ECAC METHODOLOGY FOR EMISSIONS CALCULATIONS

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ECAC RECOMMENDATION ON
METHODOLOGY FOR EMISSIONS CALCULATIONS
(Preliminary approval given by DGCA/115 and being submitted for adoption by ECAC/27)

Whereas according to the ECAC environmental policy statement, ECAC is aiming for sustainable growth in air transport by working to reduce the environmental impacts of noise and emissions,

Whereas adaptation of available international models for emissions calculation for the specific needs of aviation is part of ECAC's work programme for the period 2001-2003,

Whereas obligations exist upon States to report emissions to international organisations such as the United Nations Framework Convention on Climate Change and the United Nations Economic Commission for Europe, ECAC advocates that any methodology should be consistent with the format required for reporting of domestic aviation emissions under UN/ECE and UN/FCCC requirements, currently in accordance with the IPCC 1996 guidelines (as revised),

Noting that the level of activity in the field of emissions calculations shows considerable variation between ECAC Member States,

The Conference recommends

Article 1

Definitions

In this Recommendation, CORINAIR (**C**o-**or**dination Of **In**formation On **Air** Emissions) is the European-wide emission inventory programme that has developed the methodology on which this Recommendation is based.

Article 2

Scope

The procedures referenced in this Recommendation relate to the calculation of emissions from civil subsonic turbo-jet and turboprop aircraft flying domestic routes within the boundaries of a Member State or flying international routes departing or arriving at an airport within the boundaries of a Member State.

Article 3

Adoption of a common framework for calculation of aviation emissions

ECAC Member States should ensure that the necessary steps are taken so that procedures used in the calculation of aviation emissions for international reporting are based, at the earliest opportunity, on the criteria specified in Articles 4-7 and explained in the **Guidance Material**.

Article 4

Methodology

The ANCAT methodology is based on the EMEP/CORINAIR methodology that consists of three methods with different levels of accuracy and complexity.

ECAC Member States should calculate the emissions of aviation as accurately as possible using **ANCAT method number three** as described in the Guidance Material.

If Member States are not able to use such a detailed methodology or are unable to obtain detailed information on distances flown, they may use **ANCAT method number two**, as described in the Guidance Material.

If Member States are unable to obtain detailed information on aircraft types, they may use **ANCAT method number one**, as described in the Guidance Material.

If a peer reviewed and well-documented national methodology is available which is more accurate than ANCAT method number three, Member States may use this national methodology when producing emission inventories.

Article 5

Quality of reported data

ECAC states are urged, in line with the objective of harmonisation and consistency in the application of the emission calculations methodology, to progressively refine and improve the level of accuracy in recording aircraft emission data. States should aim towards calculation of emissions from their aviation activity in accordance with ANCAT method number three or a peer reviewed and well documented national methodology in order to achieve the best practicable level of accuracy.

Article 6

Traffic Data

ECAC Member States should use their own national traffic data. If such data are not available, Member States may use data available from EUROCONTROL on aircraft movements.

Article 7

Emissions Database

When producing emission inventories using ANCAT 1, 2, or 3, ECAC Member States should use the emission data tables as described the Guidance Material.

GUIDANCE MATERIAL ON ECAC METHODOLOGY FOR EMISSIONS CALCULATIONS

FOREWORD

This Guidance Material aims to explain the methodology for calculating air emissions from civil aviation activities and the data required for such calculations. This document is written to support the ECAC Recommendation on a common methodology for emissions calculations and should be read in conjunction with that Recommendation.

Note that the methodology described in this document is intended for producing emissions inventories. The methodology is not intended to provide a basis for initiatives such as emissions charging.

The Guidance Material contains references to emission related products of other organisations (for example, the UNECE and the UNFCCC). In order to keep the Guidance Material a reasonably short guidance document and to avoid duplication, most of those references are included as references to web pages. Subsequently, when actual calculations are being made using this document, the user will need to have access to the Internet.

A complete list of all references to relevant web pages can be found in Appendix A. The references are also explained in the text of the Guidance Material where needed. When references are made to specific tables in the CORINAIR Emission Inventory Guidebook, the CORINAIR table numbers are used. Again, to keep the Guidance Material relatively short and to avoid duplication, these tables are not copied into this Guidance Material.

When hard copies are made of the CORINAIR Emission Inventory Guidebook or the data tables, the user shall refer to the web page to ensure that the most recent versions are used because the methodology and the data tables will be up-dated from time to time.

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ABBREVIATIONS

ANCAT: (ECAC) Group of Experts on the Abatement of Nuisances Caused by Air Transport

ARTEMIS: (EU-project) Assessment and Reliability of Transport Emission Models and Inventory Systems

CAEP: (ICAO) Committee on Aviation Environmental Protection

CORINAIR: Co-ordination Of Information On Air Emissions

Cruise: Part of the flight outside the LTO-cycle

ECAC: European Civil Aviation Conference

EMCAL: (ANCAT) Subgroup on Emissions Calculations

EMEP: Co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe

EU: European Union

ICAO: International Civil Aviation Organization

IPCC: Intergovernmental Panel on Climate Change

LTO: Landing and Take-Off cycle: one LTO cycle comprising a landing plus a take-off

LRTAP: Long-Range Transboundary Air Pollution

UNECE: United Nations Economic Commission for Europe

UNFCCC: United Nations Framework Convention on Climate Change

CHEMICAL SYMBOLS

CH_4 = methane
CO = carbon monoxide
CO_2 = carbon dioxide
HFCs = hydrofluorocarbons (hydrogenated fluorocarbons)
N_2O = nitrous oxide
NH_3 = ammonia
NMVOC = non-methane volatile organic compounds (hydrocarbons)
NO = nitric oxide
NO_x = nitrogen oxides (sum of NO and NO_2)
PCFs = perfluorocarbons
POPs = persistent organic pollutants (especially polychlorinated biphenols, dioxins)
SF_6 = sulphur hexafluoride
SO_2 = sulphur dioxide

CHAPTER 1

INTRODUCTION

The demand in air traffic has shown an impressive growth over the past years and this growth is expected to continue over the next decade(s). As a consequence more attention has been drawn to the environmental effects of aviation, such as the exposure to aircraft noise and the contribution of aviation to (local) air pollution and the global climate effects.

Emissions inventories can be produced to evaluate the contribution of air traffic to global, regional and national air pollution. Depending upon the use made of aircraft emissions inventories, the method of calculation and level of detail in which information is needed may be different.

In 1998 the Group of Experts on the Abatement of Nuisances Caused by Air Transport (ANCAT) of the European Civil Aviation Conference (ECAC) initiated a Subgroup on Emissions Calculations (EMCAL). The main objective of this Subgroup was to recommend a common methodology for emissions calculations, given ECAC Member States' need for one. The Subgroup has produced a Recommendation on a Methodology for Emissions for Calculations and the accompanying Guidance Material.

