ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT): 2023 Version

— Design, Development and Validation —

October 2023

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1. INTRODUCTION

To facilitate the implementation of the Standards and Recommended Practices relating to the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), the ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT) was developed. The ICAO document entitled "ICAO CORSIA CO_2 Estimation and Reporting Tool" is referenced in Annex 16, Volume IV, Appendix 3, and is referred to as an ICAO CORSIA Implementation Element.

The ICAO CORSIA CERT tool supports aeroplane operators in:

a) assessing whether or not an aeroplane operator is within the applicability scope of the Monitoring, Reporting and Verification (MRV) requirements (Annex 16, Volume IV, Part II, Chapter 2, 2.1);

b) assessing their eligibility to use fuel use monitoring methods in support of their Emissions Monitoring Plan (Annex 16, Volume IV, Part II, Chapter 2, 2.2);

c) filling any CO_2 emissions data gaps (Annex 16, Volume IV, Part II, Chapter 2, 2.5); and

d) fulfilling their monitoring and reporting requirements by supporting the development of the standardized Emissions Monitoring Plan and Emissions Report templates (Appendix 1 of the *Environmental Technical Manual* (Doc 9501), Volume IV – *Procedures for demonstrating compliance with the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)*).

ICAO's Committee on Aviation Environmental Protection (CAEP) will develop and recommend updates to the ICAO CORSIA CERT information that will be captured in some form of ICAO document and, following approval by the ICAO Council, the ICAO CORSIA Implementation Element will be published on the ICAO CORSIA website (www.icao.int/corsia).

2. HIGH LEVEL ARCHITECTURE AND EVOLUTION OF THE ICAO CORSIA CERT

2.1 General Overview

The ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT) is expected to be updated and enhanced over time to reflect: (1) evolving requirements from the implementation of CORSIA (i.e., Annex 16, Volume IV) such as the phased implementation of CORSIA reflected in the ICAO document entitled "CORSIA States for Chapter 3 State Pairs" that will be available on the ICAO CORSIA website from 2020, (2) increasing data coverage in terms of aeroplane types and geographic distribution; and (3) improvements in fuel efficiency observable from input data and resulting from technology and operations. A version/release of the tool is expected to be only valid for a given reporting year.

With the 2018 version of the ICAO CORSIA CERT, an aeroplane operator, that uses the CO_2 estimation functionality of the ICAO CORSIA CERT, was able to estimate for each year if its annual CO_2 emissions are above the thresholds as described in Annex 16, Volume IV [1].

[1] The Standards and Recommended Practices of Annex 16, Volume IV, Part II, Chapter 2 shall be applicable to an aeroplane operator that produces annual CO_2 emissions greater than 10 000 tonnes from the use of an aeroplane(s) with a maximum certificated take-off mass greater than 5 700 kg conducting international flights, as defined in Annex 16, Volume IV, Part II, Chapter 1, 1.1.2, on or after 1 January 2019, with the exception of humanitarian, medical and firefighting flights.
The Standards and Recommended Practices of Annex 16, Volume IV, Part II, Chapter 2 shall not be applicable to international flights, as defined in Annex 16, Volume IV, Part II, Chapter 1, 1.1.2, preceding or following a humanitarian, medical or firefighting flight provided such flights were conducted with the same aeroplane, and were required to accomplish the related humanitarian, medical or firefighting activities or to reposition thereafter the aeroplane for its next activity. The aeroplane operator shall provide supporting evidence of such activities to the verification body or, upon request, to the State.

An aeroplane operator was also able to determine its eligibility to use simplified compliance procedures (as per Annex 16, Volume IV, Part II, Chapter 2, 2.2)[2]. The ICAO CORSIA CERT was based on the ICAO CO_2 Estimation Models (CEMs) that capture the set of equations that allow to estimate for a given aeroplane type the CO_2 emissions as a function of Great Circle Distance.

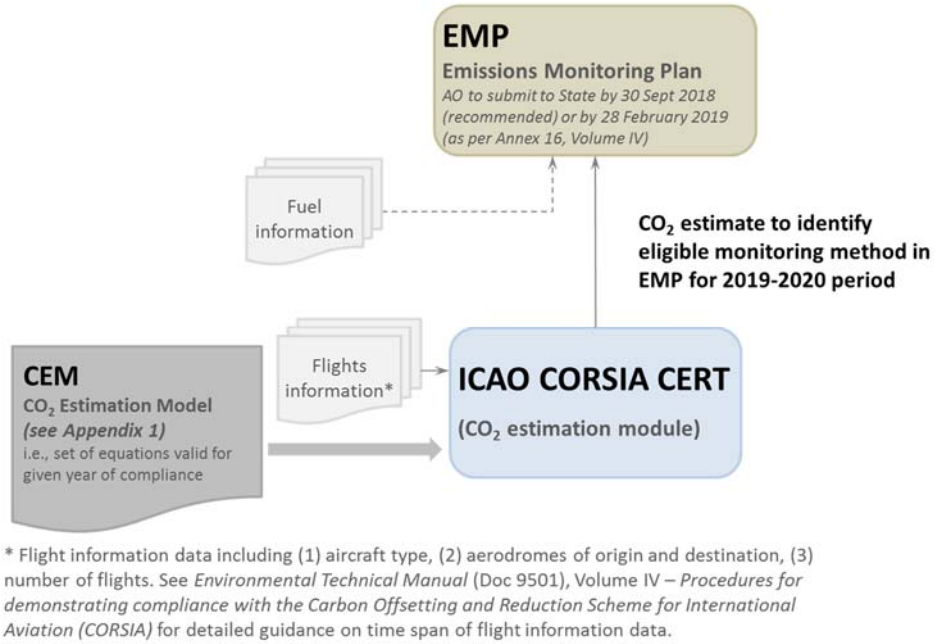


Figure 1: Architecture of CORSIA Emissions Monitoring Plan and reporting system (2018 or aeroplane operator year of entry into CORSIA)

Starting with the 2019 version of the ICAO CORSIA CERT, aeroplane operators can comply with simplified monitoring and reporting requirements from Annex 16, Volume IV, Part II, Chapter 2. The ICAO CORSIA CERT will allow aeroplane operators to import or manually input the required information: (1) individual or aggregated information at the individual flight, or aerodrome-pair level, (2) flights for which there are data gaps to generate emissions estimations.

Aeroplane operators eligible to use simplified compliance procedures (as per Annex 16, Volume IV, Chapter 2, 2.2) will be able to manually and/or automatically input information at individual flight level to estimate their CO_2 emissions for the compliance year and generate the Emissions Report.

Figure 3 summarizes the evolution of the functionalities of the ICAO CORSIA CERT, where the 2018 version only included the CO_2 estimation functionality to determine the applicability of CORSIA and

[2] For the 2019-2020 period: the aeroplane operator with annual CO_2 emissions from international flights, as defined in Annex 16, Volume IV, Part II, Chapter 1, 1.1.2, and Chapter 2, 2.1, greater than or equal to 500 000 tonnes shall use a Fuel Use Monitoring Method as described in Appendix 2. The aeroplane operator with annual CO_2 emissions from international flights, as defined in Annex 16, Volume IV, Part II, Chapter 1, 1.1.2, and Chapter 2, 2.1 of less than 500 000 tonnes shall use either a Fuel Use Monitoring Method or the ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT), as described in Annex 16, Volume IV, Appendices 2 and 3 respectively.
For the 2021-2035 period: the aeroplane operator, with annual CO_2 emissions from international flights subject to offsetting requirements, as defined in Annex 16, Volume IV, Part II, Chapter 1, 1.1.2, and Chapter 3, 3.1, of greater than or equal to 50 000 tonnes, shall use a Fuel Use Monitoring Method as described in Annex 16, Volume IV, Appendix 2 for these flights. For international flights, as defined in Annex 16, Volume IV, Part II, Chapter 1, 1.1.2, and Chapter 2, 2.1, not subject to offsetting requirements, as defined in Annex 16, Volume IV, Part II, Chapter 3, 3.1, the aeroplane operator shall use either a Fuel Use Monitoring Method, as described in Annex 16, Volume IV, Appendix 2, or the ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT), as described in Annex 16, Volume IV, Appendix 3. The aeroplane operator, with annual CO_2 emissions from international flights subject to offsetting requirements, as defined in Annex 16, Volume IV, Part II, Chapter 1, 1.1.2, and Chapter 3, 3.1, of less than 50 000 tonnes, shall use either a Fuel Use Monitoring Method or the ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT) as described in Annex 16, Volume IV, Appendices 2 and 3 respectively.

eligibility to the use of the ICAO CORSIA CERT. The 2019 and 2020 versions include the monitoring and report generation functionality. The 2021-2035 versions will then include splitting of the emissions between those subject to offsetting requirements, as they belong to routes between pairs of participating States, and those that have only to be reported but that are not subject to offsetting requirements.

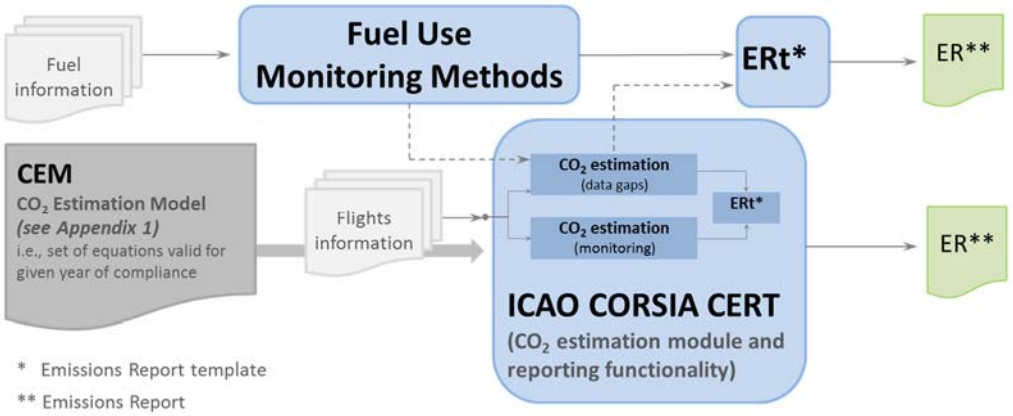


Figure 2: Architecture of CORSIA reporting system (2019 onward for compliance purposes)

	CERT CO_2 Estimation and Reporting Tool		
Year of validity	2018	2019-2020	2021-2035
Estimation of CO_2 for determination of simplified compliance procedures eligibility	Yes	Yes	Yes
Monitoring (estimating CO_2)	No	Yes	Yes
Report generation functionality	No	Yes	Yes
States for Chapter 3 State pairs	No	No	Yes

Figure 3: Phased development and implementation of the ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT)

2.2 Architecture of the 2023 Version of the ICAO CORSIA CERT

Based on requirements from Annex 16 Volume IV, a more detailed architecture of the 2023 version of the ICAO CORSIA CERT was developed. First, potential and expected users of the CERT were identified. Through an iterative process of mapping processes/tasks by different users required functionalities were identified.

2.2.1 Potential Users of the ICAO CORSIA CERT 2023

Figure 4 shows the list of potential users of the ICAO CORSIA CERT along with whether they have a submitted/approved EMP, their primary monitoring method, description of the use of the CERT and needed functionalities.

Users	Submitted/Approved EMP	Primary Monitoring Method (PMM)	Description of Use of the CERT	Needed Functionalities
Aeroplane Operators	**Yes**	Eligible to use the CERT as PMM	Estimating emissions and filling ER using the CERT (only)	- CO_2 Estimation - ER generation
Aeroplane Operators	**Yes**	Required to use a Fuel Use Monitoring Method as PMM	Using the CERT to fill data gaps and generate ER	- CO_2 Estimation - ER generation
Aeroplane Operators	**Yes**	Required to use a Fuel Use Monitoring Method as PMM	Using the CERT to fill data gaps	- CO_2 Estimation - Summary Assessment
Aeroplane Operators	**No**	n/a	Evaluating applicability of CORSIA and eligibility to use the CERT	- CO_2 Estimation - Summary Assessment
States	n/a	n/a	Order of Magnitude checks and Data gap filling	- CO_2 Estimation - Summary Assessment
ICAO	n/a	n/a	Data gap filling	- CO_2 Estimation - Summary Assessment
Verifiers	n/a	n/a	Order of Magnitude checks	- CO_2 Estimation - Summary Assessment

Figure 4: Potential Users of the ICAO CORSIA CERT 2019+ versions

2.2.2 ICAO CORSIA CERT 2019+ High-Level Architecture

The ICAO CORSIA CERT 2023 version was built on the 2022 version with regard to the input of aeroplane operator information, the CO_2 estimation and the generation of a summary assessment functionalities. To meet the additional requirements from monitoring of emissions according to Annex 16 Volume IV, additional functionalities will be added in the 2019+ versions, including;

- ICAO CEMs: The 2023 version of the ICAO CORSIA CERT contains an updated set of ICAO CEMs based on the 2023 version of the COFdb.

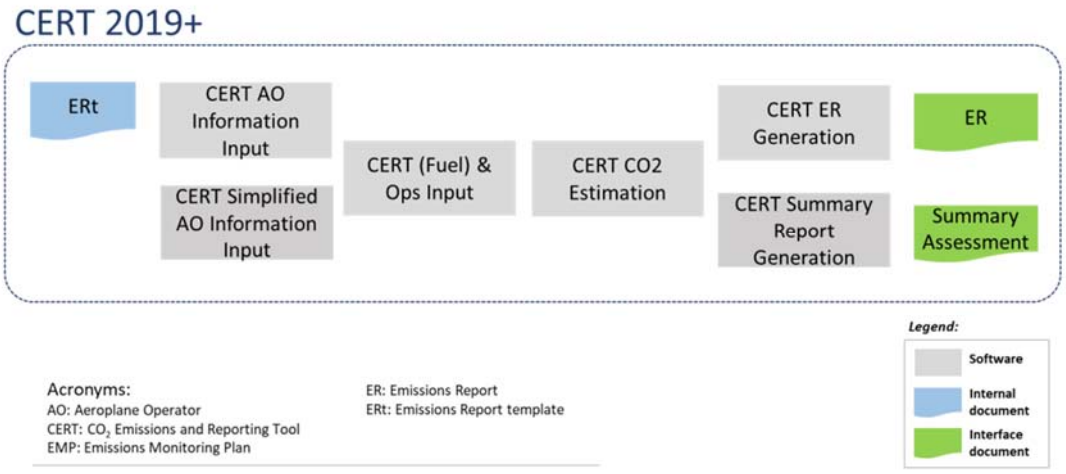


Figure 5: High Level Architecture of the 2019+ versions of the ICAO CORSIA CERT

In accordance with the requirements from Annex 16 Volume IV and the ETM Volume IV, the 2018 version of the ICAO CORSIA CERT only required the CO_2 estimation functionality and no reporting capabilities. The reporting functionality was added to the 2019 version which will be used by aeroplane operators to monitor (via estimation) and report their 2019 CO_2 emissions as well as to fill data gaps if needed. The template of the Emissions Report based on the Second Edition of the Environmental Technical Manual (ICAO Doc 9501) was integrated into the CERT 2023. The ICAO CORSIA CERT allows operators to automatically fill and export the Emissions Report.

2.2.3 Detailed Use Cases for the ICAO CORSIA CERT 2019+

Figure 6 shows the processes expected to be followed by an aeroplane operator for which the State has approved the submitted EMP and the right to use the ICAO CORSIA CERT as a primary monitoring method. This (aeroplane operator) user would also use the ICAO CORSIA CERT to generate its Emissions Report.

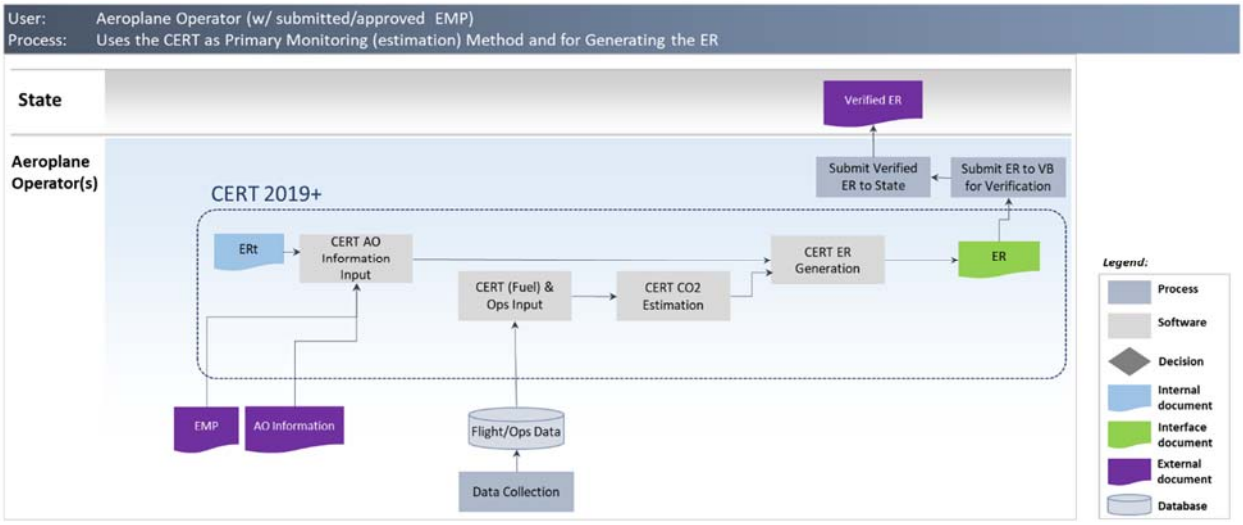


Figure 6: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator with an approved EMP and using the ICAO CORSIA CERT as primary monitoring method and to generate its ER

Figure 7 shows the processes expected to be followed by an aeroplane operator for which the State has approved the submitted EMP and that uses the ICAO CORSIA CERT to fill data gaps (i.e., flights with no data from the approved Fuel Use Monitoring Method). This (aeroplane operator) user would also use the ICAO CORSIA CERT to generate its Emissions Report.

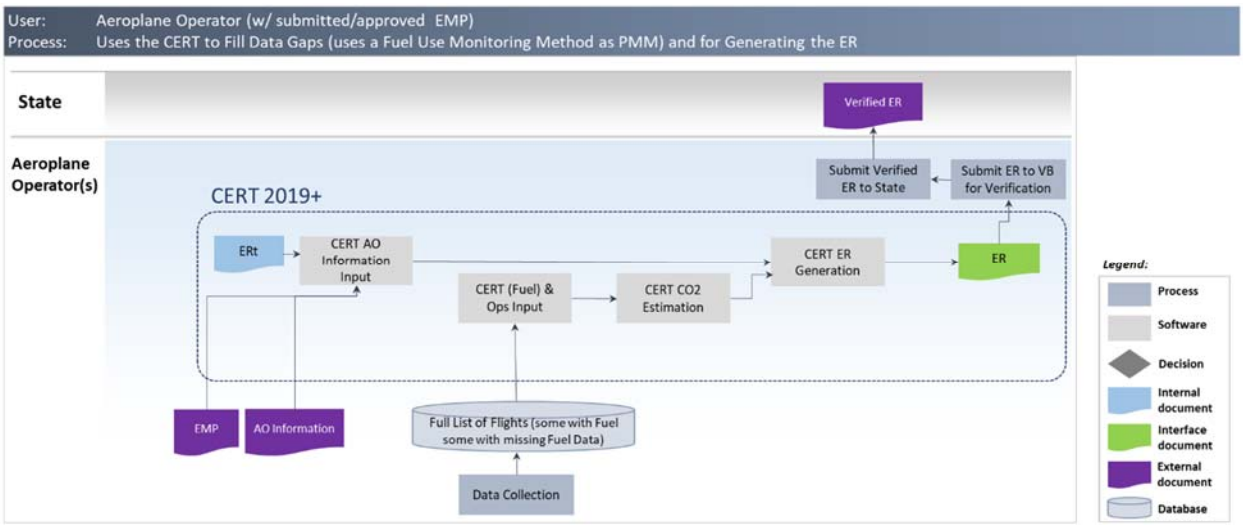


Figure 7: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator with an approved EMP and using the ICAO CORSIA CERT to fill data gaps and generate its ER

Figure 8 shows the processes expected to be followed by an aeroplane operator that uses the ICAO CORSIA CERT only to estimate the fuel and emissions for data gaps (i.e., flights with no data from the approved Fuel Use Monitoring Method). This (aeroplane operator) user would not use the ICAO CORSIA CERT to generate its Emissions Report.

