airport were analysed. It was calculated that there was 55% increase in the aircraft movements at City Airport. The % increase was used to upscale the original data for City Airport. The data for the other small airport remained the same as in LAEI 2006.

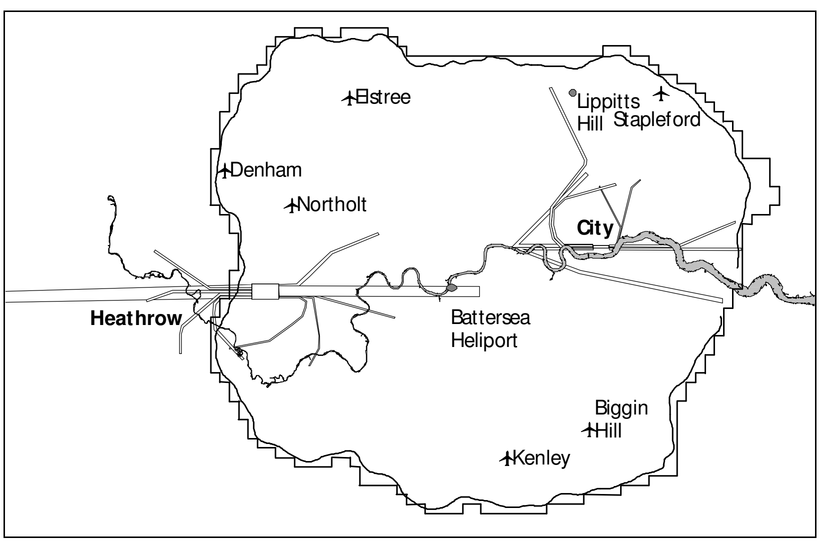
It should be noted that this study did not undertake emission estimation for large airports such as Heathrow and only included those airports or airfield as listed above within the M25 orbital, with the exception of Kenley, which was assumed to have negligable impact due to the assumption that all aircraft operating from Kenley are gliders.

Additionally, only airside emissions have been estimated, no emissions have been calculated for landside road traffic (i.e. those on public access roads), heating plants or car parking. Therefore the sources for which emissions have been calculated are: the aircraft landing and take-off cycle (LTO), auxiliary power units (APU), refuelling and airside vehicles and plant equipment (i.e. baggage loaders and other aircraft support equipment).

Emissions have been calculated for the following pollutants: oxides of nitrogen; sulphur dioxide; carbon monoxide; non-methane volatile organic compounds; carbon dioxide; benzene; 1,3-butadiene, methane and particulate matter (PM_{10}).

The Greater London Authority provided the initial contact details for all airports/airfields and AEA Technology liased with the operators to obtain suitable data. It should be noted that the airports/airfields were under no obligation to provide the data and as such a considerable amount of time elapsed before sufficient data was gathered for the airports/airfield, with the exception of Denham who have, to date, supplied no data. After considerable effort it was decided to assume Denham had 30,000 movements (all twin-engined propeller) based on Elstree. Denham were informed of the assumption of 30,000 movements and given time to respond, but to date have not responded.

Figure 1: Location of airports in the Greater London area



Usually, an emissions inventory relates to a specific spatial domain, for example a given city, region or country. The aim in the current work, however, is to quantify airport-related emissions to the extent that they impact on local air quality.

For aircraft, emissions at cruise altitude are best considered in relation to the total demand for air travel and the inventory considers emissions only in the Landing and Take-Off (LTO) cycle, which conventionally extends up to 1,000m. In practice, the impact on ground-level concentrations per unit emission decreases rapidly with the height of emissions, such that the total aircraft emissions above ground level have a much smaller impact on local air quality than those at ground level on the airport.

The following sources are included in the inventory:

- aircraft in the LTO cycle, including APU emissions;
- airside vehicles/plant;
- Fuel storage and aircraft refuelling.

For PM_{10}, the inventory includes exhaust emissions and fugitive emissions from brake and tyre wear (for aircraft).