This report is the Guidance Material, which describes background information on the methodology and data needed for the calculation of aviation emissions. Chapter 2 presents some background information on international bodies that are active in the field of emissions and on international reporting obligations. Chapter 3 describes the methodology for the calculation of fuel used and emissions. More information on data needed for emission calculations can be found in Chapter 4. Chapter 5 highlights some uncertainties regarding methodology and data.

CHAPTER 2

BACKGROUND

2.1 International Organisations

For many years the International Civil Aviation Organisation (ICAO) has been involved in establishing procedures and setting standards to control aircraft engine emissions. Nowadays there are a number of other UN policy-making bodies with a legitimate interest in the emissions generated by civil aviation. Their interest is closely linked with the responsibility for implementation of international agreements such as the Kyoto Protocol of the UN Framework Convention on Climate Change (UNFCCC), the Montreal Protocol on Substances that Deplete the Ozone Layer and the relevant protocols to the Convention on Long-range Transboundary Air Pollution. Each of these agreements seeks to address specific environmental problems caused by certain man-made emissions. Aviation is one of the many sources of such emissions.

2.1.1 UN Framework Convention on Climate Change, Kyoto Protocol

This Convention came into force in 1994. Its principal policy-making body is the Conference of the Parties (CoP), which is supported by a number of subsidiary bodies and working groups and which often calls on the UN Intergovernmental Panel on Climate Change (IPCC) for scientific and technical advice. The Convention has the objective of stabilising greenhouse gas concentrations at a safe level within an acceptable time frame. At the third session of the Conference of the Parties (Kyoto, December 1997) international aviation emissions were not included in the agreed targets. On aviation, the Kyoto Protocol reads as follows:

"The Parties included in Annex 1 shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively."

2.1.2 Montreal Protocol on Substances that Deplete the Ozone Layer

The Montreal Protocol has set out target dates for phasing out most ozone-depleting substances. Its principal policy-making body is the annual Meeting of Parties, supported by the Ozone Secretariat. The Protocol requires the Parties to assess measures concerning substances that deplete the ozone layer, on the basis of available scientific, environmental, technical and economic information. Previous assessments dealt with aviation, but primarily focussed on supersonic aircraft. The Montreal Protocol process and ICAO co-operate regarding international civil aviation's contribution to stratospheric ozone depletion.

2.1.3 Protocols to the Convention on Long-Range Transboundary Air Pollution (LRTAP)

The LRTAP Convention aims at preventing acid rain and photochemical smog. It is open to accession by member States of the UN Economic Commission for Europe (ECE). Most European States, Canada and the United States are parties to the Convention. The Convention's principal policy-making body is its Executive Body, which is supported by the ECE Secretariat. Several protocols are in force, dealing with different emissions (SO_2, NO_x, VOC).

The protocols to the Convention and associated guidance material include information on abatement measures for mobile sources such as aircraft. There is a liaison with ICAO aimed at ensuring consistency with ICAO's work in this field and avoidance of duplication.

2.2 International Reporting Obligations

The above UN policy-making bodies maintain an ongoing interest in the amount of emissions produced by civil air traffic. For the UNFCCC and the UNECE, this interest is expressed for example in the obligation for Member States to report their domestic emissions from aviation to these bodies. Guidelines have been developed to assist States in compiling their national inventories. This paragraph describes existing international reporting obligations and highlights some differences in reporting requirements.

2.2.1 UNECE

The UNECE/LRTAP Convention deals with the following pollutants: SO_2, NO_x, NMVOC, CH_4, CO, CO_2, N_2O, NH_3, heavy metals and POPs.

Within the UNECE a methodology has been developed to support countries that participate in the European-wide emission inventory programme EMEP/CORINAIR. An electronic version of the EMEP/CORINAIR method can be found on: "http://reports.eea.eu.int/technical_report_2001_3/en". (Choose "access to Chapters". Aviation is part of Group 8: "Other mobile sources and machinery" and can be found on pages 63-95 (B851).

- **UNECE definitions of national and international emissions**

For the UNECE, emissions from *LTO* are considered to be part of the national inventory of the country concerned. Emissions from *cruise* are considered international emissions. The only exception is CO_2, which has to be reported according to UNFCCC requirements (see below).

2.2.2 UNFCCC

The UNFCCC requires all Parties to develop national inventories of greenhouse gas emissions. It deals with the following pollutants: CO_2, NO_x, CH_4, NMVOC, SO_2, CO, N_2O, HFC's, PCF's and SF_6. The IPCC has established guidelines for producing national inventories for emissions (Revised 1996 IPCC Guidelines for Greenhouse Gas Inventories, Vol 1, 2, 3; 1997). The methodology in the IPCC Guidelines has been further elaborated in the IPCC report "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories".

For the UNFCCC, the EMEP/CORINAIR method and reference tables are used, but the reporting protocol and some of the emissions to be reported are different than for the UNECE. The revised 1996 IPCC Guidelines can be found at: "http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm". The IPCC Good Practice Guidance Report can be found at:
"http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm". (The aircraft methodology is described in paragraph 2.5 (pages 57-69) of Chapter 2 (Energy)).

For the UNFCCC, greenhouse gas emissions data should be reported using the **C**ommon **R**eporting **F**ormat (CRF), which is accessible through:
"http://www.unfccc.int/resource/ghg/tempemis2.html".

- **UNFCCC definitions of national and international emissions**

For the UNFCCC, emissions of *domestic flights* are considered to be part of the national inventory of the country concerned. With respect to emissions of *international flights* (often referred to as 'emissions from aviation bunker fuels'), there is ongoing discussion on how to allocate these emissions to national inventories. As long as there is no agreement on which option to choose, the practice recommended to Parties is that they collect information on international aviation emissions on the basis of fuel sold in their country and submit it to the UNFCCC along with their national inventory, but not included in their national totals of greenhouse gas emissions.

To summarise:

Organisation	Pollutants[1]	National Emissions	International Emissions
UNFCCC	CO_2, NO_x, CH_4, NMVOC, SO_2, CO, N_2O, HFC's, PCF's, SF_6	Emissions from domestic flights	Emissions from international flights
UNECE	CO_2, NO_x, CH_4, NMVOC, SO_2, CO, N_2O, NH_3, heavy metals, POP's	Emissions from LTO	Emissions from cruise
UNECE exception: CO_2 should be reported according to UNFCCC requirements			

2.3 ECAC ANCAT Subgroup on Emissions Calculations (EMCAL)

Member states of ECAC have been reporting national emissions in accordance with the broad requirements of these bodies for many years but the methodologies applied have varied greatly in terms of complexity and accuracy. In 1998, ANCAT recognised the value in moving towards a harmonised and consistent basis for the reporting of civil aviation emissions by its states and initiated work, through a subgroup on Emissions Calculation (EMCAL) to recommend a methodology that states could use. ANCAT has acknowledged the existence of the EMEP/CORINAIR to provide a sound tiered approach for calculating aircraft emissions. In order to avoid duplication of effort and product, the recommended ECAC methodology is harmonised with the EMEP/CORINAIR methodology.

The next chapter contains more information on the CORINAIR methodology.

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1 Not all pollutants relate to aviation.

