ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT): 2024 Version

— Design, Development and Validation —

November 2024

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1. INTRODUCTION

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

The ICAO CORSIA CERT tool supports aeroplane operators in:

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

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

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

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

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

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

2.1 General Overview

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

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

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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.

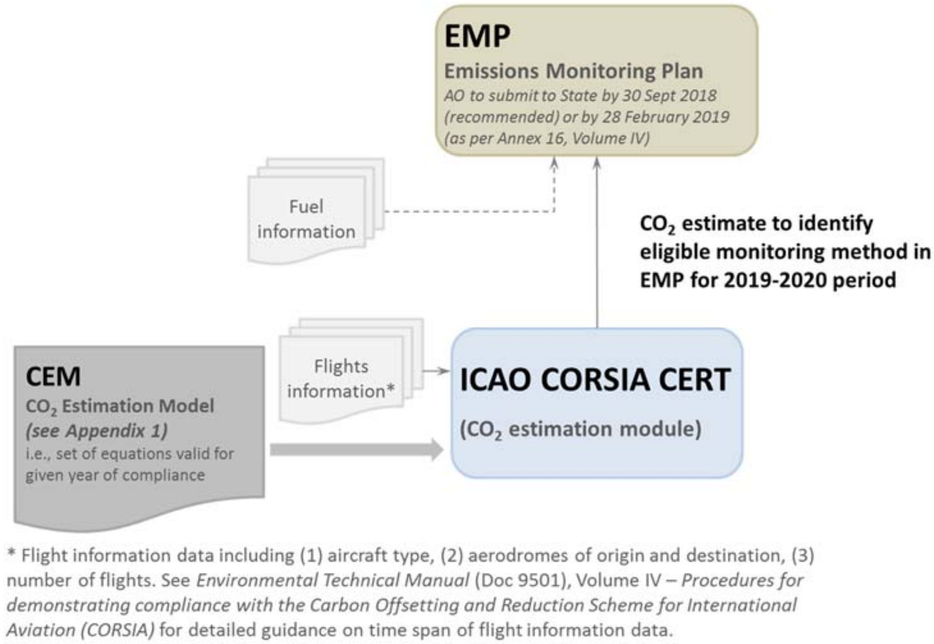

Figure 1: Architecture of CORSIA Emissions Monitoring Plan and reporting system (2018 or aeroplane operator year of entry into CORSIA)

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

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

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

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

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

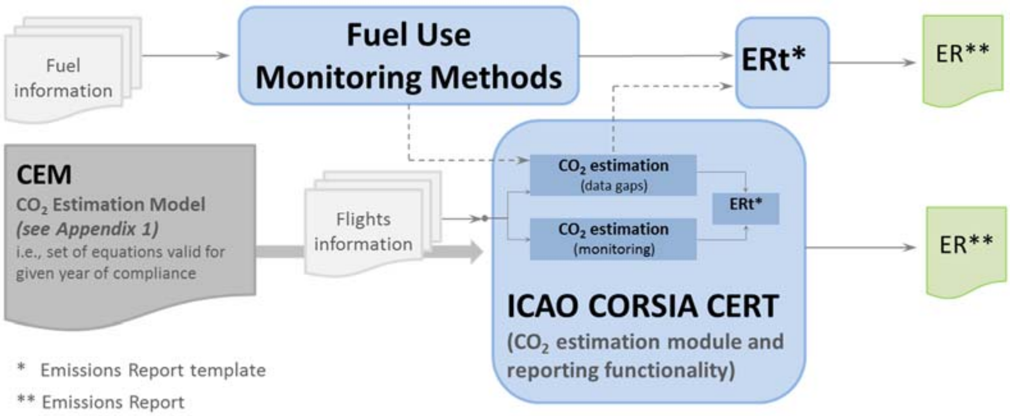

Figure 2: Architecture of CORSIA reporting system (2019 onward for compliance purposes)

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

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

2.2 Architecture of the 2024 Version of the ICAO CORSIA CERT

Based on requirements from Annex 16 Volume IV, a more detailed architecture of the 2024 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 2024

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 2024 version was built on the 2023 version with regard to the input of aeroplane operator information, the CO_2 estimation and the generation of a summary assessment functionalities. To meet the additional requirements from monitoring of emissions according to Annex 16 Volume IV, additional functionalities will be added in the 2019+ versions, including;

- ICAO CEMs: The 2024 version of the ICAO CORSIA CERT contains an updated set of ICAO CEMs based on the 2024 version of the COFdb.

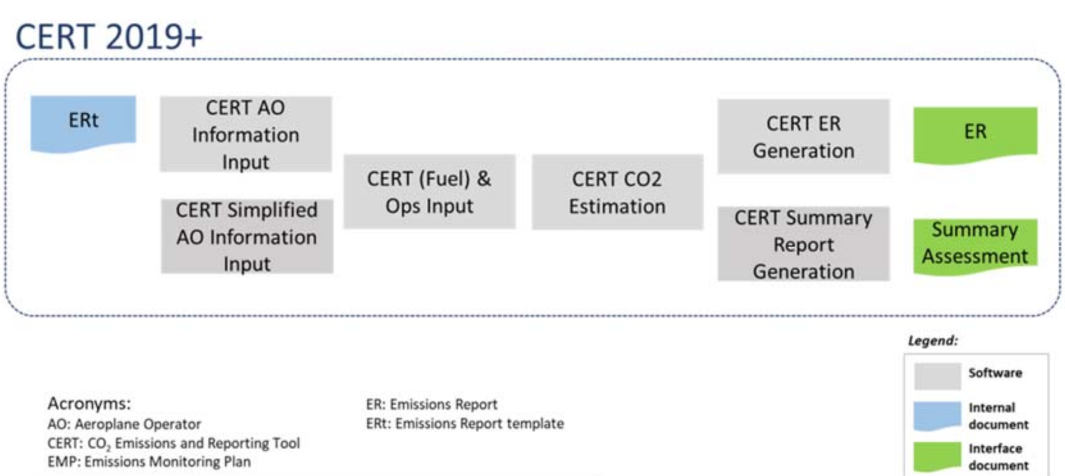

Figure 5: High Level Architecture of the 2019+ versions of the ICAO CORSIA CERT

In accordance with the requirements from Annex 16 Volume IV and the ETM Volume IV, the 2018 version of the ICAO CORSIA CERT only required the CO_2 estimation functionality and no reporting capabilities. The reporting functionality was added to the 2019 version which will be used by aeroplane operators to monitor (via estimation) and report their 2019 CO_2 emissions as well as to fill data gaps if needed. The template of the Emissions Report based on the Second Edition of the Environmental Technical Manual (ICAO Doc 9501) was integrated into the CERT 2024. The ICAO CORSIA CERT allows operators to automatically fill and export the Emissions Report.

2.2.3 Detailed Use Cases for the ICAO CORSIA CERT 2019+

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

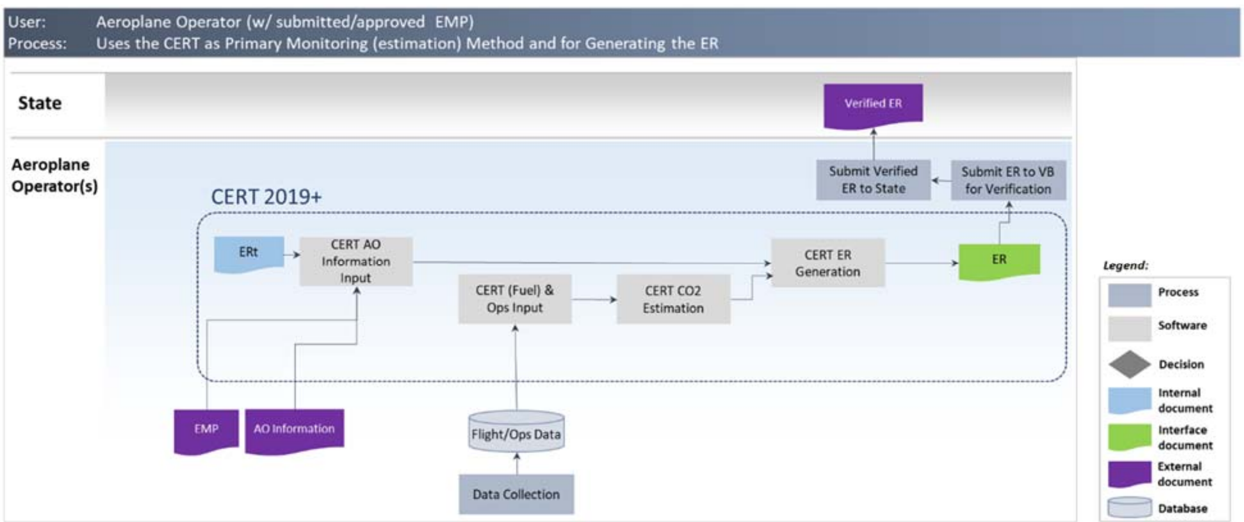

Figure 6: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator with an approved EMP and using the ICAO CORSIA CERT as primary monitoring method and to generate its ER

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

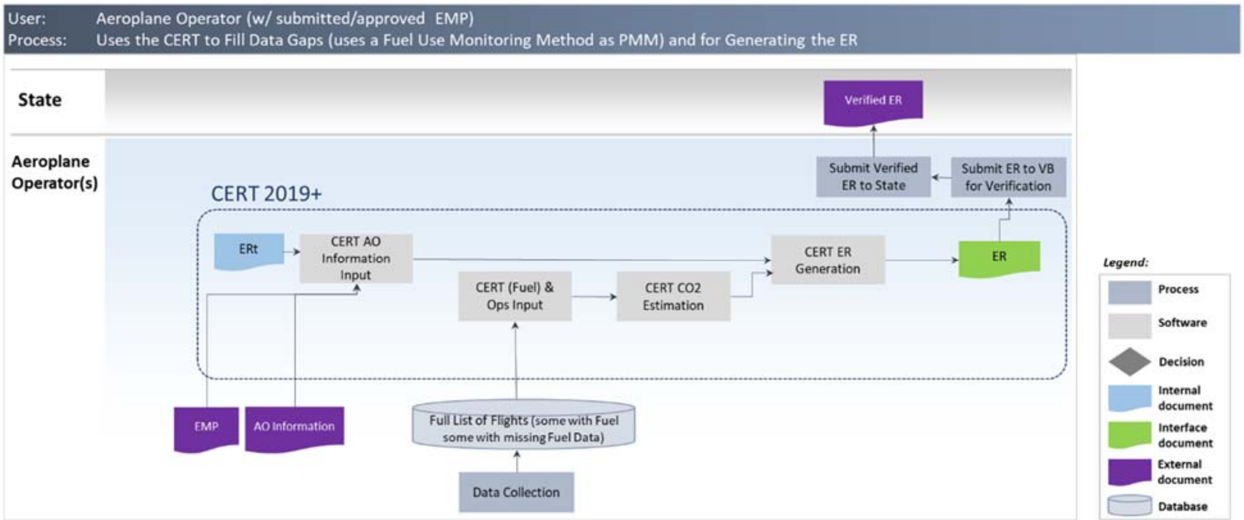

Figure 7: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator with an approved EMP and using the ICAO CORSIA CERT to fill data gaps and generate its ER

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

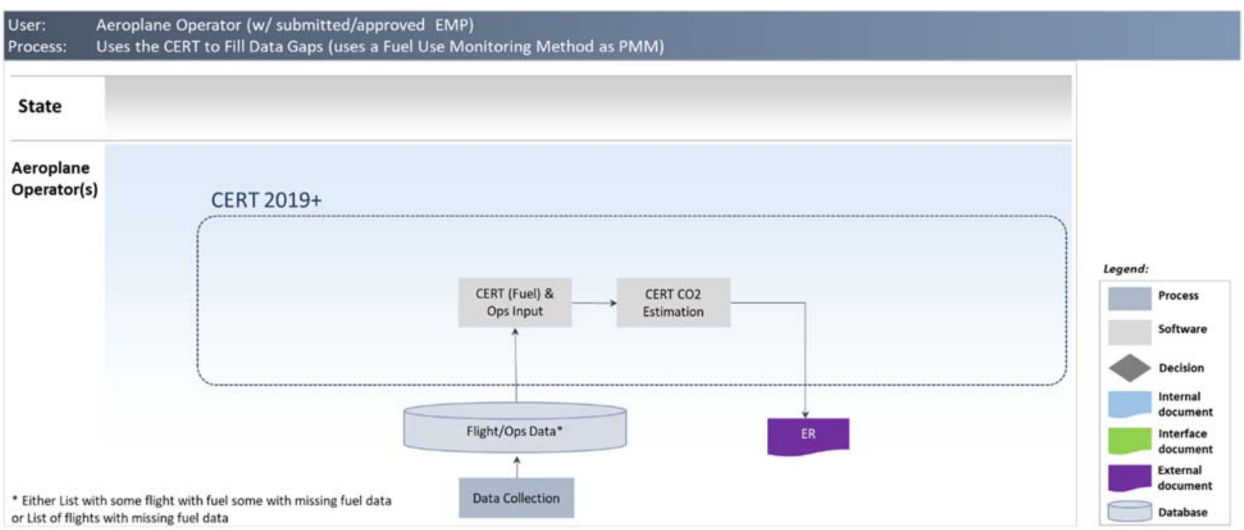

Figure 8: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator using the ICAO CORSIA CERT only to fill data gaps

