ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT): 2021 Version

— Design, Development and Validation —

November 2021

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1. INTRODUCTION

In order 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].

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[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.

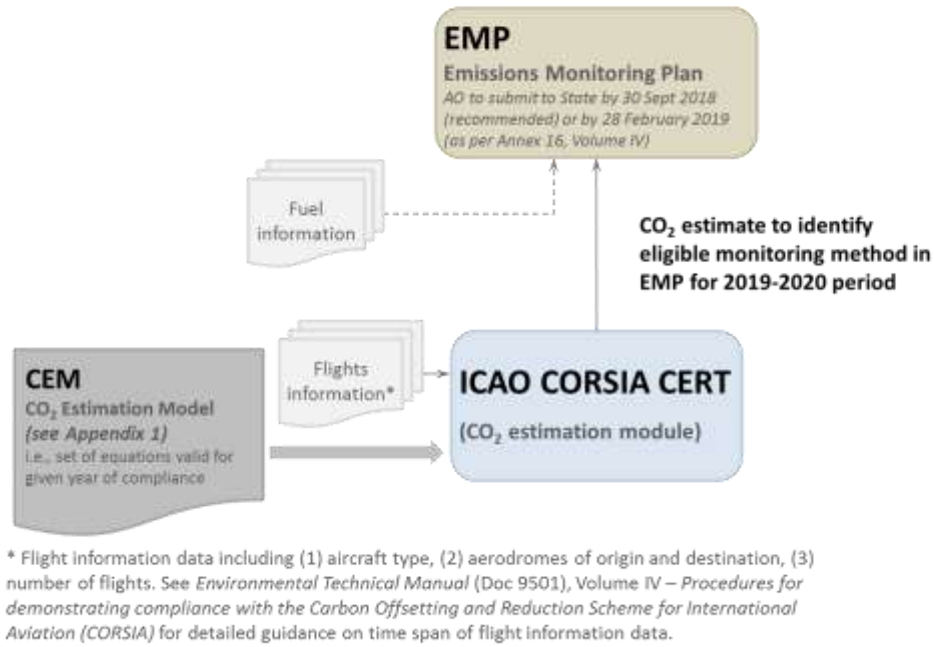


Figure 1: Architecture of CORSIA Emissions Monitoring Plan and reporting system (2018 or aeroplane operator year of entry into CORSIA)

Starting with the 2019 version of the ICAO CORSIA CERT, aeroplane operators are able to 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 in order 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 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.

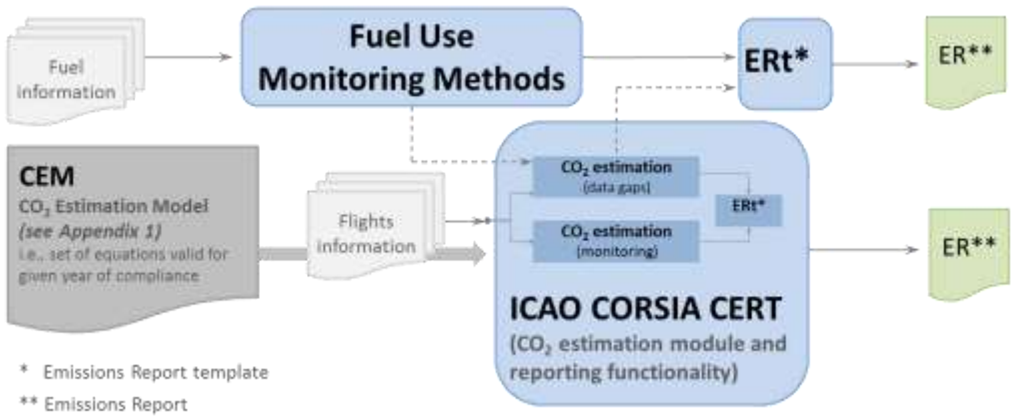


Figure 2: Architecture of CORSIA reporting system (2019 onward for compliance purposes)

	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 2021 Version of the ICAO CORSIA CERT

Based on requirements from Annex 16 Volume IV, a more detailed architecture of the 2021 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 2021

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 2021 version was built on the 2020 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+ version, including;

- ICAO CEMs: The 2021 version of the ICAO CORSIA CERT contains the same ICAO CEMs as in the 2020 version that were based on the 2020 version of the COFdb.

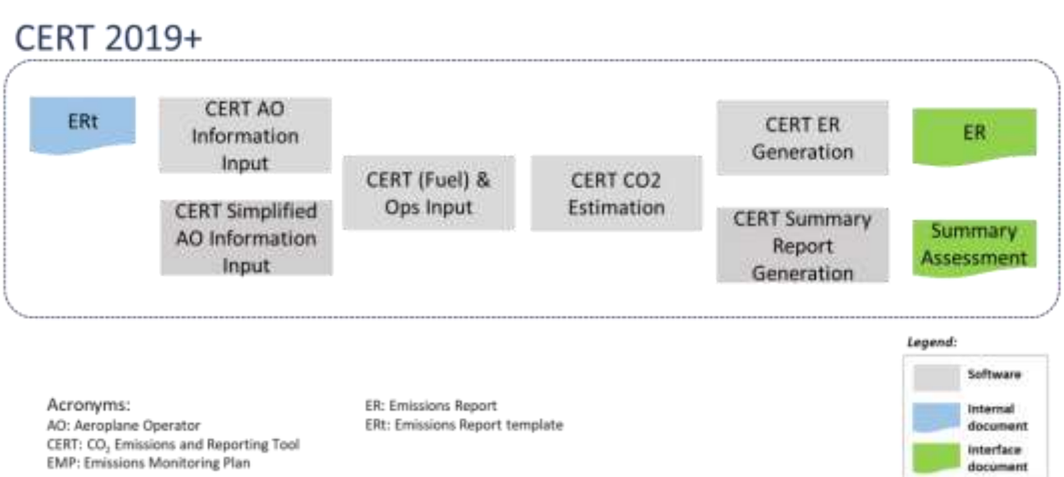


Figure 5: High Level Architecture of the 2019+ versions of the ICAO CORSIA CERT

In accordance with the requirements from Annex 16 Volume IV and the ETM Volume IV, the 2018 version of the ICAO CORSIA CERT only requires 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 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.

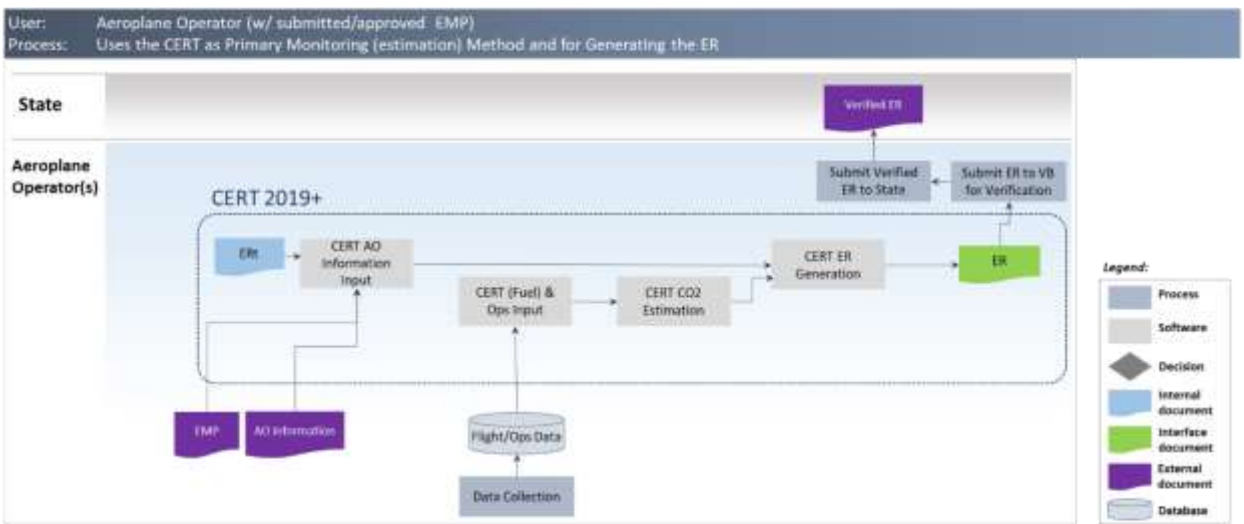


Figure 6: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator with an approved EMP and using the ICAO CORSIA CERT as primary monitoring method and to generate its ER.

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.