CHAPTER 3

METHODOLOGY

The methodology and standard data tables, to which the Guidance Material refers, will be up-dated from time to time, but the Guidance Material may not be updated as regularly. The user must ensure that the most recent versions of the methodology and data tables are being used when producing emission inventories. References can be found in Appendix A and will be explained in this chapter.

3.1 Explanation of LTO

Operations of aircraft can be divided into two parts: Landing/Take-Off and Cruise.

The *Landing and Take-Off* (LTO) cycle includes all activities of aircraft near the airport that take place below the altitude of 3000 feet (915 meters). It includes taxi-out, take-off, climb-out, approach, landing and taxi-in. ICAO has defined the LTO cycle[1].

Cruise is defined as all activities of aircraft that take place above the altitude of 3000 feet (915 meters). Cruise includes the climb from 3000 feet (end of LTO-cycle) to cruise altitudes, level-flight cruise, and descent from cruise altitudes to 3000 feet (beginning of LTO-cycle). Aircraft will fly at different cruise altitudes, depending on aircraft type, flight distance, instructions from Air Traffic Control, weather conditions, etc.

The distinction between LTO and cruise is not only important for calculating aviation emissions, as is explained in this chapter, but also for international emission reporting as described in paragraph 2.2.

3.2 The method

The ECAC methodology is based on the one that was developed to support countries that participate in the European-wide emission inventory programme EMEP/CORINAIR. The EMEP/CORINAIR methodology has been developed to calculate all emissions needed for international emission reporting as described in paragraph 2.2. The EMEP/CORINAIR methodology will be explained in this chapter and can be found on "http://reports.eea.eu.int/technical_report_2001_3/en". (Choose "access to Chapters". Aviation is part of Group 8 (Other mobile sources and machinery) and can be found on pages 63-95 (B851)).

3.2.1 Three-staged methodology

Within EMEP/CORINAIR, there are three methods, which have different levels of accuracy and complexity. These are used to calculate the quantity of fuel used by aircraft and the emissions associated with that fuel use. The aggregated data then

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1 ICAO: International Standards and Recommended Practices - Environmental Protection, Annex 16, Volume II, Aircraft Engine Emissions. Second edition, July 1993, ICAO, Montreal.

form the inventory. The three methods, listed here in increasing complexity and report detail, are known as **ANCAT 1**, **ANCAT 2** and **ANCAT 3**, and equate to the CORINAIR Very Simple, Simple and Detailed methods. ECAC's goal is that states should progressively move towards calculating their annual aviation emissions using the ANCAT 3 method to achieve accurate reporting across all ECAC states. If a peer reviewed and well-documented national methodology is available which is more accurate than ANCAT method number three, Member States may use this national methodology when producing emission inventories.

ANCAT 1, **ANCAT 2** and **ANCAT 3** will be described in paragraphs 3.3, 3.4 and 3.5 respectively.

3.2.2 Data requirements

Table 1 gives an indication of the data required for the different methods.

Table 1 Minimum data requirements for the three methods

ANCAT 1	ANCAT 2	ANCAT 3
Total quantity of fuel consumed	Total quantity of fuel consumed	Total quantity of fuel consumed
Proportion of fuel Domestic – international	Proportion of fuel Domestic - international	Proportion of fuel Domestic – international
Total number of movements Domestic – international	Movements by aircraft type	Movements by aircraft type
	Details of aircraft types Domestic - international	Details of aircraft types Domestic – international
		Details of departure and arrival airports of individual aircraft both domestic and international

In Table 1, if the precise value cannot be obtained, the term 'fuel consumed' may also be taken as the quantity of fuel delivered to the airports, and failing this, the quantity of fuel shipped from the refinery. This last option must be treated with care because some of the aviation fuel may have been exported or used for non-aviation purposes.

Table 1 shows that the choice of which method to use to prepare an inventory will depend on detail and quality of available data. It shows that, for example, if the number of movements per aircraft type is NOT known, **ANCAT 1** is the only method of the three that can be used.

3.2.3 Representative aircraft

When preparing an inventory using **ANCAT 1, ANCAT 2** and **ANCAT 3,** representative aircraft are used for the calculations. These aircraft are selected to represent the existing fleet.

ANCAT 1

In **ANCAT 1** no more than four or five representative aircraft are used to calculate fuel used and emissions in *LTO and cruise*. Different aircraft are used to represent domestic and international flights. In addition, the fleet may be described as 'old' and 'average'. The term 'old' is taken to mean a fleet where the majority of the aircraft comply with the Chapter 2 noise standard but exceed the noise levels contained in Chapter 3[1]. These representative aircraft can be found in Table 8.2 in the CORINAIR Emission Inventory Guidebook.

ANCAT 2

For **ANCAT 2** calculations of fuel used and emissions in *LTO*, actual aircraft are modelled through ‘conversion’ to 19 aircraft which represent the world’s passenger jet fleet (see **ANCAT 3**). Thus, in ANCAT 2 the data on fuel used and emissions in *LTO* are derived from the whole fleet, not just from the few aircraft representing domestic and international flights in **ANCAT 1**.

For calculations of fuel used and emissions in *cruise* in **ANCAT 2**, the same four or five representative aircraft and also the method are used as in **ANCAT 1**.

ANCAT 3

For **ANCAT 3** calculations of fuel used and emissions in *LTO* and *cruise*, actual aircraft are modelled through 'conversion' to 30 aircraft which represent the world's passenger jet fleet. Thus, in **ANCAT 3** the data on fuel used and emissions in *LTO* and *cruise* are derived from the whole fleet.

The conversion of actual aircraft to the 30 representative aircraft for the *LTO* part in **ANCAT 2** and for *LTO* and *cruise* in **ANCAT 3** is shown in Table 4.2 of the CORINAIR Emission Inventory Guidebook.

3.2.4 Data on fuel and emissions

Default data on the quantity of fuel used and emissions for the representative jet aircraft used in **ANCAT 1** and the *cruise* part in **ANCAT 2** are given in Table 8.2 of the CORINAIR Emission Inventory Guidebook. Note that Table 8.2 gives *total fuel use and emissions for LTO operations* (kg/LTO) and *emission factors for cruise* (kg/tonne fuel used).

For the representative aircraft that are used in **ANCAT 3**, detailed fuel and emission data can be obtained from the CORINAIR reference tables, which can be found in “B851 spreadsheet 1” and “B851 spreadsheet 2” on: “http://reports.eea.eu.int/technical_report_2001_3/en/page017.html”.

The next three paragraphs will describe how to use these data for **ANCAT 1**, **2** and **3**.