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

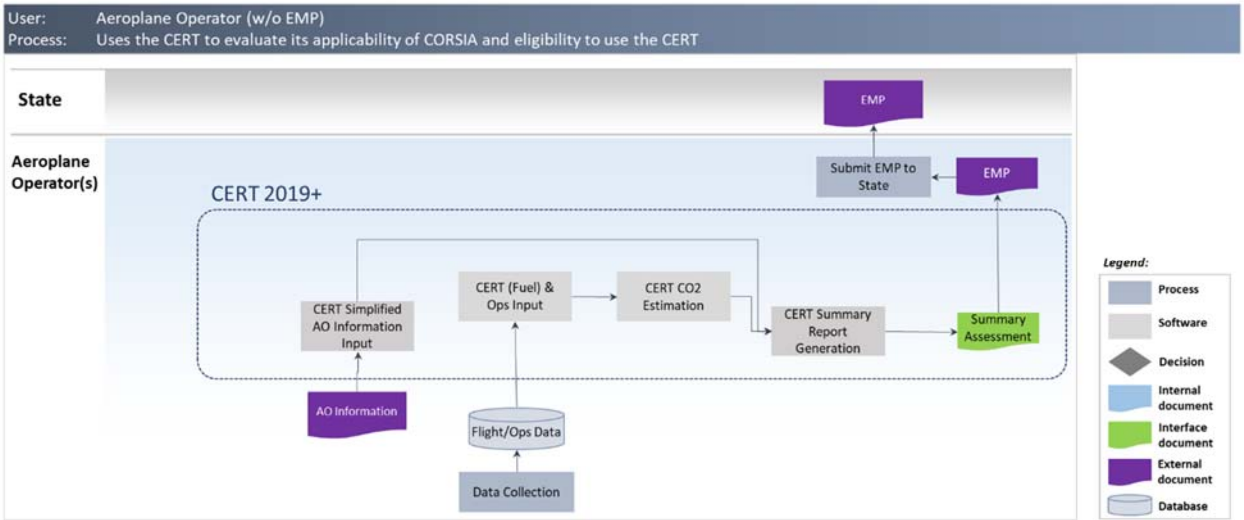

Figure 9: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for an aeroplane operator to determine the applicability of CORSIA and eligibility to user the ICAO CORSIA CERT

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

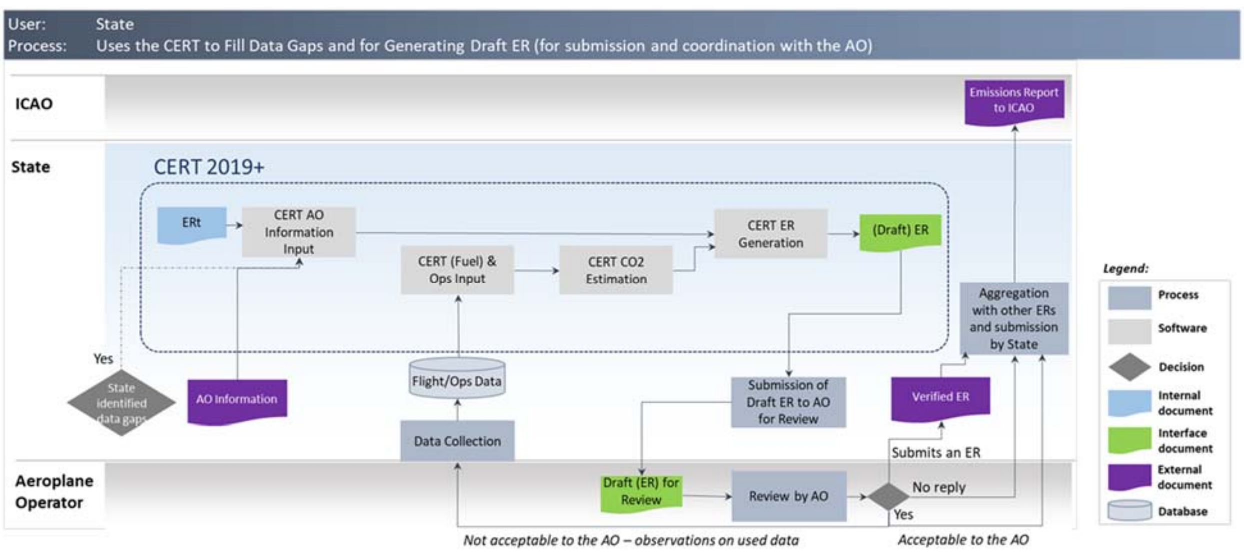

Figure 10: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for a State to fill data gaps

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

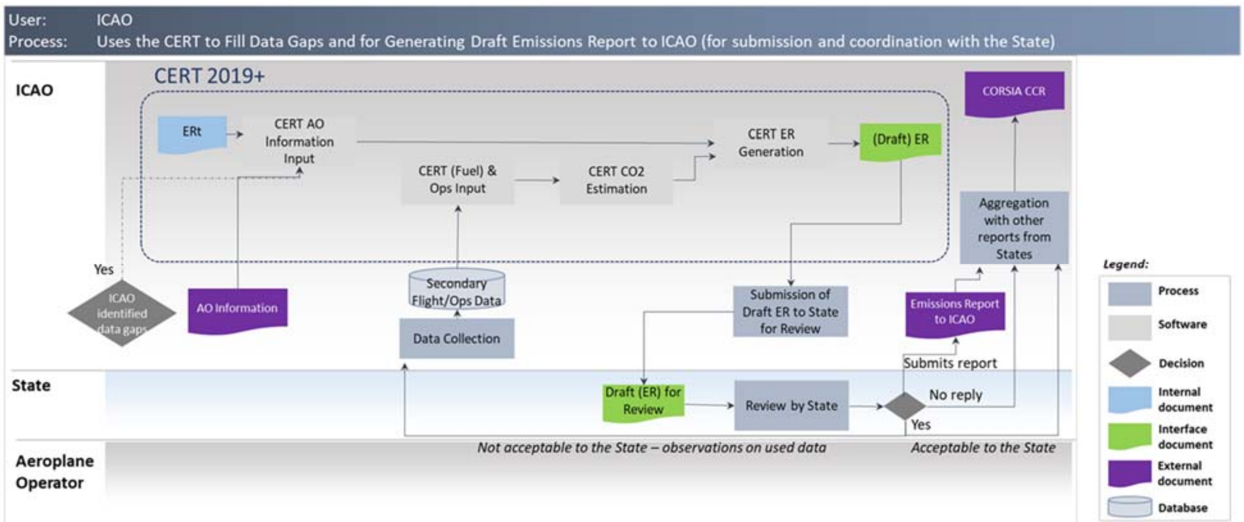

Figure 11: Mapping of processes supported by the 2019+ versions of the ICAO CORSIA CERT for ICAO to fill data gaps

3. DESIGN AND DEVELOPMENT OF THE ICAO CORSIA CERT

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

3.1 Functionality of the ICAO CORSIA CERT

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

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

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

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

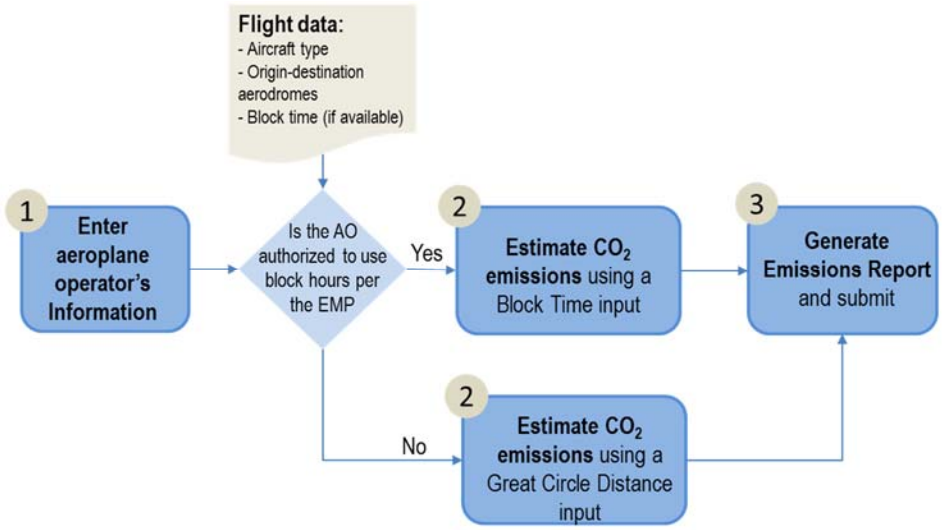

Figure 12: Overview of the high-level functions of the potential CORSIA CO_2 Estimation and Reporting Tool

3.2 Development of the ICAO CO_2 Estimation Models (CEMs)

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

3.2.1 Overview of the Process for Developing ICAO CEMs

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

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

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

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

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

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

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

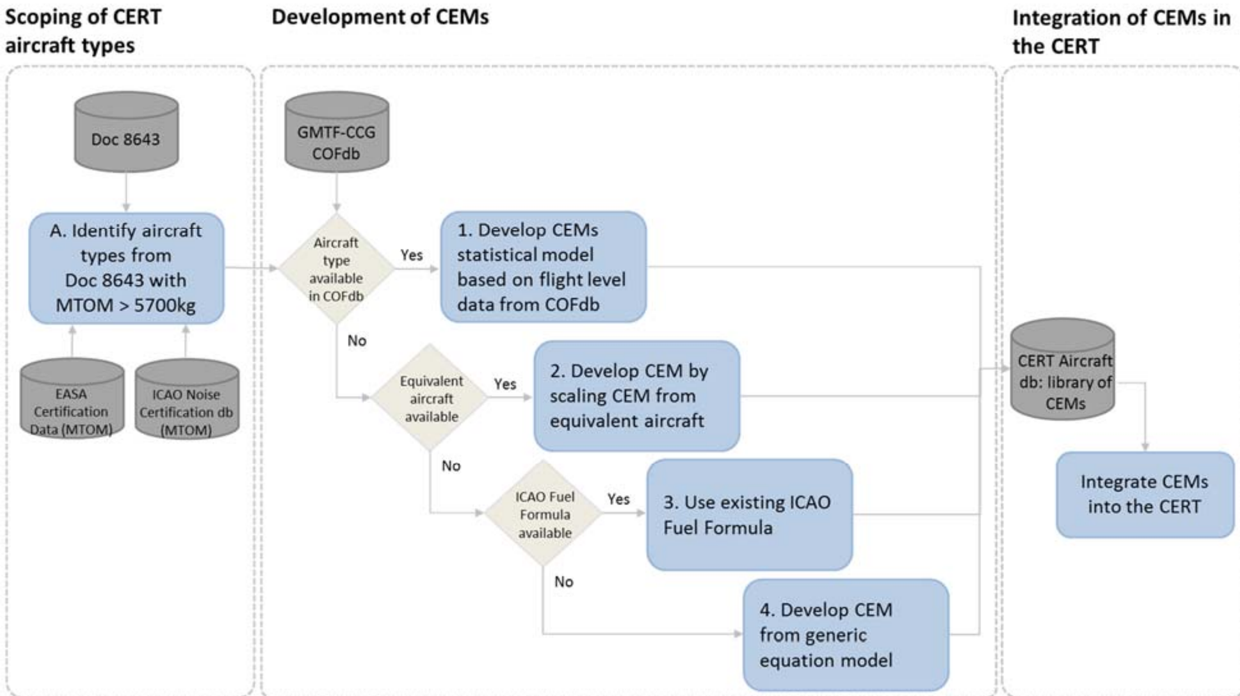

Figure 13: Summary of process for developing ICAO CO_2 Emissions Estimation Models (CEMs)

3.2.2 Scoping of ICAO CORSIA CERT aeroplane database

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

Data sources

- Doc 8643:
  - The 2024 version of the ICAO CORSIA CERT is based on the version of Doc 8643 that was last updated on 04 May 2024.
- Maximum Take Off Mass (MTOM):
  - The following version of the EASA Noise Certification Databases (www.easa.europa.eu/document-library/noise-type-certificates-approved-noise-levels) were used to obtain MTOM data by aircraft type.
    - EASA approved noise levels (Heavy propeller driven aeroplanes), Issue 35, last updated: 28 October 2021