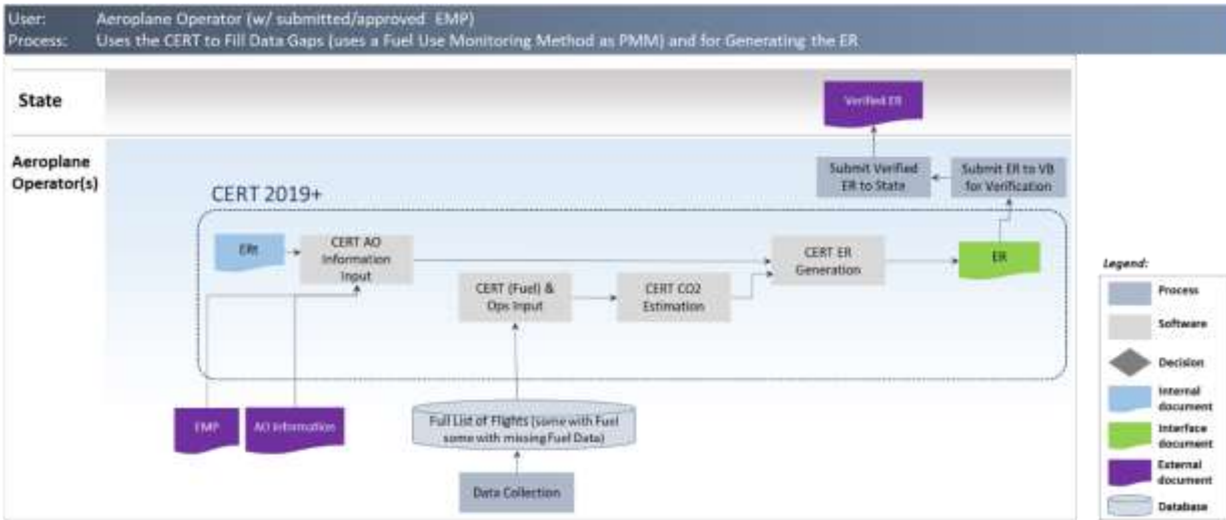


Figure 7: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator with an approved EMP and using the ICAO CORSIA CERT to fill data gaps and generate its ER.

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.

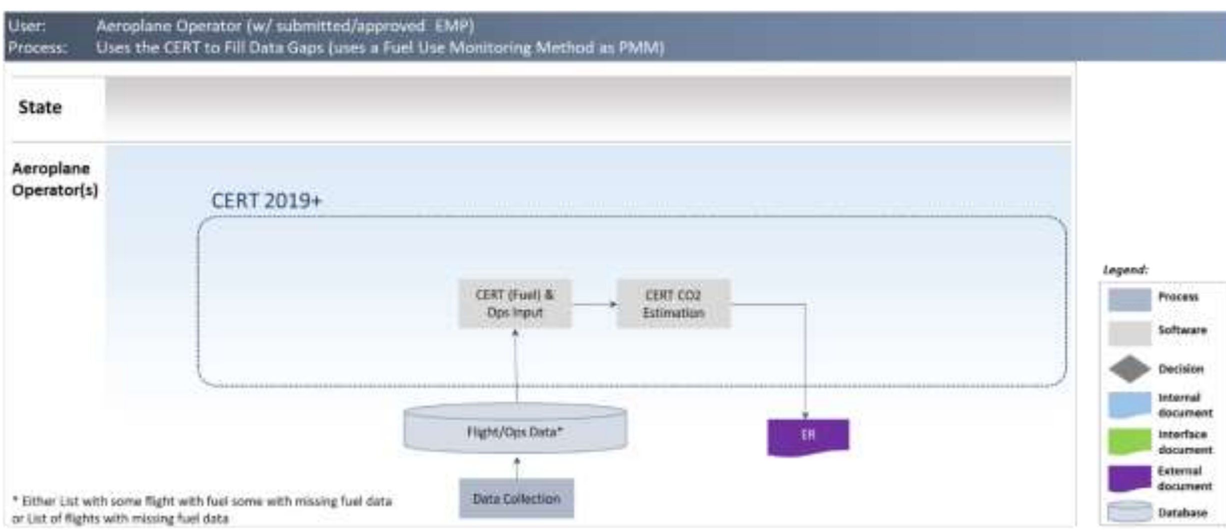


Figure 8: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator using the ICAO CORSIA CERT only to fill data gaps.

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.

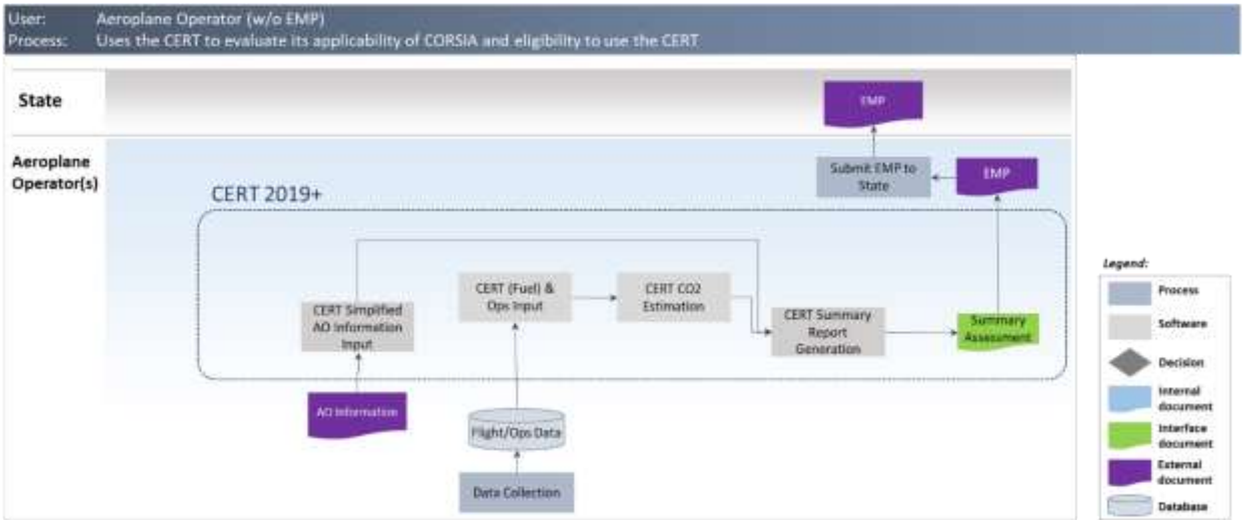


Figure 9: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator to determine the applicability of CORSIA and eligibility to user the ICAO CORSIA CERT.

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

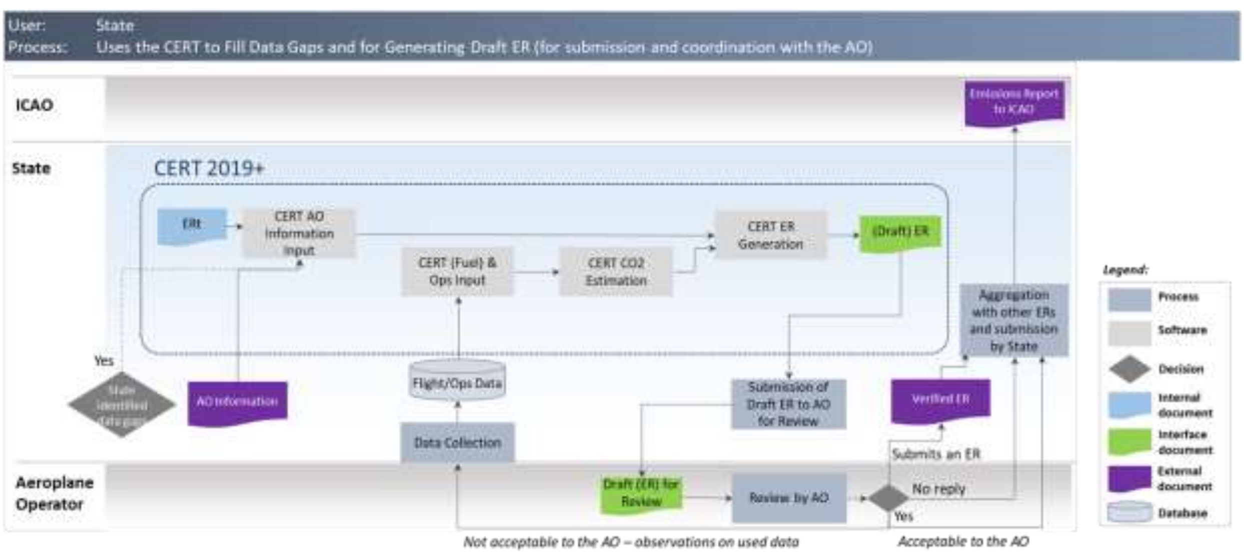


Figure 10: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for a State to fill data gaps.