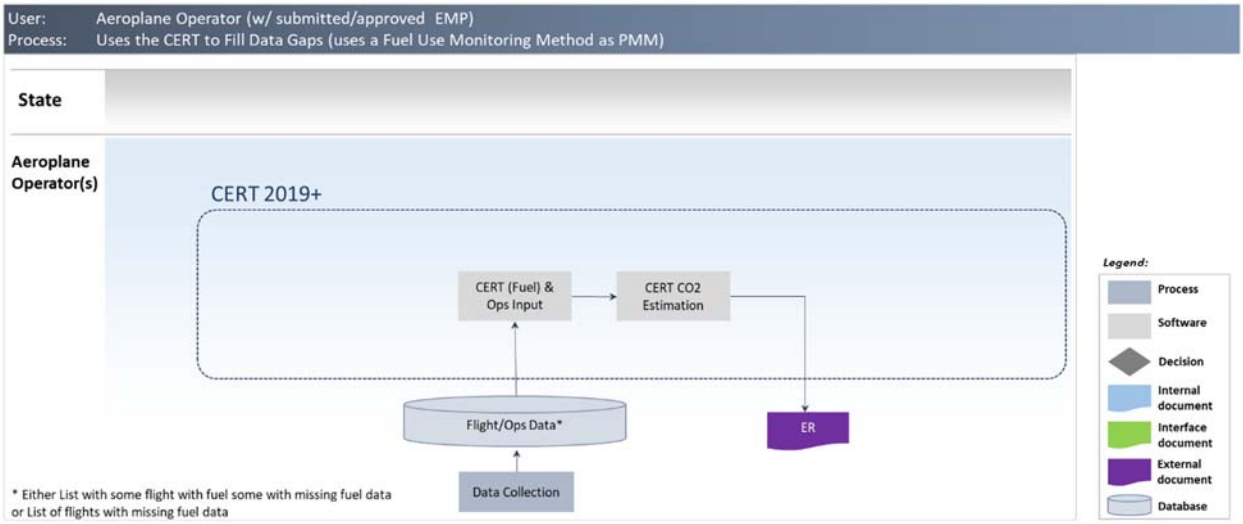


Figure 8: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator using the ICAO CORSIA CERT only to fill data gaps

Figure 9 shows the processes expected to be followed by an aeroplane operator to determine the applicability of CORSIA and eligibility to user the ICAO CORSIA CERT. Note: this process is similar to the use of the 2018 version of the ICAO CORSIA CERT.

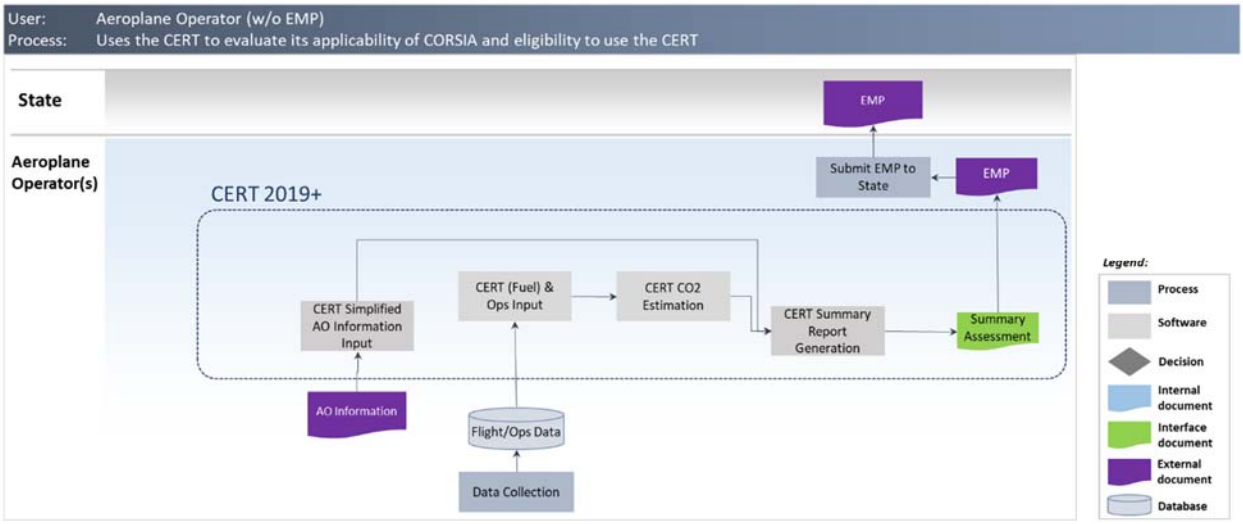


Figure 9: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator to determine the applicability of CORSIA and eligibility to user the ICAO CORSIA CERT

Figure 10 shows the processes expected to be followed by a State to fill data gaps.

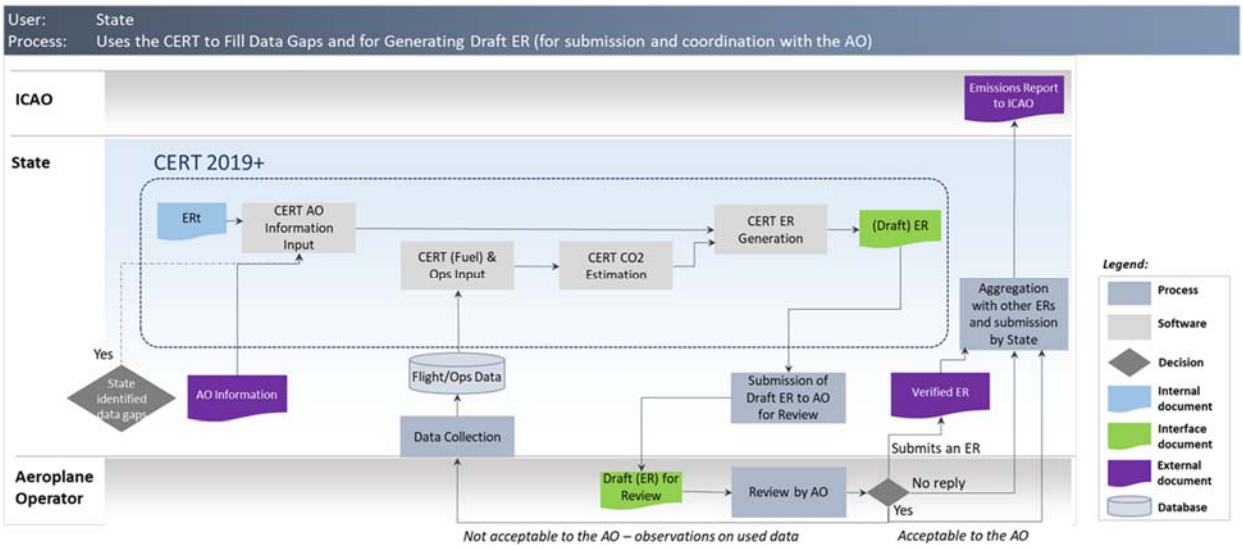


Figure 10: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for a State to fill data gaps

Figure 11 shows the processes expected to be followed by ICAO to fill data gaps.

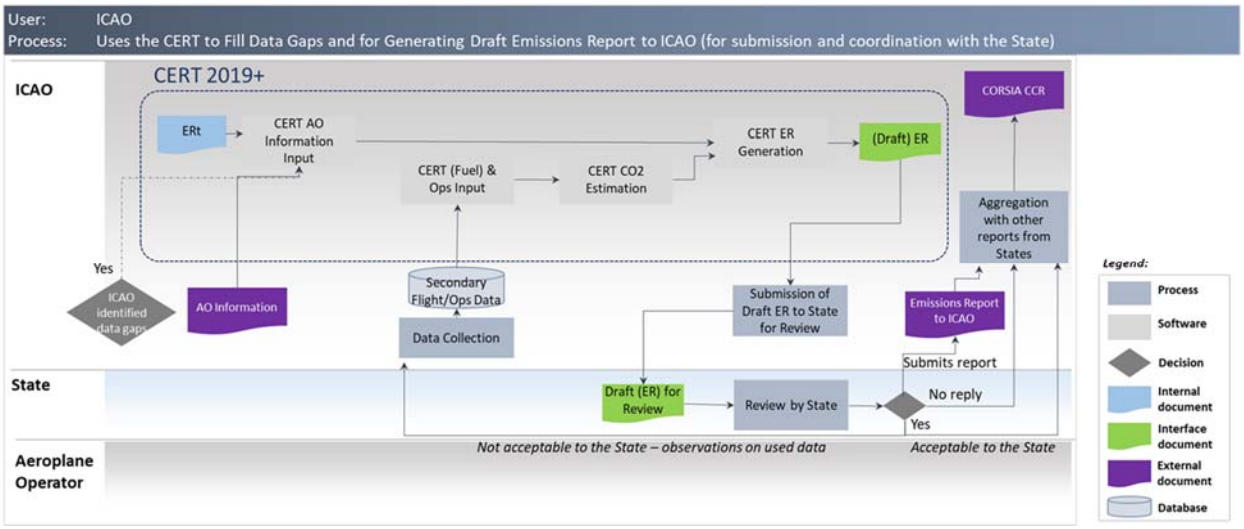


Figure 11: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for ICAO to fill data gaps

3. DESIGN AND DEVELOPMENT OF THE ICAO CORSIA CERT

Based on assessment conducted by the ICAO-CAEP of the potential candidate methods that could be used as a basis for a CO_2 estimation tool, it was recommended that a modeling approach and tool based on a statistical method was most appropriate and fit for purpose for developing the ICAO CEMs underlying the ICAO CORSIA CERT. The statistical method is based on actual historic fuel burn data, provided by aeroplane operators, that are used to establish statistical models to estimate fuel burn for a particular distance or time and aircraft type. Similar to the Fuel Use Monitoring Methods as described in Annex 16, Volume IV, Appendix 2, a menu of ICAO CEMs based on Great Circle Distance input or Block Time input could provide flexibility to aeroplane operators to meet the monitoring and reporting requirements from the CORSIA.

3.1 Functionality of the ICAO CORSIA CERT

The ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT) comprises a three-step process as described in Figure 12. This includes:

(1) Entering aeroplane operator's information (to meet the requirements of the Emissions Report template per the *Environmental Technical Manual* (Doc 9501), Volume IV);

(2) Entering flight data either manually or using a file upload, to estimate CO_2 emissions using either the Block Time or Great Circle Distance (GCD). The user enters a) Aircraft type and b) aerodrome designator for origin-destination based on Doc 7910 — *Location Indicators* (i.e., Great Circle Distance GCD) or flight operating time (i.e., Block Time) as input to estimate an aeroplane operator's CO_2 emissions; and

(3) Generating the Emissions Report, reviewing and submitting it.

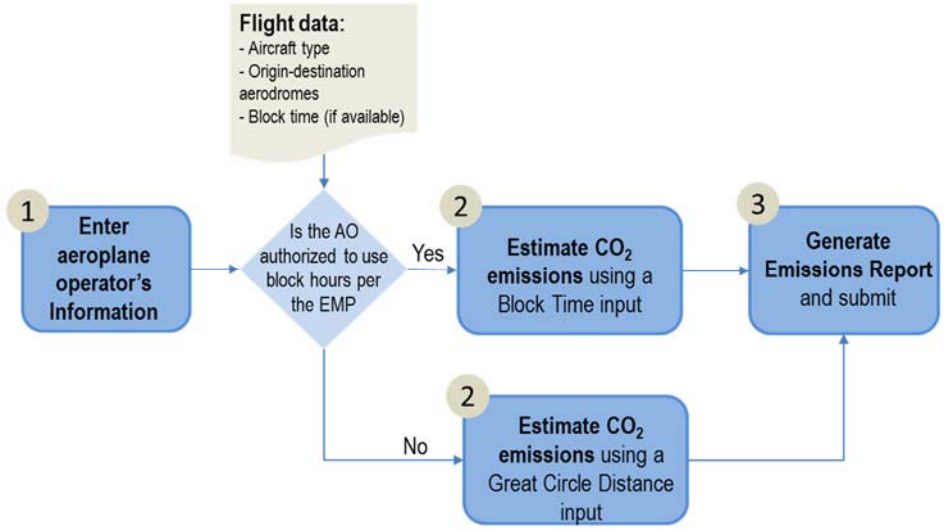


Figure 12: Overview of the high-level functions of the potential CORSIA CO_2 Estimation and Reporting Tool

3.2 Development of the ICAO CO_2 Estimation Models (CEMs)

Underlying the ICAO CORSIA CERT CO_2 estimation functionality (i.e., step 2 in Figure 12), the ICAO CEMs allow to convert the users input (i.e., aircraft types, aerodromes of origin and destination, Block Time if available) into estimated CO_2 emissions.

3.2.1 Overview of the Process for Developing ICAO CEMs

Figure 13 shows an overview of the process for developing the ICAO CEMs. First, the list of aircraft types, by ICAO Type Designator, for which an ICAO CEM needs to be established were scoped and identified. Doc 8643 — *Aircraft Type Designators* [3] was analyzed to identify those aircraft types that are within the scope of applicability of Annex 16, Volume IV, i.e., Maximum Take Off Mass (MTOM) greater than 5 700 kg. Because Doc 8643 does not include MTOM information, several information sources, including: the EASA Certification Database, the ICAO Noise Certification database, and complementary information such as the US FAA Type Certificate Data Sheets (TCDS) were used and mapped to each aircraft type designators in Doc 8643. The identified aircraft types form the basis for the ICAO CORSIA CERT aeroplane database. Section 3.2.2 provides additional information about the process for scoping the ICAO CORSIA CERT aeroplane database.

For each of the aircraft types identified in the scoping process described above, an ICAO CEM was developed. As shown in Figure 13, a four-tier approach was developed and implemented:

(1) First, if the aircraft type can be mapped to an aircraft type available in the validated CCG Operations and Fuel database (COFdb), an ICAO CEM is developed using the methodology described in section 3.2.3;

(2) Second, if the aircraft type is not available in the COFdb but there is an equivalent aircraft type which is modeled using (1) within the same family (and same manufacturer), an ICAO CEM is developed through scaling of the ICAO CEM of the equivalent aircraft type, using the method described in 3.2.4;

[3] *ICAO Document* Aircraft Type Designators *(Doc 8643)*, available for query at: https://www.icao.int/publications/DOC8643/Pages/Search.aspx

(3) Third, if the aircraft type is not mapped to the COFdb via steps 1 or 2, then the ICAO Fuel Formula is used, (see section 3.2.5 for background on the ICAO Fuel Formula); and

(4) Finally, if an aircraft type is missing an ICAO CEM after steps 1 to 3, a generic equation can be developed using the methodology described in section 3.2.6. This approach is used for aircraft types identified in Appendix A-1 (Table A-1.2.d) as well as aircraft types that can be entered into the ICAO CORSIA CERT as Custom Aeroplane.

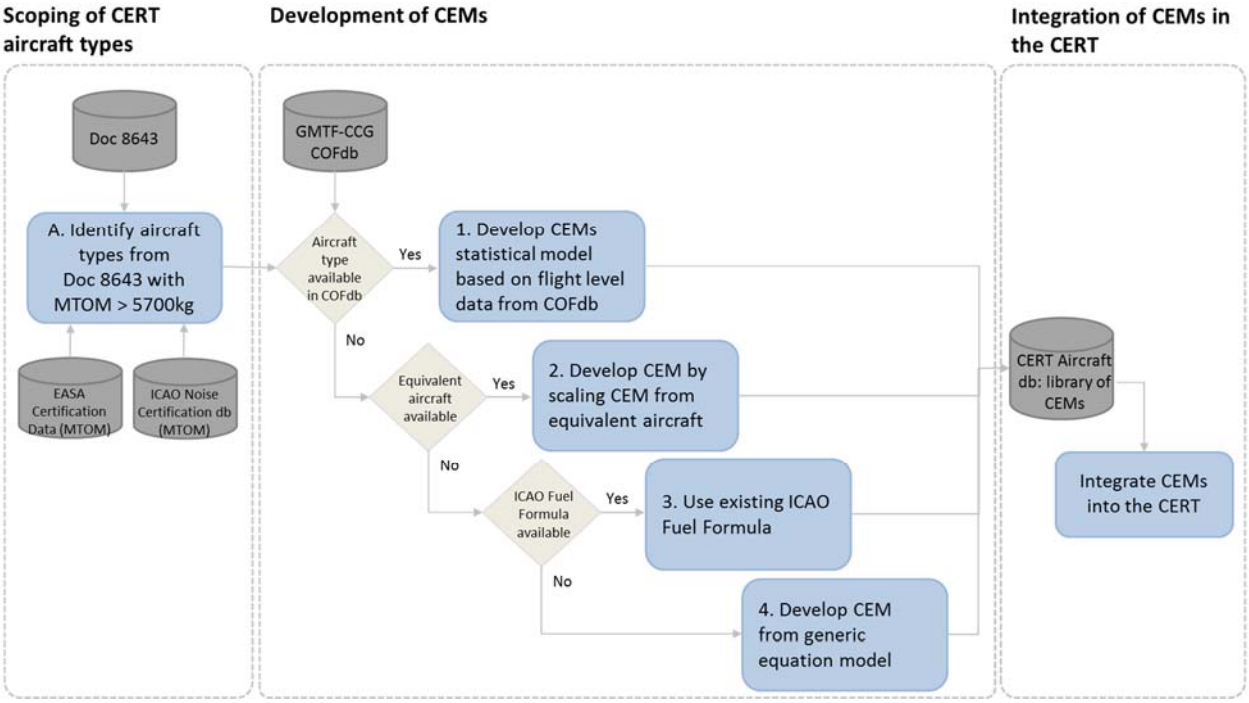


Figure 13: Summary of process for developing ICAO CO_2 Emissions Estimation Models (CEMs)

3.2.2 Scoping of ICAO CORSIA CERT aeroplane database

Users of the ICAO CORSIA CERT can enter aircraft type by ICAO Type Designator (e.g., B738 for a Boeing B737-800 or A321 for an Airbus A321). The Type Designators are consistent with Doc 8643 — *Aircraft Type Designators which is filtered to only include aircraft types that are under the scope of applicability of Annex 16, Volume IV (i.e., Maximum Take Off Mass (MTOM) greater than 5 700 kg).*

Data sources

- Doc 8643:
    - The 2023 version of the ICAO CORSIA CERT is based on the version of Doc 8643 that was last updated on 03 May 2023.
- Maximum Take Off Mass (MTOM):
    - The following version of the EASA Noise Certification Databases (www.easa.europa.eu/document-library/noise-type-certificates-approved-noise-levels) were used to obtain MTOM data by aircraft type.
        - EASA approved noise levels (Heavy propeller driven aeroplanes), Issue 35, last updated: 28 October 2021
        - EASA approved noise levels (Jet aeroplanes), Issue 37, last updated: 28

October 2021

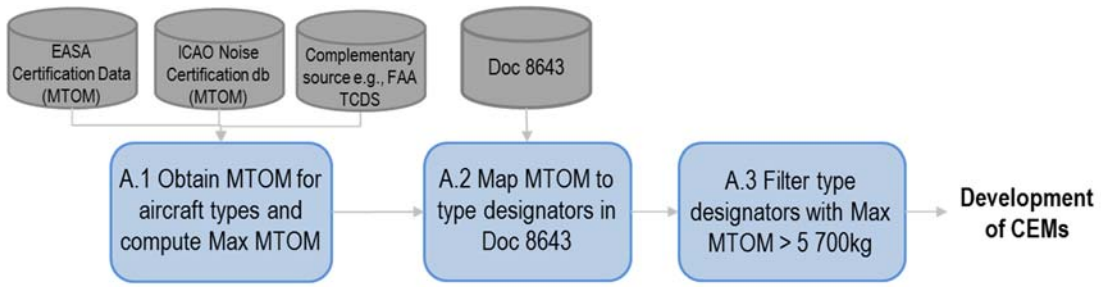
- EASA approved noise levels (Light propeller driven aeroplanes), Issue 37, last updated: 28 October 2021

- In addition, the ICAO Noise Certification Database, version 2.24 that was validated by the CAEP Working Group 1 (WG1) on the 8th November 2017 was used. The Noise Certification database is available at: http://noisedb.stac.aviation-civile.gouv.fr
- Complementary data sources were also used when needed, including the U.S. Federal Aviation Administration (FAA) Type Certificate Data Sheet (TCDS), available at: http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgMakeModel.nsf/Frameset?OpenPage

Methodology

To ensure that aircraft types (by Type Designator) with a variant greater than 5 700 kg Maximum Take-Off Mass (MTOM) is available in the ICAO CORSIA CERT, the Maximum MTOM was derived from across aeroplane variants and the multiple available MTOM databases.

Figure 14 illustrates the process for filtering aircraft types with MTOM greater than 5 700 kg. Aircraft types from the MTOM databases were mapped to Doc 8643 — Aircraft Type Designators. The Maximum MTOMs were then used to filter and identify Type Designators with MTOM greater than 5700 kg.