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

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

Methodology

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

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

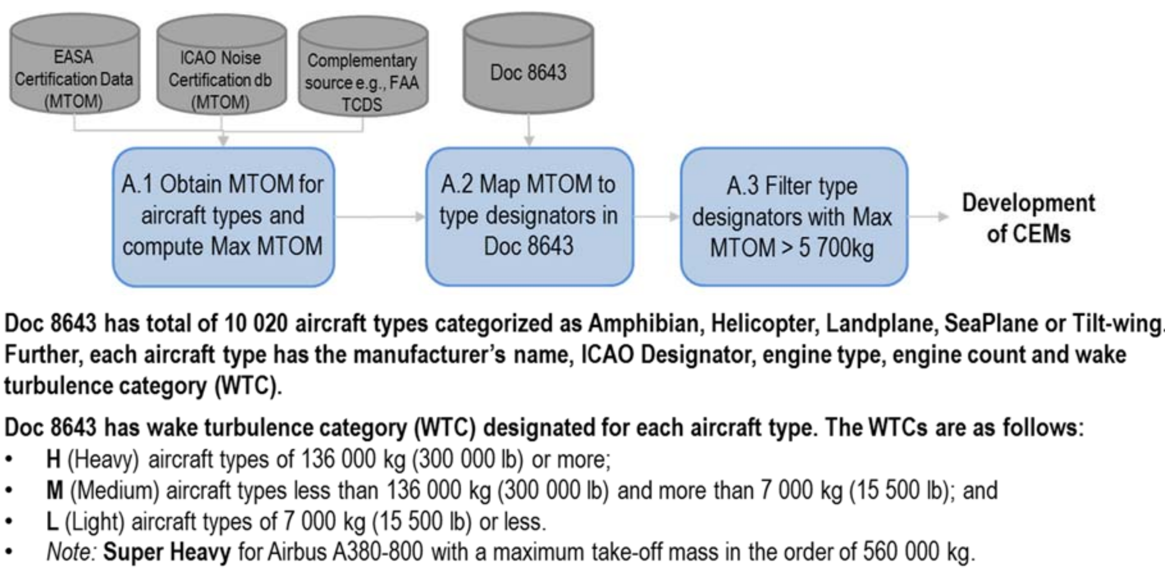

Figure 14: Development of list of aircraft types with MTOM>5 700kg for CORSIA CO_2 emissions estimation tool development process

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

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

Overview of the CCG Operations and Fuel database (COFdb)

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

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

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

When providing data to CAEP, DPOs are responsible for:

- validating, to the extent possible to the Organization, the correctness of the departure and arrival aerodrome as well as of the correct use of the ICAO aircraft type designator as per Doc 8643 for each flight having indeed been operated between those aerodromes, coordinating with the aeroplane operator as necessary;
- computing the Great Circle Distance, rounded to the kilometer, between the departure and arrival aerodrome, using the latitude and longitude of the aerodromes as provided in the applicable version of Doc 7910 (applicability determined on the basis of the date of flight and the date of issue of the ICAO Document) or applicable AIP information and with the Earth modelled according to the WGS84 reference system and geodetic datum; the Great Circle Distance field is to be left empty if either the departure or the arrival aerodrome is not available in Doc 7910;
- computing whether the flight is international or domestic on the basis of the departure and arrival aerodrome and in accordance with the prescriptions of Annex 16, Volume IV, Part II, Chapter 1, 1.1.2;
- including for each flight record a unique identifier per aircraft type, identifier which allows the DPO to identify the related flight data supplier in order to coordinate with the latter as and if required;
- ensuring that, when available, the block time is provided in minutes without decimals, leaving the field empty if not available;
- excluding from the provided data records for which:
    - o the validation of the first point is unsuccessful; or
    - o 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
    - o 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 2024 version of the ICAO CORSIA CERT

For the 2024 version of the ICAO CORSIA CERT, the COFdb version 2024_1.0 as of February 27, 2024 was used. This 2024 version 1.0 of the COFdb includes data from approximately 6.8 million flights (after removal of older data) for 136 aircraft types by ICAO Type Designator. Data ranged from 2006 to 2024 with about 85% of the data coming from 2017 to 2024.

Identifying and removing outliers from aeroplane operator's raw data

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

Regression model selection and development

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

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

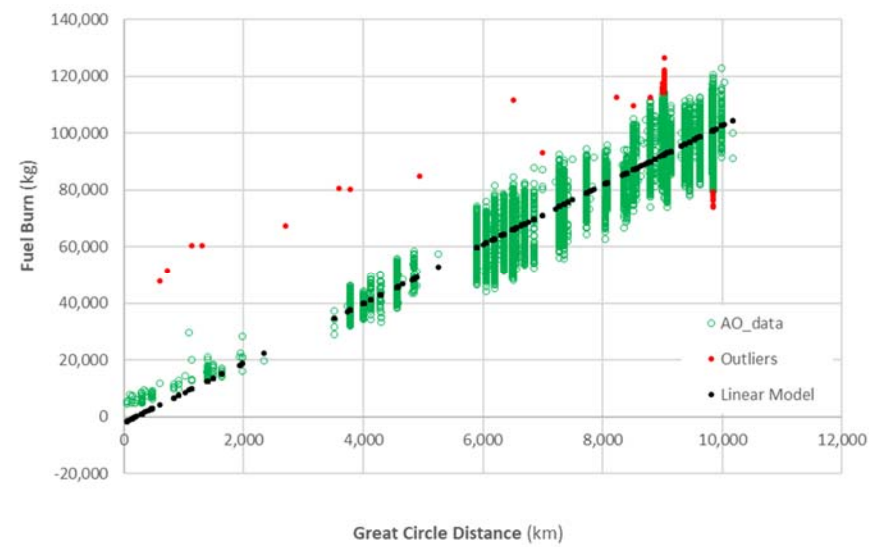

Figure 15: Illustration of sample data used to generate ICAO CEMs, including outlier data removed from the process of generating the ICAO CEM

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

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

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

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

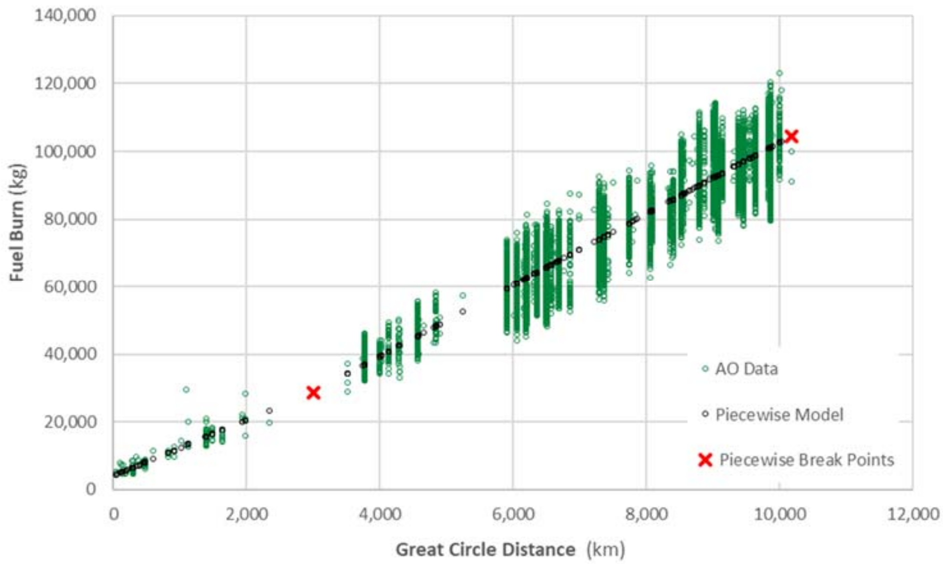

Figure 16: Illustration of fuel burn statistical method model formulation (GCD Model)

3.2.4 Development of ICAO CEMs based on equivalent aircraft types

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

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

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

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

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

3.2.5 ICAO CEMs based on ICAO Fuel Formula

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

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

3.2.6 Development of ICAO CEMs based on generic equation model

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

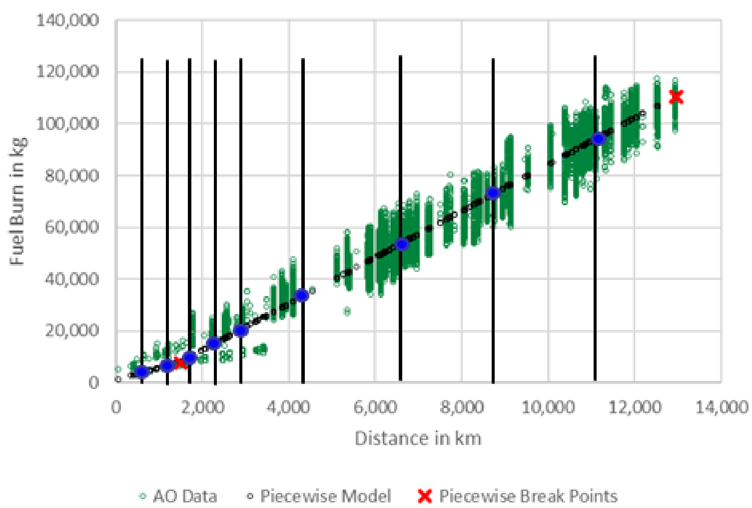

Figure 17: Illustration of process for binning data for developing generic equation

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

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

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

[4] Heavy Jets, Medium Jets, Turboprops and Turboshaft powered aircraft based on categorization included in Doc 8643.
[5] The Medium Jets category was split into two subcategories to capture different trends across the broad MTOM range from approximately 10 tonnes to approximately 120 tonnes. A breakpoint at 60 tonnes was established as it captures trends appropriately. In addition, the 60 tonnes thresholds leverages and is consistent with the ICAO CO_2 emissions standard (governed by Annex 16, Volume III) that includes a breakpoint at 60 tonnes certified MTOM.

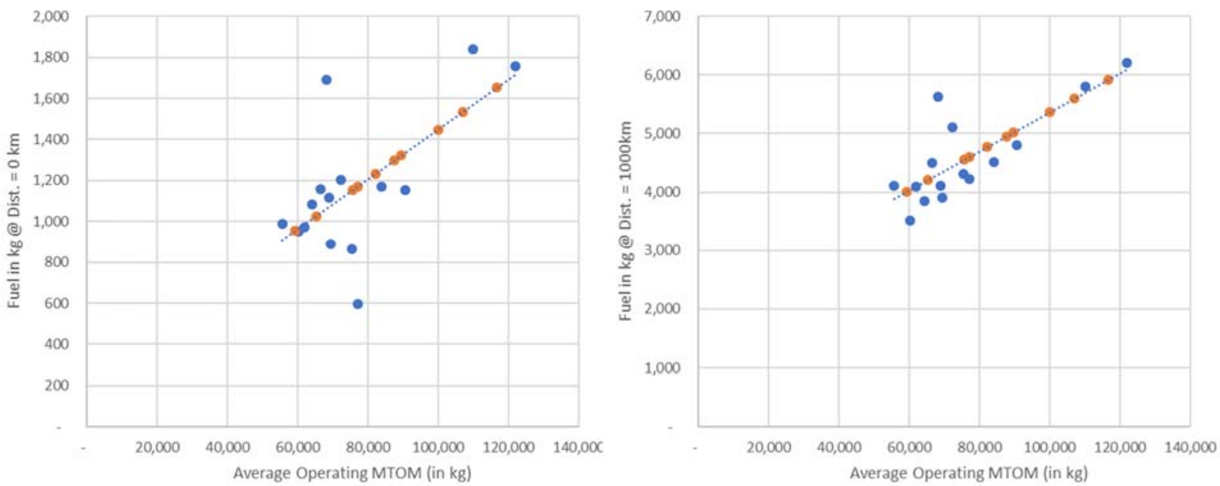

Figure 4: Illustration of generic aeroplane fuel burn-MTOM based regressions for a given distance

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

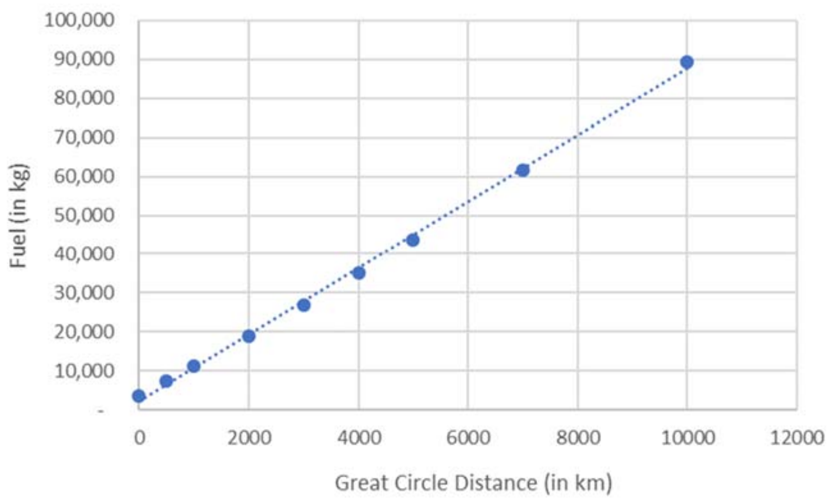

Figure 5: Illustration of generic aeroplane ICAO CEM

4. IMPLEMENTATION OF THE ICAO CORSIA CERT: VERSION 2024

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

The ICAO CORSIA CERT version 2024 -includes two key functionalities:

a) Summary of assessment of applicability of CORSIA and eligibility to use the ICAO CORSIA CERT in 2024,

b) CO_2 Estimation and Reporting for 2024.