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

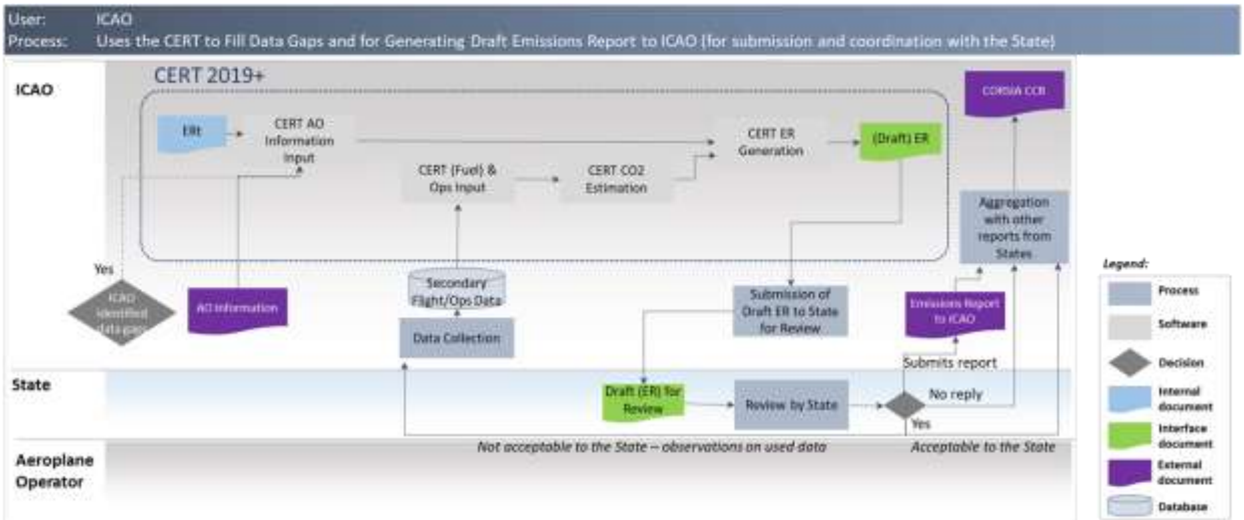


Figure 11: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for ICAO to fill data gaps.

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.

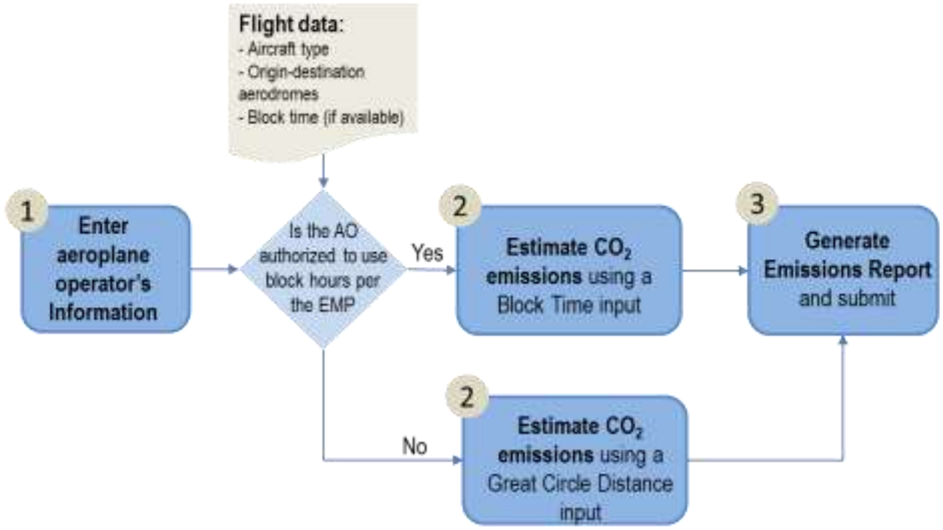


Figure 12: Overview of the high-level functions of the potential CORSIA CO_2 Estimation and Reporting Tool

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

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

is developed through scaling of the ICAO CEM of the equivalent aircraft type, using the method described in 3.2.4;

(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.

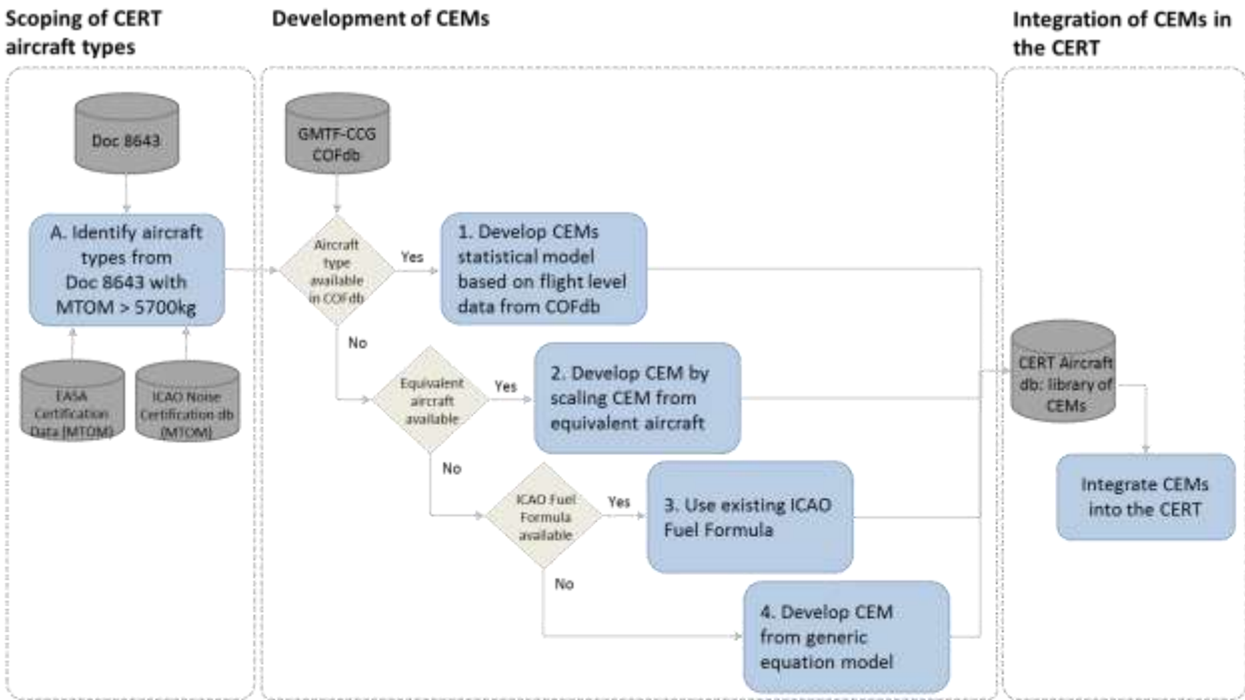


Figure 13: Summary of process for developing ICAO CO_2 Emissions Estimation Models (CEMs)

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).*

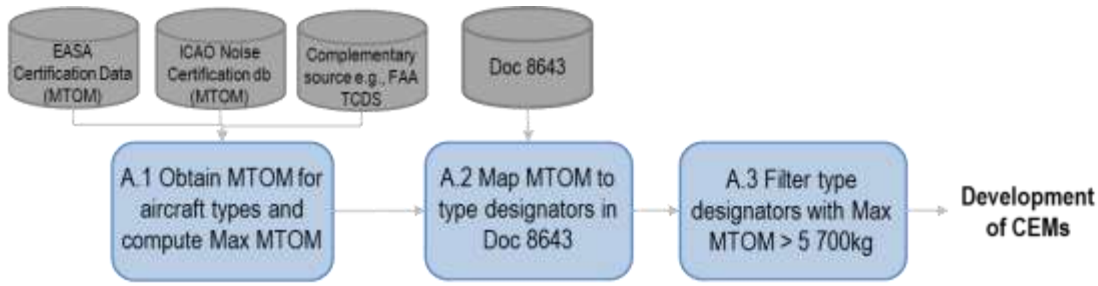
Data sources

- Doc 8643:
  - The 2021 version of the ICAO CORSIA CERT is based on the version of Doc 8643 that was last updated on 17 December 2019.
- 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 29, last updated: 6 August 2019
    - EASA approved noise levels (Jet aeroplanes), Issue 31, last updated: 6 August 2019
    - EASA approved noise levels (Light propeller driven aeroplanes), Issue 28, last updated: 6 August 2019
  - 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

In order 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).