Doc 8643 has total of 10 020 aircraft types categorized as Amphibian, Helicopter, Landplane, SeaPlane or Tilt-wing. Further, each aircraft type has the manufacturer's name, ICAO Designator, engine type, engine count and wake turbulence category (WTC).

Doc 8643 has wake turbulence category (WTC) designated for each aircraft type. The WTCs are as follows:

- **H** (Heavy) aircraft types of 136 000 kg (300 000 lb) or more;
- **M** (Medium) aircraft types less than 136 000 kg (300 000 lb) and more than 7 000 kg (15 500 lb); and
- **L** (Light) aircraft types of 7 000 kg (15 500 lb) or less.
- *Note:* **Super Heavy** for Airbus A380-800 with a maximum take-off mass in the order of 560 000 kg.

Figure 14: Development of list of aircraft types with MTOM>5 700kg for CORSIA CO_2 emissions estimation tool development process

3.2.3 Development of ICAO CEMs based on aeroplane operator data (COFdb)

As described in the first step of the four-tier approach in Figure 13, if the aircraft type can be mapped to an aircraft type available from the CCG Operations and Fuel database (COFdb), an ICAO CEM is developed using statistical models.

Overview of the CCG Operations and Fuel database (COFdb)

The CAEP Working Group 4 (WG4) CCG Operations and Fuel database (COFdb) is a database of actual flights that includes: aircraft type, great circle distance (based on aerodrome of origin and destination), fuel burn, block time, and operation year for each flight.

Data contained in the COFdb comes from aeroplane operators who have voluntarily agreed to provide data for the development of the ICAO CORSIA CERT as per recommendation from Annex 16, Volume IV, Appendix 3. Given the commercial sensitivity of flight level fuel burn information, the COFdb is the result of a multi-step process used to ensure that data in the COFdb is anonymized i.e., that neither the aeroplane operator nor the individual flight can be identified from the COFdb data. Aeroplane operators provide relevant flight level data to DPO Data Providing Organizations (DPOs) who process the flight level data anonymizing it to remove references to the actual aeroplane operators and flight, assigning to it a unique code to allow traceability if needed, and provide it to the WG4-CCG co-leads for it to be integrated in the COFdb replacing the DPO unique code with a COFdb specific unique code. Once validated by the CCG co-leads, the resulting COFdb is shared only with WG4 CCG members and governed by a Use Agreement and for the sole purpose of supporting and facilitating the work of developing, validating, and maintaining the ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT) and the underlying ICAO CO_2 Estimation Models (CEMs).

<u>Data collection and validation processes</u>

When providing data to CAEP, DPOs are responsible for:

- validating, to the extent possible to the Organization, the correctness of the departure and arrival aerodrome as well as of the correct use of the ICAO aircraft type designator as per Doc 8643 for each flight having indeed been operated between those aerodromes, coordinating with the aeroplane operator as necessary;
- computing the Great Circle Distance, rounded to the kilometer, between the departure and arrival aerodrome, using the latitude and longitude of the aerodromes as provided in the applicable version of Doc 7910 (applicability determined on the basis of the date of flight and the date of issue of the ICAO Document) or applicable AIP information and with the Earth modelled according to the WGS84 reference system and geodetic datum; the Great Circle Distance field is to be left empty if either the departure or the arrival aerodrome is not available in Doc 7910;
- computing whether the flight is international or domestic on the basis of the departure and arrival aerodrome and in accordance with the prescriptions of Annex 16, Volume IV, Part II, Chapter 1, 1.1.2;
- including for each flight record a unique identifier per aircraft type, identifier which allows the DPO to identify the related flight data supplier in order to coordinate with the latter as and if required;
- ensuring that, when available, the block time is provided in minutes without decimals, leaving the field empty if not available;
- excluding from the provided data records for which:
    - the validation of the first point is unsuccessful; or
    - the aircraft type is not in the applicable version of Doc 8643 (applicability determined on the basis of the date of the flight and the date of issue of the ICAO Document); or
    - both the Great Circle Distance and the block time are unknown.

Integration of data into the COFdb (pre-verification)

Prior to integrating data received from a DPO into the COFdb, CAEP conducts a parallel and redundant process that includes (1) pre-verification of the COFdb in order to ensure the quality of the data as well as (2) accurate and appropriate data integration in the COFdb.

Verification and distribution of the COFdb

CAEP also conducts verification of the integrated COFdb, including checks that the data available in the received version of the COFdb is complete. The COFdb is then made available to each CAEP expert contributing to the development of the ICAO CORSIA CERT and that have executed a Use Agreement at the time of the distribution of the COFdb.

Version of the COFdb used for the 2023 version of the ICAO CORSIA CERT

For the 2023 version of the ICAO CORSIA CERT, the COFdb version 2023_3.0 as of March 23, 2023 was used. This 2023 version 3.0 of the COFdb includes data from approximately 6.3 million flights (after removal of older data) for 116 aircraft types by ICAO Type Designator. Data ranged from 2006 to 2022 with about 75% of the data coming from 2017 to 2022.

Identifying and removing outliers from aeroplane operator's raw data

Before final regression models were developed for each of the aircraft type, outliers were identified and removed. To identify outliers, a first regression on the entire dataset is developed. This allows the calculation of the standardized residual absolute value for all data points. As an initial step, data points with a standardized residual absolute value greater than 3σ were identified as outliers and were examined. For each aircraft type and regressions, CCG evaluated the fitness of the 3σ criterion for the given dataset. If deemed appropriate, the default 3σ criterion was used. For a few aircraft types, 4σ or 5σ were used to better capture the distribution of flights across the dataset. Once outliers were removed, single or multi-segment regressions were developed.

Regression model selection and development

The ICAO CEMs are based on piece-wise linear fuel burn vs. GCD or block time functions. The dependent variable is fuel burn. There are two potential explanatory variables in the model: (1) Block Time or (2) Great Circle Distance (GCD) of the flight. The 2019 version of the ICAO CORSIA CERT and subsequent versions include both Great Circle Distance and Block Time input.

Figure 15 shows an illustration for a sample aircraft type with the COFdb data split into data retained for the development of the regression i.e., ICAO CEM (in green) and outliers (in red).

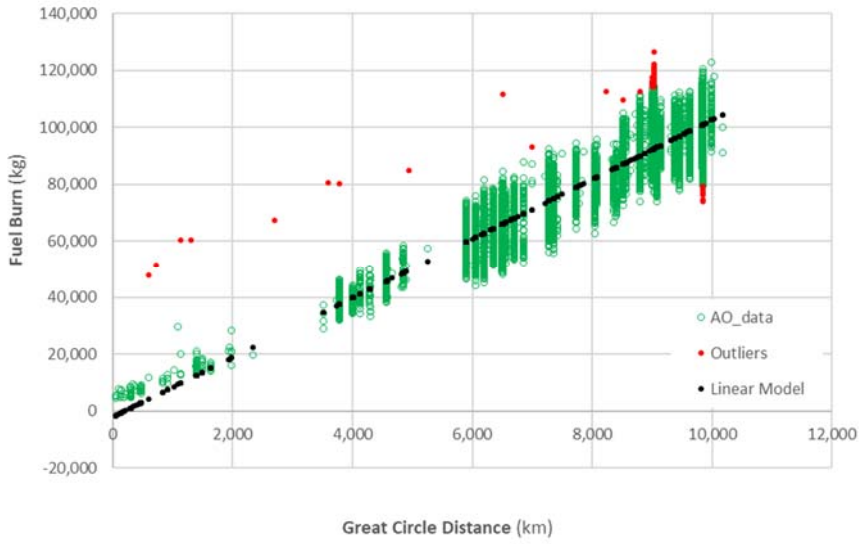


Figure 15: Illustration of sample data used to generate ICAO CEMs, including outlier data removed from the process of generating the ICAO CEM

To generate an ICAO CEM, the CCG followed the following steps:

- Import an aircraft type database;
- Generate a regression on entire dataset (i.e., linear OLS model);
- Identify outliers and remove them; and
- Run a second single-segment regression or a piece-wise regression (up to three segments with breakpoints).

If breakpoints are not used on some aircraft types, uncorrected linear regression ICAO CEMs may result in negative intercept. Piecewise linear equations are used to address this and better represent the dataset. The need for breakpoints was determined using the following rules:

- If there is a negative intercept -> introduce a breakpoint;
- If there is a cluster consistently above or below -> introduce a breakpoint; and
- If there is a Great Circle Distance (GCD) gap -> potentially introduce breakpoints.

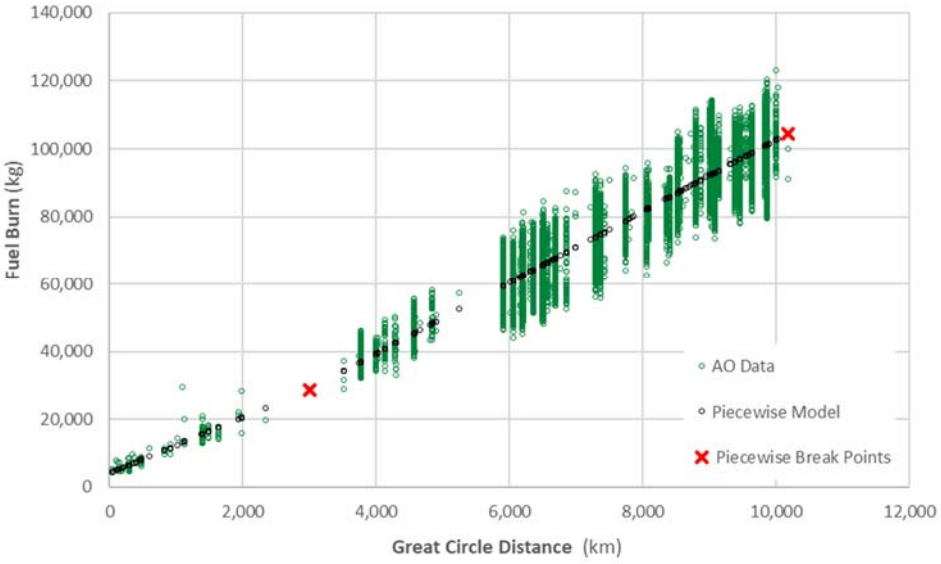


Figure 16: Illustration of fuel burn statistical method model formulation (GCD Model)

3.2.4 Development of ICAO CEMs based on equivalent aircraft types

If the aircraft type is not available in the COFdb but can be mapped to an equivalent aircraft type within the same family (and same manufacturer), an ICAO CEM is developed through scaling of the ICAO CEM of the equivalent aircraft type.

The development of equivalent aircraft type model was only allowed for aircraft within the same family (and same aeroplane manufacturer) if deemed appropriate. For example, an Airbus A342 was deemed equivalent to an Airbus A343 for which an ICAO CEM based on data from the COFdb was available.

Once equivalent aeroplane are identified, the ICAO CEM was adjusted by scaling (multiplying) it using a Mass ratio of the Average Operating MTOM of both aircraft types:

$$\text{MTOM ratio factor} = \frac{\text{Avg. MTOM}_{\text{aeroplane not in COFdb}}}{\text{Avg. MTOM}_{\text{equivalent aeroplane in the COFdb}}}$$

Data from a global registration database was used to develop Average MTOM values for each aircraft types in the ICAO CORSIA CERT aeroplane database.

3.2.5 ICAO CEMs based on ICAO Fuel Formula

If the aircraft type is not mapped to the COFdb or equivalent aircraft type, then the ICAO Fuel Formula is re-used.

Additional information on the ICAO Fuel Formula used in the ICAO Carbon Calculator is available at ICAO Carbon Emissions Calculator Methodology Version 10, https://www.icao.int/environmental-protection/CarbonOffset/Documents/Methodology%20ICAO%20Carbon%20Calculator_v10-2017.pdf

3.2.6 Development of ICAO CEMs based on generic equation model

Finally, to allow the estimation of fuel burn and CO_2 emissions for an aircraft type that is missing an ICAO CEM after applying the steps in 3.2.3 to 3.2.5, a set of generic equation models are developed from which an ICAO CEM for such aircraft type can then be derived. This step forms the basis for the ICAO CORSIA CERT functionality of entering custom aeroplane that can either be (1) one of the aircraft types identified in Appendix A-1, Table A-1.2.d or (2) an aircraft type not included in Doc 8643 that a user may need to enter and use towards the estimation of its emissions. For each linear regression-based model the fuel is calculated on specific distances. Those are determined to ensure a sufficient level of granularity and account for the possible variation of the piecewise breakpoints.

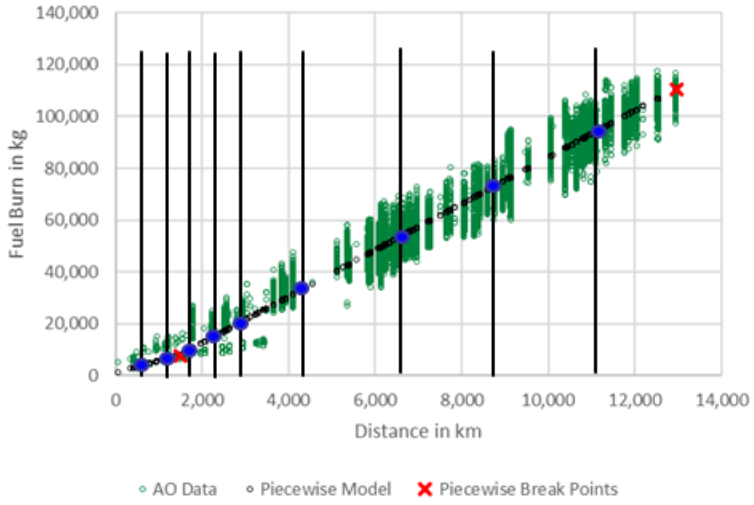


Figure 17: Illustration of process for binning data for developing generic equation

For each distance band value the calculated fuel are reported versus the aeroplane average Maximum Take-off Mass (MTOM). To develop generic equation models most representative, aircraft types are grouped by category including:

- Heavy Jets[4];
- Medium Jets with Certified MTOM greater than 60 000 kg[5];
- Medium Jets with Certified MTOM lower or equal to 60 000 kg; and
- Turboprops and Turboshaft aeroplane.

Figure 18 illustrates the development of generic aeroplane (fuel burn) values (in orange) for a given distance within the category of Medium Jets with Certified MTOM greater than 60 000 kg based on values from the ICAO CEMs (in blue) for aeroplane in the same category. Distances of 0 km and 1 000 km are shown for illustration.

[4] Heavy Jets, Medium Jets, Turboprops and Turboshaft powered aircraft based on categorization included in Doc 8643.

[5] The Medium Jets category was split into two subcategories to capture different trends across the broad MTOM range from approximately 10 tonnes to approximately 120 tonnes. A breakpoint at 60 tonnes was established as it captures trends appropriately. In addition, the 60 tonnes thresholds leverages and is consistent with the ICAO CO_2 emissions standard (governed by Annex 16, Volume III) that includes a breakpoint at 60 tonnes certified MTOM.

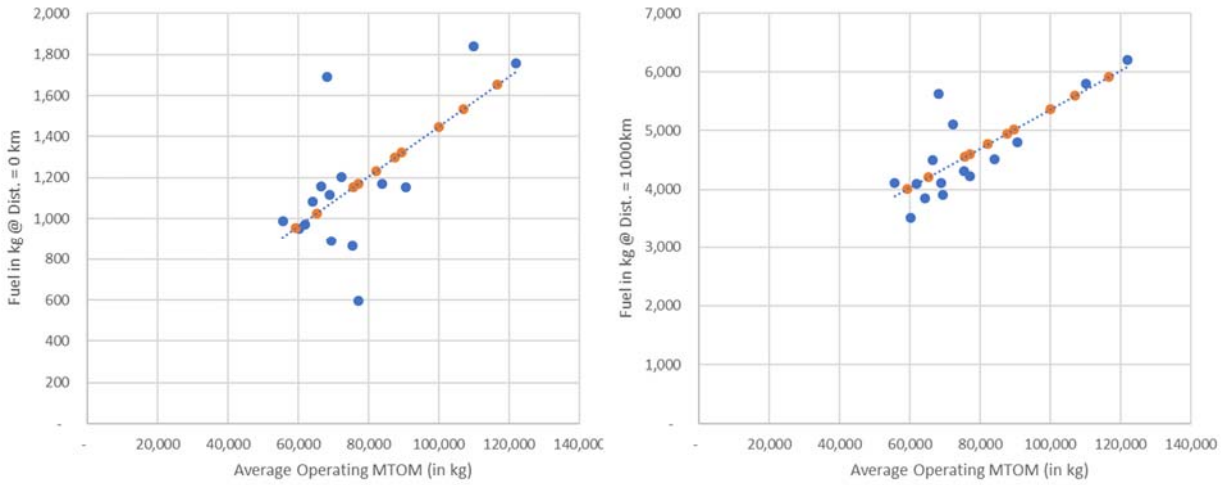


Figure 4: Illustration of generic aeroplane fuel burn-MTOM based regressions for a given distance

Similarly to aeroplane operator fuel burn data, a linear regression is then calculated. The result is a set of equations (per aeroplane category and distance band) returning a fuel as a function of the aeroplane maximum take-off mass. As based on that set of equations, a fuel estimation model (equation) can be derived for any aircraft type (Figure 11).

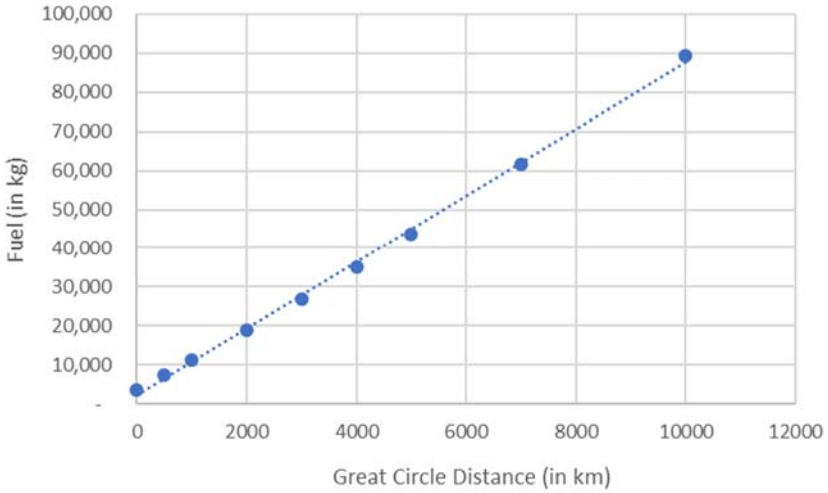


Figure 5: Illustration of generic aeroplane ICAO CEM

4. IMPLEMENTATION OF THE ICAO CORSIA CERT: VERSION 2023

ICAO CORSIA CERT has been developed, tested, and validated on Microsoft Excel 2013 and Windows 11 as Operating System. This should not be considered the minimum possible configuration. However, due to possible compatibility issues with older Excel versions and/or operating systems other than those tested, it is recommended to use Windows 7 or higher and Excel version 2010 or later. ICAO CORSIA CERT has not been tested on any MAC OS.

The ICAO CORSIA CERT version 2023 -includes two key functionalities:

a) Summary of assessment of applicability of CORSIA and eligibility to use the ICAO CORSIA CERT in 2023,

b) CO_2 Estimation and Reporting for 2023.

4.1 Summary of assessment of applicability of CORSIA and eligibility to use the ICAO CORSIA CERT in 2023

The ICAO CORSIA CERT version 2023 takes the user through a simple three steps process where the user:

(1) Enters aeroplane operator information relevant for assessing the applicability of CORSIA and eligibility to use the ICAO CORSIA CERT for monitoring and reporting of CO_2 emissions;

(2) Estimates its CO_2 emissions from international flights; and

(3) Generates a summary assessment of applicability of CORSIA and eligibility of the aeroplane operator to use the ICAO CORSIA CERT, with the possibility to generate documents to save them for record keeping.

4.1.1 Aeroplane operator identification

To allow for the identification of the aeroplane operator on the summary documents, the user can enter key information on the aeroplane operator. The format of the required information is consistent with the identification page of the Emissions Monitoring Plan. This information is then used in the summary assessment and saved documents.

4.1.2 Calculation of CO_2 emissions

The core functionality of the ICAO CORSIA CERT is the estimation of CO_2 emissions based on user input data.

4.1.3 Loading and entering data into the ICAO CORSIA CERT

The user can enter aircraft type and flight information data into the ICAO CORSIA CERT using two key paths:

a) Manual entry by selecting an aircraft type designator from the list of types available in the ICAO CORSIA CERT aeroplane database. If needed, the user can also enter codes that are not included in the ICAO CORSIA CERT aeroplane database which become ‘custom aeroplane code’. See below for details on the custom aeroplane and aerodrome functionality in the ICAO CORSIA CERT; and

b) Direct upload into the ICAO CORSIA CERT by loading a file containing aircraft types, origin and destination aerodromes as well as number of flights. This file in csv format can be used as the interface between an aeroplane operator’s Operations and Flight Management System and the ICAO CORSIA CERT.