4.1 Summary of assessment of applicability of CORSIA and eligibility to use the ICAO CORSIA CERT in 2024

The ICAO CORSIA CERT version 2024 takes the user through a simple three steps process where the user:

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

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

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

4.1.1 Aeroplane operator identification

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

4.1.2 Calculation of CO_2 emissions

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

4.1.3 Loading and entering data into the ICAO CORSIA CERT

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

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

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

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

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

Entering custom aeroplane codes

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

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

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

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

d) Turboprop.

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

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

The following coefficients are used in the 2024 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	-1664.869276	0.01527618	0.955725671	2.54277E-05
Jet with certified MTOM >= 60 000 kg and < 136 000 kg	100.5100799	0.011693273	1.053862628	2.91411E-05
Jet (Heavy) with certified MTOM < 60 000 kg	204.6994483	0.013666443	0.157986645	5.12399E-05
Turboprop	-12.97214409	0.013127282	0.337285445	4.77165E-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	3756.904256	-0.030431816	-0.617065586	0.000435849
Jet with certified MTOM >= 60 000 kg and < 136 000 kg	702.0216567	-0.011410619	4.825632398	0.000483445
Jet (Heavy) with certified MTOM < 60 000 kg	23.6098985	0.002002471	4.078066337	0.000534298
Turboprop	33.38052469	0.001952939	0.142480231	0.000480079

Figure 20: Coefficients used in the 2024 version of the ICAO CORSIA CERT to generate generic equations (as a function of entered Average MTOM) for aircraft types entered as custom aeroplane

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

CERT Aerodrome Database

The CERT Aerodrome database contained in the 2024 version of the CERT is based on the Edition 192 of the ICAO eDoc7910. Some aerodromes contained in ICAO eDoc 7910 with latitude and longitude in erroneous formats were addressed for the purpose of the development of the CERT Aerodrome database. The CERT aerodrome database also includes a short list of aerodromes that complement the subset of aerodromes from ICAO eDoc7910. Appendix C contains the short list of aerodromes to be added to the CERT Aerodrome database underlying the CERT 2024.

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

Entering custom aerodrome codes

If needed, the user can enter custom aerodrome codes in order to allow for the calculation of CO_2 emissions for each flight entered. The user is prompted to enter aerodrome latitude using WGS84 coordinates. In the 2024 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 2024.

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 2024 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 2024, 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 2024

The CO_2 Estimation and Reporting functionality of the ICAO CORSIA CERT version 2024 takes the user through each step of the Emissions Report generation process where the user:

a. Enters aeroplane operator identification and description of activities,

b. Enters underlying basic information of the Emissions Report,

c. Enters aeroplane fleet and fuel types

d. Select Fuel density

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

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

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

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

i. Completes the prefilled “Data gaps” information.

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

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

4.2.1 Starting to Fill the Emissions Report

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

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

4.2.2 Loading and entering data into the ICAO CORSIA CERT

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

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

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

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

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

Entering custom aeroplane codes

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

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

b) Jet with certified MTOM $\geq$ 60 000 kg and < 136 000 kg;

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

d) Turboprop.

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

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

The following coefficients are used in the 2024 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	-1664.869276	0.01527618	0.955725671	2.54277E-05
Jet with certified MTOM >= 60 000 kg and < 136 000 kg	100.5100799	0.011693273	1.053862628	2.91411E-05
Jet (Heavy) with certified MTOM < 60 000 kg	204.6994483	0.013666443	0.157986645	5.12399E-05
Turboprop	-12.97214409	0.013127282	0.337285445	4.77165E-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	3756.904256	-0.030431816	-0.617065586	0.000435849
Jet with certified MTOM >= 60 000 kg and < 136 000 kg	702.0216567	-0.011410619	4.825632398	0.000483445
Jet (Heavy) with certified MTOM < 60 000 kg	23.6098985	0.002002471	4.078066337	0.000534298
Turboprop	33.38052469	0.001952939	0.142480231	0.000480079

Figure 21: Coefficients used in the 2024 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 2024" 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 2024". See section 4.1.4 for details.

4.3 Data entry error and plausibility of input data

The ICAO CORSIA CERT 2024 version also includes a number of functionality that allows the user to identify potential data entry errors and confirm the accuracy of the input data, including;

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

warning are for information only. The intent is to identify potential input errors (e.g., order of magnitude error such as 0 added to input data).

4.4 Calculation of CO_2 emissions

4.4.1 The ICAO CORSIA CERT 2024 version builds on the 2023 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 2024 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 2024. The second edition (revision 1) version (September 2021) of CORSIA Implementation Element titled as "CORSIA States for Chapter 3 State Pairs" is available on the CORSIA website6. This document includes the list of 115 States that participate in CORSIA from 1 January 2024. The CCG developed functionality to embed this list in the CERT 2024 and scripts to calculate and report CO_2 emissions subject to offsetting requirements into the Emissions Report (ER) template.

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

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

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

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

- Total annual measured and/or estimated CO_2 emissions (international). It should be noted that emissions are for all international State pairs. For the 2024 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 2024 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

6 Reference: ICAO document, "CORSIA States for Chapter 3 State Pairs", Version October 2023, available at: https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA%20States%20for%20Chapter%203%20State%20Pairs_4Ed_rev_web.pdf, last retrieved on August 13th, 2024.

CORSIA CERT, total number of flights, fuel type, total mass of fuel, fuel conversion factors, total CO_2 emissions. In the 2024 version, the ICAO CORSIA CERT indicates whether the State Pair is subject to offsetting requirements.

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

- Total annual measured and/or estimated CO_2 emissions (international). It should be noted that emissions are for all international State pairs. For the 2024 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 2024 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 2024 version, the ICAO CORSIA CERT indicates whether the Aerodrome Pair is subject to offsetting requirements.

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

- Based on input and calculations in the “CO_2 Emissions Estimation & Data Gap Filling” section, the ICAO CORSIA CERT automatically assesses whether data gaps occurred during the reporting year and whether the threshold of 5 per cent for data gaps was exceeded and reports the percent of data gaps. The 2024 version of the ICAO CORSIA CERT follows the requirements from Annex 16 Volume IV, where starting in 2021, the percentage of data gaps are calculated by dividing the total number of flights subject to offsetting requirements with data gaps by total number of international flights subject to offsetting requirements.

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

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

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

To support the Emissions Reporting (ER) in 2024, the aeroplane operator can use the ICAO CORSIA CERT to estimate its emissions and generate a filled version of the Emissions Report.

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

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

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

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

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

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

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

6. PHASED DEVELOPMENT OF THE ICAO CORSIA CERT AND FEEDBACK

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

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

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

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

(iii) filling any CO_2 emissions data gaps.

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

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

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

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

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

APPENDIX A-1: ICAO CO_2 Estimation Model (CEM) based on Great Circle Distance (GCD) Input in version 2024 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				
B78X	787-10 Dreamliner	Yes				
MD11	MD-11	Yes				
A20N	A-320neo	Yes				
A21N	A-321neo	Yes				
A318	A-318	Yes				
A319	A-319	Yes				
A320	A-320	Yes				
A321	A-321	Yes				
B38M	737 MAX 8	Yes				
B722	727-200	Yes				
B733	737-300	Yes				
B734	737-400	Yes				
B735	737-500	Yes				
B736	737-600	Yes				
B737	737-700	Yes				
B738	737-800	Yes				
B739	737-900	Yes				
B752	757-200	Yes				
B753	757-300	Yes				
BCS1	BD-500 CSeries CS100	Yes				
BCS3	BD-500 CSeries CS300	Yes				
E295	E195-E2	Yes				
MD82	MD-82	Yes				
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				
C25C	525C Citation CJ4	Yes				
C550	550 Citation 2	Yes				
C56X	560XL Citation Excel	Yes				
C68A	680A Citation Latitude	Yes				
C750	750 Citation 10	Yes				
CL30	BD-100 Challenger 300	Yes				
CL35	BD-100 Challenger 350	Yes				
CL60	CL-600 Challenger 650	Yes				
CRJ1	Regional Jet CRJ-100	Yes				
CRJ2	Challenger 800	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
CRJ7	Challenger 870	Yes				
CRJ9	Challenger 890	Yes				
CRJX	Regional Jet CRJ-1000	Yes				
DC95	DC-9-50	Yes				
E135	ERJ-135	Yes				
E145	ERJ-145EP	Yes				
E170	ERJ-170-100	Yes				
E190	ERJ-190 Lineage 1000	Yes				
E195	ERJ-190-200	Yes				
E290	E190-E2	Yes				
E35L	EMB-135BJ Legacy	Yes				
E45X	EMB-145XR	Yes				
E55P	EMB-505 Phenom 300	Yes				
E75L	ERJ-170-200 (long wing)	Yes				
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				
LJ75	75	Yes				
RJ85	RJ-85 Avroliner	Yes				
AN26	An-26	Yes				
AT43	ATR-42-300	Yes				
AT45	ATR-42-500	Yes				
AT46	ATR-42-600	Yes				
AT72	ATR-72-201	Yes				
AT75	ATR-72-500	Yes				

** 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
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				
SB20	2000	Yes				
SF34	SF-340	Yes				
MD87	MD-87	Yes				
C525	525 Citation CJ1	Yes				
E75S	ERJ-170-200 (short wing)	Yes				
GA5C	Gulfstream G500 (G-7)	Yes				
GA6C	G-7 Gulfstream G600	Yes				
BE4W	Hawker 400XT	Yes				
GL7T	Global 7000	Yes				
AN72	An-72	Yes				
BE20	Super King Air (200)	Yes				
A225	An-225 Mriya	Yes				
AN22	AN22	Yes				
B350	King Air 350	Yes				
C25A	CitationJet/M2	Yes				
C510	Cessna Citation Mustang	Yes				
C650	650 Citation 3	Yes				
C680	680 Citation Sovereign	Yes				
E50P	Phenom100EV	Yes				
E545	EMB-545 Legacy 450	Yes				
E550	EMB-550 Legacy 500	Yes				
HDJT	HondaJet	Yes				
PC12	PC12	Yes				
PC24	PC-24	Yes				