3.3 ANCAT 1

ANCAT 1 can be used when the number of aircraft movements is known, but the individual aircraft types and their routes are not. In other words, in

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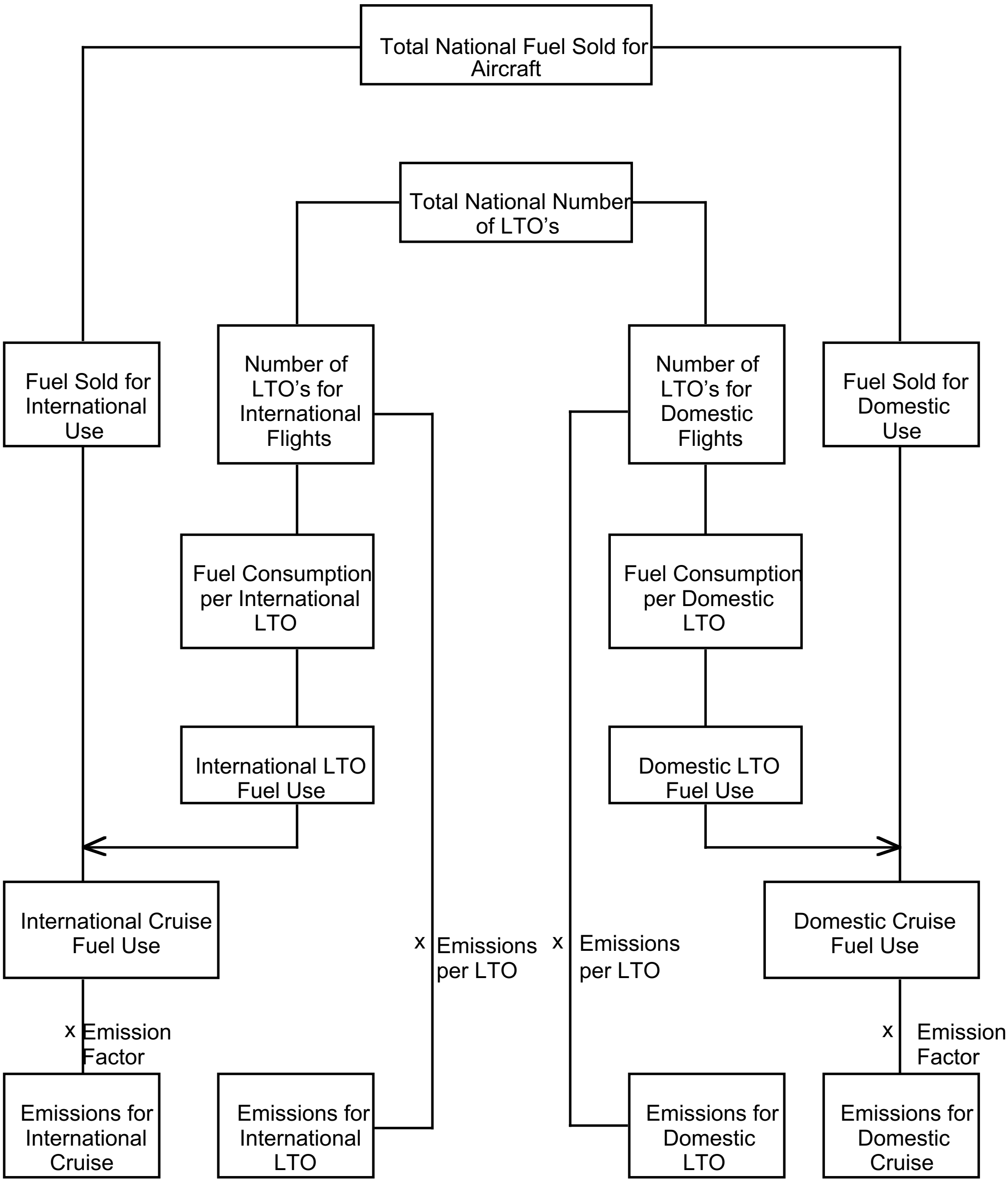
1 ICAO: International Standards and Recommended Practices - Environmental Protection, Annex 16, Volume I, Aircraft Noise. Third edition, July 1993, ICAO, Montreal.

ANCAT 1, computations can be made without any detailed knowledge of air traffic data. Data needed for **ANCAT 1** are (Table 1 of paragraph 3.2.2):

- The quantity of fuel used. The assumption is made that the amount used for domestic and international operations can be identified or estimated,

- The total number of domestic flights and the total number of international flights.

Figure 3.1 Estimation of aircraft emissions with ANCAT 1



Note the difference in 'emission factor' (also known as 'emission index') for the cruise part of the flight (being kg emissions/tonne fuel used) and 'emissions per LTO' for the LTO part of the flight (being total kg emissions for one LTO).

Step 1: Calculation of fuel using ANCAT 1

The quantity of fuel used in *LTO* operations is calculated as the number of LTO operations multiplied by the total fuel use per LTO as is given in Table 8.2 of the CORINAIR Emission Inventory Guidebook. The quantity of fuel used in *cruise* becomes the difference between the total quantity of fuel known or assumed to be used and the quantity of fuel used in LTO operations. These calculations must be done separately for domestic and international flights.

Step 2: Calculation of emissions using ANCAT 1

Emissions from *LTO* operations are obtained using the number of domestic and international LTO operations and the appropriate total emissions per LTO (domestic or international). Note that the quantity of fuel used in LTO is not needed for calculations of emissions in LTO, but is only needed for obtaining the quantity of fuel used in cruise. The emissions in LTO are directly obtained from the number of operations, since for LTO operations Table 8.2 of the CORINAIR Emission Inventory Guidebook gives *total fuel used and emissions per LTO*, not emission factors (kg emissions/tonne fuel used).

This is different for emissions in *cruise*. The emissions for the 'cruise' part of the flight relate to the quantity of fuel used in cruise. Multiply this quantity of fuel used in domestic and international cruise operations by the emission factor for domestic or international cruise operations (in Table 8.2 CORINAIR Emission Inventory Guidebook) to yield the emissions in cruise.

Step 3: total fuel used and emissions for domestic and international flights using ANCAT 1

The quantity of fuel used and emissions produced then becomes the sum of the LTO plus cruise results, again separately for domestic and international flights.

Improvement of accuracy of international fuel use and emissions using ANCAT 1

Detailed knowledge of flight distances is NOT required for **ANCAT 1**. However, when the number of flights less than and greater than 1000 nm is known, the recommendation is made to use the aircraft appropriate to short and long distance international flights. This will improve the quality of the emissions data for international operations, because in general different aircraft types will be used for short (smaller aircraft) and long distance flights (larger aircraft).

Applying this distinction will yield more accurate results for the quantity of fuel used and emissions in international LTO operations, thus leading to a more precise calculation of the quantity of fuel used and emissions in international cruise operations. Without this distinction a B747-400 is assumed to represent all international flights in **ANCAT 1,** including those from, for example, London to Paris or Amsterdam to Frankfurt. This may be explained as follows. Relatively large aircraft such as a B747-400 will consume far more fuel during LTO than a smaller aircraft. The smaller aircraft will generally be used for these short distance international flights, and therefore the calculated quantity of fuel used and emissions in international LTO will be overestimated. Since the quantity of fuel used in cruise is the difference between ‘total’ fuel and LTO fuel, fuel in international cruise would be underestimated by using the larger aircraft.