4.1.4 Comparison of the operations input data against the ICAO CORSIA CERT aeroplane and aerodrome databases

When loading operations data into the ICAO CORSIA CERT or calculating CO_2 emissions, the user can choose to compare the input aircraft type and aerodromes entries against the internal ICAO CORSIA CERT aeroplane and aerodromes databases. This comparison checks for consistency and returns any aircraft type code and aerodrome code that does not match the internal ICAO CORSIA CERT aeroplane and aerodromes databases. The user can then choose to enter custom aeroplane and aerodromes information for these codes or return to the input data and correct the codes if an error was

made in the data entry.

Entering custom aeroplane codes

If the user chooses to use custom aeroplane codes, he/she is prompted to select an aircraft category from the following list:

a) Jet (Heavy) with certified MTOM ≥136 000 kg;

b) Jet with certified MTOM ≥ 60 000 kg and < 136 000 kg;

c) Jet with certified MTOM < 60 000 kg; and

d) Turboprop.

The user is also prompted to enter the Average Maximum Take Off Mass (MTOM) in the aeroplane operator fleet. The Average MTOM is calculated using the arithmetical average of individual MTOMs of aeroplane in the fleet of a given aircraft type code. The individual MTOMs are the individual maximum permissible take-off mass of each individual aeroplane according to the certificate of airworthiness, the flight manual or other official documents as defined by ICAO Annex 16, Volume IV.

Based on the aeroplane category selected and the Average Maximum Take Off Mass (MTOM) in the aeroplane operator fleet, the ICAO CORSIA CERT derives a tailored ICAO CEM from the relevant generic equation model according to the approach described in section 3.2.6. The custom aeroplane functionality displays information on the fuel burn rate (kg/km) and intercept value (fuel at great circle distance of 0 km) depending on the underlying regression model associated with a manually selected aeroplane category and average MTOM. The indicated fuel burn rate and interception value are used within ICAO CORSIA CERT to calculate the estimated fuel and emissions for all flights with this Custom Aeroplane Code.

The following coefficients are used in the 2023 version of the ICAO CORSIA CERT to generate generic equations (as a function of entered Average MTOM) for aircraft types entered as custom aeroplane, by aircraft type category.

Aircraft Type Category	Coefficients for Linear Function to Derive the **Intercept** of the Generic Equation		Coefficients for Linear Function to Derive the **Slope** of the Generic Equation	
Coefficients for Generic Equation based on Great Circle Distance (i.e., Fuel = slope * GCD + intercept)				
	Intercept	Slope	Intercept	Slope
Jet (Heavy) with certified MTOM >= 136 000 kg	-1738.323789	0.015494476	0.851400944	2.58006E-05
Jet with certified MTOM >= 60 000 kg and < 136 000 k	102.5191681	0.011587369	1.035425787	2.94163E-05
Jet (Heavy) with certified MTOM < 60 000 kg	186.6981954	0.014121257	0.172655568	5.10469E-05
Turboprop	-21.96949515	0.013831192	0.33173559	4.80238E-05
Coefficients for Generic Equation based on Block Time (i.e., Fuel = slope * Block_Time + intercept)				
	Intercept	Slope	Intercept	Slope
Jet (Heavy) with certified MTOM >= 136 000 kg	4810.166517	-0.03674015	-4.778898921	0.000455796
Jet with certified MTOM >= 60 000 kg and < 136 000 k	750.9498712	-0.01224546	4.683460687	0.000484168
Jet (Heavy) with certified MTOM < 60 000 kg	23.53124626	0.002441058	4.135109741	0.000532874
Turboprop	-19.78366888	0.005858582	0.723039936	0.00043942

Figure 20: Coefficients used in the 2023 version of the ICAO CORSIA CERT to generate generic equations (as a function of entered Average MTOM) for aircraft types entered as custom aeroplane

Note. - If custom aircraft types are entered but already exist in the ICAO CORSIA CERT aeroplane database, the information in the ICAO CORSIA CERT aeroplane database will anyhow be used as default for calculating CO_2 emissions.

CERT Aerodrome Database

The CERT Aerodrome database contained in the 2023 version of the CERT is based on the Edition 189 of the ICAO eDoc7910. Some aerodromes contained in ICAO eDoc 7910 with latitude and longitude in erroneous formats were addressed for the purpose of the development of the CERT Aerodrome database. The CERT aerodrome database also includes a short list of aerodromes that complement the subset of aerodromes from ICAO eDoc7910. Appendix C contains the short list of aerodromes to be added to the CERT Aerodrome database underlying the CERT 2023.

These aerodromes or any aerodromes contained in the CERT aerodrome database can be overwritten by users following the procedure described in the next section.

Entering custom aerodrome codes

If needed, the user can enter custom aerodrome codes in order to allow for the calculation of CO_2 emissions for each flight entered. The user is prompted to enter aerodrome latitude using WGS84 coordinates. In the 2023 version of the ICAO CORSIA CERT, the user has greater flexibility for entering aerodrome coordinates. The separation symbols can be defined by the user.

Latitude and longitude pairs for aerodromes or Aerodrome Reference Points (ARP) within the ICAO CORSIA CERT shall be used with the following Latitude & Longitude sign convention.

A negative latitude (-) means South of the Equator. A negative longitude (-) means West of the Prime Meridian.

In addition, the user is prompted to enter an ICAO Member State attributed to the aerodrome by selecting from the list of 193 ICAO Member States as of April 2020. In order to help with the attribution of aerodromes to ICAO Member States, the ICAO CORSIA CERT provide a suggestion on a potential ICAO Member State based on the first two letters of the Custom Aerodrome Code (for codes with four letters only).

Note. - If custom aerodromes are entered but already exist in the ICAO CORSIA CERT aeroplane database, the information for the custom aerodromes will be used as default for the purpose of calculating CO_2 emissions.

Note. – In order to help the user search the ICAO CORSIA CERT aeroplane and aerodrome databases, a search functionality was developed. Additional information on the underlying Doc 8643 can be found at: https://www.icao.int/publications/DOC8643/Pages/default.aspx. In addition, additional information on Doc 7910 can be found at https://gis.icao.int/7910FLEX/.

4.1.5 Computation of Great Circle Distance

For each aerodrome pair entered as input into the tool, the ICAO CORSIA CERT calculates a Great Circle Distance (GCD).

Doc 7910 was used as the basis for the aerodrome latitudes and longitudes. The input latitude and longitude is based on WGS84. In order to compute Great Circle Distance used as input to the ICAO CORSIA CERT underlying ICAO CEMs, the Vincenty's Method was used and implemented in the ICAO CORSIA CERT. The Vincenty's method is an iterative process used in geodesy to calculate the distance between two points on the surface of a spheroid, developed by Thaddeus Vincenty (1975a). It is based on the assumption that the figure of the Earth is an oblate spheroid, and hence is more accurate than methods that assume a spherical Earth, such as Great Circle Distance. The method is widely used in geodesy because they are accurate to within 0.5 mm (0.020″) on the Earth ellipsoid.

4.1.6 Generation of a summary assessment of CO_2 emissions

After ensuring that the entered information is complete and calculating CO_2 emissions, the user can generate a summary assessment of applicability of Annex 16, Volume IV, Chapter 2 and eligibility to use the ICAO CORSIA CERT in 2023.

The summary assessment includes:

a) **Aeroplane operator information** based on input from the user;

b) **Estimated CO_2 emissions and status of aeroplane operator.** This comprises:

- Total annual estimated CO_2 emissions (international). It should be noted that emissions are for all international State pairs. For the 2023 version of the ICAO CORSIA CERT, this total splits between State pairs with offsetting requirements and State pairs not subject to offsetting requirements (see Annex 16, Volume IV, Chapter 3 for details).
- Total annual estimated CO_2 emissions (domestic). Domestic aviation is outside the scope of applicability of Annex 16, Volume IV. Information is provided for awareness of tool user in the event domestic flights are entered in the input tables.
- Status of aeroplane operator as to whether the aeroplane operator falls under the scope of applicability of CORSIA as per Annex 16, Volume IV, Chapter 2 and whether the aeroplane operator is eligible to use the ICAO CORSIA CERT or required to use one of the five Fuel Use Monitoring Methods. For details on Fuel Use Monitoring Methods refer to Annex 16, Volume IV, Chapter 2 and Appendix 2 and the Environmental Technical Manual (Doc 9501), Volume IV.

c) **Detailed estimated CO_2 emissions by State pairs.**

4.1.7 Generation of report on summary assessment

To support the Emissions Monitoring Plan (EMP) in 2023, the aeroplane operator can use the ICAO CORSIA CERT to estimate its emissions. The ICAO CORSIA CERT can produce a copy summary assessment along with a copy of the Appendix to the summary assessment containing the custom aeroplane and aerodromes information (if entered in the tool).

The user can save a copy for its records. In accordance with Annex 16, Volume IV, Appendix 4, 2.3.1.1 a) on the supporting information on methods and means for calculating emissions from international flights, the aeroplane operator can submit a copy of the summary assessment to its State along with the Emissions Monitoring Plan.

4.2 CO_2 Estimation and Reporting for 2023

The CO_2 Estimation and Reporting functionality of the ICAO CORSIA CERT version 2023 takes the user through each step of the Emissions Report generation process where the user:

a. Enters aeroplane operator identification and description of activities,

b. Enters underlying basic information of the Emissions Report,

c. Enters aeroplane fleet and fuel types

d. Select Fuel density

e. Selected the level of aggregation of the information reported,

f. Load its operations (and fuel) data to estimation CO_2 emissions,

g. Completes the prefilled “Reporting - State pairs” report, or

h. Completes the prefilled “Reporting - Aerodrome pairs”, and

i. Completes the prefilled “Data gaps” information.

j. Review the Emissions Report and Export the Emissions Report in various formats to meet the need of the aeroplane operator.

The following section provides additional information on each of the steps and the associated underlying methodologies and assumptions.

4.2.1 Starting to Fill the Emissions Report

If the ICAO CORSIA CERT is used to fill an Emissions Report, the user will be prompted to enter information on (1) Aeroplane operator identification and description of activities, (2) Underlying basic information of the Emissions Report, (3) Aeroplane fleet and fuel types, (4) Fuel density and (5) Level of aggregation of the information reported.

The ICAO CORSIA CERT replicates the same process and format as the ICAO Emissions Report template.

4.2.2 Loading and entering data into the ICAO CORSIA CERT

In order to estimate fill the relevant portions of the Emission Report, the ICAO CORSIA CERT will estimate CO_2 emissions and fill data gaps (as needed). The first step is to load or enter data into the ICAO CORSIA CERT. An aeroplane operator can enter aircraft type and flight information data into the ICAO CORSIA CERT using two key paths:

a) Manual entry by selecting an aircraft type designator from the list of types available in the ICAO CORSIA CERT aeroplane database. If needed, the user can also enter codes that are not included in the ICAO CORSIA CERT aeroplane database which become ‘custom aeroplane code’. See section 4.2.3 for details on the custom aeroplane and aerodrome functionality in the ICAO CORSIA CERT; and

b) Direct upload into the ICAO CORSIA CERT by loading a file containing aircraft types, origin and destination aerodromes as well as number of flights. This file in .csv format can be used as the interface between an aeroplane operator’s Operations and Flight Management System and the ICAO CORSIA CERT.

4.2.3 Comparison of the operations input data against the ICAO CORSIA CERT aeroplane and aerodrome databases

When loading operations data into the ICAO CORSIA CERT or calculating CO_2 emissions, the user can choose to compare the input aircraft type and aerodromes entries against the internal ICAO CORSIA CERT aeroplane and aerodromes databases. This comparison checks for consistency and returns any aircraft type code and aerodrome code that does not match the internal ICAO CORSIA CERT aeroplane and aerodromes databases. The user can then choose to enter custom aeroplane and aerodromes information for these codes or return to the input data and correct the codes if an error was made in the data entry.

Entering custom aeroplane codes

If the user chooses to use custom aircraft type codes, he/she is prompted to select an aeroplane category

from the following list:

a) Jet (Heavy) with certified MTOM ≥ 136 000 kg;

b) Jet with certified MTOM ≥ 60 000 kg and < 136 000 kg;

c) Jet with certified MTOM < 60 000 kg; and

d) Turboprop.

The user is also prompted to enter the Average Maximum Take Off Mass (MTOM) in the aeroplane operator fleet. The Average MTOM is calculated using the arithmetical average of individual MTOMs of aeroplane in the fleet of a given aeroplane code. The individual MTOMs are the individual maximum permissible take-off mass of each individual aeroplane according to the certificate of airworthiness, the flight manual or other official documents as defined by ICAO Annex 16, Volume IV.

Based on the aeroplane category selected and the Average Maximum Take Off Mass (MTOM) in the aeroplane operator fleet, the ICAO CORSIA CERT derives a tailored ICAO CEM from the relevant generic equation model according to the approach described in section 3.2.6. The custom aeroplane functionality displays information on the fuel burn rate (kg/km) and intercept value (fuel at great circle distance of 0 km) depending on the underlying regression model associated with a manually selected aeroplane category and average MTOM. The indicated fuel burn rate and interception value are used within ICAO CORSIA CERT to calculate the estimated fuel and emissions for all flights with this Custom Aeroplane Code.

The following coefficients are used in the 2023 version of the ICAO CORSIA CERT to generate generic equations (as a function of entered Average MTOM) for aircraft types entered as custom aeroplane, by aircraft type category.

Aircraft Type Category	Coefficients for Linear Function to Derive the **Intercept** of the Generic Equation		Coefficients for Linear Function to Derive the **Slope** of the Generic Equation	
Coefficients for Generic Equation based on Great Circle Distance (i.e., Fuel = slope * GCD + intercept)				
	Intercept	Slope	Intercept	Slope
Jet (Heavy) with certified MTOM >= 136 000 kg	-1738.323789	0.015494476	0.851400944	2.58006E-05
Jet with certified MTOM >= 60 000 kg and < 136 000 k	102.5191681	0.011587369	1.035425787	2.94163E-05
Jet (Heavy) with certified MTOM < 60 000 kg	186.6981954	0.014121257	0.172655568	5.10469E-05
Turboprop	-21.96949515	0.013831192	0.33173559	4.80238E-05
Coefficients for Generic Equation based on Block Time (i.e., Fuel = slope * Block_Time + intercept)				
	Intercept	Slope	Intercept	Slope
Jet (Heavy) with certified MTOM >= 136 000 kg	4810.166517	-0.03674015	-4.778898921	0.000455796
Jet with certified MTOM >= 60 000 kg and < 136 000 k	750.9498712	-0.01224546	4.683460687	0.000484168
Jet (Heavy) with certified MTOM < 60 000 kg	23.53124626	0.002441058	4.135109741	0.000532874
Turboprop	-19.78366888	0.005858582	0.723039936	0.00043942

Figure 21: Coefficients used in the 2023 version of the ICAO CORSIA CERT to generate generic equations (as a function of entered Average MTOM) for aircraft types entered as custom aeroplane

Note. - If custom aircraft types are entered but already exist in the ICAO CORSIA CERT aeroplane database, the information in the ICAO CORSIA CERT aeroplane database will anyhow be used as default for calculating CO_2 emissions.

Entering custom aerodrome codes

Note. – The Custom Aerodrome functionality for the "CO_2 Estimation and Reporting for 2023" functionality is identical to the Custom Aerodrome functionality for the "Summary of assessment of applicability of CORSIA and eligibility to use the ICAO CORSIA CERT in 2023". See section 4.1.4 for details.

4.3 Data entry error and plausibility of input data

The ICAO CORSIA CERT 2023 version also includes a number of functionality that allows the user to identify potential data entry errors and confirm the accuracy of the input data, including;

- **Date;** Date is an Optional Field. When importing an Input File and/or Calculating CO_2 Emissions, the ICAO CORSIA CERT checks that the year of the entered date matches the Reporting Year (as described in "2 Underlying basic information of the Emissions Report" section a) of the Emissions Report). Warning messages are displayed as "Date" in the last column (i.e., "Warnings") of the input/output table.
- **ICAO Aircraft Type Designator availability;** The tool will prompt the user to check the aircraft type designator against the underlying ICAO CORSIA CERT Aeroplane database and the Custom Aeroplane entered by the user. If any discrepancies are found, the user will be prompted to update/edit existing Custom Aircraft Types or enter new ones,
- **Origin Aerodrome and Destination Aerodrome availability**; Similar to the aircraft type input, the tool will prompt the user to check the origin and destination aerodromes against the underlying ICAO CORSIA CERT Aerodrome database and the Custom Aerodromes entered by the user. If any discrepancies are found, the user will be prompted to update/edit existing Custom Aerodromes or enter new ones.
- **"Total Number of Flights" valid input checks**; The tool will check that input values of total number of flights for flight entries are; (1) greater or equal to 0, (2) integer values (i.e., not fractions of flights). If errors are identified, a pop up message will appear and flight entries will be highlighted.
- **Type of Fuel valid input checks;** The tool will check that a correct Type of Fuels (i.e., Jet-A, Jet-A1, Jet-B, AvGas) are entered. It should be noted that the Type of Fuel selected can include equivalent fuels. If discrepancies between input data and acceptable Type of Fuels are identified, the tool will return an error message and the flight entries with errors will be highlighted.
- **Great Circle Distance comparison with Aeroplane Type's Potential Max Range;** For each of the flight entries for which Great Circle Distance (GCD) was computed, the tool will also compare the GCD to a Maximum Range for the associated aircraft type. If the GCD exceeds this maximum range, a warning will be return. It should be noted that this comparison and possible warning are for information only. The intent is to identify potential input errors (e.g., order of magnitude error such as 0 added to input data). The warning can also result from normal operations if longer range versions of the aeroplane are operated.
- **Estimated and/or Reported Fuel comparison with Aeroplanes Maximum Fuel Tank Capacity;** For each of the flight entries, the tool will identify cases where average reported and/or estimated fuel (and resulting CO_2 emissions) per flight exceed the ICAO CORSIA CERT default maximum fuel tank capacity value for that ICAO Aircraft Type and/or Custom aeroplane code. In order to avoid a possible overestimation of CO_2 emissions, the user is prompted to check the following flight entries flagged with "Fuel Cap". It should be noted that this warning message may be ignored since individual maximum fuel tank capacity and fuel tank configuration can differ from the ICAO CORSIA CERT default values (e.g., some

aeroplanes can have additional fuel tanks which could be one explanation). It should be noted that this comparison and possible warning are for information only. The intent is to identify potential input errors (e.g., order of magnitude error such as 0 added to input data).

4.4 Calculation of CO_2 emissions

4.4.1 The ICAO CORSIA CERT 2023 version builds on the 2022 version with regard to the input of aeroplane operator information, the CO_2 estimation and the generation of a summary assessment functionalities. To meet requirements from Annex 16 Volume IV Chapters 2 and 3, the CERT 2023 embeds the CORSIA Implementation Element titled as "CORSIA States for Chapter 3 State Pairs" that will be used to determine the CO_2 emissions subject to offsetting requirements in 2023. The second edition (revision 1) version (September 2021) of CORSIA Implementation Element titled as "CORSIA States for Chapter 3 State Pairs" is available on the CORSIA website6. This document includes the list of 115 States that participate in CORSIA from 1 January 2023. The CCG developed functionality to embed this list in the CERT 2023 and scripts to calculate and report CO_2 emissions subject to offsetting requirements into the Emissions Report (ER) template.

4.4.2 Generation of Emissions Report (5.1 Reporting - State Pairs and 5.2 Reporting - Aerodrome Pairs, 6 Data Gaps)

After ensuring that the entered information is complete and calculating CO_2 emissions and based on the selection in "5 Reporting" (i.e., reporting on a State pair level or reporting on an aerodrome pair level), the user can fill the portion of the Emissions Report template with statistics on number of flights, emissions, data gaps, etc.