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

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

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

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

Table A-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
BA11	BAC-111 One-Eleven					B11
DC91	DC-9-10					D91
DC92	DC-9-20					D92
DC93	DC-9-30					D93
DC94	DC-9-40					D94
F28	F-28 Fellowship					F28
FA10	Falcon 10					DF2
J328	Dornier 328JET					FRJ
S601	SN-601 Corvette					NDC
WW24	1124 Westwind					WWP
YK40	Yak-40					YK4
YK42	Yak-42					YK2
A140	IRAN-140 Faraz					A40
A748	748					HS7
AN12	An-12					ANF
AN24	An-24					AN4
AN28	An-28					A28
ATP	ATP					ATP
BELF	SC-5 Belfast					SHB
C130	L-100 Hercules					LOH
C212	C-212 Aviocar					CS2
CN35	CN-235					CS5
CVLP	Convairliner					CVR
CVLT	Cosmopolitan					CV5
D228	Dornier 228					D28
DC3	DC-3					DC3
DC6	DC-6					DC6
DHC6	DHC-6 Twin Otter					DHT
E110	EMB-110 Bandeirante					EMB
E120	EMB-120 Brasilia					EM2
F27	F-27					F27
G159	G-159 Gulfstream 1					GRS
I114	Il-114					I14
IL18	Il-18					IL8
JS31	BAe-3100 Jetstream 31					J31
JS32	BAe-3200 Jetstream Super 31					J32
JS41	BAe-4100 Jetstream 41					J41
L188	Electra (L-188)					LOE
L410	L-410 Turbolet					L4T
N262	N-262 Frégate					ND2
SC7	SC-7 Skyliner					SHS
SH33	SD3-30					SH3
SH36	360					SH6
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 2024 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	6,633	14,911	23,189	31,467	39,745	48,023	56,301	63,451	70,497	77,544	84,590						
A306	2,718	5,586	8,454	11,322	14,190	17,057	19,925	22,793	25,661	28,529	31,396	34,264	37,132	42,868			
A310	1,527	4,399	7,271	10,144	13,016	15,888	18,760	21,632	24,504	27,376	30,248	33,120	35,992	41,736	47,480	53,224	
A332	2,350	5,388	8,427	11,466	14,505	17,543	20,582	23,621	26,993	30,530	34,066	37,602	41,138	48,211	55,283	62,356	69,428
A333	2,114	6,033	9,952	13,307	16,612	19,917	23,222	26,527	29,832	33,137	36,442	39,810	43,203	49,990	56,777	63,564	70,351
A339	1,691	4,678	7,665	10,652	13,639	16,626	19,614	22,601	25,588	28,575	31,567	34,909	38,251	44,935	51,619	58,303	64,987
A343	2,684	6,486	10,289	14,091	17,894	21,696	25,499	29,301	33,104	36,906	40,709	44,511	48,314	56,171	65,581	74,991	82,034
A346	3,558	8,242	12,927	17,611	22,295	26,980	31,664	36,348	41,033	45,717	50,402	55,086	59,770	70,340	81,207	92,073	102,939
A359	3,007	6,301	9,595	12,889	16,183	19,477	22,771	26,065	29,358	32,652	35,946	39,240	42,534	49,866	57,382	64,898	72,414
A388	8,887	15,811	22,735	29,660	36,584	43,508	50,433	57,357	64,282	71,206	78,130	85,055	91,979	105,828	119,676	136,960	155,352
B744	5,174	10,951	16,728	22,505	28,282	34,059	39,836	45,613	51,390	57,167	62,944	68,721	74,498	86,052	99,107	113,116	127,125
B748	6,000	11,302	16,604	21,906	27,208	32,511	37,813	43,115	48,417	53,719	59,021	64,323	69,847	82,693	95,539	108,384	121,230
B762	1,279	4,146	7,012	9,878	12,744	15,610	18,476	21,342	24,209	27,075	29,941	32,807	35,673	41,406	47,138	52,870	
B763	1,573	4,433	7,293	10,153	13,012	15,872	18,732	21,592	24,452	27,380	30,449	33,518	36,587	42,725	48,863	55,001	61,139
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	3,253	7,024	10,794	14,564	18,334	22,104	25,874	29,644	33,415	37,185	40,955	44,725	48,495	56,749	65,104	73,459	81,814
B773	3,766	8,065	12,363	16,662	20,960	25,259	29,844	34,464	39,084	43,704	48,324	52,944	57,564	66,804	76,044	85,284	94,524
B77L	3,245	7,155	11,065	14,975	18,885	22,795	26,705	30,615	35,333	40,474	45,615	50,756	55,897	66,180	76,462	86,455	94,533
B77W	3,782	8,056	12,330	16,604	20,878	25,152	29,426	33,700	38,086	42,922	47,758	52,594	57,430	67,102	76,774	86,446	96,118
B788	2,035	4,592	7,148	9,705	12,261	14,818	17,374	19,931	22,822	25,821	28,819	31,818	34,816	40,813	46,810	52,807	58,804
B789	1,825	4,715	7,604	10,493	13,382	16,272	19,161	22,050	24,939	27,829	30,718	33,764	37,083	43,722	50,360	56,999	63,638
B78X	1,785	4,853	7,921	10,990	14,058	17,126	20,194	23,265	26,510	29,755	33,000	36,245	39,491	45,981	52,471	58,961	65,452
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	825	2,193	3,465	4,729	6,054	7,393	8,732	10,071	11,409	12,748	14,087	15,426	16,765				
A21N	908	2,372	3,836	5,300	6,764	8,376	9,991	11,607	13,222	14,838	16,453	18,069	19,684	22,915			
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	785	2,502	3,903	5,304	6,845	8,450	10,055	11,660	13,265	14,870	16,475	18,080	19,685				
A320	1,088	2,630	4,172	5,714	7,256	8,916	10,606	12,295	13,985	15,674	17,364	19,053					
A321	755	3,044	4,845	6,646	8,448	10,249	12,050	13,851	15,653	17,454	19,255	21,056	22,858				
B38M	665	1,991	3,318	4,646	6,041	7,436	8,832	10,227	11,622	13,017	14,413	15,808	17,203				
B722	1,227	4,495	7,086	9,514	11,943	14,371	16,800	19,228	21,657	24,085	26,514	28,942					
B733	705	2,495	4,007	5,518	7,030	8,541	10,053	11,564	13,076	14,587	16,099	17,610	19,122				
B734	1,082	2,606	4,130	5,698	7,267	8,836	10,405	11,974	13,543	15,112	16,681	18,250	19,819	22,957	26,095	29,233	32,371
B735	785	2,518	4,055	5,592	7,129	8,665	10,202	11,739	13,276	14,813	16,350	17,887	19,424	22,498	25,571	28,645	
B736	1,029	2,276	3,522	4,789	6,138	7,488	8,837	10,187	11,536	12,886	14,235	15,585	16,934	19,633			
B737	645	2,172	3,557	4,943	6,401	7,858	9,315	10,773	12,230	13,688	15,145	16,602	18,060				
B738	645	2,357	3,931	5,504	7,078	8,651	10,208	11,654	13,099	14,545	15,991	17,437					
B739	1,052	2,705	4,358	6,010	7,663	9,316	10,969	12,622	14,275	15,928	17,581						
B752	1,593	3,670	5,747	7,824	9,833	11,773	13,713	15,654	17,594	19,534	21,474	23,415	25,355	29,236	33,116		
B753	1,379	3,823	6,268	8,712	11,157	13,601	16,046	18,490	20,935	23,379	25,824	28,268	30,713	35,602	40,491		
BCS1	498	2,017	3,127	4,238	5,348	6,459	7,569										
BCS3	576	2,093	3,296	4,499	5,702	6,906	8,109	9,312	10,515								
E295	658	1,838	2,835	3,832	4,829	5,827	6,824	7,821	8,819	9,816							
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	119	554	804	1,053	1,302	1,552	1,801										
C25C	171	627	936	1,245	1,554	1,863	2,172	2,481	2,790								
C550	199	702	1,039	1,376	1,713	2,050	2,386	2,723									
C56X	219	767	1,109	1,450	1,792	2,133	2,475	2,816									
C68A	274	995	1,434	1,873	2,312	2,751	3,190	3,629	4,068	4,507	4,946	5,385	5,824				
C750	249	1,062	1,518	1,975	2,431	2,888	3,344	3,801	4,257	4,714	5,170	5,627	6,083				
CL30	251	1,009	1,522	2,035	2,548	3,054	3,545	4,037	4,528	5,019	5,511	6,002					
CL35	302	1,024	1,475	1,927	2,412	2,904	3,396	3,887	4,379	4,870	5,362	5,853					
CL60	326	1,056	1,649	2,242	2,861	3,509	4,157	4,804	5,452	6,099	6,747	7,394	8,042	9,337			
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	384	1,228	2,023	2,735	3,447	4,159	4,871	5,583	6,295	7,007	7,719	8,431	9,143				

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
CRJ7	501	1,665	2,655	3,646	4,636	5,627											
CRJ9	579	1,773	2,778	3,759	4,740	5,720											
CRJX	566	1,847	2,926	4,004	5,082												
DC95	1,684	3,675	5,666	7,657													
E135	252	1,325	2,086	2,695	3,304	3,913	4,522	5,130	5,739								
E145	311	1,272	1,947	2,623	3,298	3,974	4,649	5,325	6,000								
E170	495	1,773	2,734	3,939	5,145	6,350	7,556										
E190	662	2,099	3,288	4,488	5,736	6,984	8,232	9,480	10,728	11,976	13,225	14,473	15,721	18,217	20,713		
E195	493	2,154	3,471	4,789	6,106	7,424	8,741	10,058	11,376	12,693	14,011	15,328	16,646	19,280	21,915		
E290	562	1,801	2,705	3,609	4,513	5,417	6,321	7,226	8,130	9,034	9,938						
E35L	325	1,237	1,897	2,556	3,216	3,875	4,535	5,194	5,854	6,513	7,173	7,832	8,492	9,811			
E45X	327	1,392	2,196	2,999	3,752	4,463	5,175	5,886									
E55P	209	670	944	1,209	1,475	1,741	2,006	2,272									
E75L	572	1,649	2,678	3,628	4,578	5,528	6,478										
F100	713	2,268	3,571	4,868	6,165	7,462	8,759	10,056	11,353								
F2TH	317	1,045	1,554	2,064	2,574	3,083	3,593	4,102	4,612	5,121	5,631	6,140	6,650	7,669			
F70	640	1,957	3,126	4,296	5,466	6,635	7,805										
F900	388	1,149	1,764	2,378	2,993	3,607	4,222	4,836	5,451	6,065	6,680	7,295	7,909	9,138	10,367		
FA50	321	1,084	1,698	2,196	2,693	3,190	3,688	4,185	4,682	5,180	5,677	6,174	6,672				
FA7X	389	1,361	2,040	2,720	3,399	4,078	4,758	5,437	6,116	6,796	7,475	8,155	8,834	10,193	11,551	12,910	14,269
FA8X	396	1,245	1,959	2,674	3,389	4,103	4,818	5,532	6,247	6,962	7,676	8,391	9,106	10,535	11,964	13,393	14,823
G280	281	876	1,357	1,839	2,320	2,801	3,282	3,764	4,245	4,726	5,207	5,688	6,170				
GL5T	760	1,741	2,632	3,501	4,370	5,239	6,108	6,978	7,847	8,716	9,585	10,454	11,323	13,062	14,800	16,538	
GLEX	622	1,748	2,623	3,498	4,373	5,247	6,122	6,997	7,872	8,747	9,622	10,497	11,372	13,122	14,872	16,622	18,372
GLF4	534	1,813	2,520	3,226	4,072	4,918	5,765	6,611	7,457	8,304	9,150	9,997	10,843	12,536			
GLF5	716	1,697	2,491	3,285	4,079	4,874	5,668	6,462	7,256	8,050	8,844	9,638	10,432	11,991	13,527	15,064	16,601
GLF6	392	1,633	2,437	3,241	4,045	4,849	5,653	6,457	7,261	8,065	8,869	9,673	10,477	12,085	13,693	15,301	16,909
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	132	654	985	1,315	1,645	1,976	2,306										
LJ45	119	683	1,021	1,360	1,698	2,037	2,375	2,714	3,052								
LJ60	205	645	1,023	1,400	1,778	2,156	2,534	2,912	3,290	3,668	4,046						
LJ75	123	588	909	1,230	1,551	1,872	2,193	2,514									
RJ85	911	2,487	4,063	5,639	7,215	8,791	10,367	11,943									
AN26	261	1,656	3,022	3,714	4,406	5,098											
AT43	118	719	1,274	1,829	2,383	2,938	3,493	4,047	4,602	5,157	5,711						
AT45	100	825	1,415	2,005	2,595	3,184	3,774										
AT46	138	865	1,510														
AT72	54	866	1,489	2,112	2,735												
AT75	134	890	1,581	2,273													

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
AT76	175	923	1,623														
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	260	1,174	2,014	2,854	3,694												
F50	108	865	1,486	2,107	2,727	3,348	3,969	4,590	5,211	5,832	6,453	7,074	7,695				
SB20	387	1,005	1,623	2,241	2,859	3,477											
SF34	149	617	1,085	1,553	2,021	2,489											
MD87	1,691	3,154	4,616	6,079	7,720	9,517	11,315	13,112	14,910	16,707	18,505	20,302	22,100				
C525	101	462	693	924	1,155	1,386											
E75S	671	1,951	3,072	4,165	5,258	6,351	7,444	8,537	9,630								
GA5C	563	1,457	2,182	2,843	3,505	4,166	4,828	5,489	6,151	6,812	7,474	8,135	8,797	10,120	11,443	12,766	
GA6C	481	1,581	2,395	3,209	4,023	4,838	5,652	6,466	7,280	8,094	8,908	9,723	10,537	12,165	13,794	15,422	17,050
BE4W	159	512	780	1,047	1,315	1,582	1,850	2,118	2,385								
GL7T	686	1,520	2,354	3,189	4,023	4,857	5,691	6,525	7,360	8,194	9,028	9,862	10,696	12,365	14,033	15,702	17,370
AN72	1,122	2,635	4,148	5,662	7,175	8,688	10,202	11,715	13,228								
BE20	162	405	647	890	1,132	1,375	1,617	1,860									
A225	1,381	15,731	30,081	44,431	58,781	73,131	87,481	101,831	116,181	129,335	137,665	145,995	154,325	170,985	187,645	204,305	220,965
AN22	4,238	10,352	16,466	22,580	28,694	34,808	40,922	47,036	53,150	59,264	65,378						
B350	161	431	701	971	1,241	1,511	1,781	2,051	2,321								
C25A	90	532	769	1,007	1,245	1,482	1,720										
C510	92	405	617	784	950												
C650	228	886	1,324	1,763	2,202	2,641	3,080	3,519	3,958	4,397							
C680	211	941	1,390	1,839	2,288	2,736	3,185	3,634	4,083	4,532	4,980	5,429					
E50P	118	420	644	838	1,032	1,226											
E545	434	917	1,399	1,882	2,365	2,848	3,331	3,813	4,296	4,779	5,262						
E550	227	1,000	1,488	1,975	2,462	2,949	3,437	3,924	4,411	4,898	5,385	5,873					
HDJT	90	436	663	841	1,018												
PC12	68	282	465	647	830	1,013	1,195										
PC24	165	712	1,043	1,375	1,706	2,038	2,370										