Flights shorter than 1000 nm are considered to be short distance flights. Flights of 1000 nm or more are considered long distance flights. Within **ANCAT 1** a split in short and long distance flights can be done on the basis of the percentage of movements if the exact flight distances are not known. For short distance and long distance flights, representative aircraft and default fuel and emissions values are shown in Table 8.2 of the CORINAIR Emission Inventory Guidebook.

3.4 ANCAT 2

ANCAT 2 may be used when individual aircraft used in domestic and international traffic are identified, but the precise domestic and international destinations are not available.

Data needed for **ANCAT 2** are (Table 1 in paragraph 3.2.2):

- The quantity of fuel used. The assumption is made that the amount used for domestic and international operations can be identified or estimated,
- The total number of domestic flights and the total number of international flights,
- Details of individual aircraft types used in domestic and international traffic.

ANCAT 2 is a combination of **ANCAT 1** and parts of **ANCAT 3**. A higher level of accuracy is obtained because for the LTO data on individual aircraft are used. This means that in **ANCAT 2** a detailed knowledge is needed of the aircraft types operating from the airports so that the LTO component of the flight can be calculated more precisely than in **ANCAT 1**.

For *cruise*, the same representative aircraft and method of calculation as in **ANCAT 1** are used. The distance that each aircraft flies is not specifically required for calculations with **ANCAT 1** or for calculation of cruise emissions with **ANCAT 2**, although, here again, the accuracy of cruise can be improved by using the aircraft appropriate to missions of less than or greater than 1000 nautical miles.

Step 1: Calculation of fuel using ANCAT 2

For calculating the fuel used in *LTO*, the aircraft actually operating are assigned to representative aircraft, which are shown in Table 4.2 of the CORINAIR Emission Inventory Guidebook. Data from those representative aircraft are then used to calculate the fuel used in domestic and international LTO operations. Thus, in **ANCAT 2** data on fuel used in LTO are derived from the whole fleet, not just from the few aircraft representing 'old' or 'average' for domestic and international flights as in **ANCAT 1**.

To obtain the fuel used in LTO, the total LTO fuel use per aircraft type is multiplied by the total number of LTO operations per aircraft type. The quantity of fuel used in LTO is then deducted from the domestic and international totals to yield fuel used in *cruise* in the same manner as in **ANCAT 1**.

Step 2: Calculation of emissions using ANCAT 2

The total *LTO* emissions for individual representative aircraft are shown in Table 8.3 of CORINAIR Emission Inventory Guidebook. These are used to determine the amount of emissions from the number of LTO operations for each aircraft type. Note again, that the quantity of fuel used in LTO is not needed for calculating LTO emissions, but is only needed for obtaining the quantity of fuel used in cruise. The emissions in LTO are directly obtained from the number of operations per aircraft type, since for LTO operations Table 8.3 of the CORINAIR Emission Inventory Guidebook gives *total fuel used and emissions per LTO* per aircraft type, not emission factors (kg emissions/tonne of fuel used).

For *cruise*, the same method is used that is specified in **ANCAT 1**, namely, the quantity of fuel in cruise is multiplied by the emission factor for domestic and international cruise operations (Table 8.2 of the CORINAIR Emission Inventory Guidebook) to yield the emissions in cruise.

Step 3: Total fuel used and emissions for domestic and international flights using ANCAT 2

The total quantity of fuel used and emissions in domestic and international operations is then the sum of the LTO operations based upon steps 1 and 2 above plus cruise operations as in **ANCAT 1** described in section 3.3.

Note: If the results from **ANCAT 1** and **ANCAT 2** are compared, the quantity of fuel used in LTO is different and this leads to a difference in cruise fuel. This comes about because in **ANCAT 2** the quantity of fuel in LTO is calculated more precisely than in **ANCAT 1** and cruise fuel is calculated as total fuel (in domestic or international operations) less the respective LTO fuel. Since in **ANCAT 2** the fuel used in LTO is calculated more precisely, the calculated fuel use in cruise will also be more accurate.

3.5 ANCAT 3

ANCAT 3 is the most detailed method of the three and may be used when individual aircraft movements and departure and arrival airports are known. The advantage of **ANCAT 3** is that both the LTO and cruise estimates become more accurate than with **ANCAT 1** and cruise estimates become more accurate than with **ANCAT 2**.

Data needed for **ANCAT 3** are (Table 1 of paragraph 3.2.2):

- The quantity of fuel used. The assumption is made that the amount used for domestic and international operations can be identified or estimated,
- The total number of domestic flights and the total number of international flights,
- Details of individual aircraft types used in domestic and international traffic,
- Details of departure and arrival airports of individual aircraft.

Step 1: Calculation of fuel using ANCAT 3

In **ANCAT 3**, the computations of fuel in *LTO* are made in the same manner as described in **ANCAT 2**, namely, the number of LTO operations per aircraft type multiplied by the total fuel use in LTO for the appropriate aircraft type (table 8.3 of the CORINAIR Emission Inventory Guidebook).

The quantity of fuel used in *cruise* per representative aircraft depends on the distance flown. To determine the distances flown, information on departure and arrival airports is needed. The fuel used in cruise is calculated per mission distance per representative aircraft type.

For the representative aircraft, calculations of fuel used (and emissions) have already been performed for standard mission distances. The results of these calculations are presented in standard data tables for jet aircraft and turbo propeller aircraft, which can be found in "B851 spreadsheet 1" and "B851spreadsheet 2" on: "http://reports.eea.eu.int/technical_report_2001_3/en/page017.html".

The data contained in the tables of standard distances are used to interpolate data for actual mission distances flown. In paragraph 3.7.3 an example is given how to calculate fuel used for any given mission distances based on these standard data tables.

Note that in **ANCAT 3**, the quantity of fuel used in cruise is obtained on the basis of a precise calculation, not by deducting the fuel used in LTO operations from the total amount of fuel sold (as is done in **ANCAT 1** and **2**). This means that calculations have to be made for all representative aircraft and for all mission distances. The amount of computational work may however be reduced by adding up the number of flights of like-aircraft per mission distance. For example, 100 Airbus 321's fly a route where the airport to airport distance is 1000 nm and 200 Airbus 320's fly a different route which is also 1000 nm. The A320 is the representative type for the A321. That means that calculations can be represented by 300 A320's flying 1000 nm.

Step 2: Calculation of emissions using ANCAT 3

In **ANCAT 3**, the computations of emissions in *LTO* are made in the same manner as described in **ANCAT 2**. The total LTO emissions for the individual representative aircraft are shown in Table 8.3 of the CORINAIR Emission Inventory Guidebook. These are used to determine the amount of emissions from the number of LTO operations for each aircraft type.

Calculations of *cruise* emissions are made using the emissions per standard mission distance per aircraft type in the CORINAIR standard data tables.

Step 3: Total fuel used and emissions for domestic and international flights using ANCAT 3

The fuel used and emissions in cruise per mission distance per aircraft type are aggregated to yield the cruise totals per aircraft type. Add the cruise totals per aircraft type to the LTO totals per aircraft type to yield the total fuel used and emissions for the total number of flights per aircraft type. Add up these totals per aircraft type to yield the total fuel used and emissions for the whole fleet (domestic and international).