The sections of the Emissions Report automatically and partially filled by the ICAO CORSIA CERT include:

a) **5.1 Reporting at State Pair Level.** This comprises:

- Total annual measured and/or estimated CO_2 emissions (international). It should be noted that emissions are for all international State pairs. For the 2023 version of the ICAO CORSIA CERT, this total splits between State pairs with offsetting requirements and State pairs not subject to offsetting requirements (see Annex 16, Volume IV, Chapter 3 for details).
- Total annual number of flights during the reporting period (international). It should be noted that flights are for all international State pairs. For the 2023 version of the ICAO CORSIA CERT, this total splits between State pairs with offsetting requirements and State pairs not subject to offsetting requirements (see Annex 16, Volume IV, Chapter 3 for details).
- The user can manually enter the Total emissions reductions claimed from the use of CORSIA eligible fuels.
- If the ICAO CORSIA CERT is used for data gap filling and actual fuel quantities (based on one of the five Fuel Use Monitoring Methods) are used, the break down will be automatically calculated by the ICAO CORSIA CERT and presented in section b).
- The user can manually enter the details of emissions reductions claimed from the use of CORSIA eligible fuels.
- Based on input and calculations in the "CO_2 Emissions Estimation & Data Gap Filling"

[6] Reference: ICAO document, "CORSIA States for Chapter 3 State Pairs", Version July 2022, available at: https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA%20States%20for%20Chapter%203%20State%20Pairs_3Ed_web.pdf, last retrieved on August 7th, 2023.

section, the ICAO CORSIA CERT automatically generated the list of State Pairs including; State of departure, State of arrival, whether the CO_2 emissions were estimated by the ICAO CORSIA CERT, total number of flights, fuel type, total mass of fuel, fuel conversion factors, total CO_2 emissions. In the 2023 version, the ICAO CORSIA CERT indicates whether the State Pair is subject to offsetting requirements.

b) **5.2 Reporting at Aerodrome Pair Level.** This comprises:

- Total annual measured and/or estimated CO_2 emissions (international). It should be noted that emissions are for all international State pairs. For the 2023 version of the ICAO CORSIA CERT, this total splits between State pairs with offsetting requirements and State pairs not subject to offsetting requirements (see Annex 16, Volume IV, Chapter 3 for details).
- Total annual number of flights during the reporting period (international). It should be noted that flights are for all international State pairs. For the 2023 version of the ICAO CORSIA CERT, this total splits between State pairs with offsetting requirements and State pairs not subject to offsetting requirements (see Annex 16, Volume IV, Chapter 3 for details).
- The user can manually enter the Total emissions reductions claimed from the use of CORSIA eligible fuels.
- If the ICAO CORSIA CERT is used for data gap filling and actual fuel quantities (based on one of the five Fuel Use Monitoring Methods) are used, the break down will be automatically calculated by the ICAO CORSIA CERT and presented in section b).
- The user can manually enter the details of emissions reductions claimed from the use of CORSIA eligible fuels.
- Based on input and calculations in the "CO_2 Emissions Estimation & Data Gap Filling" section, the ICAO CORSIA CERT automatically generates the list of Aerodrome Pairs including; ICAO aerodrome code and State for the Departure, ICAO aerodrome code and State for the Arrival, whether the CO_2 emissions were estimated by the ICAO CORSIA CERT, total number of flights, fuel type, total mass of fuel, fuel conversion factors, total CO_2 emissions. In the 2023 version, the ICAO CORSIA CERT indicates whether the Aerodrome Pair is subject to offsetting requirements.

c) **6 Data Gaps.** This comprises:

- Based on input and calculations in the "CO_2 Emissions Estimation & Data Gap Filling" section, the ICAO CORSIA CERT automatically assesses whether data gaps occurred during the reporting year and whether the threshold of 5 per cent for data gaps was exceeded and reports the percent of data gaps. The 2023 version of the ICAO CORSIA CERT follows the requirements from Annex 16 Volume IV, where starting in 2021, the percentage of data gaps are calculated by dividing the total number of flights subject to offsetting requirements with data gaps by total number of international flights subject to offsetting requirements.

  Note. – In the 2019 and 2020 versions of the ICAO CORSIA CERT, the percentage of data gaps were calculated by dividing total number of flights with data gaps by total number of international flights.

- The user can manually enter the details on the data gaps if the 5 per cent threshold has been exceeded in the reporting year.

4.5 Exporting copies of the Emissions Report and Generation of Log of Assumptions

To support the Emissions Reporting (ER) in 2023, the aeroplane operator can use the ICAO CORSIA CERT to estimate its emissions and generate a filled version of the Emissions Report.

The ICAO CORSIA CERT can export and produce a copy of the Emissions Report in Excel Format (i.e., as a stand-alone version of the Emissions Report).

The ICAO CORSIA CERT can also generate (if needed and/or for purposes of record keeping) a time stamp pdf version of the Emissions Report. The user can save a copy for its records.

In addition, the ICAO CORSIA CERT returns a Log of Assumptions containing general information as well as the Custom aeroplane and Custom aerodrome information (if entered in the tool).

In accordance with Annex 16, Volume IV, Appendix 4, 2.3.1.1 a) on the supporting information on methods and means for calculating emissions from international flights, the aeroplane operator can submit a copy of the Log of Assumptions to its State along with the Emissions Report.

For purpose of tools interfaces (if needed), the user can export a .csv file of the data contained in "CO_2 Emissions Estimation & Data Gap Filling". Similarly, the user can export a .csv file of the data contained in "Custom aeroplane information" and "Custom aerodrome information".

5. VALIDATION AND REVIEW OF THE ICAO CO_2 ESTIMATION MODELS (CEMS)

The work on the ICAO CO_2 Estimation Models (CEMs), ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT) and the associated development/maintenance documentation was led by the CAEP Working Group 4 (WG4). The CAEP Modeling and Database Group (MDG) subsequently conducted a validation exercise to ensure the ICAO CORSIA CERT was fit for purpose in terms of its use within CORSIA.

6. PHASED DEVELOPMENT OF THE ICAO CORSIA CERT AND FEEDBACK

The ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT) can be used by an aeroplane operator to support the monitoring and reporting of their CO_2 emissions, in accordance with the requirements from ICAO Annex 16, Volume IV, Part II, Chapter 2, 2.2 and Appendix 3.

The ICAO CORSIA CERT supports aeroplane operators in fulfilling their monitoring and reporting requirements by populating the standardized Emissions Monitoring Plan and Emissions Report templates in Appendix 1 of the Environmental Technical Manual (Doc 9501), Volume IV – Procedures for demonstrating compliance with the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). This support includes:

(i) assessing its eligibility to use Fuel Use Monitoring Methods in support of their Emissions Monitoring Plan (e.g. CO_2 emissions threshold requirements);

(ii) assessing whether or not it is within the applicability scope of Annex 16, Volume IV, Chapter 2 (MRV requirements); and

(iii) filling any CO_2 emissions data gaps.

6.1 Phased development of the ICAO CORSIA CERT and expected 2024 version

As described in section 2, the ICAO CORSIA CERT is expected to be valid for a given year to address the evolution of the required functionality of the ICAO CORSIA CERT in accordance with Annex 16,

Volume IV.

In support of the recommendations from Annex 16, Volume IV, Appendix 3 on the collection of data to further develop and maintain the ICAO CO_2 Estimation Models (CEMs) used within the ICAO CORSIA CERT, Appendix A-2 shows the list of aeroplane that will be the focus of further and targeted data collection towards the 2024 version of the ICAO CORSIA CERT. Any operator and/or State willing to contribute to the development of the ICAO CORSIA CERT and provide data is encouraged to contact ICAO-CAEP.

6.2 Process for providing feedback and input towards the future versions of the ICAO CORSIA CERT

Feedback on the ICAO CORSIA CERT functionalities or questions can be directed to CERT@icao.int

APPENDIX A-1: ICAO CO_2 Estimation Model (CEM) based on Great Circle Distance (GCD) Input in version 2023 of the ICAO CORSIA CERT

Table A-1.1.a. Aircraft types (by ICAO type designator) modelled with ICAO CEM based on aeroplane operator data from the COFdb

Type Designator	Example of Model*	CEM based on AO data (from COFdb)	CEM based on Equivalent Aircraft Type		CEM based on ICAO Fuel Formula	
		Source of CEM	Source of CEM	Type Designator of Equivalent Aircraft	Source of CEM	ICAO Aircraft Code
A124	An-124 Ruslan	Yes				
A306	A-300B4-600	Yes				
A310	A-310	Yes				
A332	A-330-200	Yes				
A333	A-330-300	Yes				
A339	A-330-900	Yes				
A343	A-340-300	Yes				
A346	A-340-600	Yes				
A359	A-350-900 XWB	Yes				
A388	A-380-800	Yes				
B744	747-400 (international, wingle	Yes				
B748	747-8	Yes				
B762	767-200	Yes				
B763	767-300	Yes				
B764	767-400	Yes				
B772	777-200	Yes				
B773	777-300	Yes				
B77L	777-200LR	Yes				
B77W	777-300ER	Yes				
B788	787-8 Dreamliner	Yes				
B789	787-9 Dreamliner	Yes				
B78X	787-10 Dreamliner	Yes				
MD11	MD-11	Yes				
A20N	A-320neo	Yes				
A21N	A-321neo	Yes				
A318	A-318	Yes				
A319	A-319	Yes				
A320	A-320	Yes				
A321	A-321	Yes				
B38M	737 MAX 8	Yes				
B722	727-200	Yes				
B733	737-300	Yes				
B734	737-400	Yes				
B735	737-500	Yes				
B736	737-600	Yes				
B737	737-700	Yes				
B738	737-800	Yes				
B739	737-900	Yes				
B752	757-200	Yes				
B753	757-300	Yes				
BCS1	BD-500 CSeries CS100	Yes				
BCS3	BD-500 CSeries CS300	Yes				
E295	E195-E2	Yes				
MD82	MD-82	Yes				
MD87	MD-87	Yes				
MD88	MD-88	Yes				
MD90	MD-90	Yes				
B462	BAe-146-200	Yes				
B463	BAe-146-300	Yes				
B712	717-200	Yes				
BE4W	Hawker 400XT	Yes				
C25B	525B Citation CJ3	Yes				
C25C	525C Citation CJ4	Yes				
C550	550 Citation 2	Yes				
C56X	560XL Citation Excel	Yes				
C68A	680A Citation Latitude	Yes				
C750	750 Citation 10	Yes				
CL30	BD-100 Challenger 300	Yes				
CL35	BD-100 Challenger 350	Yes				
CL60	CL-600 Challenger 650	Yes				

** Example of model: Doc 8643 includes one or more model for a given type designator. Sample/example of model is provided in this table. For additional details of other applicable models for a given type designator see: https://www.icao.int/publications/DOC8643/Pages/Search.aspx*

Table A-1.1.a (cont.). Aircraft types (by ICAO type designator) modelled with ICAO CEM based on aeroplane operator data from the COFdb

Type Designator	Example of Model*	CEM based on AO data (from COFdb)	CEM based on Equivalent Aircraft Type		CEM based on ICAO Fuel Formula	
		Source of CEM	Source of CEM	Type Designator of Equivalent Aircraft	Source of CEM	ICAO Aircraft Code
CRJ1	Regional Jet CRJ-100	Yes				
CRJ2	Challenger 800	Yes				
CRJ7	Challenger 870	Yes				
CRJ9	Challenger 890	Yes				
CRJX	Regional Jet CRJ-1000	Yes				
DC95	DC-9-50	Yes				
E135	ERJ-135	Yes				
E145	ERJ-145EP	Yes				
E170	ERJ-170-100	Yes				
E190	ERJ-190 Lineage 1000	Yes				
E195	ERJ-190-200	Yes				
E290	E190-E2	Yes				
E35L	EMB-135BJ Legacy	Yes				
E45X	EMB-145XR	Yes				
E55P	EMB-505 Phenom 300	Yes				
E75L	ERJ-170-200 (long wing)	Yes				
E75S	ERJ-170-200 (short wing)	Yes				
F100	100	Yes				
F2TH	Falcon 2000	Yes				
F70	70	Yes				
F900	Falcon 900	Yes				
FA50	Falcon 50	Yes				
FA7X	Falcon 7X	Yes				
FA8X	Falcon 8X	Yes				
G280	Gulfstream G280	Yes				
GA6C	G-7 Gulfstream G600	Yes				
GL5T	Global 5000	Yes				
GL7T	Global 7000	Yes				
GLEX	Global Express	Yes				
GLF4	Gulfstream 4	Yes				
GLF5	Gulfstream 5	Yes				
GLF6	Gulfstream G650	Yes				
H25B	Hawker 800	Yes				
LJ31	31	Yes				
LJ40	40	Yes				
LJ45	45	Yes				
LJ60	60	Yes				
LJ75	75	Yes				
RJ85	RJ-85 Avroliner	Yes				
AN26	An-26	Yes				
AT43	ATR-42-300	Yes				
AT45	ATR-42-500	Yes				
AT46	ATR-42-600	Yes				
AT72	ATR-72-201	Yes				
AT75	ATR-72-500	Yes				
AT76	ATR-72-600	Yes				
B190	1900	Yes				
BE20	Super King Air (200)	Yes				
BE30	300 Super King Air	Yes				
D328	328	Yes				
DH8A	Dash 8 (100)	Yes				
DH8D	Dash 8 (400)	Yes				
F50	50 Maritime Enforcer	Yes				
SB20	2000	Yes				
SF34	SF-340	Yes				

** Example of model: Doc 8643 includes one or more model for a given type designator. Sample/example of model is provided in this table. For additional details of other applicable models for a given type designator see: https://www.icao.int/publications/DOC8643/Pages/Search.aspx*

Table A-1.1.b. Aircraft types (by ICAO type designator) modelled with equivalent aircraft types

Type Designator	Example of Model*	CEM based on AO data (from COFdb)	CEM based on Equivalent Aircraft Type		CEM based on ICAO Fuel Formula	
		Source of CEM	Source of CEM	Type Designator of Equivalent Aircraft	Source of CEM	ICAO Aircraft Code
A30B	A-300B2		Yes	A306		
A338	A-330-800		Yes	A339		
A342	A-340-200		Yes	A343		
A345	A-340-500		Yes	A346		
A35K	A-350-1000 XWB		Yes	A359		
B741	747-100		Yes	B744		
B742	747-200		Yes	B744		
B743	747-300		Yes	B744		
B74R	747SR		Yes	B744		
B74S	747SP		Yes	B744		
A19N	A-319neo		Yes	A20N		
B37M	737 MAX 7		Yes	B38M		
B39M	737 MAX 9		Yes	B38M		
B3XM	737 MAX 10		Yes	B38M		
MD81	MD-81		Yes	MD82		
MD83	MD-83		Yes	MD82		
B461	BAe-146-100		Yes	B462		
B732	737-200		Yes	B733		
C525	525 Citation CJ1		Yes	C550		
C55B	550B Citation Bravo		Yes	C550		
C560	560 Citation 5		Yes	C550		
FA6X	Falcon 6X		Yes	FA7X		
GA5C	Gulfstream G500 (G-7)		Yes	GA6C		
GA7C	Gulfstream G700		Yes	GLF6		
H25A	HS-125-1		Yes	H25B		
H25C	Hawker 1000		Yes	H25B		
LJ25	25		Yes	LJ40		
LJ35	35		Yes	LJ40		
RJ1H	RJ-100 Avroliner		Yes	B463		
RJ70	RJ-70 Avroliner		Yes	RJ85		
AN30	An-30		Yes	AN26		
AN32	An-32		Yes	AN26		
AT73	ATR-72-211		Yes	AT72		
DH8B	Dash 8 (200)		Yes	DH8D		
DH8C	Dash 8 (300)		Yes	DH8D		
DHC7	DHC-7 Dash 7		Yes	DH8D		

** Example of model: Doc 8643 includes one or more model for a given type designator. Sample/example of model is provided in this table. For additional details of other applicable models for a given type designator see: https://www.icao.int/publications/DOC8643/Pages/Search.aspx*

Table A-1.1.c. Aircraft types (by ICAO type designator) modelled with ICAO Fuel Formula

Type Designator	Example of Model*	CEM based on AO data (from COFdb)	CEM based on Equivalent Aircraft Type		CEM based on ICAO Fuel Formula	
		Source of CEM	Source of CEM	Type Designator of Equivalent Aircraft	Source of CEM	ICAO Aircraft Code
DC10	DC-10					D10
DC85	DC-8-50					D8T
DC86	DC-8-60					D8L
DC87	DC-8-70					D8Q
IL62	Il-62					IL6
IL76	Il-76					IL7
IL86	Il-86					ILW
IL96	Il-96					IL9
L101	L-1011 TriStar					L10
B701	707-100					70M
B721	727-100					721
T134	Tu-134					TU3
T154	Tu-154					TU5
T204	Tu-204					T20
A148	An-148					A81
AN72	An-72					AN7
BA11	BAC-111 One-Eleven					B11
DC91	DC-9-10					D91
DC92	DC-9-20					D92
DC93	DC-9-30					D93
DC94	DC-9-40					D94
F28	F-28 Fellowship					F28
FA10	Falcon 10					DF2
J328	Dornier 328JET					FRJ
S601	SN-601 Corvette					NDC
WW24	1124 Westwind					WWP
YK40	Yak-40					YK4
YK42	Yak-42					YK2
A140	IRAN-140 Faraz					A40
A748	748					HS7
AN12	An-12					ANF
AN24	An-24					AN4
AN28	An-28					A28
ATP	ATP					ATP
BELF	SC-5 Belfast					SHB
C130	L-100 Hercules					LOH
C212	C-212 Aviocar					CS2
CN35	CN-235					CS5
CVLP	Convairliner					CVR
CVLT	Cosmopolitan					CV5
D228	Dornier 228					D28
DC3	DC-3					DC3
DC6	DC-6					DC6
DHC6	DHC-6 Twin Otter					DHT
E110	EMB-110 Bandeirante					EMB
E120	EMB-120 Brasilia					EM2
F27	F-27					F27
G159	G-159 Gulfstream 1					GRS
I114	Il-114					I14
IL18	Il-18					IL8
JS31	BAe-3100 Jetstream 31					J31
JS32	BAe-3200 Jetstream Super 31					J32
JS41	BAe-4100 Jetstream 41					J41
L188	Electra (L-188)					LOE
L410	L-410 Turbolet					L4T
N262	N-262 Frégate					ND2
SC7	SC-7 Skyliner					SHS
SH33	SD3-30					SH3
SH36	360					SH6

** Example of model: Doc 8643 includes one or more model for a given type designator. Sample/example of model is provided in this table. For additional details of other applicable models for a given type designator see: https://www.icao.int/publications/DOC8643/Pages/Search.aspx*

Table format of ICAO CO_2 Estimation Models (CEMs) based on Great Circle Distance (GCD) Input in version 2023 of the ICAO CORSIA CERT

*Note: Tables provide fuel in kg. CO_2 emissions can be calculated using CO_2 (in kg) = 3.16 * Fuel (in kg).*

Table A-1.2.a. Aircraft types (by ICAO type designator) modelled with ICAO CEM based on aeroplane operators data from the COFdb