Estimating emissions

The usual approach to calculate emissions from specific sources is to multiply an activity statistic, for example fuel usage or distance travelled, by an emission factor (expressed as mass of pollutant emitted per kg of fuel burned or per km travelled respectively). Emission factors are usually derived from measurement data but are often calculated from a limited sample of measurements. Specific emission factors for individual sources are not always available, in these cases a representative emission factor is usually used, this is however often subject to some educated judgement. The aim of the current work is to quantify the airport and airfield emissions within the M25, excluding Heathrow Airport, to a height of 1000m.

LTO Cycle aircraft exhaust emissions

The dominant aircraft source of emissions is main-engine exhaust during the LTO cycle, and this will be the principal focus of the discussion below. However, separate consideration is also given to emissions from Auxiliary Power Units (APU's).

The following 'modes' (phases) of the LTO cycle are distinguished for purposes of emissionsestimation:

(1) taxi-out;
(2) take-off roll (from start-of-roll to wheels-off);
(3) initial climb (i.e., wheels-off to throttle-back, assumed to occur at 450m);
(4) climb-out (from 450m to 1,000m);
(6) approach (from 1,000m to touchdown);
(7) landing roll (from touchdown to runway exit);
(8) taxi-in.

It was assumed that emissions from the holding of aircraft ready to depart would be minimal at small airports and would be encompassed by the taxiing emissions.

'Taxi-out' commences at stand or apron and ends when the aircraft reaches the end of the runway where take-off begins. The 'taxi-in' commences when the aircraft completes its landing and leaves the runway and ends when the aircraft reaches the stand or apron. Taxi times were based on mapped taxi distances between runways and aprons and an assumed 10mph speed based on data from other studies. Thrust was assumed to be at 7% for taxi.

Take-off roll and initial-climb emissions are estimated from emission rate at take-off thrust multiplied by the take-off roll time (time from start of roll to wheels-off) and initial-climb time (time from wheels-off to 450 m altitude) respectively. Initial climb and take-off had an assumed thrust of 100%, for smaller aircraft. However, reduced thrust for some larger aircraft operating at London City, Biggin Hill and Northolt was assumed for take-off and initial climb, with estimates of take-off thrust taken from a study undertaken at Gatwick (Underwood et al, 2004a).
Once aircraft reach approximately 450 m altitude they will reduce their thrust setting from take-off thrust to climb-out thrust this is termed "throttle back". Climb-out emissions are estimated from the time to climb to 450 m 1000 m multiplied by the emission rate at climb-out thrust (typically 85%).

Approach emissions are estimated from the time in approach from 1000 m multiplied by the emission rate at 30% thrust. In line with the airport studies, the time in approach was assumed to be 286 s for large, medium and small aircraft, 312 s for light aircraft and 390 s for helicopters.

In general, aircraft will land at idle thrust (7%). However, most aircraft make use of reverse thrust (usually 30%) for some of the time. Data from Gatwick study (Underwood et al, 2004a) gave the percentage of aircraft that use reverse thrust for each specific aircraft type. The total time in landing-roll and the time in reverse thrust as well as the reverse thrust settings by aircraft types were taken from the Gatwick study (Underwood et al, 2004a). Some aircraft have periods of reverse thrust during landing roll, in place of braking. Where information is available for specific aircraft types emissions for reverse thrust have been included. Where it is not available it has been assumed that no reverse thrust is used during landing roll.

Times-in-mode

The times-in-mode for take-off roll, initial climb, climb-out, approach and landing roll were base on survey data used in the 2002/3 Gatwick emission inventory report (Underwood et al, 2004a). Take-off roll, initial climb, climb-out, approach and landing roll are not as airport specific as taxiing times. The taxiing times in mode have been estimated using mapped data as described above.

Movement data

Movement data was provided by each airport, with the exception of Denham. The CAA also supplied the movement data for both Biggin Hill and London City. This was supplemented with data from London City airport.

Engine assignment

The movement data provided did not provide engine type directly nor did it include details of each aircraft registration number. Therefore weighted average emissions, based on Gatwick data for the mix of engine types used per aircraft, were calculated and applied to the relevant aircraft.