Reconciliation of fuel estimated and fuel sold/delivered in ANCAT 3

ANCAT 3 is a bottom-up methodology, because the starting point is the individual aircraft and flight. The total quantity of fuel that is estimated in this way may miss some flights and may not account for route deviations or holding before landing.

Accordingly, the quality of the information needs to be checked. The quantity of fuel that results from the **ANCAT 3** calculations must be compared to the quantity of fuel sold / delivered. If there is a difference, and most likely there will be, the quantity of fuel calculated by individual or grouped flights must be adjusted to reflect the quantity of fuel sold / delivered, and the emissions must be adjusted accordingly (see calculation example in paragraph 3.7.3).

3.6 VFR and Military flights

The CORINAIR methodology may also be used to calculate the fuel used and emissions produced from VFR (Visual Flight Rules) and military flights. A way to calculate the emissions is to combine default fuel-related emission factors with total fuel consumption, if the latter figure is available. Otherwise the fuel use and emissions can be estimated from the number of flight hours, average fuel flow figures and default emission factors. Please refer to Tables 8.6 to 8.10 of the CORINAIR Emission Inventory Guidebook.

3.7 Calculation examples

This paragraph is intended to illustrate the methods **ANCAT 1**, **ANCAT 2** and **ANCAT 3** with some calculation examples. For these calculation examples, the following assumptions are made:

- 500,000 tonnes of aviation fuel are sold, of which an estimated 200,000 tonnes are used for domestic aviation. This means that the remaining 300,000 tonnes are used for international operations;
- There are 200,000 movements of domestic aircraft, and 100,000 movements of international traffic. For the calculations, one LTO cycle is taken as one landing plus one take off for each aircraft and therefore, the number of LTO cycles is HALF the number of movements. Accordingly, in this example there are 100,000 domestic LTO cycles and 50,000 international LTO cycles;
- The fleet can be characterised as 'average';
- NO_x is used as an example of the emissions burden.

Fuel used and emissions can be calculated using the **ANCAT 1, 2** and **3** methods, as will be explained in the next paragraphs.

3.7.1 ANCAT 1

From Table 8.2 of the CORINAIR Emission Inventory Guidebook, use the data for the average fleet (B737-400 for domestic traffic and B767 for international traffic):

Fuel used for domestic aviation:

Fuel in LTO	= 825 kg * no of LTO cycles (domestic)	= 825 * 100000 /1000	= 82500 tonnes
Fuel in cruise (All operations at altitudes greater than 3000 feet)	= Domestic fuel less fuel consumed in LTO	= 200000 – 82500	= 117500 tonnes
Total domestic fuel			200000 tonnes

Emissions (NOx) from domestic aviation:

NOx in LTO	= 8.3 kg * no of LTO cycles (domestic)	= 8.3 * 100000 /1000	= 830 tonnes
NOx in cruise	= Fuel used in cruise * emission index for NOx in cruise	= 117500 * 10.3 / 1000	= 1210 tonnes
Total domestic NOx	Sum of LTO and cruise emissions		2040 tonnes

The same calculation could be performed for international traffic using the B767 to represent the average fleet, again using Table 8.2 of the CORINAIR Emission Inventory Guidebook as a source of data.

Fuel used for international aviation:

Fuel in LTO	= 1617 kg * no of LTO cycles (international)	= 50000 *1617/1000	= 80850 tonnes
Fuel in cruise (All operations at altitudes greater than 3000 feet)	= International fuel less fuel consumed in LTO	= 300000 – 80850	= 219150 tonnes
Total international fuel			300000 tonnes

Emissions (NOx) from international aviation:

NOx in LTO	= 26.0 kg * no of LTO cycles	= 26.0 * 50000 /1000	= 1300 tonnes
NOx in cruise	= Fuel used in cruise * emission index for NOx in cruise	=219150 * 12.8 / 1000	= 2805 tonnes
Total international NOx	Sum of LTO and cruise emissions		4105 tonnes

The total domestic plus international inventory using **ANCAT 1** then becomes:

Fuel used	500000 tonnes (given)
NOx produced	6145 tonnes (calculated)

3.7.2 ANCAT 2

Let us assume that the movements in domestic aviation are broken down by aircraft type as follows:

A319	20%
A320	25%
A321	5%
B737 200	20%
B737 400	10%
BAe 146	5%
F100.	15%

The breakdown of aircraft movements into representative types is as follows:

Aircraft type	% of domestic movements by aircraft type	Representative aircraft (Table 4.2 of CORINAIR)	% of domestic movements by representative type	No of domestic LTO cycles (take-off plus landing)
A319	20	A320	50	50000
A320	25			
A321	5			
B737 200	20	B737 100	20	20000
B737 400	10	B737 400	10	10000
BAe 146	5	BAe 146	5	5000
F100	15	F100	15	15000
Totals	100		100	100000

The same process is used as for **ANCAT 1** to determine the quantity of fuel used in LTO, but this time use the data for the representative aircraft types in Table 8.3 of the CORINAIR Emission Inventory Guidebook.

Representative aircraft type	No of LTO cycles	Fuel per LTO cycle (kg)	Total fuel used in LTO = fuel in LTO * No of LTO cycles (tonnes)	NOx per LTO cycle (kg)	Total NOx in LTO = NOx in LTO * No of LTO cycles (tonnes)
A320	50000	802.3	40115.0	10.8	540.0
B737 100	20000	919.7	18294.0	8.0	160.0
B737 400	10000	825.4	8254.0	8.3	83.0
BAe 146	5000	569.5	2847.5	4.2	21.0
F100	15000	744.4	11166.0	5.8	87.0
Totals	100000		80676.5		891.0

The quantity of fuel used in cruise is known but, although the types of aircraft flying are known, the individual distances may not be. Therefore, review the fleet to determine whether it is old or average. In this example, the assumption was made that the fleet is average because the number of old technology B737 200 represented by the B737 100 is small. Thus, from Table 8.2, use the B737 400 as the representative aircraft.

Emissions (NOx) for cruise aviation:

NOx in cruise	= Fuel used in cruise * emission index for NOx in cruise	= (200000 - 80676.5) * 10.3 / 1000	= 1229.03 tonnes
Total domestic NOx	Sum of LTO and cruise emissions	= 891.00 + 1229.03	= 2120.03 tonnes

The same rationale can be applied to the international flights, but here the aircraft that would be used to simulate cruise may be the Boeing 767 for the average fleet or the DC10 if the fleet contained predominantly older aircraft.

3.7.3 ANCAT 3

The minimum data that are required to apply the **ANCAT 3** method are the individual aircraft types, for example, by name, IATA or ICAO code, plus the distances travelled. Distance travelled between airports can be obtained from reference books such as the Air Distances Manual published by IATA as a CD ROM obtainable from "http://www.iataonline.com/shop/find.asp" or from the OAG Flight Guide that is published by Reed Elsevier plc group at "http://www.oag.com/". However, note that these distances are Great Circle (the shortest distance between two points) and do not account for any deviation caused by ATC constraints or for distance travelled during stacking before landing.