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

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	8000	9000	10000
A30B	2,634	5,413	8,192	10,970	13,749	16,528	19,307	22,085	24,864	27,643	30,421	33,200	35,979	41,536	47,094		
A338	1,665	4,607	7,550	10,492	13,434	16,376	19,318	22,260	25,203	28,145	31,092	34,384	37,675	44,259	50,842	57,425	64,009
A342	2,529	6,112	9,696	13,279	16,862	20,446	24,029	27,612	31,196	34,779	38,362	41,946	45,529	52,934	61,801	70,669	77,305
A345	3,592	8,322	13,052	17,782	22,512	27,242	31,972	36,702	41,431	46,161	50,891	55,621	60,351	71,023	81,995	92,967	103,939
A35K	3,458	7,246	11,033	14,821	18,608	22,395	26,183	29,970	33,758	37,545	41,333	45,120	48,908	57,339	65,981	74,624	83,266
B741	4,426	9,368	14,309	19,251	24,193	29,135	34,077	39,019	43,960	48,902	53,844	58,786	63,728	73,611	84,779		
B742	4,894	10,358	15,823	21,288	26,752	32,217	37,681	43,146	48,610	54,075	59,540	65,004	70,469	81,398	93,747	106,998	120,250
B743	4,916	10,404	15,893	21,382	26,870	32,359	37,848	43,337	48,825	54,314	59,803	65,291	70,780	81,758	94,161	107,471	120,781
B74R	4,236	8,966	13,696	18,425	23,155	27,885	32,615	37,345	42,074	46,804	51,534	56,264	60,994	70,453	81,142	92,612	104,081
B74S	4,108	8,696	13,283	17,871	22,458	27,046	31,633	36,221	40,808	45,396	49,983	54,571	59,158	68,333	78,700	89,824	100,949
A19N	822	2,185	3,453	4,712	6,033	7,367	8,701	10,036	11,370	12,704	14,038	15,372	16,706				
B37M	629	1,884	3,140	4,396	5,716	7,036	8,356	9,676	10,997	12,317	13,637	14,957	16,277	18,917			
B39M	721	2,159	3,598	5,037	6,550	8,063	9,576	11,088	12,601	14,114	15,627	17,139	18,652				
B3XM	703	2,107	3,510	4,915	6,391	7,867	9,343	10,819	12,295	13,771	15,247	16,723	18,199				
MD81	792	2,771	4,749	6,728	8,706	10,685	12,664	14,642	16,621	18,599	20,578						
MD83	902	3,155	5,409	7,662	9,915	12,168	14,421	16,674	18,927	21,181	23,434	25,687	27,940	32,446			
B461	676	2,160	3,645	5,129													
B732	623	2,208	3,546	4,883	6,221	7,559	8,896	10,234	11,571	12,909	14,246						
C55B	216	759	1,123	1,488	1,852	2,216	2,580	2,945									
C560	235	828	1,225	1,623	2,020	2,417	2,815	3,212									
FA6X	412	1,441	2,161	2,880	3,600	4,319	5,039	5,758	6,478	7,197	7,917	8,636	9,356	10,795	12,234	13,673	15,112
GA7C	441	1,835	2,738	3,641	4,544	5,447	6,350	7,253	8,156	9,059	9,962	10,865	11,768	13,574	15,380	17,186	18,992
H25A	219	744	1,144	1,544	1,944	2,344	2,744	3,145	3,545	3,945	4,345						
H25C	263	894	1,374	1,855	2,335	2,816											
LJ25	94	468	704	941	1,177	1,413	1,650										
LJ35	115	571	859	1,148	1,436	1,724	2,013	2,301	2,589	2,877							
LJ55	116	666	997	1,327	1,657	1,988	2,318										
LJ70	120	684	1,024	1,363	1,702	2,041	2,381	2,720									
RJ1H	690	2,631	4,571	6,512	8,453	10,393	12,334	14,274	16,215								
RJ70	899	2,455	4,011	5,566	7,122												
AN30	250	1,587	2,896	3,559	4,223	4,886											
AN32	293	1,863	3,400	4,178	4,957	5,735	6,514										
AT73	54	866	1,490	2,113	2,736												
DH8B	147	664	1,138	1,613													
DH8C	174	783	1,343	1,903	2,463												
DHC7	180	814	1,397														

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									
BA11	558	2,209	3,861	5,512	7,164	8,815	10,467	12,118	13,770	15,421							
DC91	685	2,234	3,784	5,333													
DC92	693	2,262	3,830	5,399	6,967	8,536											
DC93	741	2,418	4,095	5,772	7,449	9,126	10,803	12,480	14,157	15,834	17,511						
DC94	796	2,596	4,397	6,197	7,998	9,798	11,599										
F28	419	2,221	3,404	4,588	5,771	6,955	8,138	9,322	10,505								
FA10	159	844	1,293	1,743	2,192	2,642	3,091										
J328	183	968	1,484	2,000													
S601	184	407	630	853	1,076	1,299											
WW24	122	646	990	1,334	1,678	2,022	2,366	2,710	3,054								
YK40	171	906	1,389	1,872													
YK42	703	3,514	5,076	6,638	8,200	9,762	11,324	12,886	14,448								
A140	314	963	1,612	2,261	2,909	3,558	4,207										
A748	321	982	1,644	2,306													
AN12	1,262	3,335	5,408	7,482	9,555	11,629	13,702	15,776	17,849	19,923	21,996	24,069					
AN24	433	1,135	1,837	2,539	3,241												
AN28	157	482	806														
ATP	282	865	1,447	2,029	2,612	3,194	3,777	4,359	4,942								
BELF	397	3,910	6,502	9,094	11,686	14,278	16,870	19,462	22,054	24,646	27,238	29,830	32,422	37,606	42,790		
C130	869	2,664	4,459	6,254	8,049	9,844	11,639	13,434									
C212	138	423	707	992													
CN35	210	642	1,075	1,507	1,940	2,372	2,805	3,237	3,670								
CVLP	20	1,294															
CVLT	20	1,294	1,856	2,418	2,980	3,542	4,104	4,666									
D228	115	353	590	828	1,065	1,303											
DC3	6	397	569	742	914												
DC6	22	1,412	2,026	2,639	3,253	3,866	4,480	5,093	5,707	6,320	6,934	7,547	8,161	9,388			
DHC6	26	366	608														
E110	35	342	569	796													
E120	169	539	909	1,279													
F27	48	1,048	1,743	2,438	3,133	3,828	4,523	5,218	5,913	6,608							
G159	90	977	1,625	2,273	2,921	3,569	4,217	4,865	5,513								
I114	113	1,195	1,987														
IL18	890	2,729	4,567	6,405	8,243	10,082	11,920										
JS31	120	369	618														
JS32	129	394	659														
JS41	177	544	910	1,276	1,642	2,008	2,375	2,741									
L188	287	3,149	5,236	7,324	9,411	11,499	13,586	15,674									
L410	49	434	722	1,010													
N262	132	404	677														
SC7	87	267	448														
SH33	166	508	850	1,193													
SH36	177	544	910	1,276													
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 2024 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.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
B78X	787-10 Dreamliner	Yes				
MD87	MD-87	Yes				
C25C	525C Citation CJ4	Yes				
C525	525 Citation CJ1	Yes				
E75L	ERJ-170-200 (long wing)	Yes				
E75S	ERJ-170-200 (short wing)	Yes				
GA5C	Gulfstream G500 (G-7)	Yes				
GA6C	G-7 Gulfstream G600	Yes				
LJ75	75	Yes				
E290	E190-E2	Yes				
E295	E195-E2	Yes				
AN72	An-72	Yes				
BE20	Super King Air (200)	Yes				
SB20	2000	Yes				
C750	750 Citation 10	Yes				
BCS1	BD-500 CSeries CS100	Yes				
BCS3	BD-500 CSeries CS300	Yes				
BE4W	Hawker 400XT	Yes				
GL7T	Global 7000	Yes				
A225	An-225 Mriya	Yes				
AN22	AN22	Yes				
B350	King Air 350	Yes				
C25A	CitationJet/M2	Yes				
C510	Cessna Citation Mustang	Yes				
C650	650 Citation 3	Yes				
C680	680 Citation Sovereign	Yes				
E50P	Phenom100EV	Yes				
E545	EMB-545 Legacy 450	Yes				
E550	EMB-550 Legacy 500	Yes				
HDJT	HondaJet	Yes				
PC12	PC12	Yes				
PC24	PC-24	Yes				

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

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

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

** 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
BA11	BAC-111 One-Eleven					B11
DC91	DC-9-10					D91
DC92	DC-9-20					D92
DC93	DC-9-30					D93
DC94	DC-9-40					D94
F28	F-28 Fellowship					F28
FA10	Falcon 10					DF2
J328	Dornier 328JET					FRJ
S601	SN-601 Corvette					NDC
WW24	1124 Westwind					WWP
YK40	Yak-40					YK4
YK42	Yak-42					YK2
A140	IRAN-140 Faraz					A40
A748	748					HS7
AN12	An-12					ANF
AN24	An-24					AN4
AN28	An-28					A28
ATP	ATP					ATP
BELF	SC-5 Belfast					SHB
C130	L-100 Hercules					LOH
C212	C-212 Aviocar					CS2
CN35	CN-235					CS5
CVLP	Convairliner					CVR
CVLT	Cosmopolitan					CV5
D228	Dornier 228					D28
DC3	DC-3					DC3
DC6	DC-6					DC6
DHC6	DHC-6 Twin Otter					DHT
E110	EMB-110 Bandeirante					EMB
E120	EMB-120 Brasilia					EM2
F27	F-27					F27
G159	G-159 Gulfstream 1					GRS
I114	Il-114					I14
IL18	Il-18					IL8
JS31	BAe-3100 Jetstream 31					J31
JS32	BAe-3200 Jetstream Super 31					J32
JS41	BAe-4100 Jetstream 41					J41
L188	Electra (L-188)					LOE
L410	L-410 Turbolet					L4T
N262	N-262 Frégate					ND2
SC7	SC-7 Skyliner					SHS
SH33	SD3-30					SH3
SH36	360					SH6
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 Block Time (BT) Input in version 2024 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)																
Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
A124	1,904	11,472	22,451	34,191	45,932	57,672	69,412										
A306	603	4,836	9,070	13,303	17,536	21,769	26,002	30,235	34,469								
A310	388	3,204	7,525	11,898	16,272	20,645	25,018	29,391	33,764	38,137	42,511	46,884					
A332	-	4,677	9,473	14,343	19,213	24,738	30,642	36,546	42,450	48,354	54,258	60,161	66,065	71,969	77,873	83,777	
A333	-	4,450	9,526	14,603	19,680	25,844	32,008	38,172	44,336	50,499	56,663	62,827	68,991	75,155			
A339	162	3,551	8,442	13,333	18,224	23,115	28,006	33,895	39,814	45,733	51,652	57,571	63,490	69,409	75,328	81,247	
A343	-	4,442	10,011	16,632	23,253	29,874	36,495	43,116	49,737	57,041	64,553	72,066	79,578	87,090	94,603	102,115	
A346	-	6,354	14,001	21,648	29,295	36,943	44,590	52,237	61,324	70,794	80,264	89,735	99,205	108,675	118,145	127,615	137,085
A359	-	4,762	9,790	15,085	20,380	25,990	32,421	38,852	45,283	51,714	58,145	64,576	71,007	77,438	83,869	90,300	96,731
A388	550	8,807	19,788	31,994	44,201	56,408	68,615	80,822	93,071	107,754	122,437	137,120	151,803	166,486	181,169	195,852	210,535
B744	-	6,367	16,321	26,276	36,231	46,645	57,519	68,393	79,266	90,140	101,014	111,887	122,761	133,634	144,508	155,382	166,255
B748	-	7,525	16,789	26,053	35,317	44,581	53,845	63,109	74,892	86,805	98,718	110,631	122,544	134,457	146,370	158,283	170,196
B762	628	3,792	7,471	12,354	17,237	22,121	27,004	31,887	36,770	41,653	46,537	51,420					
B763	342	3,322	7,986	12,650	17,314	21,978	26,657	31,700	36,744	41,787	46,830	51,874	56,917	61,961	67,004	72,047	
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	253	5,066	10,233	16,493	22,753	29,079	36,566	44,052	51,539	59,026	66,512	73,999	81,486	88,972	96,459	103,946	111,432
B773	2,761	7,040	11,477	18,926	26,375	33,436	39,992	46,547	53,102	59,658	66,213	72,768	79,324	85,879	92,435	98,990	
B77L	-	6,459	12,917	19,376	25,834	32,345	40,860	49,503	58,146	66,789	75,431	84,074	92,717	101,360	110,003	118,645	127,288
B77W	259	6,075	11,892	18,019	26,726	35,433	44,140	52,847	61,554	70,261	78,968	87,675	96,351	103,611	110,871	118,131	
B788	-	3,729	7,825	12,104	16,383	20,661	25,980	31,435	36,890	42,346	47,801	53,256	58,711	64,167	69,622	75,077	80,533
B789	3	4,057	8,248	13,084	17,920	22,757	27,593	33,225	39,355	45,485	51,615	57,745	63,874	70,004	76,134	82,264	88,394
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	125	1,864	3,880	6,022	8,163	10,305	12,447	14,588									
A21N	-	2,078	4,314	6,669	9,325	11,981	14,637	17,294	19,950								
A318	62	2,080	4,125	6,705	9,285	11,864	14,444	17,023	19,603								
A319	195	2,156	4,388	6,664	9,280	11,896	14,513	17,129	19,745								
A320	-	2,254	4,606	7,208	9,809	12,410	15,011										
A321	179	2,606	5,371	8,444	11,517	14,590	17,663	20,736									
B38M	380	1,613	3,607	5,869	8,131	10,393	12,654	14,916									
B722	640	3,723	7,788	11,853	15,919	19,984	24,049										
B733	363	2,141	4,365	6,781	9,197	11,613	14,029	16,445									
B734	302	2,200	4,564	7,022	9,480	11,938	14,396	16,854	19,312	21,770	24,228	26,686	29,143	31,601			
B735	79	2,135	4,192	6,248	8,305	10,362	12,418	14,475	16,531	18,588	20,644	22,701					
B736	24	1,894	3,813	5,733	7,652	9,571	11,491	13,410	15,329								
B737	27	1,803	3,937	6,209	8,480	10,752	13,023	15,295									
B738	204	1,998	4,407	6,950	9,488	11,852	14,217										
B739	575	2,367	4,858	7,536	10,214	12,892	15,570										
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	60	445	829	1,214	1,599												
C550	10	525	956	1,345	1,735												
C56X	21	629	1,191	1,677	2,163												
C68A	2	811	1,579	2,199	2,819	3,438	4,058	4,678									
CL30	4	852	1,700	2,548	3,347	4,114	4,882										
CL35	6	819	1,597	2,375	3,153	3,930	4,708										
CL60	40	846	1,783	2,720	3,715	4,712	5,709	6,707	7,704								
CRJ1	40	1,110	2,059	2,998	3,936	4,874	5,812	6,750									
CRJ2	3	843	1,887	2,987	4,087	5,187	6,288	7,388									
CRJ7	26	1,367	2,901	4,223													
CRJ9	94	1,539	2,984	4,428													
CRJX	-	1,616	3,000														
DC95	1,549	3,673	5,797														
E135	-	1,078	2,172	3,266	4,361												
E145	7	1,040	2,033	3,006	3,979	4,952											