Data collection and validation processes

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 2021 version of the ICAO CORSIA CERT

For the 2021 version of the ICAO CORSIA CERT, the COFdb version 2021_1.1 as of January 17, 2020 was used. This 2020 version 1.1 of the COFdb includes data from approximately 4.5 million flights (after removal of older data) for 104 aircraft types by ICAO Type Designator. Data ranged from 2006 to 2018 with about 66% of the data coming from 2015 to 2019.

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).

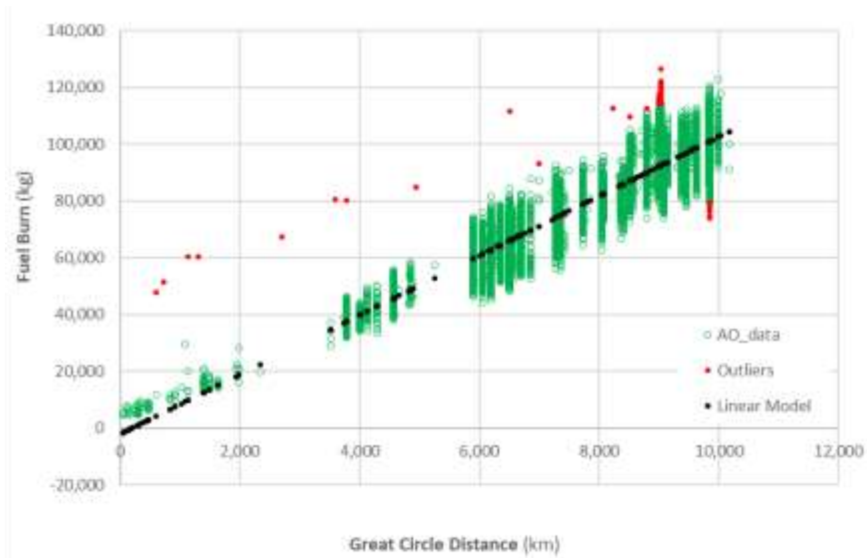


Figure 15: Illustration of sample data used to generate ICAO CEMs, including outlier data removed from the process of generating the ICAO CEM

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.

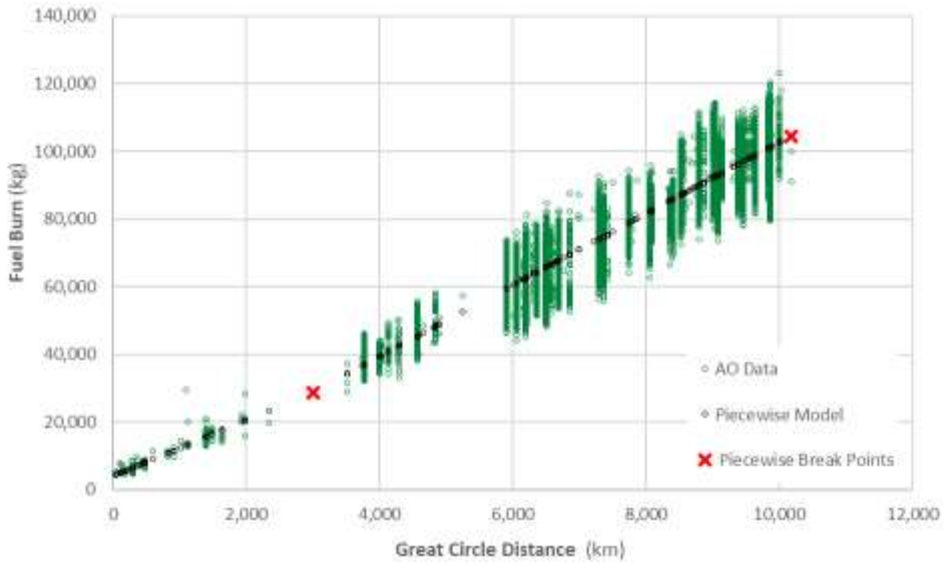


Figure 16: Illustration of fuel burn statistical method model formulation (GCD Model)

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.

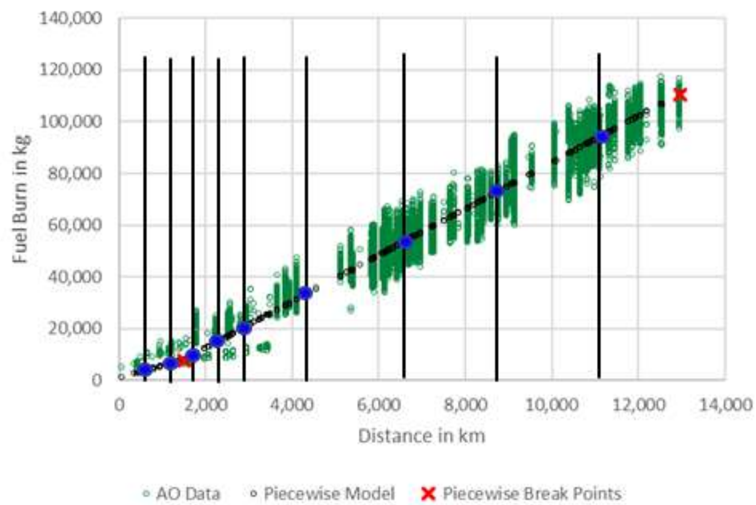


Figure 17: Illustration of process for binning data for developing generic equation

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

[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.

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.

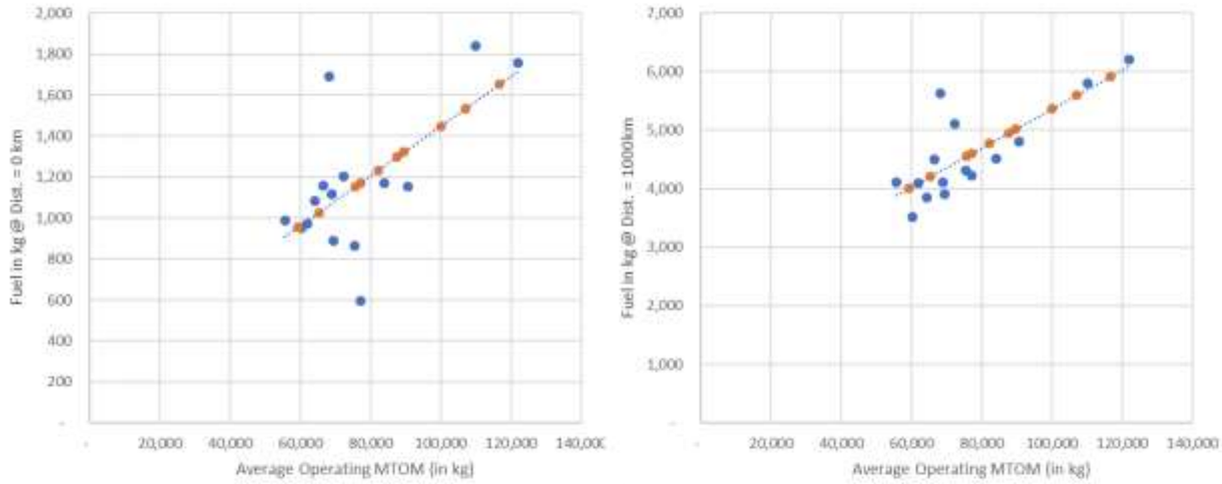


Figure 4: Illustration of generic aeroplane fuel burn-MTOM based regressions for a given distance

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).

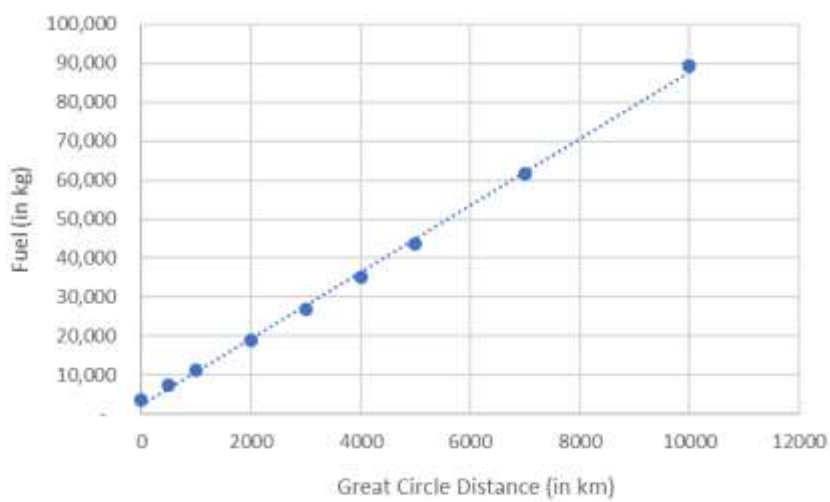


Figure 5: Illustration of generic aeroplane ICAO CEM

4. IMPLEMENTATION OF THE ICAO CORSIA CERT: VERSION 2021

ICAO CORSIA CERT has been developed, tested and validated on Microsoft Excel 2013 and Windows 7 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 2021 was developed to include two key functionalities;

a) Summary of assessment of applicability of CORSIA and eligibility to use the ICAO CORSIA CERT in 2021

b) CO_2 Estimation and Reporting for 2021

4.1 Summary of assessment of applicability of CORSIA and eligibility to use the ICAO CORSIA CERT in 2021

The ICAO CORSIA CERT version 2021 was developed to take 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 2021 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	-113.7137664	0.009291852	0.951365126	2.57593E-05
Jet with certified MTOM >= 60 000 kg and < 136 000 kg	137.7074107	0.011128137	1.747754615	2.21315E-05
Jet (Heavy) with certified MTOM < 60 000 kg	199.515606	0.013327825	0.081018763	5.61413E-05
Turboprop	-4.19723143	0.01234964	0.324835791	4.96388E-05

Figure 20: Coefficients used in the 2021 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

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 2021 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 2022.