An example of an **ANCAT 3** calculation is given below:

Assume an A300 flies from London to New York. From the Air Distances Manual, the distance from Heathrow to New York airport, in this example JFK, is given as 5 536 km, 3 440 statute miles or 2 989 nautical miles. If distances are in km, they have to be converted into nautical miles for compatibility with the reference tables. 1 nautical mile is equivalent to 1.852 km or 1.15078 statute mile.

From Table 4.2 of the CORINAIR Emission Inventory Guidebook, the Airbus A300, given as AB3, is represented by the Boeing 767.

Fuel in LTO, from Table 8.3 for the B767-300 ER = 1617.1 kg

NOx in LTO, from Table 8.3 for the Boeing B767 300 ER = 26.0 kg

To determine the quantity of fuel used and NOx emitted in the cruise phase of flight, refer to the B767 in the CORINAIR standard data tables, which can be found in "B851 spreadsheet 1" on:
"http://reports.eea.eu.int/technical_report_2001_3/en/page017.html".

The mission distance is 2989 nm, and therefore the bracket distances are 2500 and 3000 nm.

Fuel for the flight:

	Data for 2500 nm	Data for 3000 nm	Calculation for 2989 nm	Result (kg)
Fuel used in flight total (kg)	24804.4	29909.4		
Fuel used in LTO (kg)	1617.1	1617.1		1617.1
Fuel used in cruise (see also climb/ cruise/descent) (kg)	= 24804.4 - 1617.1 = 23187.3	= 29909.4 - 1617.1 = 28292.3	=(2989-2500)/ (3000-2500)* (28292.3-23187.3) +23187.3	27250.9
Total fuel for the flight	Fuel in LTO + fuel in cruise		=1617.1+27250.9	**28868**

NOx for the flight:

	Data for 2500 nm	Data for 3000 nm	Calculation for 2989 nm	Result (kg) (kg)
NOx produced in flight total (kg)	320.3	388.1		
NOx produced in LTO (kg)	26.0	26.0		26.0
NOx produced in cruise (see also climb/ cruise/descent) (kg)	= 320.3 - 26.0 = 294.3	= 388.1- 26.0 = 362.1	=(2 989-2 500) /(3000-2 500)* (362.1-294.3) +294.3	360.6
Total NOx for the flight	NOx in LTO + NOx in cruise		=26.0 + 360.6	**386.6**

This type of calculation would then be done for all of the aircraft and for all of the flights to build up an inventory of domestic and international flights.

Match the quantity of fuel calculated in ANCAT 3 to the quantity of fuel sold

Where the quantity of fuel sold and the quantity calculated are different, an adjustment is necessary to account for the difference between the shortest (Great Circle) distances between city pairs and flights not accounted for, route deviations or holding before landing.

The quantity of emissions should be adjusted accordingly. This adjustment should be made individually for each of domestic and international operations if the split between domestic and international fuel sales is known. Usually this split is not known so precisely and therefore the adjustment has to be made on the basis of total fuel sales.

The adjustment, whether on the basis of total or individually for domestic and international fuel sales, is made only to cruise fuel because the quantities of LTO fuel and NOx are calculated according to the number of LTO operations and the relevant aircraft types. These values do not change if the aircraft is held before landing or is diverted.

From the quantity of fuel sold (total, domestic, or international as appropriate) deduct the quantity of LTO fuel calculated by **ANCAT 3**. This now gives a quantity of fuel used in cruise assessed in the same manner as described in **ANCAT 1** and **2**. The quantity of NOx that had been calculated for cruise using **ANCAT 3** is then adjusted in the ratio of this new cruise fuel value to that calculated using **ANCAT 3**, thus yielding an adjusted NOx value. Add back the LTO fuel and NOx to give the totals for fuel (this will equal the quantity sold) and NOx (calculated LTO plus adjusted cruise).

In our example for domestic aviation the assumed total quantity of fuel sold was 200 000 tonnes. Of this total, 80 676.5 tonnes were calculated for LTO using the **ANCAT 2** method, but this would have been the same when **ANCAT 3** had been used. The reason for that is that **ANCAT 2** and **ANCAT 3** both calculate the LTO data from representative aircraft. If we further assume that 100 000 tonnes of fuel would have been calculated for domestic cruise, then the adjustment to the calculated cruise NOx would have been (200 000 – 80 676.5)/100 000. The same logic would apply to international flights.

3.8 Comparison of ANCAT 1, ANCAT 2 and ANCAT 3

Before accepting CORINAIR as a basis for an ECAC recommendation EMCAL has validated the CORINAIR methodology and gauged the differences in outcome of ANCAT 1, ANCAT 2 and ANCAT 3. This paragraph gives some insight in these differences.

ANCAT 1, being the most simple method, uses only two aircraft types to represent all movements on the assumption that the number of flights below and above 1000 nm is unknown. The B737-400 is used for domestic flights and the B747-400 for international flights. For the LTO-part of the flight, this means that it is likely that LTO fuel use is overestimated, but this depends on the fleet characteristics. For instance, for a small country where domestic flights are generally flown with aircraft smaller than the B737-400, the calculated fuel use of domestic LTOs will be overestimated. Since fuel use of domestic cruise is the difference between fuel used for domestic LTO and fuel sold for domestic flights, the fuel use of domestic cruise will be underestimated.

For international flights the B747-400 is being used as a representative aircraft. When a great portion of the international flights are relatively short distance, the overestimation for fuel use of international LTO and, subsequently, the underestimation of fuel use of international cruise might be even bigger than for domestic flights. These differences for fuel consumption will generally result in similar differences for emissions. The relatively large overestimation of fuel use in international LTOs and, subsequently, underestimation of fuel consumption in international cruise, gave rise to the split in short distance and long distance international flights which has been incorporated in the EMEP/CORINAIR methodology and in ANCAT 1 (see paragraph 3.3, step 2).

In ANCAT 2 (and ANCAT 3) individual aircraft are being used to calculate LTO fuel use and LTO emissions. This yields more accurate results for LTO fuel use and LTO emissions than with ANCAT 1 and, subsequently, for fuel use and emissions of the cruise part of the flight. The difference between ANCAT 2 and ANCAT 3 lies in the calculation of fuel used and emissions in cruise. In ANCAT 2, these are calculated deducting the LTO fuel use from the total amount of fuel sold (separate for domestic and international flights). In ANCAT 3, fuel use and emissions in cruise are calculated using representative aircraft and mission distances.

To summarise: the advantage of ANCAT 2 is that the LTO estimates become more accurate than with ANCAT 1. The advantage of ANCAT 3 is that both LTO and cruise estimates become more accurate than with ANCAT 1 and the cruise estimates become more accurate than with ANCAT 2.

When validating CORINAIR some calculations have been made by Member States using national ‘best practice’ methods. In general the national methods used are more detailed than ANCAT 3 using, for instance, specific tail numbers, appropriate engines and real LTO operation times. The comparison of results of ANCAT 1, ANCAT 2 and ANCAT 3 with results of these ‘best practice’ methods showed that generally the more detailed method resulted in lower calculated fuel use and emissions.