Engine exhaust emission factors

Emissions from aircraft originate from the fuel burned in the main aircraft engines, and the engines powering the auxiliary power units. The combustion products from the engines include greenhouse gases and other pollutants. Carbon dioxide and oxides of nitrogen are emitted in the greatest quantities per tonne of fuel consumed, but methane, nitrous oxide, other by-product gases, and trace amounts of metals are emitted also. The fuel use and emissions will be dependent on the fuel type, aircraft type, engine type, engine load and flying altitude. The chief source of emission factors (and fuel flow rates) used in the present work is the ICAO databank (CAA, 2006), which gives certification test results for most of the engines in service, at four thrust settings (7%, 30%, 85% and 100%). It is a key assumption of the methodology that these engine test results are representative of the emissions performance of in-service engines. Data for some engines not listed in the ICAO databank (usually turboprops) were obtained from the FAA Aircraft Engine Emission Database (FAA). A significant proportion of aircraft engines were identified from the databanks. In a few cases surrogate engines of similar size were used.

Table 1: Emission factors for aviation fuels (kg/t)

Fuel	CO_2	SO_2
	(kt / tonne)	(kg / tonne)
Aviation Turbine Fuel	859	0.82
Aviation Spirit	865	0.82

The ICAO databank only contains emission factors for NOx, HC, and CO. It does not include emission factors for PM_{10} directly, but does include 'smoke number' (SN), an indirect measure of particulate emissions calculated from the reflectance of a filter paper measured before and after the passage of a known quantity of smoke-bearing gas. A method developed as part of the Project Sustainable Development Heathrow Project (DfT, 2006) to derive an emission factor (g pollutant per kg of fuel consumed) from SN was used. The core of the method depends on generalising from a sparse data set relating SN to a gravimetric measure (from example, g/m^3 of exhaust gas). This method of emission factor estimation has been used in similar airport emission estimation for airports such as Gatwick, Birmingham, Manchester and Heathrow. Emissions of carbon dioxide and sulphur dioxide were calculated by assumed amounts of the particular pollutant per tonne of fuel consumed.

In general there are three fuels that are used to power aircraft: aviation gasoline, jet gasoline, and jet kerosene. Aviation Gasoline is motor spirit prepared especially for aviation piston engines, with an octane number suited to the engine, a freezing point of -60°C and a distillation range usually within the limits of 30°C and 180°C. Jet Gasoline (Naphtha type Jet Fuel or JPA) is a light hydrocarbon oil distilling between 100°C and 250°C for use in aviation turbine power units. It is obtained by blending kerosenes and gasoline or naphthas in such a way that the aromatic content does not exceed 25 per cent in volume, and the vapour pressure is between 13.7 kPa and 20.6 kPa. Jet Kerosene is a distillate also used for aviation turbine power units. It has the same distillation characteristics between 150°C and 300°C (generally not above 250°C) and flash point as kerosene. In addition, it has particular specifications (such as freezing point) which are established by the International Air Transport Association (IATA).

Emissions of carbon dioxide and sulphur dioxide are derived from the carbon and sulphur contents in the fuels. The sulphur contents are updated annually from data provided by UKPIA. The carbon contents of the fuels are currently under review.

Emissions of benzene, 1, 3-butadiene, methane were calculated from the hydrocarbon emissions calculated using the ICAO emission factors. The methodology described in Memorandum from R. Cook to R. Wilcox. .'Exhaust THC to VOC Correction Factors for Aircraft," July, 1992 was used to first convert hydrocarbons to methane and NMVOC. The NMVOC was then converted to benzene and 1,3 butadiene using 1.97 and 1.8 factors respectively.
In terms of spatial apportionment, all airports and airfields, except Biggin Hill, were assumed to use the main runway only, with the operation direction split based on Heathrow meteorological data for 2004. For Biggin Hill only a small percentage of the light aircraft were apportioned to the short runway (based on analysis of meteorological wind direction data), others were apportioned to the main runway. Take-off and landing were apportioned to runways and assumptions made concerning length of take off and landing typical to the aircraft size. Similarly, approach was assumed to be a straight line from 1000m to touch down. Initial climbout assumed to be a straight line from wheels of up to 450m, climbout a straight line from 450m to 1000m. Taxi emissions were apportioned to the most obvious route between runway end and apron. APU emissions were apportioned to aprons. Brake and tyre wear were assumed to be apportioned to landing.