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)																
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	245	1,781	3,677	5,573	7,468	9,364	11,259	13,155	15,051	16,946							
E195	-	1,819	3,900	6,041	8,183	10,324	12,466	14,608	16,749	18,891							
E35L	1	1,007	2,018	3,029	4,067	5,118	6,168	7,218	8,269								
E45X	47	1,144	2,314	3,484	4,655												
E55P	7	556	1,008	1,402	1,796												
F100	-	1,855	3,833	5,573	7,277	8,981											
F2TH	87	920	1,752	2,585	3,418	4,251	5,084	5,917	6,750								
F70	137	1,641	3,340	5,039													
F900	-	921	1,968	3,014	4,060	5,071	6,051	7,031	8,012	8,992	9,972						
FA50	94	1,139	2,022	2,905	3,787	4,670	5,553	6,436									
FA7X	19	1,189	2,359	3,529	4,698	5,868	7,038	8,208	9,378	10,548	11,718	12,887	14,057				
FA8X	49	1,093	2,339	3,586	4,833	6,079	7,326	8,573	9,820	11,066	12,313	13,560	14,807	16,053			
G280	-	782	1,568	2,355	3,141	3,927	4,714	5,500									
GL5T	147	1,562	2,976	4,396	5,889	7,383	8,877	10,371	11,865	13,359	14,852	16,346					
GLEX	101	1,504	2,907	4,311	5,714	7,217	8,772	10,328	11,883	13,439	14,994	16,550	18,105	19,661			
GLF4	51	1,466	2,822	4,026	5,465	6,904	8,343	9,782	11,221								
GLF5	323	1,671	3,019	4,367	5,714	7,062	8,410	9,758	11,105	12,453	13,801	15,149	16,496	17,844	19,192	20,540	21,887
GLF6	4	1,442	2,880	4,318	5,755	7,193	8,631	10,101	11,587	13,073	14,559	16,045	17,531	19,017	20,503	21,989	
H25B	63	797	1,445	2,093	2,742	3,390											
LJ31	88	487	950	1,414													
LJ40	38	590	1,141	1,692													
LJ45	43	611	1,179	1,748	2,316												
LJ60	48	574	1,153	1,732	2,311	2,890	3,468										
RJ85	363	1,958	3,553	5,149	6,744												
AN26	4	929	1,853	2,777													
AT43	52	507	972	1,444	1,917	2,390											
AT45	10	590	1,153	1,695													
AT46	27	558															
AT72	28	553	1,078														
AT75	95	642															
AT76	1	577															
B190	-	298	600	902													
BE30	110	343	577	810	1,044												
D328	78	475	873														
DH8A	3	491	979														
DH8D	8	888	1,834														
F50	96	541	1,085	1,628	2,171	2,715	3,258	3,801									
SF34	108	373	638	902													

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)																
Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
B78X	1,045	4,724	8,403	12,082	16,120	22,749	29,379	36,008	42,637	49,267	55,896	62,525	69,154	75,784	82,413	89,042	95,672
MD87	82	2,621	5,161	7,720	10,528	13,337	16,145	18,954									
C25C	8	552	1,045	1,501	1,957												
C525	49	366	683	1,001													
E75L	-	1,429	2,961	4,435													
E75S	387	1,490	2,672	4,444	6,217												
GA5C	1	1,300	2,599	3,859	5,010	6,161	7,312	8,463	9,614	10,765	11,916						
GA6C	30	1,409	2,788	4,168	5,547	6,926	8,305	9,684	11,063	12,442	13,821	15,200	16,579	17,958	19,337		
LJ75	-	523	1,045	1,568	2,091												
E290	197	1,541	2,885	4,229	5,573	6,917	8,262										
E295	9	1,559	3,143	4,795	6,448	8,101											
AN72	313	1,933	3,552	5,171	6,790	8,410											
BE20	61	299	537	776	1,014												
SB20	-	849	1,698	2,548													
C750	-	861	1,767	2,583	3,400	4,217	5,034	5,850									
BCS1	-	1,654	3,379	5,100													
BCS3	22	1,666	3,551	5,436	7,297	9,155											
BE4W	-	440	853	1,249	1,645												
GL7T	-	1,326	2,732	4,138	5,544	6,951	8,357	9,763	11,169	12,575	13,981	15,387	16,794	18,200	19,606	21,012	22,418
A225	-	16,790	34,453	52,291	70,128	87,966	105,804	123,641	141,479	155,493	166,777	178,060	189,343	200,627	211,910	223,193	234,476
AN22	462	7,231	14,001	20,771	27,541	34,311											
B350	61	335	610	885	1,160												
C25A	55	407	786	1,132													
C510	-	326	575														
C650	53	815	1,535	2,249	2,963	3,677											
C680	5	763	1,521	2,279	2,931	3,505	4,080										
E50P	1	331	639														
E545	41	822	1,602	2,382	3,163	3,943	4,723										
E550	24	835	1,645	2,445	3,208	3,971	4,734										
HDJT	71	365	658														
PC12	0	186	360	524													
PC24	68	574	1,081	1,587													

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)																
: Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
A30B	584	4,686	8,788	12,890	16,991	21,093	25,195	29,297	33,398	37,500							
A338	160	3,498	8,315	13,132	17,950	22,767	27,584	33,385	39,215	45,045	50,874	56,704	62,534	68,364	74,194	80,024	85,854
A342	-	4,186	9,434	15,673	21,912	28,152	34,391	40,631	46,870	53,753	60,833	67,912	74,991	82,071	89,150	96,229	103,309
A345	-	6,416	14,137	21,859	29,580	37,301	45,023	52,744	61,920	71,482	81,044	90,606	100,168	109,731	119,293	128,855	138,417
A35K	-	5,475	11,257	17,345	23,434	29,884	37,279	44,674	52,068	59,463	66,858	74,253	81,647	89,042	96,437	103,831	111,226
B741	-	5,446	13,962	22,478	30,993	39,902	49,204	58,505	67,807	77,109							
B742	-	6,022	15,439	24,855	34,272	44,123	54,408	64,694	74,979	85,265	95,550	105,836	116,121	126,407	136,693		
B743	-	6,049	15,507	24,965	34,423	44,318	54,649	64,980	75,311	85,642	95,973	106,304	116,635	126,966	137,297	147,628	157,959
B74R	-	5,213	13,363	21,513	29,664	38,190	47,093	55,995	64,898	73,800	82,703	91,606	100,508				
B74S	-	5,056	12,961	20,866	28,771	37,041	45,675	54,310	62,945	71,579	80,214	88,849	97,483				
A19N	125	1,858	3,866	6,001	8,135	10,269	12,403	14,537	16,672								
B37M	359	1,526	3,413	5,553	7,693	9,833	11,973	14,113	16,254								
B39M	412	1,749	3,911	6,363	8,816	11,268	13,720	16,173									
B3XM	402	1,706	3,816	6,208	8,601	10,994	13,387	15,780									
MD81	167	2,711	5,426	8,312	11,199	14,086	16,973										
MD83	191	3,087	6,179	9,466	12,754	16,041	19,328	22,616	25,903								
B461	262	1,606	3,419														
B732	322	1,894	3,863	6,001	8,139	10,277	12,415										
C55B	11	567	1,034	1,455	1,876												
C560	12	619	1,128	1,587	2,046												
GA7C	4	1,619	3,234	4,849	6,464	8,079	9,694	11,345	13,014	14,683	16,352	18,021	19,690	21,359	23,028	24,697	26,366
H25A	59	739	1,340	1,941	2,542	3,143	3,745										
H25C	71	888	1,610	2,332													
LJ25	27	422	816	1,211													
LJ35	33	515	996	1,477	1,958	2,439											
LJ55	42	596	1,151	1,705	2,260												
LJ70	43	612	1,182	1,751	2,321												
RJ1H	169	1,989	3,809	5,629	7,449												
RJ70	358	1,933	3,508														
AN30	4	890	1,776	2,661													
AN32	5	1,045	2,084	3,124	4,040												
AT73	28	553	1,078														
DH8B	5	502	1,037														
DH8C	5	592	1,223														
DHC7	6	616															
FA6X	20	1,259	2,498	3,737	4,976	6,215	7,454	8,693	9,932	11,171	12,410	13,649					

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)															
: Designator	0.11756	185.7787	359.8102	524.2779												
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											
BA11	-	3,057	6,114	9,172	12,229	15,286										
DC91	-	2,638	5,276													
DC92	-	2,670	5,340	8,010												
DC93	-	2,855	5,709	8,564	11,419	14,274	17,128									
DC94	-	3,065	6,130	9,195												
F28	-	2,000	4,000	6,000	8,000	10,000										
FA10	-	760	1,520	2,280	3,040											
J328	-	872	1,744													
S601	-	376	752													
WW24	-	582	1,163	1,745	2,326	2,908										
YK40	-	816	1,632													
YK42	683	3,316	5,949	8,582	11,214											
A140	-	720	1,440	2,160												
A748	-	734	1,469													
AN12	354	2,651	4,947	7,243	9,539	11,835	14,132									
AN24	126	903	1,680													
AN28	-	360														
ATP	-	646	1,293	1,939	2,586	3,232										
BELF	-	2,880	5,760	8,640	11,520	14,400	17,280	20,160	23,040	25,920						
C130	-	1,992	3,984	5,976	7,968											
C212	-	316														
CN35	-	480	960	1,440	1,920	2,400										
CVLP	-															
CVLT	-	992	1,984	2,976	3,968											
D228	-	264	527	791												
DC3	-	304	608													
DC6	-	1,082	2,165	3,247	4,330	5,412	6,494	7,577	8,659							
DHC6	-	270														
E110	-	252	504													
E120	4	413														
F27	-	772	1,544	2,316	3,088	3,860										
G159	-	720	1,440	2,160	2,880											
I114	-	880														
IL18	-	2,040	4,080	6,120												
JS31	-	276														
JS32	-	294														
JS41	-	406	813	1,219	1,626											
L188	-	2,319	4,638	6,958	9,277											
L410	-	320														
N262	-	302														
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 2024 version of the ICAO CORSIA CERT

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

Type Designator	Manufacturer	Example of Model*
	#N/A	#N/A
B39M	BOEING	737 MAX 9
MD83	BOEING	MD-83
A35K	AIRBUS	A-350-1000 XWB
DC10	BOEING	DC-10
F28	FOKKER	F-28 Fellowship
A30B	AIRBUS	A-300B2
IL76	ILYUSHIN	Il-76
SU95	SUKHOI	Superjet 100-95
IL96	ILYUSHIN	Il-96
AN12	ANTONOV	An-12
A345	AIRBUS	A-340-500
B742	BOEING	747-200
T204	TUPOLEV	Tu-204
A148	ANTONOV	An-148
RJ1H	AI(R)	RJ-100 Avroliner
B732	BOEING	737-200
BE40	BEECH	400
A342	AIRBUS	A-340-200
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
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)
C560	CESSNA	560 Citation 5
FA20	DASSAULT	Falcon 200
H25C	BRITISH AEROSPACE	Hawker 1000
HA4T	HAWKER BEECHCRAFT	4000 Hawker 4000
FA10	DASSAULT	Falcon 10
ATP	BRITISH AEROSPACE	ATP
T154	TUPOLEV	Tu-154
...		
	...continue on top of next column	
	... continued from previous column	
B721	BOEING	727-100
G150	GULFSTREAM AEROSPACE	Gulfstream G150
MD81	BOEING	MD-81
DHC6	DE HAVILLAND CANADA	DHC-6 Twin Otter
JS31	BRITISH AEROSPACE	BAe-3100 Jetstream 31
DC87	DOUGLAS	DC-8-70
GALX	GULFSTREAM AEROSPACE	Gulfstream G200
C551	CESSNA	551
D228	DORNIER	Dornier 228
CN35	AIRBUS	CN-235
JS41	AI(R)	BAe-4100 Jetstream 41
E110	EMBRAER	EMB-110 Bandeirante
GLF3	GULFSTREAM AEROSPACE	G-1159A
T134	TUPOLEV	Tu-134
B461	BRITISH AEROSPACE	BAe-146-100
SH36	SHORT	360
AJ27	COMAC	ARJ-21-700 Xiangfeng
C212	AIRBUS	C-212 Aviocar
LJ55	GATES LEARJET	55
G159	GRUMMAN	G-159 Gulfstream 1
YK40	YAKOVLEV	Yak-40
B37M	BOEING	737 MAX 7
L101	LOCKHEED	L-1011 TriStar
SC7	SHORT	SC-7 Skyliner
A748	AIL	748
I114	ILYUSHIN	Il-114
LJ70	LEARJET	70