CHAPTER 4

DATA SOURCES

This chapter provides some information on where data that are needed for emissions calculations can be found. In the next chapter some uncertainties regarding data will be highlighted.

As has been explained in Chapter 3, the EMEP/CORINAIR methodology has been developed to calculate all emissions needed for international reporting. However, published and peer reviewed national methods may also be used for international emission reporting. Often, these national methods may have been developed for other purposes, such as calculating the contribution of aviation to local air quality or assessing policy options to limit emissions, etc. Depending on the use of the emission inventory, the data required for the calculations and the calculation method may be very different.

Some of the data described in this chapter are not needed for emission calculations using **ANCAT 1, ANCAT 2 or ANCAT 3** (Table 1 in Chapter 3). These data may be needed for calculations that are more detailed than **ANCAT 3.**

4.1 Traffic data

Traffic data can be obtained from:

- Air navigation service providers,
- Airport authorities,
- Airline operators,
- EUROCONTROL,
- The OAG timetable.

These data may include number of aircraft movements, aircraft types, aircraft/engine combinations, departure and arrival airport, flight distance, departure and arrival times, etc.

4.2 Data on fuel sold

Data on the quantity of fuel sold can be obtained from:

- Oil company that delivers fuel to airports,
- Company handling fuel at airports,
- Airport authorities,
- Airline operators.

4.3 Data on engine emissions

For calculations with **ANCAT 1**, **ANCAT 2** and **ANCAT 3**, default fuel use and emission factors can be found in Table 8.2 and 8.3 of the CORINAIR Emission Inventory Guidebook and in the standard CORINAIR data tables.

If more detailed information on aircraft/engine combination and LTO times-in-mode is available, fuel use and emission factors for turbojet and turbofan engines can be found in the ICAO Aircraft Exhaust Emissions Databank ("http://www.qinetiq.com/aviation_emissions_databank/index.asp").

Data on emissions from turboprop engines are currently not regulated by ICAO. Consequently, the ICAO Databank does not contain information on emissions of these engines. The CORINAIR Guidebook contains information on emissions from turboprops. Also, data on turboprops are included in the CORINAIR standard tables. These data have been gathered within the European project ARTEMIS which started in 1999 (see also Chapter 5).

CHAPTER 5

UNCERTAINTIES

The uncertainties with every calculation are related to the method that has been used or to data with which the calculations have been made. Uncertainties are mostly a consequence of assumptions, incomplete data or partly incorrect data. In this chapter some of the uncertainties are listed. This chapter is NOT intended to be complete or to quantify the uncertainties. It should be regarded as a warning for people dealing with inventories.

5.1 Flight profile and flight characteristics

It is assumed that all aircraft fly the *standard LTO cycle* (thrust settings and times in mode) defined by ICAO. In practice thrust settings and times in mode may be somewhat different than the standard LTO, depending on the type of aircraft, payload and on the airport characteristics. Using the standard LTO defined by ICAO gives an estimate of the LTO emissions of an aircraft, but this estimate may differ from the emissions calculated with actual thrust settings and times in mode.

The actual *distance flown* may differ from Great Circle distances that are given in the OAG timetable. Also the *altitude flown* may differ from the altitude with which the standard tables for representative aircraft are calculated.

5.2 Aircraft types, engines and emission factors

Different codes may be used when describing an aircraft type (ICAO code / IATA code). For example, a B737-200 may be described as B732 or 732. Using ANCAT 1, 2 or 3 the actual fleet should be converted into the representative aircraft types. The adequacy of such a conversion will depend on the quality of information on the fleet and the experience of the user.

The data in the CORINAIR standard data tables are calculated for representative aircraft types, which are fitted with one or two engine types that are most frequently used in Western aviation. In practice, a significant number of aircraft may however be fitted with other engines. The aircraft-engine combination for the representative aircraft determines the emission factors used for calculating the standard data tables. These emission factors are uncertain, with emission factors for cruise being more uncertain than those for the LTO-cycle.

As has been explained in Chapter 4, turboprop engines are currently not the subject of emissions regulation resulting in a lack of data. **It should be noted that the data on turbo propeller aircraft in the CORINAIR standard data tables are not verified with certification quality.** Therefore, the data on turbo propeller aircraft are more uncertain than those on jet aircraft.

5.3 Traffic data

Data on traffic can be obtained from different sources: from the OAG World Airlines Guide, from EUROCONTROL, from Air navigation service providers or from airports. It should be kept in mind that not all data are complete and that each data source has its advantages and disadvantages.

For example, data on traffic can be obtained from the OAG World Airlines Guide, but these are only scheduled flights that are due to take place. Therefore flights that have been cancelled are still included but charter and non-scheduled freight flights are excluded.

Data from EUROCONTROL represent aircraft that have actually flown (scheduled, non-scheduled freight and charter), but these are only flights with Instrument Flight Rules (IFR flights), so flights with Visual Flight Rules (VFR flights) are being missed. With respect to airport data, there may be variations from airport to airport in registration numbers and codes used to identify aircraft.

5.4 Fuel statistics

Differences in the amount of fuel that has been calculated versus the amount of fuel sold and differences in the amount of fuel sold versus the amount of fuel delivered to an airport are very likely. Since kerosene occasionally may be used for other purposes such as heating, there may be a difference between the quantity of fuel sold for aircraft and the quantity of fuel that has been delivered to the airport. Also, as described in Chapter 3, the calculated amount of fuel used may differ from the amount sold because route deviations or holding before landing are not accounted for in the calculations. The calculations should be adjusted to reconcile the calculated amount of fuel with the fuel sold.

5.5 Meteorological factors

None of the three methods (ANCAT1, ANCAT2 and ANCAT3) include the effect of meteorological effects upon emissions performance. It is acknowledged that greater precision can be achieved in the construction of inventories by accounting for such parameters and these may be reflected in more detailed national methodologies. However, in this Guidance Material the tiered uniform approach relates to the core parameters needed to achieve a sound inventory, leaving States to apply higher levels of accuracy where this is required.

APPENDIX

References to relevant web pages needed for emission calculations as described in the Guidance Material

Reference	Page of Guidance Material
1. CORINAIR Emission Inventory Guidebook http://reports.eea.eu.int/technical_report_2001_3/en.	10 and 12
2. IPCC Guidelines for Greenhouse Gas Inventories, Vol 1,2,3; 1997 http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm.	10
3. IPCC Good Practice Guidance Report http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm.	10
4. UNFCCC Common Reporting Format http://www.unfccc.int/resource/ghg/tempemis2.html.	10
5. CORINAIR reference tables or standard data tables http://reports.eea.eu.int/technical_report_2001_3/en/page017.html.	14, 18 and 23
6. IATA, Air Distances Manual http://www.iataonline.com/shop/find.asp	23
7. Reed Elsevier, OAG Flight Guide http://www.oag.com/	23
8. ICAO Aircraft Exhaust Emissions Databank http://www.qinetiq.com/aviation_emissions_databank/index.asp	27

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