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 2021 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 2021, 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 2021

The CO_2 Estimation and Reporting functionality of the ICAO CORSIA CERT version 2021 was developed to take 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:

e) Jet (Heavy) with certified MTOM $\geq$ 136 000 kg;

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

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

h) 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 2021 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	-113.7137664	0.009291852	0.951365126	2.57593E-05
Jet with certified MTOM >= 60 000 kg and < 136 000 kg	137.7074107	0.011128137	1.747754615	2.21315E-05
Jet (Heavy) with certified MTOM < 60 000 kg	199.515606	0.013327825	0.081018763	5.61413E-05
Turboprop	-4.19723143	0.01234964	0.324835791	4.96388E-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	3242.96057	-0.025916812	0.289704965	0.000431018
Jet with certified MTOM >= 60 000 kg and < 136 000 kg	784.8502339	-0.012637172	11.03636464	0.000425351
Jet (Heavy) with certified MTOM < 60 000 kg	119.6022853	0.000242613	3.006234178	0.000583241
Turboprop	-18.57018159	0.006084983	0.858892757	0.000423119

Figure 21: Coefficients used in the 2021 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 2019" 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 2021". See section 4.1.4 for details.

4.3 Data entry error and plausibility of input data

The ICAO CORSIA CERT 2021 version also includes a number of new 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

1.1.1 The ICAO CORSIA CERT 2021 version builds on the 2020 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 2021 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 2021. The first version (July 2020) of CORSIA Implementation Element titled as "CORSIA States for Chapter 3 State Pairs" is available on the CORSIA website[6]. This document includes the list of 88 States that participate in CORSIA from 1 January 2021. The CCG developed functionality to embed this list in the CERT 2021 and scripts to calculate and report CO_2 emissions subject to offsetting requirements into the Emissions Report (ER) template.

4.4.1 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:

d) **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 2021 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 2021 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 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 2021 version, the ICAO CORSIA CERT indicates whether the State Pair is subject to offsetting requirements.

[6] Reference: ICAO document, "CORSIA States for Chapter 3 State Pairs", Version July 2020, available at: https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA_States_for_Chapter3_State_Pairs_Jul2020.pdf, last retrieved on August 4th 2020.

e) **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 2021 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 2021 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 2021 version, the ICAO CORSIA CERT indicates whether the Aerodrome Pair is subject to offsetting requirements.

f) **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 2021 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 with data gaps by total number of international flights <u>subject to offsetting requirements</u>.

  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 2021, 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 2022 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 2022 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 2021 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, winglets	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				
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				
BCS3	BD-500 CSeries CS300	Yes				
MD82	MD-82	Yes				
MD88	MD-88	Yes				
MD90	MD-90	Yes				
B462	BAe-146-200	Yes				
B463	BAe-146-300	Yes				
B712	717-200	Yes				
C25B	525B Citation CJ3	Yes				
C550	550 Citation 2	Yes				
C56X	560XL Citation Excel	Yes				
C68A	680A Citation Latitude	Yes				
CL30	BD-100 Challenger 300	Yes				
CL35	BD-100 Challenger 350	Yes				
CL60	CL-600 Challenger 650	Yes				
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				

** 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
E145	ERJ-145EP	Yes				
E170	ERJ-170-100	Yes				
E190	ERJ-190 Lineage 1000	Yes				
E195	ERJ-190-200	Yes				
E35L	EMB-135BJ Legacy	Yes				
E45X	EMB-145XR	Yes				
E55P	EMB-505 Phenom 300	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				
GL5T	Global 5000	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				
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				
BE30	300 Super King Air	Yes				
D328	328	Yes				
DH8A	Dash 8 (100)	Yes				
DH8D	Dash 8 (400)	Yes				
F50	50 Maritime Enforcer	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		
B78X	787-10 Dreamliner		Yes	B789		
A19N	A-319neo		Yes	A20N		
B37M	737 MAX 7		Yes	B38M		
B39M	737 MAX 9		Yes	B38M		
B3XM	737 MAX 10		Yes	B38M		
BCS1	BD-500 CSeries CS100		Yes	BCS3		
MD81	MD-81		Yes	MD82		
MD83	MD-83		Yes	MD82		
MD87	MD-87		Yes	MD88		
B461	BAe-146-100		Yes	B462		
B732	737-200		Yes	B733		
C25C	525C Citation CJ4		Yes	C550		
C525	525 Citation CJ1		Yes	C550		
C55B	550B Citation Bravo		Yes	C550		
C560	560 Citation 5		Yes	C550		
E75L	ERJ-170-200 (long wing)		Yes	E170		
E75S	ERJ-170-200 (short wing)		Yes	E170		
GA5C	Gulfstream G500 (G-7)		Yes	GLF5		
GA6C	G-7 Gulfstream G600		Yes	GLF5		
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		
LJ75	75		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		
E290	E190-E2		EF2 Method	E190		
E295	E195-E2		EF2 Method	E195		

** 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
BE20	Super King Air (200)					BE2
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
SB20	2000					S20
SC7	SC-7 Skyliner					SHS
SH33	SD3-30					SH3

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
SH36	360					SH6
SW2	SA-26 Merlin 2					SWM
YS11	YS-11					YS1