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

ICAO Code	Location Name	Latitude	Longitude	Territory Code	ICAO Member State	Link for Confirmation
MNMG	Augusto C. Sandino (Managua) International Airport	12.1415	-86.1682	MN	Nicaragua	https://www.google.com/maps/search/12.1415,-86.168198
VDSA	Siem Reap-Angkor International Airport	13.3692	104.2231	VD	Cambodia	https://www.google.com/maps/search/13.369167,104.223056
VOGA	Manohar International Airport	15.7443	73.86063	VO	India	https://www.google.com/maps/search/15.744257,73.860625
HKSA	Embakasi Airport	-1.2982	36.91555	HK	Kenya	https://www.google.com/maps/search/-1.298219,36.915546
WARQ	Adisumarmo International Airport	-7.516	110.7575	WA	Indonesia	https://www.google.com/maps/search/-7.516044,110.757492
HSWW	Wau Airport	7.72583	27.975	HS	South Sudan	https://www.google.com/maps/search/7.72583,27.975
GQPF	Fderik Airport	22.6736	-12.72926	GQ	Mauritania	https://www.google.com/maps/search/22.673551,-12.729262
KEVB	New Smyrna Beach Municipal Airport	29.0557	-80.9489	KE	United States	https://www.google.com/maps/search/29.0557,-80.948898
KHBI	Asheboro Regional Airport	35.6545	-79.8947	KH	United States	https://www.google.com/maps/search/35.654499,-79.894699
KFHR	Friday Harbor Airport	48.5237	-123.0246	KF	United States	https://www.google.com/maps/search/48.523654,-123.024645
FAJS	O R Tambo International	-26.134	28.24232	FA	South Africa	https://www.google.com/maps/search/-26.13369444,28.24231667
FLLI	Livingstone	-17.822	25.8227	FL	Zambia	https://www.google.com/maps/search/-17.8218,25.822701
FLLS	Kenneth Kaunda Intl	-15.331	28.4525	FL	Zambia	https://www.google.com/maps/search/-15.330556,28.4525
FLND	Ndola Airport	-12.999	28.66405	FL	Zambia	https://www.google.com/maps/search/-12.998512,28.664047
FVBU	Bulawayo/Joshua Mqabuko Nkomo Intl	-20.017	28.6179	FV	Zimbabwe	https://www.google.com/maps/search/-20.017401,28.617901
HCMF	Bosaso International	11.2752	49.13923	HC	Somalia	https://www.google.com/maps/search/11.275235,49.139231
HCMH	Hargeisa/Egal International	9.51321	44.08239	HC	Somalia	https://www.google.com/maps/search/9.513207,44.082389
HCMM	Mogadishu/Aden Adde International Airport	2.01361	45.30472	HC	Somalia	https://www.google.com/maps/search/2.013611,45.304722
HECW	Cairo West Air Base	30.1079	30.91522	HE	Egypt	https://www.google.com/maps/search/30.107943,30.915222
HEMK	Moubarak / Intl	26.34	31.73944	HE	Egypt	https://www.google.com/maps/search/26.34,31.739444
HSSJ	Juba	4.879	31.59283	HS	South Sudan	https://www.google.com/maps/search/4.879,31.59283333
HSSK	Khartoum	15.5895	32.5532	HS	Sudan	https://www.google.com/maps/search/15.5895,32.5532
HSSS	Khartoum	15.5894	32.55306	HS	Sudan	https://www.google.com/maps/search/15.589444,32.553056
KANJ	Sault Ste Marie Muni/Sanderson Fld	46.4792	-84.3684	KA	United States	https://www.google.com/maps/search/46.479198,-84.368401
KBKV	Brooksville-Tampa Bay Rgnl	28.4736	-82.4554	KB	United States	https://www.google.com/maps/search/28.4736,-82.455399
KDTO	Denton Enterprise	33.2007	-97.198	KD	United States	https://www.google.com/maps/search/33.200699,-97.197998
FLLI	Livingstone	-17.8218	25.8227	FL	Zambia	https://www.google.com/maps/search/-17.8218,25.822701
FLLS	Kenneth Kaunda Intl	-15.3306	28.4525	FL	Zambia	https://www.google.com/maps/search/-15.330556,28.4525
FLND	Ndola Airport	-12.9985	28.6640	FL	Zambia	https://www.google.com/maps/search/-12.998512,28.664047
FVBU	Bulawayo/Joshua Mqabuko Nkomo Intl	-20.0174	28.6179	FV	Zimbabwe	https://www.google.com/maps/search/-20.017401,28.617901
HCMF	Bosaso International	11.2752	49.1392	HC	Somalia	https://www.google.com/maps/search/11.275235,49.139231
HCMH	Hargeisa/Egal International	9.5132	44.0824	HC	Somalia	https://www.google.com/maps/search/9.513207,44.082389
HCMM	Mogadishu/Aden Adde International Airport	2.0136	45.3047	HC	Somalia	https://www.google.com/maps/search/2.013611,45.304722
HECW	Cairo West Air Base	30.1079	30.9152	HE	Egypt	https://www.google.com/maps/search/30.107943,30.915222
HEMK	Moubarak / Intl	26.3400	31.7394	HE	Egypt	https://www.google.com/maps/search/26.34,31.739444

ICAO Code	Location Name	Latitude	Longitude	Territory Code	ICAO Member State	Link for Confirmation
HSSJ	Juba	4.8790	31.5928	HS	South Sudan	https://www.google.com/maps/search/4.879,31.59283333
HSSK	Khartoum	15.5895	32.5532	HS	Sudan	https://www.google.com/maps/search/15.5895,32.5532
HSSS	Khartoum	15.5894	32.5531	HS	Sudan	https://www.google.com/maps/search/15.589444,32.553056
KANJ	Sault Ste Marie Muni/Sanderson Fld	46.4792	-84.3684	KA	United States	https://www.google.com/maps/search/46.479198,-84.368401
KBKV	Brooksville-Tampa Bay Rgnl	28.4736	-82.4554	KB	United States	https://www.google.com/maps/search/28.4736,-82.455399
KDTO	Denton Enterprise	33.2007	-97.1980	KD	United States	https://www.google.com/maps/search/33.200699,-97.197998
KDTS	Destin Exec	30.4001	-86.4715	KD	United States	https://www.google.com/maps/search/30.400101,-86.471497
KDTS	Destin Exec	30.4001	-86.4715	KD	United States	https://www.google.com/maps/search/30.400101,-86.471497
KGYH	Donaldson Fld	34.7583	-82.3764	KG	United States	https://www.google.com/maps/search/34.758301,-82.376404
KHEF	Manassas Rgnl/Harry P Davis Fld	38.7214	-77.5154	KH	United States	https://www.google.com/maps/search/38.721401,-77.515404
KHXD	Hilton Head	32.2244	-80.6975	KH	United States	https://www.google.com/maps/search/32.2244,-80.697502
KHYI	San Marcos Rgnl	29.8927	-97.863	KH	United States	https://www.google.com/maps/search/29.8927,-97.862999
KJYO	Leesburg Exec	39.078	-77.5575	KJ	United States	https://www.google.com/maps/search/39.077999,-77.557503
KJZI	Charleston Exec	32.7009	-80.0029	KJ	United States	https://www.google.com/maps/search/32.700901,-80.002899
KMKY	Marco Island Exec	25.995	-81.6725	KM	United States	https://www.google.com/maps/search/25.995001,-81.672501
KPMP	Pompano Beach Airpark	26.2471	-80.1111	KP	United States	https://www.google.com/maps/search/26.247101,-80.111099
KSUT	Cape Fear Rgnl Jetport/Howie Franklin Fld	33.9293	-78.075	KS	United States	https://www.google.com/maps/search/33.929298,-78.074997
KTKI	Mckinney Ntl	33.1779	-96.5905	KT	United States	https://www.google.com/maps/search/33.177898,-96.5905
KTME	Houston Exec	29.8072	-95.8979	KT	United States	https://www.google.com/maps/search/29.807199,-95.897903
KTYQ	Indianapolis Exec	40.0307	-86.2514	KT	United States	https://www.google.com/maps/search/40.030701,-86.251404
KUZA	Rock Hill/York County/Bryant Fld	34.9878	-81.0572	KU	United States	https://www.google.com/maps/search/34.987801,-81.057198
MHSC	Comayagua International Airport	14.3824	-87.6212	MH	Honduras	https://www.google.com/maps/search/14.3824,-87.6212
MMIM	Isla Mujeres	21.246	-86.74037	MM	Mexico	https://www.google.com/maps/search/21.245962,-86.740365
MPHO	Howard Intl	8.91479	-79.5996	MP	Panama	https://www.google.com/maps/search/8.91479,-79.599602
MPRH	Scarlett Martinez International Airport	8.37588	-80.1279	MP	Panama	https://www.google.com/maps/search/8.37588,-80.127899
MYGW	West End Airport	26.6853	-78.975	MY	Bahamas	https://www.google.com/maps/search/26.685301,-78.974998
MYPI	Nassau Paradise Island Airport	25.0781	-77.29869	MY	Bahamas	https://www.google.com/maps/search/25.078138,-77.298689
OERY	Riyadh / King Salman Air Base	24.7257	46.72234	OE	Saudi Arabia	https://www.google.com/maps/search/24.725725,46.722336
OKBK	Kuwait Intl	29.2268	47.97995	OK	Kuwait	https://www.google.com/maps/search/29.22676667,47.97995278
OOSR	Sur	22.5377	59.47977	OO	Oman	https://www.google.com/maps/search/22.537729,59.479766
OPRN	Islamabad/ Benazir Bhutto International	33.6167	73.0992	OP	Pakistan	https://www.google.com/maps/search/33.616699,73.099197
SBJH	Sao Paulo Catarina Aeroporto Executivo - Intl	-23.427	-47.16583	SB	Brazil	https://www.google.com/maps/search/-23.426944,-47.165833
SDSC	Sao Carlos International Airport	-21.875	-47.9037	SD	Brazil	https://www.google.com/maps/search/-21.875401,-47.903703
SPIM	Lima - Callao / Jorge Chavez Intl	-12.022	-77.11432	SP	Peru	https://www.google.com/maps/search/-12.02188611,-77.11431667

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SYGO	Ogle International Airport	6.80628	-58.1059	SY	Guyana	https://www.google.com/maps/search/6.80628,-58.1059
TKPN	Vancew.Amoryinternational_Airport	17.2034	-62.58725	TK	Saint Kitts and Nevis	https://www.google.com/maps/search/17.203405853,-62.587252651
UAFL	Tamchy/Ysykkul	42.5856	76.70118	UA	Kyrgyzstan	https://www.google.com/maps/search/42.585584,76.701181
UAFM	Bishkek/Manas	43.0614	74.4775	UA	Kyrgyzstan	https://www.google.com/maps/search/43.061389,74.4775
UAFO	Osh	40.6089	72.79306	UA	Kyrgyzstan	https://www.google.com/maps/search/40.608889,72.793056
UAIT	Turkistan	43.3131	68.54988	UA	Kazakhstan	https://www.google.com/maps/search/43.313126,68.549881
UTKF	Fergana International Airport	40.3588	71.745	UT	Uzbekistan	https://www.google.com/maps/search/40.358799,71.745003
UTKN	Namangan Airport	40.9846	71.5567	UT	Uzbekistan	https://www.google.com/maps/search/40.9846,71.556702
UUMU	Chkalovskiy Air Base	55.8783	38.0617	UU	Russian Federation	https://www.google.com/maps/search/55.8783,38.061699
VAGO	Goa	15.3808	73.8314	VA	India	https://www.google.com/maps/search/15.3808,73.831398
VGZR	Dhaka / Hazrat Shahjalal Int	23.8433	90.39778	VG	Bangladesh	https://www.google.com/maps/search/23.84334722,90.39778333
VIBN	Lal Bahadur Shastri/Varanasi Domestic	25.4521	82.86181	VI	India	https://www.google.com/maps/search/25.452129,82.861805
VREI	Ifuru Island/Airport	5.7083	73.025	VR	Maldives	https://www.google.com/maps/search/5.7083,73.025
WIPT	Padang Pariaman/Minangkabau	-0.7869	100.281	WI	Indonesia	https://www.google.com/maps/search/-0.786917,100.280998
ZUTF	Chengdu/Tianfu	30.3125	104.4413	ZU	China	https://www.google.com/maps/search/30.31252,104.441284

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