APU emissions

Data from Heathrow and Gatwick studies (Underwood et al, 2004a) enabled aircraft types and APU types to be matched. Stansted data gave one average APU running times prior to departure and after arrival for all aircraft and this was used in conjunction with the typical APU types per aircraft taken from the Gatwick and Heathrow studies.

APU emissions (kg) from an aircraft movement were estimated from the product of the APU running time (s), the fuel consumption (kg/s) and the emission factor (kg pollutant per kg fuel consumed).

There are limited source of emission factors for APUs, emission factors have been taken from the Heathrow and Gatwick studies (Underwood et al, 2004 and 2004a).

The APU emission factor dataset does not contain PM_{10} emission factors. However, total APU fuel used can be calculated, and an estimate of APU PM_{10} emissions was derived by taking a representative emission factor of 0.1g/kg fuel. This value is approximately equal to the ratio of total PM_{10} emissions in the LTO cycle to total fuel used in the LTO cycle found in the current work and in past airport emission inventories such as those for Gatwick and Heathrow.

Engine testing emissions

It was decided from past experience that the emission from this source would be insignificant for small airports and they were therefore not calculated.

Aircraft-related fugitive emissions

It was assumed for this air quality assessment based on previous assessments for Heathrow and Gatwick that the quantity of eroded material per landing should be scale with the size of aircraft. The most suitable way of scaling by size was thought to be by the maximum take-off weight. The estimate of the contribution of tyre and brake wear to emissions should be treated with caution, the method used is the same as used in the PSDH project (Dft, 2006).

Airside support vehicle/plant emissions

For the purposes of this report it has been assumed that the fuel consumption of aircraft (excluding helicopters) during the approach mode can be used as a surrogate statistic to scale emissions from other airport studies, in this case for Belfast City Airport, where airside fuel consumption for support vehicles and plant were available. Approach fuel use has been used as a surrogate as approach time is normally assumed to be fairly consistent from one airport to another. Fuel at Belfast City Airport was estimated in 2005 to be 110, 5547kg for aircraft approach and 206047 litres of airside fuel (assumed diesel).

Emission factors from the National Atmospheric Emission Inventory (NAEI, 2005) have been used for diesel fuelled support vehicles and plant. The emissions calculated should be treated with caution due to the assumed fuel use. Estimated emissions are detailed below and have been apportioned to the aprons:

Aircraft fuel storage and handling

There will be emissions of hydrocarbons due to evaporation of aircraft fuel from storage, tank filling and from any spillages. It has been reported in previous air quality assessments for airports (Underwood et al, 2004 and 2004a) that these sources are not thought to be major contributors to the overall emissions of hydrocarbons.

It has been assumed that the fuel use is related to the estimated approach fuel burn and a similar methodology to that used to estimate airside vehicle/plant emissions has been used. The aviation fuel related evaporative emissions at Belfast City Airport have been used and factored using approach fuel use. Evaporative emissions have been apportioned to the apron areas. Benzene, 1,3 butadiene and methane have been estimated from the ratio of aircraft hydrocarbon emissions to these pollutant as the emissions of these pollutants is related to the relative proportions of different types of fuel used at different airports.

Breathing losses at the fuel farms consist of vapour expelled due to pressure changes arising from diurnal temperature cycling. Working losses from fixed-roof tanks are the sum of the loading losses (vapour expelled on filling) and unloading losses (saturation of new air intake with vapour). These losses are normally calculated using the methodology in 5th Edition of AP-42 (USEPA, 1995) for fixed-roof tanks. The principal data required for calculating total vapour loss are the dimensions of the tanks and the total annual throughput of fuel. These data were not available for the airports under consideration at the time of this study. It was also assumed that refuelling losses are the same as the working loses from the tanks. The emissions calculated should be treated with caution due to the assumed fuel use. The total emissions from aircraft fuel storage and handling are below and have been apportioned to the aprons.

References

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