** 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 2021 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	2,611	5,314	8,017	10,720	13,423	16,885	20,347	23,809	27,271	30,733	34,195	37,658	41,120	48,007	54,745	61,483	68,222
A333	2,624	6,196	9,768	13,340	16,685	19,902	23,120	26,338	29,556	32,773	35,991	39,209	42,494	49,605	56,716	63,827	70,938
A339	1,818	4,891	7,965	11,038	14,111	17,185	20,258	23,331	26,404	29,478	32,551	35,624	38,698	44,844	50,991	57,137	63,284
A343	1,835	6,736	10,482	14,227	17,973	21,719	25,465	29,211	32,957	36,702	40,448	44,194	47,940	56,030	64,993	73,956	82,919
A346	3,961	7,999	12,038	16,076	20,115	24,153	28,705	33,974	39,243	44,511	49,780	55,049	60,318	70,855	81,393	91,930	102,468
A359	3,414	6,570	9,725	12,881	16,036	19,192	22,347	25,503	28,658	32,246	35,884	39,523	43,161	50,438	57,715	64,992	72,269
A388	4,211	11,401	18,592	25,782	32,973	40,163	47,354	54,544	61,735	68,925	76,116	83,306	90,497	104,878	119,259	136,779	154,932
B744	5,932	11,289	16,646	22,003	27,360	32,717	38,439	44,273	50,108	55,942	61,777	67,611	73,446	85,115	98,324	113,922	129,520
B748	6,377	11,625	16,874	22,122	27,371	32,619	37,868	43,116	48,365	53,613	58,862	64,110	69,572	82,362	95,152	107,942	120,732
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	1,685	4,488	7,290	10,092	12,895	15,697	18,500	21,302	24,104	27,150	30,316	33,483	36,649	42,981	49,313	55,645	61,977
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	3,139	6,932	10,725	14,518	18,311	22,104	25,896	29,689	33,482	37,275	41,068	44,861	48,654	56,445	65,235	74,024	82,813
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	3,291	7,265	11,238	15,212	19,185	23,159	27,132	31,106	35,452	40,604	45,756	50,908	56,060	66,364	76,668	86,607	94,083
B77W	5,239	9,022	12,805	16,588	20,371	24,154	27,937	31,723	36,780	41,837	46,894	51,951	57,008	67,122	77,236	87,350	96,653
B788	2,155	4,697	7,238	9,779	12,320	14,861	17,402	20,280	23,238	26,195	29,152	32,109	35,067	40,981	46,896	52,810	58,725
B789	2,357	5,161	7,964	10,767	13,570	16,373	19,176	21,979	24,782	27,842	31,206	34,571	37,935	44,664	51,393	58,122	64,851
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	811	2,158	3,488	4,790	6,092	7,453	8,828	10,203	11,578	12,953	14,328	15,703	17,078				
A21N	721	2,157	3,592	5,153	6,714	8,275	9,885	11,495	13,104	14,714	16,323	17,933	19,543	22,762			
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	743	2,350	3,839	5,328	6,818	8,334	10,170	12,006	13,842	15,678	17,514	19,350	21,186				
A320	659	2,710	4,220	5,729	7,238	8,747	10,495	12,249	14,002	15,756	17,510	19,263					
A321	1,149	2,956	4,747	6,532	8,349	10,225	12,100	13,975	15,851	17,726	19,601	21,477	23,352				
B38M	754	2,125	3,496	4,845	6,162	7,479	8,801	10,124	11,448	12,771	14,095	15,419	16,742				
B722	1,461	4,314	7,052	9,477	11,902	14,327	16,752	19,177	21,602	24,027	26,452	28,877					
B733	1,062	2,525	4,070	5,680	7,289	8,899	10,508	12,118	13,727	15,337	16,946	18,556	20,165				
B734	817	2,754	4,570	6,102	7,633	9,164	10,695	12,227	13,758	15,289	16,820	18,352	19,883	22,945	26,008	29,070	32,133
B735	965	2,513	4,061	5,609	7,157	8,705	10,253	11,801	13,349	14,897	16,445	17,993	19,541	22,637	25,733	28,829	
B736	1,031	2,277	3,523	4,789	6,140	7,490	8,840	10,191	11,541	12,891	14,242	15,592	16,943	19,643			
B737	988	2,351	3,784	5,286	6,788	8,290	9,791	11,293	12,795	14,297	15,799	17,300	18,802				
B738	778	2,329	3,922	5,514	7,107	8,700	10,293	11,713	13,131	14,549	15,967	17,386					
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		
BCS3	541	1,999	3,456	4,914	6,371	7,829	9,286	10,744	12,201								
MD82	820	2,867	4,915	6,962	9,010	11,057	13,105	15,152	17,200	19,247							
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									
C25B	109	561	824	1,087	1,350	1,613	1,876										
C550	189	617	944	1,266	1,588	1,910	2,232	2,554									
C56X	222	764	1,105	1,445	1,786	2,126	2,467	2,807									
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				
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	300	1,027	1,476	1,926	2,405	2,895	3,385	3,876	4,366	4,856	5,346	5,836					
CL60	332	1,090	1,662	2,233	2,839	3,468	4,096	4,725	5,353	5,982	6,610	7,239	7,867	9,124			
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	248	1,202	2,038	2,873	3,709	4,544	5,380	6,215	7,051	7,886	8,722	9,557	10,393				
CRJ7	501	1,665	2,655	3,646	4,636	5,627											
CRJ9	549	1,738	2,783	3,807	4,831	5,855											
CRJX	517	1,850	2,891	3,931	4,970												
DC95	1,684	3,675	5,666	7,657													
E135	249	1,338	2,099	2,860	3,621	4,382	5,143	5,904	6,665								

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**
E145	257	1,248	1,935	2,622	3,309	3,996	4,682	5,369	6,056								
E170	495	1,773	2,734	3,939	5,145	6,350	7,556										
E190	608	2,125	3,334	4,574	5,944	7,313	8,683	10,052	11,422	12,791	14,160	15,530	16,899	19,638	22,377		
E195	466	2,145	3,476	4,806	6,137	7,467	8,798	10,128	11,459	12,789	14,120	15,450	16,781	19,442	22,103		
E35L	351	1,264	1,892	2,514	3,135	3,757	4,378	5,000	5,621	6,243	6,864	7,486	8,107	9,350			
E45X	327	1,392	2,196	2,999	3,752	4,463	5,175	5,886									
E55P	207	672	938	1,203	1,469	1,734	2,000	2,265									
F100	597	2,179	3,529	4,879	6,230	7,580	8,930	10,280	11,631								
F2TH	327	1,032	1,545	2,059	2,572	3,086	3,599	4,113	4,626	5,140	5,653	6,167	6,680	7,707			
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	357	1,311	1,979	2,648	3,317	3,985	4,654	5,322	5,991	6,660	7,328	7,997	8,666	10,003	11,340	12,677	14,015
FA8X	372	1,262	1,975	2,688	3,402	4,115	4,828	5,541	6,255	6,968	7,681	8,395	9,108	10,534	11,961	13,388	14,814
G280	435	892	1,350	1,807	2,264	2,721	3,178	3,636	4,093	4,550	5,007	5,464	5,922				
GLST	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	
GLEX	668	1,815	2,693	3,572	4,450	5,328	6,207	7,085	7,964	8,842	9,720	10,599	11,477	13,234	14,991	16,748	18,505
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	207	648	1,026	1,404	1,782	2,160	2,538	2,916	3,294	3,672	4,050						
RJ85	540	2,363	4,187	6,010	7,834	9,657	11,481	13,304									
AN26	458	1,696	2,924	3,699	4,474	5,250											
AT43	133	719	1,271	1,823	2,375	2,927	3,479	4,031	4,584	5,136	5,688						
AT45	93	858	1,485	2,111	2,738	3,364	3,991										
AT46	138	865	1,510														
AT72	48	864	1,486	2,108	2,730												
AT75	213	879	1,588	2,294													
AT76	169	927	1,628														
B190	96	446	796	1,146	1,496	1,845											
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	299	1,118	1,938	2,757	3,577												
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				
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	2,696	5,541	8,386	11,230	14,075	16,919	19,764	22,608	25,453	28,297	31,142	33,987	36,831	42,520	48,209		
A338	1,801	4,844	7,888	10,932	13,976	17,020	20,064	23,108	26,151	29,195	32,239	35,283	38,327	44,415	50,502	56,590	62,678
A342	1,802	6,614	10,293	13,971	17,650	21,328	25,006	28,685	32,363	36,042	39,720	43,398	47,077	55,022	63,823	72,625	81,426
A345	3,997	8,074	12,150	16,226	20,302	24,379	28,973	34,291	39,609	44,926	50,244	55,562	60,880	71,516	82,152	92,787	103,423
A35K	3,896	7,497	11,098	14,700	18,301	21,902	25,503	29,104	32,705	36,800	40,952	45,104	49,257	57,561	65,866	74,171	82,475
B741	5,112	9,728	14,344	18,961	23,577	28,194	33,125	38,153	43,181	48,209	53,237	58,265	63,293	73,349	84,732		
B742	5,640	10,733	15,827	20,920	26,014	31,107	36,548	42,095	47,643	53,190	58,738	64,285	69,833	80,928	93,488	108,319	123,149
B743	5,565	10,591	15,616	20,642	25,668	30,694	36,062	41,536	47,010	52,483	57,957	63,431	68,905	79,852	92,245	106,879	121,512
B74R	4,881	9,289	13,698	18,106	22,514	26,923	31,631	36,433	41,234	46,035	50,836	55,638	60,439	70,041	80,912	93,747	106,583
B74S	4,762	9,063	13,364	17,665	21,966	26,267	30,861	35,545	40,230	44,914	49,598	54,283	58,967	68,335	78,941	91,464	103,987
B78X	2,377	5,204	8,031	10,858	13,685	16,512	19,339	22,166	24,993	28,079	31,472	34,865	38,258	45,044	51,830	58,616	65,402
A19N	779	2,073	3,350	4,601	5,852	7,159	8,480	9,801	11,121	12,442	13,763	15,084	16,405				
B37M	707	1,992	3,276	4,541	5,775	7,010	8,248	9,489	10,729	11,970	13,210	14,451	15,691	18,172			
B39M	809	2,279	3,748	5,195	6,607	8,020	9,437	10,856	12,275	13,694	15,114	16,533	17,952				
B3XM	790	2,227	3,663	5,077	6,457	7,837	9,222	10,609	11,996	13,383	14,770	16,157	17,544				
BCS1	496	1,831	3,166	4,502	5,837	7,172	8,508										
MD81	790	2,761	4,733	6,705	8,676	10,648	12,620	14,591	16,563	18,535	20,506						
MD83	900	3,148	5,396	7,644	9,892	12,140	14,388	16,636	18,884	21,132	23,380	25,628	27,876	32,372			
MD87	1,618	3,424	5,231	7,038	9,125	11,352	13,580	15,807	18,034	20,261	22,488	24,715	26,943				
B461	675	2,158	3,642	5,125													
B732	944	2,245	3,620	5,051	6,483	7,914	9,346	10,777	12,208	13,640	15,071						
C25C	234	764	1,169	1,568	1,966	2,365	2,764	3,163	3,562								
C525	148	485	741	994	1,247	1,500											
C55B	204	668	1,021	1,369	1,717	2,066	2,414	2,762									
C560	222	728	1,113	1,493	1,872	2,252	2,632	3,012									
E75L	522	1,870	2,884	4,156	5,429	6,701	7,973										
E75S	506	1,813	2,796	4,029	5,262	6,496	7,729										
GA5C	620	1,462	2,165	2,868	3,571	4,274	4,977	5,681	6,384	7,087	7,790	8,493	9,196	10,524	11,815	13,105	
GA6C	745	1,758	2,603	3,448	4,294	5,139	5,984	6,830	7,675	8,520	9,366	10,211	11,056	12,652	14,204	15,757	17,309
GA7C	580	1,825	2,674	3,522	4,371	5,219	6,068	6,917	7,765	8,614	9,463	10,311	11,160	12,857	14,555	16,252	17,949
H25A	219	742	1,142	1,541	1,940	2,340	2,739	3,138	3,537	3,937	4,336						
H25C	263	894	1,375	1,856	2,337	2,818											
LJ25	92	432	713	994	1,276	1,557	1,838										
LJ35	113	527	870	1,213	1,556	1,899	2,242	2,585	2,928	3,271							
LJ55	71	638	961	1,284	1,607	1,930	2,253										
LJ70	72	652	983	1,313	1,644	1,974	2,305	2,635									
LJ75	74	668	1,006	1,344	1,683	2,021	2,359	2,698									
RJ1H	688	2,625	4,561	6,497	8,433	10,369	12,305	14,242	16,178								
RJ70	538	2,355	4,173	5,990	7,807												
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	48	868	1,492	2,116	2,740												
DH8B	169	632	1,095	1,559													
DH8C	199	744	1,289	1,835	2,380												
DHC7	207	774	1,341														
E290	492	1,718	2,696	3,699	4,806	5,914	7,021	8,128	9,236	10,343	11,451						
E295	397	1,826	2,959	4,092	5,225	6,357	7,490	8,623	9,756	10,888							