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	8000	9000	10000
A124	6,771	15,059	23,347	31,635	39,923	48,211	55,730	62,655	69,581	76,506	83,432						
A306	2,718	5,586	8,454	11,322	14,190	17,057	19,925	22,793	25,661	28,529	31,396	34,264	37,132	42,868			
A310	1,527	4,399	7,271	10,144	13,016	15,888	18,760	21,632	24,504	27,376	30,248	33,120	35,992	41,736	47,480	53,224	
A332	2,350	5,391	8,433	11,474	14,516	17,557	20,599	23,640	26,776	30,346	33,916	37,486	41,056	48,196	55,336	62,476	69,616
A333	2,036	6,014	9,993	13,314	16,603	19,891	23,180	26,468	29,756	33,045	36,333	39,649	43,088	49,965	56,842	63,719	70,596
A339	1,680	4,676	7,671	10,667	13,662	16,658	19,653	22,649	25,644	28,640	31,635	34,947	38,299	45,003	51,707	58,411	65,115
A343	2,666	6,465	10,265	14,064	17,864	21,663	25,463	29,262	33,062	36,861	40,661	44,460	48,260	56,338	65,452	74,566	82,067
A346	3,558	8,242	12,927	17,611	22,295	26,980	31,664	36,348	41,033	45,717	50,402	55,086	59,770	70,340	81,207	92,073	102,939
A359	2,865	6,182	9,500	12,817	16,135	19,452	22,770	26,087	29,405	32,722	36,040	39,357	42,675	49,776	57,238	64,700	72,162
A388	8,887	15,811	22,735	29,660	36,584	43,508	50,433	57,357	64,282	71,206	78,130	85,055	91,979	105,828	#######	136,960	155,352
B744	5,219	10,916	16,613	22,310	28,007	33,704	39,401	45,098	50,795	56,492	62,189	67,886	73,583	84,977	97,904	113,443	128,982
B748	6,000	11,302	16,604	21,906	27,208	32,511	37,813	43,115	48,417	53,719	59,021	64,323	69,847	82,693	95,539	108,384	121,230
B762	1,279	4,146	7,012	9,878	12,744	15,610	18,476	21,342	24,209	27,075	29,941	32,807	35,673	41,406	47,138	52,870	
B763	1,515	4,393	7,272	10,150	13,028	15,906	18,784	21,663	24,541	27,479	30,541	33,603	36,665	42,789	48,913	55,037	61,161
B764	1,764	4,816	7,869	10,921	13,974	17,026	20,079	23,131	26,184	29,236	32,288	35,341	38,393	44,498	50,603	56,708	62,813
B772	3,142	6,933	10,724	14,515	18,306	22,097	25,888	29,679	33,470	37,261	41,052	44,843	48,634	56,361	65,168	73,975	82,782
B773	3,766	8,065	12,363	16,662	20,960	25,259	29,844	34,464	39,084	43,704	48,324	52,944	57,564	66,804	76,044	85,284	94,524
B77L	3,245	7,155	11,065	14,975	18,885	22,795	26,705	30,615	35,333	40,474	45,615	50,756	55,897	66,180	76,462	86,455	94,533
B77W	4,021	8,228	12,435	16,641	20,848	25,055	29,262	33,469	38,131	42,909	47,686	52,464	57,242	66,797	76,353	85,908	95,464
B788	2,035	4,592	7,148	9,705	12,261	14,818	17,374	19,931	22,822	25,821	28,819	31,818	34,816	40,813	46,810	52,807	58,804
B789	1,344	4,320	7,295	10,271	13,247	16,222	19,198	22,174	25,149	28,125	31,101	34,076	37,052	43,003	49,357	56,220	63,082
B78X	1,989	4,932	7,876	10,819	13,762	16,706	19,649	22,593	25,536	28,480	31,423	34,367	37,417	44,081	50,745	57,409	64,073
MD11	2,080	6,767	11,454	16,141	20,828	25,515	30,202	34,889	39,576	44,264	48,951	53,638	58,325	67,699	77,073	86,448	95,822
A20N	817	2,213	3,481	4,724	6,053	7,397	8,741	10,085	11,429	12,773	14,117	15,461	16,805				
A21N	921	2,376	3,832	5,287	6,743	8,317	9,950	11,584	13,217	14,851	16,484	18,117	19,751	23,018			
A318	1,244	2,460	3,859	5,258	6,657	8,057	9,456	10,855	12,254	13,654	15,053	16,452	17,851				
A319	810	2,499	3,912	5,324	6,834	8,440	10,046	11,652	13,258	14,864	16,470	18,076	19,682				
A320	1,084	2,623	4,162	5,701	7,240	8,868	10,563	12,259	13,954	15,650	17,345	19,041					
A321	756	3,003	4,811	6,619	8,426	10,234	12,042	13,849	15,657	17,465	19,272	21,080	22,888				
B38M	656	1,970	3,284	4,598	5,975	7,373	8,770	10,168	11,565	12,963	14,360	15,758	17,155				
B722	1,215	4,475	7,009	9,445	11,881	14,316	16,752	19,188	21,623	24,059	26,495	28,930					
B733	590	2,438	3,966	5,495	7,024	8,553	10,082	11,611	13,140	14,669	16,198	17,726	19,255				
B734	907	2,567	4,226	5,878	7,394	8,910	10,426	11,941	13,457	14,973	16,489	18,004	19,520	22,552	25,583	28,615	31,646
B735	785	2,518	4,055	5,592	7,129	8,665	10,202	11,739	13,276	14,813	16,350	17,887	19,424	22,498	25,571	28,645	
B736	1,029	2,276	3,522	4,789	6,138	7,488	8,837	10,187	11,536	12,886	14,235	15,585	16,934	19,633			
B737	614	2,138	3,555	4,972	6,392	7,815	9,237	10,660	12,082	13,505	14,927	16,350	17,772				
B738	615	2,327	3,909	5,491	7,074	8,656	10,201	11,654	13,107	14,561	16,014	17,467					
B739	1,134	2,822	4,511	6,199	7,888	9,576	11,265	12,953	14,642	16,330	18,019						
B752	1,593	3,670	5,747	7,824	9,833	11,773	13,713	15,654	17,594	19,534	21,474	23,415	25,355	29,236	33,116		
B753	1,379	3,823	6,268	8,712	11,157	13,601	16,046	18,490	20,935	23,379	25,824	28,268	30,713	35,602	40,491		
BCS1	498	2,017	3,127	4,238	5,348	6,459	7,569										
BCS3	576	2,093	3,296	4,499	5,702	6,906	8,109	9,312	10,515								
E295	540	1,819	2,822	3,824	4,826	5,828	6,831	7,833	8,835	9,837							
MD82	820	2,867	4,915	6,962	9,010	11,057	13,105	15,152	17,200	19,247							
MD87	1,691	3,154	4,616	6,079	7,720	9,517	11,315	13,112	14,910	16,707	18,505	20,302	22,100				
MD88	1,739	3,680	5,622	7,563	9,807	12,200	14,594	16,987									
MD90	703	3,105	5,099	6,858	8,616	10,375	12,134	13,892									
B462	750	2,396	4,043	5,690	7,336	8,983											
B463	667	2,543	4,420	6,296	8,172	10,048											
B712	705	2,368	4,030	5,693	7,356	9,018	10,681	12,344									
BE4W	159	512	780	1,047	1,315	1,582	1,850	2,118	2,385								
C25B	107	562	824	1,086	1,348	1,610	1,872										
C25C	171	615	929	1,243	1,557	1,871	2,185	2,499	2,813								
C550	199	702	1,039	1,376	1,713	2,050	2,386	2,723									
C56X	224	767	1,110	1,453	1,796	2,139	2,482	2,825									
C68A	309	981	1,438	1,870	2,302	2,734	3,167	3,599	4,031	4,463	4,895	5,327	5,759				
C750	382	952	1,522	2,092	2,662	3,231	3,801	4,371	4,941	5,510	6,080	6,650	7,220				
CL30	264	1,025	1,566	2,107	2,648	3,122	3,552	3,982	4,412	4,842	5,272	5,702					
CL35	305	1,028	1,473	1,918	2,398	2,891	3,384	3,877	4,370	4,863	5,356	5,849					
CL60	338	1,077	1,658	2,239	2,850	3,488	4,126	4,764	5,402	6,040	6,678	7,316	7,954	9,230			

Table A-1.2.a (cont.). Aircraft types (by ICAO type designator) modelled with ICAO CEM based on aeroplane operators data from the COFdb

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	8000	9000	10000
CRJ1	454	1,223	1,981	2,653	3,325	3,997	4,669	5,341	6,013	6,685	7,357	8,029	8,701				
CRJ2	380	1,230	2,023	2,737	3,450	4,164	4,877	5,591	6,304	7,018	7,731	8,445	9,158				
CRJ7	501	1,665	2,655	3,646	4,636	5,627											
CRJ9	579	1,773	2,778	3,759	4,740	5,720											
CRJX	566	1,847	2,926	4,004	5,082												
DC95	1,684	3,675	5,666	7,657													
E135	247	1,337	2,104	2,820	3,535	4,251	4,966	5,682	6,397								
E145	317	1,275	1,941	2,604	3,266	3,929	4,591	5,254	5,916								
E170	495	1,773	2,734	3,939	5,145	6,350	7,556										
E190	720	2,107	3,332	4,507	5,753	7,055	8,357	9,659	10,960	12,262	13,564	14,865	16,167	18,770	21,374		
E195	572	2,152	3,468	4,784	6,101	7,417	8,733	10,049	11,365	12,681	13,997	15,313	16,630	19,262	21,894		
E290	562	1,791	2,715	3,638	4,561	5,485	6,408	7,332	8,255	9,178	10,102						
E35L	342	1,238	1,899	2,559	3,220	3,880	4,541	5,201	5,862	6,522	7,183	7,843	8,504	9,825			
E45X	327	1,392	2,196	2,999	3,752	4,463	5,175	5,886									
E55P	211	671	944	1,210	1,476	1,741	2,007	2,273									
E75L	551	1,569	2,566	3,521	4,475	5,430	6,385										
E75S	671	1,951	3,072	4,165	5,258	6,351	7,444	8,537	9,630								
F100	713	2,268	3,571	4,868	6,165	7,462	8,759	10,056	11,353								
F2TH	320	1,044	1,559	2,074	2,588	3,103	3,618	4,133	4,648	5,162	5,677	6,192	6,707	7,736			
F70	640	1,957	3,126	4,296	5,466	6,635	7,805										
F900	176	1,042	1,643	2,244	2,845	3,446	4,047	4,648	5,249	5,850	6,451	7,052	7,653	8,855	10,057		
FA50	337	1,084	1,696	2,189	2,682	3,175	3,668	4,161	4,654	5,147	5,640	6,133	6,626				
FA7X	359	1,310	1,970	2,630	3,291	3,951	4,611	5,272	5,932	6,593	7,253	7,913	8,574	9,895	11,215	12,536	13,857
FA8X	396	1,245	1,959	2,674	3,389	4,103	4,818	5,532	6,247	6,962	7,676	8,391	9,106	10,535	11,964	13,393	14,823
G280	260	848	1,311	1,775	2,238	2,702	3,165	3,629	4,092	4,556	5,019	5,483	5,946				
GA6C	264	1,448	2,282	3,116	3,950	4,785	5,619	6,453	7,287	8,121	8,956	9,790	10,624	12,293	13,961	15,629	17,298
GL5T	697	1,816	2,678	3,539	4,401	5,262	6,124	6,985	7,847	8,708	9,570	10,431	11,292	13,015	14,738	16,461	
GL7T	759	1,588	2,416	3,245	4,073	4,902	5,730	6,559	7,387	8,216	9,044	9,873	10,701	12,358	14,015	15,672	17,329
GLEX	636	1,768	2,640	3,513	4,385	5,257	6,130	7,002	7,874	8,747	9,619	10,491	11,364	13,109	14,853	16,598	18,343
GLF4	542	1,830	2,543	3,257	4,090	4,928	5,767	6,605	7,444	8,282	9,121	9,959	10,798	12,475			
GLF5	716	1,688	2,501	3,313	4,125	4,937	5,749	6,561	7,374	8,186	8,998	9,810	10,622	12,155	13,647	15,138	16,629
GLF6	557	1,753	2,568	3,383	4,198	5,013	5,828	6,643	7,458	8,273	9,088	9,903	10,718	12,348	13,978	15,608	17,238
H25B	236	802	1,234	1,665	2,097	2,528	2,960	3,391	3,823	4,254							
LJ31	132	554	895	1,209	1,415	1,621											
LJ40	129	604	997	1,391	1,784	2,177	2,570										
LJ45	72	651	981	1,311	1,640	1,970	2,300	2,630	2,960								
LJ60	210	635	1,016	1,397	1,778	2,159	2,539	2,920	3,301	3,682	4,063						
LJ75	123	588	909	1,230	1,551	1,872	2,193	2,514									
RJ85	911	2,487	4,063	5,639	7,215	8,791	10,367	11,943									
AN26	458	1,696	2,924	3,699	4,474	5,250											
AT43	118	719	1,274	1,829	2,383	2,938	3,493	4,047	4,602	5,157	5,711						
AT45	75	836	1,404	1,972	2,540	3,108	3,677										
AT46	138	865	1,510														
AT72	54	866	1,489	2,112	2,735												
AT75	154	890	1,570	2,251													
AT76	179	923	1,622														
B190	96	446	796	1,146	1,496	1,845											
BE20	125	407	690	972	1,255	1,537	1,820	2,102									
BE30	78	407	736	1,056	1,226	1,396	1,566	1,736	1,906								
D328	141	674	1,208	1,741													
DH8A	96	841	1,586	2,332	3,077												
DH8D	307	1,176	2,013	2,850	3,686												
F50	108	865	1,486	2,107	2,727	3,348	3,969	4,590	5,211	5,832	6,453	7,074	7,695				
SB20	387	1,005	1,623	2,241	2,859	3,477											
SF34	149	617	1,085	1,553	2,021	2,489											

Table A-1.2.b. Aircraft types (by ICAO type designator) modelled with equivalent aircraft types

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	8000	9000	10000
A30B	2,634	5,414	8,193	10,972	13,751	16,530	19,309	22,088	24,867	27,647	30,426	33,205	35,984	41,542	47,100		
A338	1,663	4,629	7,595	10,561	13,527	16,492	19,458	22,424	25,390	28,356	31,321	34,601	37,920	44,557	51,195	57,833	64,470
A342	2,527	6,128	9,730	13,332	16,933	20,535	24,137	27,738	31,340	34,942	38,543	42,145	45,747	53,405	62,044	70,683	77,794
A345	3,580	8,293	13,007	17,720	22,434	27,148	31,861	36,575	41,288	46,002	50,715	55,429	60,142	70,778	81,712	92,646	103,580
A35K	3,305	7,133	10,960	14,788	18,615	22,443	26,271	30,098	33,926	37,754	41,581	45,409	49,236	57,429	66,038	74,648	83,257
B741	4,465	9,338	14,212	19,085	23,958	28,832	33,705	38,579	43,452	48,325	53,199	58,072	62,946	72,692	83,751		
B742	4,937	10,326	15,715	21,104	26,493	31,881	37,270	42,659	48,048	53,437	58,826	64,215	69,604	80,381	92,609	107,308	122,007
B743	4,959	10,372	15,784	21,197	26,610	32,022	37,435	42,848	48,261	53,673	59,086	64,499	69,911	80,737	93,019	107,782	122,546
B74R	4,273	8,937	13,600	18,264	22,928	27,592	32,256	36,919	41,583	46,247	50,911	55,575	60,239	69,566	80,149	92,870	105,591
B74S	4,145	8,669	13,192	17,716	22,240	26,764	31,288	35,812	40,336	44,860	49,384	53,908	58,432	67,480	77,745	90,084	102,424
A19N	814	2,206	3,469	4,708	6,032	7,371	8,711	10,050	11,389	12,728	14,068	15,407	16,746				
B37M	620	1,864	3,107	4,350	5,653	6,975	8,297	9,620	10,942	12,264	13,586	14,908	16,230	18,875			
B39M	711	2,136	3,560	4,985	6,479	7,994	9,509	11,024	12,540	14,055	15,570	17,085	18,601				
B3XM	694	2,084	3,474	4,863	6,321	7,799	9,277	10,755	12,234	13,712	15,190	16,668	18,147				
MD81	792	2,771	4,749	6,728	8,706	10,685	12,664	14,642	16,621	18,599	20,578						
MD83	902	3,155	5,409	7,662	9,915	12,168	14,421	16,674	18,927	21,181	23,434	25,687	27,940	32,446			
B461	676	2,160	3,645	5,129													
B732	522	2,157	3,510	4,863	6,216	7,569	8,922	10,275	11,628	12,981	14,334						
C525	157	552	816	1,081	1,346	1,610											
C55B	216	759	1,123	1,488	1,852	2,216	2,580	2,945									
C560	235	828	1,225	1,623	2,020	2,417	2,815	3,212									
FA6X	380	1,387	2,086	2,785	3,485	4,184	4,883	5,583	6,282	6,981	7,681	8,380	9,080	10,478	11,877	13,276	14,674
GA5C	223	1,225	1,932	2,638	3,344	4,050	4,756	5,462	6,169	6,875	7,581	8,287	8,993	10,406	11,818	13,230	
GA7C	625	1,968	2,884	3,799	4,714	5,630	6,545	7,461	8,376	9,291	10,207	11,122	12,037	13,868	15,699	17,530	19,360
H25A	219	744	1,144	1,544	1,944	2,344	2,744	3,145	3,545	3,945	4,345						
H25C	263	894	1,374	1,855	2,335	2,816											
LJ25	92	432	714	995	1,276	1,557	1,839										
LJ35	113	527	871	1,214	1,557	1,900	2,243	2,586	2,930	3,273							
RJ1H	690	2,631	4,571	6,512	8,453	10,393	12,334	14,274	16,215								
RJ70	899	2,455	4,011	5,566	7,122												
AN30	439	1,625	2,802	3,545	4,288	5,031											
AN32	515	1,908	3,289	4,161	5,034	5,906	6,778										
AT73	54	867	1,491	2,115	2,739												
DH8B	174	665	1,138	1,611													
DH8C	205	784	1,342	1,900	2,458												
DHC7	213	816	1,396														

Table A-1.2.c. Aircraft types (by ICAO type designator) modelled with an ICAO Fuel Formula

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	8000	9000	10000
DC10	3,297	7,887	12,476	17,066	21,655	26,245	31,309	36,660	42,010	47,361	52,711	58,062	63,412	74,113	85,021		
DC85	3,118	6,126	9,135	12,143	15,152	18,160	21,169	24,177	27,186	30,194	33,203	36,211	39,220	45,237	51,254	57,271	
DC86	3,118	6,126	9,135	12,143	15,152	18,160	21,169	24,177	27,186	30,194	33,203	36,211	39,220	45,237	51,254	57,271	
DC87	3,118	6,126	9,135	12,143	15,152	18,160	21,169	24,177	27,186	30,194	33,203	36,211	39,220	45,237	51,254	57,271	
IL62	2,656	6,827	10,997	15,168	19,338	23,509	27,679	31,850	36,020	40,191	44,361	48,532	52,702	61,043	69,384		
IL76	7,415	11,716	16,018	20,749	25,845	30,941	36,037	41,133	46,229	51,325							
IL86	7,365	12,963	18,561	24,159	29,757	35,427	41,154	46,882	52,609	58,337							
IL96	2,477	7,237	11,998	16,758	21,519	26,279	31,040	35,800	40,561	45,321	50,082	54,842	59,603	69,124	78,645	88,166	97,492
L101	2,733	7,649	12,566	17,482	22,399	27,315	32,232	37,148	42,065	46,981	51,898	57,340	63,066	74,518	85,970	97,422	108,874
B701	2,632	6,027	9,421	12,816	16,210	19,605	22,999	26,394	29,594	32,680	35,766	38,852	41,938	48,110	54,282	60,454	
B721	1,520	3,586	5,651	7,717	9,782	11,848	13,788	15,716	17,644	19,572							
T134	2,065	3,584	5,104	6,623	8,142	9,662	11,181	12,701									
T154	2,805	5,809	8,813	11,817	14,821	17,825	20,734	23,594	26,453	29,313	32,172						
T204	2,801	5,806	8,812	11,817	14,823	17,828	20,734	23,594	26,453	29,313	32,172	35,032	37,891				
A148	783	1,732	2,681	3,630	4,579	5,528	6,477	7,427									
AN72	783	1,732	2,681	3,630	4,579	5,528	6,477	7,427	8,376								
BA11	558	2,209	3,861	5,512	7,164	8,815	10,467	12,118	13,770	15,421							
DC91	685	2,234	3,784	5,333													
DC92	693	2,262	3,830	5,399	6,967	8,536											
DC93	741	2,418	4,095	5,772	7,449	9,126	10,803	12,480	14,157	15,834	17,511						
DC94	796	2,596	4,397	6,197	7,998	9,798	11,599										
F28	419	2,221	3,404	4,588	5,771	6,955	8,138	9,322	10,505								
FA10	159	844	1,293	1,743	2,192	2,642	3,091										
J328	183	968	1,484	2,000													
S601	184	407	630	853	1,076	1,299											
WW24	122	646	990	1,334	1,678	2,022	2,366	2,710	3,054								
YK40	171	906	1,389	1,872													
YK42	703	3,514	5,076	6,638	8,200	9,762	11,324	12,886	14,448								
A140	314	963	1,612	2,261	2,909	3,558	4,207										
A748	321	982	1,644	2,306													
AN12	1,262	3,335	5,408	7,482	9,555	11,629	13,702	15,776	17,849	19,923	21,996	24,069					
AN24	433	1,135	1,837	2,539	3,241												
AN28	157	482	806														
ATP	282	865	1,447	2,029	2,612	3,194	3,777	4,359	4,942								
BELF	397	3,910	6,502	9,094	11,686	14,278	16,870	19,462	22,054	24,646	27,238	29,830	32,422	37,606	42,790		
C130	869	2,664	4,459	6,254	8,049	9,844	11,639	13,434									
C212	138	423	707	992													
CN35	210	642	1,075	1,507	1,940	2,372	2,805	3,237	3,670								
CVLP	20	1,294															
CVLT	20	1,294	1,856	2,418	2,980	3,542	4,104	4,666									
D228	115	353	590	828	1,065	1,303											
DC3	6	397	569	742	914												
DC6	22	1,412	2,026	2,639	3,253	3,866	4,480	5,093	5,707	6,320	6,934	7,547	8,161	9,388			
DHC6	26	366	608														
E110	35	342	569	796													
E120	169	539	909	1,279													
F27	48	1,048	1,743	2,438	3,133	3,828	4,523	5,218	5,913	6,608							
G159	90	977	1,625	2,273	2,921	3,569	4,217	4,865	5,513								
I114	113	1,195	1,987														
IL18	890	2,729	4,567	6,405	8,243	10,082	11,920										
JS31	120	369	618														
JS32	129	394	659														
JS41	177	544	910	1,276	1,642	2,008	2,375	2,741									
L188	287	3,149	5,236	7,324	9,411	11,499	13,586	15,674									
L410	49	434	722	1,010													
N262	132	404	677														
SC7	87	267	448														
SH33	166	508	850	1,193													
SH36	177	544	910	1,276													