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								
BE20	46	142	237	333	428	524	619	715									
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														
SB20	829	1,391	1,954	2,517	3,080	3,643											
SC7	87	267	448														
SH33	166	508	850	1,193													
SH36	177	544	910	1,276													
SW2	124	380	636	892	1,148	1,403	1,659	1,915									
YS11	87	958	1,593	2,228	2,863												

APPENDIX A-2: ICAO CO_2 Estimation Model (CEM) based on Block Time (BT) Input in version 2021 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, winglets	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				
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				
MD82	MD-82	Yes				
MD88	MD-88	Yes				
MD90	MD-90	Yes				
B462	BAe-146-200	Yes				
B463	BAe-146-300	Yes				
B712	717-200	Yes				
C25B	525B Citation CJ3	Yes				
C550	550 Citation 2	Yes				
C56X	560XL Citation Excel	Yes				
C68A	680A Citation Latitude	Yes				
CL30	BD-100 Challenger 300	Yes				
CL35	BD-100 Challenger 350	Yes				
CL60	CL-600 Challenger 650	Yes				
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				

** 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
E170	ERJ-170-100	Yes				
E190	ERJ-190 Lineage 1000	Yes				
E195	ERJ-190-200	Yes				
E35L	EMB-135BJ Legacy	Yes				
E45X	EMB-145XR	Yes				
E55P	EMB-505 Phenom 300	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				
GL5T	Global 5000	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				
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				
BE30	300 Super King Air	Yes				
D328	328	Yes				
DH8A	Dash 8 (100)	Yes				
DH8D	Dash 8 (400)	Yes				
F50	50 Maritime Enforcer	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		
B78X	787-10 Dreamliner		Yes	B789		
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		
MD87	MD-87		Yes	MD88		
B461	BAe-146-100		Yes	B462		
B732	737-200		Yes	B733		
C25C	525C Citation CJ4		Yes	C550		
C525	525 Citation CJ1		Yes	C550		
C55B	550B Citation Bravo		Yes	C550		
C560	560 Citation 5		Yes	C550		
E75L	ERJ-170-200 (long wing)		Yes	E170		
E75S	ERJ-170-200 (short wing)		Yes	E170		
GA5C	Gulfstream G500 (G-7)		Yes	GLF5		
GA6C	G-7 Gulfstream G600		Yes	GLF5		
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		
LJ75	75		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		
E290	E190-E2		EF2 Method	E190		
E295	E195-E2		EF2 Method	E195		

** 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
BE20	Super King Air (200)					BE2
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
SB20	2000					S20
SC7	SC-7 Skyliner					SHS
SH33	SD3-30					SH3

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
SH36	360					SH6
SW2	SA-26 Merlin 2					SWM
YS11	YS-11					YS1

** 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 2021 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	75	4,315	8,555	13,682	19,253	24,823	30,394	35,965	41,649	47,900	54,151	60,403	66,654	72,906	79,157	85,408	
A333	70	4,681	9,291	14,110	19,970	25,829	31,689	37,549	43,408	50,047	56,687	63,326	69,965	76,604			
A339	-	5,061	10,121	15,182	20,243	25,303	30,364	35,424	40,485	45,546	50,606	55,667	60,728	65,788	70,849	75,910	
A343	312	4,638	10,726	16,815	22,904	28,992	35,081	41,972	49,265	56,558	63,850	71,143	78,435	85,728	93,021	100,313	
A346	84	6,497	12,910	19,323	25,736	34,080	43,375	52,670	61,965	71,260	80,555	89,849	99,144	108,439	117,734	127,029	136,324
A359	1,280	5,331	9,381	15,229	21,456	27,682	33,909	40,135	46,362	52,588	58,815	65,041	71,268	77,494	83,721	89,947	96,174
A388	4,939	10,878	20,871	30,864	40,857	50,850	63,978	78,534	93,089	107,645	122,201	136,757	151,313	165,869	180,425	194,981	209,537
B744	7	8,168	16,330	24,492	33,723	45,092	56,462	67,831	79,201	90,570	101,940	113,309	124,679	136,048	147,418	158,787	170,157
B748	1,072	7,746	15,736	25,134	34,531	43,928	53,326	62,927	74,771	86,615	98,460	110,304	122,148	133,992	145,836	157,680	169,525
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	964	3,612	7,863	12,259	16,655	21,052	25,798	31,150	36,501	41,852	47,203	52,554	57,905	63,256	68,608	73,959	
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	70	5,363	10,656	15,949	23,098	30,248	37,398	44,547	51,697	58,846	66,460	74,167	81,874	89,581	97,288	104,995	112,702
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	153	5,546	12,202	19,112	26,021	32,931	41,448	49,965	58,482	67,000	75,517	84,034	92,551	101,068	109,585	118,103	126,620
B77W	568	6,640	12,712	18,784	24,856	33,591	42,326	51,061	59,795	68,530	77,265	86,000	94,734	103,469	112,204	118,529	
B788	996	4,244	7,492	10,772	15,983	21,194	26,405	31,616	36,827	42,038	47,249	52,460	57,671	62,882	68,093	73,304	78,515
B789	118	4,069	8,312	13,142	17,972	22,801	28,434	34,334	40,234	46,134	52,034	57,934	63,834	69,734	75,634	81,534	87,434
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	54	1,731	3,728	5,874	8,020	10,198	12,389	14,581									
A21N	434	1,773	4,130	6,582	9,212	11,841	14,471	17,101	19,730								
A318	62	2,080	4,125	6,705	9,285	11,864	14,444	17,023	19,603								
A319	492	2,172	4,391	6,610	9,351	12,099	14,847	17,594	20,342								
A320	166	2,231	4,526	7,015	9,660	12,306	14,951										
A321	158	2,593	5,361	8,343	11,477	14,611	17,745	20,879									
B38M	407	2,189	4,421	6,704	8,963	10,985	13,006	15,027									
B722	119	3,720	7,783	12,013	16,243	20,473	24,703										
B733	112	2,217	4,466	7,023	9,580	12,138	14,695	17,252									
B734	340	2,406	4,714	7,022	9,329	11,637	13,944	16,252	18,560	20,867	23,175	25,483	27,790	30,098			
B735	77	2,135	4,192	6,249	8,307	10,364	12,421	14,479	16,536	18,593	20,651	22,708					
B736	391	1,894	3,812	5,730	7,648	9,566	11,484	13,402	15,321								
B737	192	2,064	4,152	6,463	8,799	11,242	13,685	16,128									
B738	16	1,991	4,468	7,097	9,490	11,883	14,276										
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							
MD82	173	2,805	5,615	8,602	11,590	14,577											
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												
C25B	29	441	852	1,264	1,676												
C550	101	548	939	1,318	1,698												
C56X	43	718	1,212	1,707	2,202												
C68A	1	833	1,558	2,207	2,855	3,504	4,153	4,801									
CL30	9	885	1,761	2,637	3,404	4,082	4,761										
CL35	58	935	1,680	2,423	3,166	3,909	4,652										
CL60	33	858	1,804	2,751	3,697	4,644	5,590	6,537	7,483								
CRJ1	40	1,110	2,059	2,998	3,936	4,874	5,812	6,750									
CRJ2	21	939	2,067	3,194	4,321	5,449	6,576	7,703									
CRJ7	26	1,367	2,901	4,223													
CRJ9	74	1,508	3,031	4,554													
CRJX	174	1,649	3,124														
DC95	1,549	3,673	5,797														
E135	10	1,080	2,150	3,220	4,290												
E145	70	1,041	2,013	2,984	3,955	4,926											