APPENDIX A-2: ICAO CO_2 Estimation Model (CEM) based on Block Time (BT) Input in version 2023 of the ICAO CORSIA CERT

Table A-2.1.a. Aircraft types (by ICAO type designator) modelled with ICAO CEM based on aeroplane operator data from the COFdb

Type Designator	Example of Model*	CEM based on AO data (from COFdb)	CEM based on Equivalent Aircraft Type		CEM based on ICAO Fuel Formula	
		Source of CEM	Source of CEM	Type Designator of Equivalent Aircraft	Source of CEM	ICAO Aircraft Code
A124	An-124 Ruslan	Yes				
A306	A-300B4-600	Yes				
A310	A-310	Yes				
A332	A-330-200	Yes				
A333	A-330-300	Yes				
A339	A-330-900	Yes				
A343	A-340-300	Yes				
A346	A-340-600	Yes				
A359	A-350-900 XWB	Yes				
A388	A-380-800	Yes				
B744	747-400 (international, wingle	Yes				
B748	747-8	Yes				
B762	767-200	Yes				
B763	767-300	Yes				
B764	767-400	Yes				
B772	777-200	Yes				
B773	777-300	Yes				
B77L	777-200LR	Yes				
B77W	777-300ER	Yes				
B788	787-8 Dreamliner	Yes				
B789	787-9 Dreamliner	Yes				
B78X	787-10 Dreamliner	Yes				
MD11	MD-11	Yes				
A20N	A-320neo	Yes				
A21N	A-321neo	Yes				
A318	A-318	Yes				
A319	A-319	Yes				
A320	A-320	Yes				
A321	A-321	Yes				
B38M	737 MAX 8	Yes				
B722	727-200	Yes				
B733	737-300	Yes				
B734	737-400	Yes				
B735	737-500	Yes				
B736	737-600	Yes				
B737	737-700	Yes				
B738	737-800	Yes				
B739	737-900	Yes				
B752	757-200	Yes				
B753	757-300	Yes				
BCS1	BD-500 CSeries CS100	Yes				
BCS3	BD-500 CSeries CS300	Yes				
E295	E195-E2	Yes				
MD82	MD-82	Yes				
MD87	MD-87	Yes				
MD88	MD-88	Yes				
MD90	MD-90	Yes				
B462	BAe-146-200	Yes				
B463	BAe-146-300	Yes				
B712	717-200	Yes				
BE4W	Hawker 400XT	Yes				
C25B	525B Citation CJ3	Yes				
C25C	525C Citation CJ4	Yes				
C550	550 Citation 2	Yes				
C56X	560XL Citation Excel	Yes				
C68A	680A Citation Latitude	Yes				
C750	750 Citation 10	Yes				
CL30	BD-100 Challenger 300	Yes				
CL35	BD-100 Challenger 350	Yes				
CL60	CL-600 Challenger 650	Yes				

** Example of model: Doc 8643 includes one or more model for a given type designator. Sample/example of model is provided in this table. For additional details of other applicable models for a given type designator see: https://www.icao.int/publications/DOC8643/Pages/Search.aspx*

Table A-2.1.a (cont.). Aircraft types (by ICAO type designator) modelled with ICAO CEM based on aeroplane operator data from the COFdb

Type Designator	Example of Model*	CEM based on AO data (from COFdb)	CEM based on Equivalent Aircraft Type		CEM based on ICAO Fuel Formula	
		Source of CEM	Source of CEM	Type Designator of Equivalent Aircraft	Source of CEM	ICAO Aircraft Code
CRJ1	Regional Jet CRJ-100	Yes				
CRJ2	Challenger 800	Yes				
CRJ7	Challenger 870	Yes				
CRJ9	Challenger 890	Yes				
CRJX	Regional Jet CRJ-1000	Yes				
DC95	DC-9-50	Yes				
E135	ERJ-135	Yes				
E145	ERJ-145EP	Yes				
E170	ERJ-170-100	Yes				
E190	ERJ-190 Lineage 1000	Yes				
E195	ERJ-190-200	Yes				
E290	E190-E2	Yes				
E35L	EMB-135BJ Legacy	Yes				
E45X	EMB-145XR	Yes				
E55P	EMB-505 Phenom 300	Yes				
E75L	ERJ-170-200 (long wing)	Yes				
E75S	ERJ-170-200 (short wing)	Yes				
F100	100	Yes				
F2TH	Falcon 2000	Yes				
F70	70	Yes				
F900	Falcon 900	Yes				
FA50	Falcon 50	Yes				
FA7X	Falcon 7X	Yes				
FA8X	Falcon 8X	Yes				
G280	Gulfstream G280	Yes				
GA6C	G-7 Gulfstream G600	Yes				
GL5T	Global 5000	Yes				
GL7T	Global 7000	Yes				
GLEX	Global Express	Yes				
GLF4	Gulfstream 4	Yes				
GLF5	Gulfstream 5	Yes				
GLF6	Gulfstream G650	Yes				
H25B	Hawker 800	Yes				
LJ31	31	Yes				
LJ40	40	Yes				
LJ45	45	Yes				
LJ60	60	Yes				
LJ75	75	Yes				
RJ85	RJ-85 Avroliner	Yes				
AN26	An-26	Yes				
AT43	ATR-42-300	Yes				
AT45	ATR-42-500	Yes				
AT46	ATR-42-600	Yes				
AT72	ATR-72-201	Yes				
AT75	ATR-72-500	Yes				
AT76	ATR-72-600	Yes				
B190	1900	Yes				
BE20	Super King Air (200)	Yes				
BE30	300 Super King Air	Yes				
D328	328	Yes				
DH8A	Dash 8 (100)	Yes				
DH8D	Dash 8 (400)	Yes				
F50	50 Maritime Enforcer	Yes				
SB20	2000	Yes				
SF34	SF-340	Yes				

** Example of model: Doc 8643 includes one or more model for a given type designator. Sample/example of model is provided in this table. For additional details of other applicable models for a given type designator see: https://www.icao.int/publications/DOC8643/Pages/Search.aspx*

Table A-2.1.b. Aircraft types (by ICAO type designator) modelled with equivalent aircraft types

Type Designator	Example of Model*	CEM based on AO data (from COFdb)	CEM based on Equivalent Aircraft Type		CEM based on ICAO Fuel Formula	
		Source of CEM	Source of CEM	Type Designator of Equivalent Aircraft	Source of CEM	ICAO Aircraft Code
A30B	A-300B2		Yes	A306		
A338	A-330-800		Yes	A339		
A342	A-340-200		Yes	A343		
A345	A-340-500		Yes	A346		
A35K	A-350-1000 XWB		Yes	A359		
B741	747-100		Yes	B744		
B742	747-200		Yes	B744		
B743	747-300		Yes	B744		
B74R	747SR		Yes	B744		
B74S	747SP		Yes	B744		
A19N	A-319neo		Yes	A20N		
B37M	737 MAX 7		Yes	B38M		
B39M	737 MAX 9		Yes	B38M		
B3XM	737 MAX 10		Yes	B38M		
MD81	MD-81		Yes	MD82		
MD83	MD-83		Yes	MD82		
B461	BAe-146-100		Yes	B462		
B732	737-200		Yes	B733		
C525	525 Citation CJ1		Yes	C550		
C55B	550B Citation Bravo		Yes	C550		
C560	560 Citation 5		Yes	C550		
FA6X	Falcon 6X		Yes	FA7X		
GA5C	Gulfstream G500 (G-7)		Yes	GA6C		
GA7C	Gulfstream G700		Yes	GLF6		
H25A	HS-125-1		Yes	H25B		
H25C	Hawker 1000		Yes	H25B		
LJ25	25		Yes	LJ40		
LJ35	35		Yes	LJ40		
LJ55	55		Yes	LJ45		
LJ70	70		Yes	LJ45		
RJ1H	RJ-100 Avroliner		Yes	B463		
RJ70	RJ-70 Avroliner		Yes	RJ85		
AN30	An-30		Yes	AN26		
AN32	An-32		Yes	AN26		
AT73	ATR-72-211		Yes	AT72		
DH8B	Dash 8 (200)		Yes	DH8D		
DH8C	Dash 8 (300)		Yes	DH8D		
DHC7	DHC-7 Dash 7		Yes	DH8D		

** Example of model: Doc 8643 includes one or more model for a given type designator. Sample/example of model is provided in this table. For additional details of other applicable models for a given type designator see: https://www.icao.int/publications/DOC8643/Pages/Search.aspx*

Table A-2.1.c. Aircraft types (by ICAO type designator) modelled with ICAO Fuel Formula

Type Designator	Example of Model*	CEM based on AO data (from COFdb)	CEM based on Equivalent Aircraft Type		CEM based on ICAO Fuel Formula	
		Source of CEM	Source of CEM	Type Designator of Equivalent Aircraft	Source of CEM	ICAO Aircraft Code
DC10	DC-10					D10
DC85	DC-8-50					D8T
DC86	DC-8-60					D8L
DC87	DC-8-70					D8Q
IL62	Il-62					IL6
IL76	Il-76					IL7
IL86	Il-86					ILW
IL96	Il-96					IL9
L101	L-1011 TriStar					L10
B701	707-100					70M
B721	727-100					721
T134	Tu-134					TU3
T154	Tu-154					TU5
T204	Tu-204					T20
A148	An-148					A81
AN72	An-72					AN7
BA11	BAC-111 One-Eleven					B11
DC91	DC-9-10					D91
DC92	DC-9-20					D92
DC93	DC-9-30					D93
DC94	DC-9-40					D94
F28	F-28 Fellowship					F28
FA10	Falcon 10					DF2
J328	Dornier 328JET					FRJ
S601	SN-601 Corvette					NDC
WW24	1124 Westwind					WWP
YK40	Yak-40					YK4
YK42	Yak-42					YK2
A140	IRAN-140 Faraz					A40
A748	748					HS7
AN12	An-12					ANF
AN24	An-24					AN4
AN28	An-28					A28
ATP	ATP					ATP
BELF	SC-5 Belfast					SHB
C130	L-100 Hercules					LOH
C212	C-212 Aviocar					CS2
CN35	CN-235					CS5
CVLP	Convairliner					CVR
CVLT	Cosmopolitan					CV5
D228	Dornier 228					D28
DC3	DC-3					DC3
DC6	DC-6					DC6
DHC6	DHC-6 Twin Otter					DHT
E110	EMB-110 Bandeirante					EMB
E120	EMB-120 Brasilia					EM2
F27	F-27					F27
G159	G-159 Gulfstream 1					GRS
I114	Il-114					I14
IL18	Il-18					IL8
JS31	BAe-3100 Jetstream 31					J31
JS32	BAe-3200 Jetstream Super 31					J32
JS41	BAe-4100 Jetstream 41					J41
L188	Electra (L-188)					LOE
L410	L-410 Turbolet					L4T

** Example of model: Doc 8643 includes one or more model for a given type designator. Sample/example of model is provided in this table. For additional details of other applicable models for a given type designator see: https://www.icao.int/publications/DOC8643/Pages/Search.aspx*

Table format of ICAO CO_2 Estimation Models (CEMs) based on Great Circle Distance (GCD) Input in version 2023 of the ICAO CORSIA CERT

*Note: Tables provide fuel in kg. CO_2 emissions can be calculated using CO_2 (in kg) = 3.16 * Fuel (in kg).*

Table A-2.2.a. Aircraft types (by ICAO type designator) modelled with ICAO CEM based on aeroplane operators data from the COFdb

	Fuel (in kg) for given Block Hour (in min)																
Type Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
A124	2,434	11,321	22,760	34,394	46,028	57,662	69,296										
A306	603	4,836	9,070	13,303	17,536	21,769	26,002	30,235	34,469								
A310	388	3,204	7,525	11,898	16,272	20,645	25,018	29,391	33,764	38,137	42,511	46,884					
A332	-	4,621	9,483	14,346	19,208	24,293	30,276	36,260	42,243	48,226	54,210	60,193	66,176	72,159	78,143	84,126	
A333	376	4,801	9,226	14,476	19,743	25,793	31,933	38,073	44,213	50,353	56,494	62,634	68,774	74,914			
A339	-	3,910	8,500	13,405	18,310	23,215	28,120	34,086	40,052	46,019	51,985	57,951	63,917	69,883	75,849	81,815	
A343	1,573	4,114	10,584	17,054	23,523	29,993	36,463	42,933	49,435	56,889	64,343	71,796	79,250	86,704	94,157	101,611	
A346	-	6,354	14,001	21,648	29,295	36,943	44,590	52,237	61,324	70,794	80,264	89,735	99,205	108,675	118,145	127,615	137,085
A359	-	4,497	9,745	14,993	20,242	26,291	32,656	39,021	45,387	51,752	58,117	64,483	70,848	77,213	83,579	89,944	96,309
A388	550	8,807	19,788	31,994	44,201	56,408	68,615	80,822	93,071	107,754	122,437	137,120	151,803	166,486	181,169	195,852	210,535
B744	204	6,070	16,218	26,367	36,516	46,665	56,813	66,962	78,216	89,983	101,749	113,516	125,282	137,048	148,815	160,581	172,348
B748	-	7,525	16,789	26,053	35,317	44,581	53,845	63,109	74,892	86,805	98,718	110,631	122,544	134,457	146,370	158,283	170,196
B762	628	3,792	7,471	12,354	17,237	22,121	27,004	31,887	36,770	41,653	46,537	51,420					
B763	507	2,846	7,466	12,174	16,883	21,591	26,299	31,326	36,387	41,448	46,509	51,570	56,631	61,692	66,753	71,814	
B764	1,379	4,846	8,313	11,781	16,723	22,545	28,367	34,189	40,011	45,833	51,655	57,477	63,299	69,121	74,943		
B772	2,221	5,428	9,873	16,796	23,718	30,641	37,563	44,486	51,408	58,699	66,357	74,016	81,674	89,333	96,991	104,650	112,308
B773	2,761	7,040	11,477	18,926	26,375	33,436	39,992	46,547	53,102	59,658	66,213	72,768	79,324	85,879	92,435	98,990	
B77L	-	6,459	12,917	19,376	25,834	32,345	40,860	49,503	58,146	66,789	75,431	84,074	92,717	101,360	110,003	118,645	127,288
B77W	-	4,708	11,922	19,136	26,350	34,322	42,775	51,228	59,681	68,133	76,586	85,039	93,492	101,945	110,398	118,850	
B788	-	3,729	7,825	12,104	16,383	20,661	25,980	31,435	36,890	42,346	47,801	53,256	58,711	64,167	69,622	75,077	80,533
B789	48	3,968	8,169	12,911	17,653	22,395	27,208	33,117	39,025	44,934	50,843	56,751	62,660	68,568	74,477	80,386	86,294
B78X	1,441	4,737	8,033	11,330	15,205	21,678	28,152	34,625	41,099	47,573	54,046	60,520	66,994	73,467	79,941	86,415	92,888
MD11	550	5,220	12,098	20,324	28,550	36,776	45,002	53,228	61,454	69,680	77,906	86,133	94,359	102,585	110,811	119,037	127,263
A20N	-	1,849	3,850	5,985	8,119	10,253	12,387	14,521									
A21N	2	2,078	4,295	6,672	9,351	12,030	14,710	17,389	20,068								
A318	62	2,080	4,125	6,705	9,285	11,864	14,444	17,023	19,603								
A319	-	2,160	4,399	6,668	9,278	11,887	14,496	17,106	19,715								
A320	-	2,243	4,589	7,180	9,771	12,363	14,954										
A321	-	2,596	5,345	8,394	11,444	14,493	17,543	20,593									
B38M	63	1,610	3,608	5,868	8,128	10,388	12,648	14,908									
B722	187	3,697	7,721	11,772	15,823	19,874	23,926										
B733	244	2,112	4,365	6,773	9,181	11,589	13,997	16,405									
B734	329	2,362	4,569	6,980	9,391	11,802	14,213	16,624	19,035	21,446	23,857	26,268	28,679	31,090			
B735	79	2,135	4,192	6,248	8,305	10,362	12,418	14,475	16,531	18,588	20,644	22,701					
B736	24	1,894	3,813	5,733	7,652	9,571	11,491	13,410	15,329								
B737	46	1,821	3,956	6,201	8,446	10,692	12,937	15,182									
B738	261	2,011	4,421	6,961	9,501	11,844	14,158										
B739	158	2,269	4,748	7,441	10,133	12,826	15,518										
B752	661	3,071	5,924	9,138	12,352	15,566	18,780	21,994	25,209	28,423	31,637						
B753	231	3,167	6,579	10,515	14,451	18,387	22,323	26,260	30,196	34,132							
BCS1	-	1,654	3,379	5,100													
BCS3	22	1,666	3,551	5,436	7,297	9,155											
E295	31	1,547	3,117	4,804	6,490	8,177											
MD82	173	2,805	5,615	8,602	11,590	14,577											
MD87	82	2,621	5,161	7,720	10,528	13,337	16,145	18,954									
MD88	168	2,969	5,770	8,453	9,837												
MD90	27	2,499	5,084	7,717	10,350												
B462	290	1,781	3,792	5,803													
B463	163	1,923	3,682	5,442													
B712	-	2,060	4,120	6,180	8,240												
BE4W	-	440	853	1,249	1,645												
C25B	26	441	856	1,271	1,686												
C25C	4	558	1,039	1,507	1,975												
C550	10	525	956	1,345	1,735												
C56X	47	710	1,212	1,709	2,205												
C68A	1	833	1,558	2,207	2,855	3,504	4,153	4,801									
C750	42	851	1,808	2,766	3,723	4,680	5,637	6,594									
CL30	9	885	1,761	2,637	3,404	4,082	4,761										
CL35	-	849	1,622	2,369	3,116	3,863	4,610										
CL60	-	853	1,769	2,691	3,662	4,634	5,606	6,578	7,550								

Table A-2.2.a (cont.). Aircraft types (by ICAO type designator) modelled with ICAO CEM based on aeroplane operators data from the COFdb

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
CRJ1	40	1,110	2,059	2,998	3,936	4,874	5,812	6,750									
CRJ2	19	843	1,874	2,960	4,046	5,132	6,218	7,305									
CRJ7	26	1,367	2,901	4,223													
CRJ9	94	1,539	2,984	4,428													
CRJX	-	1,616	3,000														
DC95	1,549	3,673	5,797														
E135	-	1,080	2,189	3,298	4,407												
E145	-	1,053	2,011	2,966	3,921	4,876											
E170	130	1,455	3,020	4,585													
E190	313	1,814	3,704	5,594	7,484	9,374	11,264	13,154	15,044	16,934							
E195	-	1,820	3,888	6,031	8,175	10,319	12,462	14,606	16,750	18,893							
E290	201	1,538	2,876	4,213	5,550	6,887	8,224										
E35L	-	998	2,009	3,019	4,065	5,119	6,172	7,226	8,280								
E45X	47	1,144	2,314	3,484	4,655												
E55P	8	557	1,007	1,404	1,800												
E75L	200	1,355	2,872	4,389													
E75S	387	1,490	2,672	4,444	6,217												
F100	-	1,855	3,833	5,573	7,277	8,981											
F2TH	158	915	1,751	2,587	3,424	4,260	5,096	5,932	6,768								
F70	137	1,641	3,340	5,039													
F900	17	1,035	2,053	3,071	4,089	5,033	5,961	6,890	7,818	8,747	9,675						
FA50	141	1,145	2,019	2,893	3,767	4,641	5,515	6,389									
FA7X	51	1,167	2,282	3,398	4,514	5,629	6,745	7,860	8,976	10,092	11,207	12,323	13,439				
FA8X	49	1,093	2,339	3,586	4,833	6,079	7,326	8,573	9,820	11,066	12,313	13,560	14,807	16,053			
G280	9	782	1,574	2,366	3,158	3,950	4,742	5,534									
GA6C	-	1,086	2,599	4,111	5,623	7,136	8,648	10,160	11,673	13,185	14,697	16,210	17,722	19,234	20,747		
GL5T	464	1,713	2,962	4,398	5,939	7,480	9,021	10,562	12,104	13,645	15,186	16,727					
GL7T	-	1,231	2,672	4,113	5,555	6,996	8,437	9,878	11,319	12,760	14,125	15,451	16,778	18,105	19,431	20,758	22,085
GLEX	47	1,493	2,938	4,383	5,829	7,275	8,819	10,363	11,908	13,452	14,996	16,540	18,084	19,629			
GLF4	59	1,473	2,831	4,031	5,467	6,903	8,338	9,774	11,210								
GLF5	310	1,673	3,036	4,398	5,761	7,124	8,486	9,849	11,212	12,574	13,937	15,300	16,663	18,025	19,388	20,751	22,113
GLF6	21	1,511	3,000	4,489	5,979	7,468	8,957	10,447	11,936	13,425	14,915	16,404	17,893	19,383	20,872	22,361	
H25B	63	797	1,445	2,093	2,742	3,390											
LJ31	88	487	950	1,414													
LJ40	18	592	1,190	1,788													
LJ45	54	575	1,097	1,618	2,140												
LJ60	81	570	1,157	1,743	2,330	2,917	3,503										
LJ75	-	523	1,045	1,568	2,091												
RJ85	363	1,958	3,553	5,149	6,744												
AN26	98	985	1,872	2,759													
AT43	52	507	972	1,444	1,917	2,390											
AT45	19	601	1,156	1,704													
AT46	27	558															
AT72	28	553	1,078														
AT75	63	654															
AT76	25	577															
B190	-	298	600	902													
BE20	47	297	547	797	1,046												
BE30	110	343	577	810	1,044												
D328	78	475	873														
DH8A	3	491	979														
DH8D	112	896	1,767														
F50	96	541	1,085	1,628	2,171	2,715	3,258	3,801									
SB20	-	849	1,698	2,548													
SF34	108	373	638	902													

Table A-2.2.b. Aircraft types (by ICAO type designator) modelled with equivalent aircraft types

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
A30B	585	4,687	8,789	12,891	16,994	21,096	25,198	29,301	33,403	37,505							
A338	-	3,871	8,416	13,272	18,129	22,985	27,841	33,748	39,655	45,562	51,469	57,376	63,283	69,190	75,097	81,004	86,911
A342	1,491	3,900	10,033	16,166	22,299	28,432	34,565	40,697	46,861	53,927	60,992	68,058	75,124	82,189	89,255	96,320	103,386
A345	-	6,394	14,088	21,783	29,478	37,172	44,867	52,562	61,706	71,235	80,764	90,293	99,822	109,351	118,880	128,409	137,938
A35K	-	5,188	11,243	17,299	23,354	30,333	37,677	45,021	52,365	59,710	67,054	74,398	81,742	89,086	96,430	103,774	111,118
B741	175	5,192	13,874	22,555	31,237	39,918	48,600	57,282	66,909	76,974							
B742	193	5,741	15,341	24,941	34,541	44,141	53,741	63,341	73,986	85,116	96,246	107,376	118,506	129,636	140,766		
B743	194	5,767	15,409	25,051	34,694	44,336	53,978	63,621	74,313	85,492	96,672	107,851	119,030	130,209	141,389	152,568	163,747
B74R	167	4,969	13,277	21,585	29,894	38,202	46,510	54,818	64,031	73,664	83,296	92,929	102,561				
B74S	162	4,820	12,879	20,938	28,997	37,056	45,115	53,174	62,111	71,454	80,798	90,142	99,485				
A19N	-	1,842	3,837	5,964	8,090	10,217	12,344	14,471	16,597								
B37M	60	1,523	3,414	5,552	7,690	9,828	11,966	14,104	16,242								
B39M	69	1,745	3,912	6,362	8,813	11,263	13,713	16,164									
B3XM	67	1,703	3,817	6,207	8,598	10,988	13,379	15,769									
MD81	167	2,711	5,426	8,312	11,199	14,086	16,973										
MD83	191	3,087	6,179	9,466	12,754	16,041	19,328	22,616	25,903								
B461	262	1,606	3,419														
B732	216	1,869	3,862	5,993	8,125	10,256	12,387										
C525	8	412	751	1,057													
C55B	11	567	1,034	1,455	1,876												
C560	12	619	1,128	1,587	2,046												
FA6X	54	1,235	2,417	3,598	4,780	5,961	7,143	8,324	9,506	10,687	11,869	13,050					
GA5C	-	919	2,200	3,480	4,760	6,040	7,320	8,601	9,881	11,161	12,441						
GA7C	24	1,697	3,369	5,042	6,715	8,388	10,060	11,733	13,406	15,079	16,751	18,424	20,097	21,770	23,442	25,115	26,788
H25A	59	739	1,340	1,941	2,542	3,143	3,745										
H25C	71	888	1,610	2,332													
LJ25	13	424	851	1,279													
LJ35	16	517	1,039	1,560	2,082	2,604											
LJ55	53	561	1,070	1,579	2,088												
LJ70	54	577	1,099	1,622	2,145												
RJ1H	169	1,989	3,809	5,629	7,449												
RJ70	358	1,933	3,508														
AN30	94	944	1,794	2,644													
AN32	110	1,108	2,106	3,104	4,056												
AT73	28	554	1,079														
DH8B	63	507	999														
DH8C	75	598	1,178														
DHC7	78	622															

Table A-2.2.c. Aircraft types (by ICAO type designator) modelled with an ICAO Fuel Formula

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
DC10	-	8,921	17,843	26,764	35,686	44,607	53,528	62,450	71,371	80,293							
DC85	-	5,165	10,330	15,494	20,659	25,824	30,989	36,154	41,318	46,483	51,648						
DC86	-	5,165	10,330	15,494	20,659	25,824	30,989	36,154	41,318	46,483	51,648	56,813					
DC87	-	5,165	10,330	15,494	20,659	25,824	30,989	36,154	41,318	46,483	51,648						
IL62	-	7,518	15,036	22,554	30,072	37,590	45,108	52,626	60,144	67,662							
IL76	904	9,597	18,289	26,981	35,673	44,365											
IL86	1,685	11,453	21,220	30,987	40,755	50,522											
IL96	-	6,839	13,678	20,517	27,356	34,195	41,040	47,899	54,758	61,617	68,475	75,334	82,193				
L101	-	8,959	17,918	26,878	35,837	44,796	53,755	62,714	71,674	80,633	89,592	98,551	107,510	116,470	125,429	134,388	
B701	6	5,555	11,104	16,653	22,202	27,751	33,300	38,849	44,398	49,948	55,497						
B721	-	3,305	6,610	9,914	13,219	16,524											
T134	705	3,279	5,854	8,428	11,002												
T154	792	5,654	10,516	15,379	20,241	25,103	29,965										
T204	792	5,654	10,516	15,379	20,241	25,103	29,965	34,828									
A148	-	1,600	3,200	4,800	6,400												
AN72	-	1,600	3,200	4,800	6,400	8,000											
BA11	-	3,057	6,114	9,172	12,229	15,286											
DC91	-	2,638	5,276														
DC92	-	2,670	5,340	8,010													
DC93	-	2,855	5,709	8,564	11,419	14,274	17,128										
DC94	-	3,065	6,130	9,195													
F28	-	2,000	4,000	6,000	8,000	10,000											
FA10	-	760	1,520	2,280	3,040												
J328	-	872	1,744														
S601	-	376	752														
WW24	-	582	1,163	1,745	2,326	2,908											
YK40	-	816	1,632														
YK42	683	3,316	5,949	8,582	11,214												
A140	-	720	1,440	2,160													
A748	-	734	1,469														
AN12	354	2,651	4,947	7,243	9,539	11,835	14,132										
AN24	126	903	1,680														
AN28	-	360															
ATP	-	646	1,293	1,939	2,586	3,232											
BELF	-	2,880	5,760	8,640	11,520	14,400	17,280	20,160	23,040	25,920							
C130	-	1,992	3,984	5,976	7,968												
C212	-	316															
CN35	-	480	960	1,440	1,920	2,400											
CVLP	-																
CVLT	-	992	1,984	2,976	3,968												
D228	-	264	527	791													
DC3	-	304	608														
DC6	-	1,082	2,165	3,247	4,330	5,412	6,494	7,577	8,659								
DHC6	-	270															
E110	-	252	504														
E120	4	413															
F27	-	772	1,544	2,316	3,088	3,860											
G159	-	720	1,440	2,160	2,880												
I114	-	880															
IL18	-	2,040	4,080	6,120													
JS31	-	276															
JS32	-	294															
JS41	-	406	813	1,219	1,626												
L188	-	2,319	4,638	6,958	9,277												
L410	-	320															

APPENDIX A-3: Aircraft types (by type designator) that will be the focus of further and targeted data collection towards the 2024 version of the ICAO CORSIA CERT

As described above in this document, the CO_2 Estimation Models (CEMs) are developed using flight level data provided by aeroplane operators (AO based data). The CAEP continuously strive to increase the scope and accuracy of CEMs towards future versions of the CERT. The list below presents the aircraft types that will be the focus of further and targeted data collection towards the 2024 version of the ICAO CORSIA CERT. Aeroplane operators and/or data providing organization interested in contributing to future improvements of the CERT are welcome to contact cert@icao.int.

Type Designator	Manufacturer	Example of Model*
B39M	BOEING	737 MAX 9
MD83	BOEING	MD-83
A35K	AIRBUS	A-350-1000 XWB
DC10	BOEING	DC-10
F28	FOKKER	F-28 Fellowship
A30B	AIRBUS	A-300B2
IL76	ILYUSHIN	Il-76
SU95	SUKHOI	Superjet 100-95
IL96	ILYUSHIN	Il-96
AN12	ANTONOV	An-12
A345	AIRBUS	A-340-500
B742	BOEING	747-200
T204	TUPOLEV	Tu-204
A148	ANTONOV	An-148
RJ1H	AI(R)	RJ-100 Avroliner
C680	CESSNA	680
B732	BOEING	737-200
BE40	BEECH	400
A342	AIRBUS	A-340-200
C525	CESSNA	525 Citation CJ1
MD87	BOEING	MD-87
DH8C	DE HAVILLAND CANADA	Dash 8 (300)
DC93	DOUGLAS	DC-9-30
GLF2	GRUMMAN	G-1159
F27	CONAIR	F-27
CVLT	CANADAIR	Cosmopolitan
LJ35	GATES LEARJET	35
E545	EMBRAER	EMB-545 Legacy 450
AN24	ANTONOV	An-24
ASTR	GULFSTREAM AEROSPACE	Gulfstream G100
E120	EMBRAER	EMB-120 Brasilia
DC91	DOUGLAS	DC-9-10
YK42	YAKOVLEV	Yak-42
B74S	BOEING	747SP
B743	BOEING	747-300
A158	ANTONOV	An-158
DH8B	DE HAVILLAND CANADA	Dash 8 (200)
C25A	CESSNA	525A
SW2	SWEARINGEN	SA-26 Merlin 2
C560	CESSNA	560 Citation 5
FA20	DASSAULT	Falcon 200
...		

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Type Designator	Manufacturer	Example of Model*
	... continued from previous column	
H25C	BRITISH AEROSPACE	Hawker 1000
HA4T	HAWKER BEECHCRAFT	4000 Hawker 4000
FA10	DASSAULT	Falcon 10
C650	CESSNA	650
ATP	BRITISH AEROSPACE	ATP
T154	TUPOLEV	Tu-154
B721	BOEING	727-100
G150	GULFSTREAM AEROSPACE	Gulfstream G150
MD81	BOEING	MD-81
DHC6	DE HAVILLAND CANADA	DHC-6 Twin Otter
JS31	BRITISH AEROSPACE	BAe-3100 Jetstream 31
DC87	DOUGLAS	DC-8-70
GALX	GULFSTREAM AEROSPACE	Gulfstream G200
C551	CESSNA	551
D228	DORNIER	Dornier 228
CN35	AIRBUS	CN-235
JS41	AI(R)	BAe-4100 Jetstream 41
E110	EMBRAER	EMB-110 Bandeirante
BE20	BEECH	Super King Air (200)
GLF3	GULFSTREAM AEROSPACE	G-1159A
T134	TUPOLEV	Tu-134
B461	BRITISH AEROSPACE	BAe-146-100
SH36	SHORT	360
AJ27	COMAC	ARJ-21-700 Xiangfeng
C212	AIRBUS	C-212 Aviocar
LJ55	GATES LEARJET	55
G159	GRUMMAN	G-159 Gulfstream 1
YK40	YAKOVLEV	Yak-40
B37M	BOEING	737 MAX 7
L101	LOCKHEED	L-1011 TriStar
SC7	SHORT	SC-7 Skyliner
A748	AIL	748
I114	ILYUSHIN	Il-114
LJ70	LEARJET	70

APPENDIX B-1: Complementary List of Aerodromes Towards the CERT Aerodrome Database

ICAO Code	Location Name	Latitude	Longitude	Territory Code	ICAO Member State	Link for Confirmation of Location
FAJS	O R Tambo International	-26.1337	28.2423	FA	South Africa	https://www.google.com/maps/search/-26.13369444,28.24231667
FLLI	Livingstone	-17.8218	25.8227	FL	Zambia	https://www.google.com/maps/search/-17.8218,25.822701
FLLS	Kenneth Kaunda Intl	-15.3306	28.4525	FL	Zambia	https://www.google.com/maps/search/-15.330556,28.4525
FLND	Ndola Airport	-12.9985	28.6640	FL	Zambia	https://www.google.com/maps/search/-12.998512,28.664047
FVBU	Bulawayo/Joshua Mqabuko Nkomo Intl	-20.0174	28.6179	FV	Zimbabwe	https://www.google.com/maps/search/-20.017401,28.617901
HCMF	Bosaso International	11.2752	49.1392	HC	Somalia	https://www.google.com/maps/search/11.275235,49.139231
HCMH	Hargeisa/Egal International	9.5132	44.0824	HC	Somalia	https://www.google.com/maps/search/9.513207,44.082389
HCMM	Mogadishu/Aden Adde International Airport	2.0136	45.3047	HC	Somalia	https://www.google.com/maps/search/2.013611,45.304722
HECW	Cairo West Air Base	30.1079	30.9152	HE	Egypt	https://www.google.com/maps/search/30.107943,30.915222
HEMK	Moubarak / Intl	26.3400	31.7394	HE	Egypt	https://www.google.com/maps/search/26.34,31.739444
HSSJ	Juba	4.8790	31.5928	HS	South Sudan	https://www.google.com/maps/search/4.879,31.59283333
HSSK	Khartoum	15.5895	32.5532	HS	Sudan	https://www.google.com/maps/search/15.5895,32.5532
HSSS	Khartoum	15.5894	32.5531	HS	Sudan	https://www.google.com/maps/search/15.589444,32.553056
KANJ	Sault Ste Marie Muni/Sanderson Fld	46.4792	-84.3684	KA	United States	https://www.google.com/maps/search/46.479198,-84.368401
KBKV	Brooksville-Tampa Bay Rgnl	28.4736	-82.4554	KB	United States	https://www.google.com/maps/search/28.4736,-82.455399
KDTO	Denton Enterprise	33.2007	-97.1980	KD	United States	https://www.google.com/maps/search/33.200699,-97.197998
KDTS	Destin Exec	30.4001	-86.4715	KD	United States	https://www.google.com/maps/search/30.400101,-86.471497
KGYH	Donaldson Fld	34.7583	-82.3764	KG	United States	https://www.google.com/maps/search/34.758301,-82.376404
KHEF	Manassas Rgnl/Harry P Davis Fld	38.7214	-77.5154	KH	United States	https://www.google.com/maps/search/38.721401,-77.515404
KHXD	Hilton Head	32.2244	-80.6975	KH	United States	https://www.google.com/maps/search/32.2244,-80.697502
KHYI	San Marcos Rgnl	29.8927	-97.8630	KH	United States	https://www.google.com/maps/search/29.8927,-97.862999
KJYO	Leesburg Exec	39.0780	-77.5575	KJ	United States	https://www.google.com/maps/search/39.077999,-77.557503
KJZI	Charleston Exec	32.7009	-80.0029	KJ	United States	https://www.google.com/maps/search/32.700901,-80.002899
KMKY	Marco Island Exec	25.9950	-81.6725	KM	United States	https://www.google.com/maps/search/25.995001,-81.672501
KPMP	Pompano Beach Airpark	26.2471	-80.1111	KP	United States	https://www.google.com/maps/search/26.247101,-80.111099
KSUT	Cape Fear Rgnl Jetport/Howie Franklin Fld	33.9293	-78.0750	KS	United States	https://www.google.com/maps/search/33.929298,-78.074997
KTKI	Mckinney Ntl	33.1779	-96.5905	KT	United States	https://www.google.com/maps/search/33.177898,-96.5905
KTME	Houston Exec	29.8072	-95.8979	KT	United States	https://www.google.com/maps/search/29.807199,-95.897903
KTYQ	Indianapolis Exec	40.0307	-86.2514	KT	United States	https://www.google.com/maps/search/40.030701,-86.251404
KUZA	Rock Hill/York County/Bryant Fld	34.9878	-81.0572	KU	United States	https://www.google.com/maps/search/34.987801,-81.057198
MHSC	Comayagua International	14.3824	-87.6212	MH	Honduras	https://www.google.com/maps/search/14.3824,-87.6212

ICAO Code	Location Name	Latitude	Longitude	Territory Code	ICAO Member State	Link for Confirmation of Location
	Airport					
MMIM	Isla Mujeres	21.2460	-86.7404	MM	Mexico	https://www.google.com/maps/search/21.245962,-86.740365
MPHO	Howard Intl	8.9148	-79.5996	MP	Panama	https://www.google.com/maps/search/8.91479,-79.599602
MPRH	Scarlett Martinez International Airport	8.3759	-80.1279	MP	Panama	https://www.google.com/maps/search/8.37588,-80.127899
MYGW	West End Airport	26.6853	-78.9750	MY	Bahamas	https://www.google.com/maps/search/26.685301,-78.974998
MYPI	Nassau Paradise Island Airport	25.0781	-77.2987	MY	Bahamas	https://www.google.com/maps/search/25.078138,-77.298689
OERY	Riyadh / King Salman Air Base	24.7257	46.7223	OE	Saudi Arabia	https://www.google.com/maps/search/24.725725,46.722336
OKBK	Kuwait Intl	29.2268	47.9800	OK	Kuwait	https://www.google.com/maps/search/29.22676667,47.97995278
OOSR	Sur	22.5377	59.4798	OO	Oman	https://www.google.com/maps/search/22.537729,59.479766
OPRN	Islamabad/ Benazir Bhutto International	33.6167	73.0992	OP	Pakistan	https://www.google.com/maps/search/33.616699,73.099197
SBJH	Sao Paulo Catarina Aeroporto Executivo - Intl	-23.4269	-47.1658	SB	Brazil	https://www.google.com/maps/search/-23.426944,-47.165833
SDSC	Sao Carlos International Airport	-21.8754	-47.9037	SD	Brazil	https://www.google.com/maps/search/-21.875401,-47.903703
SPIM	Lima - Callao / Jorge Chavez Intl	-12.0219	-77.1143	SP	Peru	https://www.google.com/maps/search/-12.02188611,-77.11431667
SYGO	Ogle International Airport	6.8063	-58.1059	SY	Guyana	https://www.google.com/maps/search/6.80628,-58.1059
TKPN	Vancew.Amoryinternational_Airport	17.2034	-62.5873	TK	Saint Kitts and Nevis	https://www.google.com/maps/search/17.203405853,-62.587252651
UAFL	Tamchy/Ysykkul	42.5856	76.7012	UA	Kyrgyzstan	https://www.google.com/maps/search/42.585584,76.701181
UAFM	Bishkek/Manas	43.0614	74.4775	UA	Kyrgyzstan	https://www.google.com/maps/search/43.061389,74.4775
UAFO	Osh	40.6089	72.7931	UA	Kyrgyzstan	https://www.google.com/maps/search/40.608889,72.793056
UAIT	Turkistan	43.3131	68.5499	UA	Kazakhstan	https://www.google.com/maps/search/43.313126,68.549881
UTKF	Fergana International Airport	40.3588	71.7450	UT	Uzbekistan	https://www.google.com/maps/search/40.358799,71.745003
UTKN	Namangan Airport	40.9846	71.5567	UT	Uzbekistan	https://www.google.com/maps/search/40.9846,71.556702
UUMU	Chkalovskiy Air Base	55.8783	38.0617	UU	Russian Federation	https://www.google.com/maps/search/55.8783,38.061699
VAGO	Goa	15.3808	73.8314	VA	India	https://www.google.com/maps/search/15.3808,73.831398
VGZR	Dhaka / Hazrat Shahjalal Int	23.8433	90.3978	VG	Bangladesh	https://www.google.com/maps/search/23.84334722,90.39778333
VIBN	Lal Bahadur Shastri/Varanasi Domestic	25.4521	82.8618	VI	India	https://www.google.com/maps/search/25.452129,82.861805
VREI	Ifuru Island/Airport	5.7083	73.0250	VR	Maldives	https://www.google.com/maps/search/5.7083,73.025
WIPT	Padang Pariaman/Minangkabau	-0.7869	100.2810	WI	Indonesia	https://www.google.com/maps/search/-0.786917,100.280998
ZSQD	Qingdao/Jiaodong	36.3620	120.0882	ZS	China	https://www.google.com/maps/search/36.361953,120.088171
ZUTF	Chengdu/Tianfu	30.3125	104.4413	ZU	China	https://www.google.com/maps/search/30.31252,104.441284