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
E170	130	1,455	3,020	4,585													
E190	205	1,758	3,705	5,651	7,598	9,544	11,491	13,438	15,384	17,331							
E195	18	1,779	3,887	6,064	8,241	10,418	12,595	14,772	16,949	19,126							
E35L	211	1,207	2,203	3,199	4,195	5,191	6,154	6,946	7,739								
E45X	47	1,144	2,314	3,484	4,655												
E55P	58	615	1,031	1,424	1,818												
F100	28	1,869	3,774	5,699	7,624	9,548											
F2TH	149	1,009	1,838	2,667	3,496	4,325	5,154	5,982	6,811								
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	64	1,186	2,308	3,431	4,553	5,675	6,797	7,920	9,042	10,164	11,287	12,409	13,531				
FA8X	123	1,073	2,330	3,587	4,844	6,102	7,359	8,616	9,873	11,130	12,387	13,645	14,902	16,159			
G280	-	727	1,531	2,336	3,140	3,945	4,749	5,554									
GL5T	464	1,713	2,962	4,398	5,939	7,480	9,021	10,562	12,104	13,645	15,186	16,727					
GLEX	316	1,715	3,114	4,514	5,913	7,480	9,047	10,615	12,182	13,749	15,316	16,883	18,451	20,018			
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	119	672	1,225	1,779	2,332	2,885	3,438										
RJ85	566	2,042	3,517	4,993	6,468												
AN26	98	985	1,872	2,759													
AT43	63	510	976	1,458	1,940	2,421											
AT45	100	552	1,126	1,703													
AT46	27	558															
AT72	34	553	1,072														
AT75	51	673															
AT76	2	576															
B190	-	298	600	902													
BE30	110	343	577	810	1,044												
D328	78	475	873														
DH8A	3	491	979														
DH8D	94	870	1,792														
F50	96	541	1,085	1,628	2,171	2,715	3,258	3,801									
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	598	4,797	8,996	13,195	17,394	21,593	25,792	29,991	34,189	38,388							
A338	-	5,012	10,024	15,036	20,049	25,061	30,073	35,085	40,097	45,109	50,122	55,134	60,146	65,158	70,170	75,182	80,195
A342	307	4,554	10,533	16,512	22,491	28,470	34,449	41,217	48,378	55,539	62,701	69,862	77,023	84,185	91,346	98,507	105,669
A345	85	6,557	13,030	19,503	25,976	34,398	43,779	53,161	62,543	71,924	81,306	90,687	100,069	109,451	118,832	128,214	137,595
A35K	1,461	6,084	10,706	17,380	24,486	31,591	38,697	45,803	52,909	60,015	67,120	74,226	81,332	88,438	95,544	102,649	109,755
B741	6	7,039	14,073	21,106	29,061	38,859	48,657	58,454	68,252	78,050							
B742	7	7,767	15,527	23,287	32,064	42,874	53,684	64,495	75,305	86,115	96,925	107,736	118,546	129,356	140,167		
B743	6	7,663	15,320	22,977	31,638	42,304	52,971	63,637	74,304	84,970	95,637	106,304	116,970	127,637	138,303	148,970	159,636
B74R	6	6,722	13,438	20,154	27,751	37,107	46,463	55,819	65,175	74,531	83,887	93,243	102,599				
B74S	6	6,558	13,111	19,663	27,075	36,203	45,331	54,459	63,587	72,716	81,844	90,972	100,100				
B78X	119	4,103	8,383	13,254	18,124	22,995	28,676	34,626	40,576	46,526	52,476	58,427	64,377	70,327	76,277	82,228	88,178
A19N	51	1,663	3,581	5,643	7,704	9,796	11,901	14,006	16,111								
B37M	382	2,052	4,143	6,283	8,400	10,295	12,189	14,084	15,978								
B39M	437	2,347	4,741	7,188	9,611	11,778	13,946	16,113									
B3XM	427	2,294	4,633	7,025	9,392	11,510	13,628	15,747									
MD81	167	2,701	5,407	8,284	11,160	14,037	16,914										
MD83	190	3,080	6,165	9,445	12,724	16,004	19,284	22,564	25,844								
MD87	156	2,763	5,369	7,865	9,154	10,442	11,731	13,020									
B461	262	1,604	3,416														
B732	100	1,972	3,972	6,246	8,520	10,795	13,069										
C25C	125	679	1,162	1,633	2,103												
C525	79	431	737	1,035													
C55B	109	593	1,015	1,426	1,836												
C560	119	647	1,107	1,555	2,002												
E75L	138	1,535	3,187	4,838													
E75S	133	1,488	3,089	4,690													
GA5C	269	1,448	2,628	3,808	4,988	6,167	7,347	8,527	9,707	10,886	12,066						
GA6C	323	1,741	3,160	4,578	5,996	7,415	8,833	10,252	11,670	13,088	14,507	15,925	17,344	18,762	20,180		
GA7C	22	1,573	3,124	4,675	6,225	7,776	9,327	10,878	12,429	13,979	15,530	17,081	18,632	20,183	21,733	23,284	24,835
H25A	59	737	1,337	1,937	2,537	3,137	3,737										
H25C	71	888	1,611	2,333													
LJ25	13	424	851	1,278													
LJ35	16	517	1,038	1,560	2,081	2,603											
LJ55	53	564	1,075	1,586	2,096												
LJ70	54	577	1,099	1,622	2,144												
LJ75	55	590	1,125	1,660	2,195												
RJ1H	168	1,984	3,800	5,616	7,432												
RJ70	564	2,035	3,505														
AN30	94	944	1,794	2,644													
AN32	110	1,108	2,106	3,104	4,056												
AT73	34	555	1,076														
DH8B	53	492	1,013														
DH8C	62	579	1,193														
DHC7	65	602															
E290	166	1,422	2,996	4,570	6,144	7,718	9,292										
E295	15	1,515	3,309	5,163	7,016	8,870											

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											
BE20	-	106	212	318	424												
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															
N262	-	302															
SB20	578	1,202	1,825	2,449													
SC7	-	200															
SH33	-	380															
SH36	-	406															
SW2	-	284	568	852	1,136												
YS11	-	706	1,411														

APPENDIX A-3: Aircraft types (by type designator) that will be the focus of further and targeted data collection towards the 2022 version of the ICAO CORSIA CERT

Note. - List based on estimated CO_2 emissions from international emissions in 2018. Sorted by decreasing CO_2 emissions. Some aircraft types that entered service in or shortly prior to 2018 for which CO_2 emissions were limited due to limited fleet size would be of special interest towards the data collection process for the 2022 CERT.

Type Designator	Manufacturer	Example of Model*
E75L	EMBRAER	ERJ-170-200 (long wing)
B39M	BOEING	737 MAX 9
MD83	BOEING	MD-83
B78X	BOEING	787-10 Dreamliner
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
C750	CESSNA	750
C680	CESSNA	680
B732	BOEING	737-200
SB20	SAAB	2000
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)
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Type Designator	Manufacturer	Example of Model*
C25A	CESSNA	525A
SW2	SWEARINGEN	SA-26 Merlin 2
C560	CESSNA	560 Citation 5
C25C	CESSNA	525C Citation CJ4
LJ75	LEARJET	75
FA20	DASSAULT	Falcon 200
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
BCS1	AIRBUS	BD-500 CSeries CS100
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

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