ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT)

2019 Version

— Design, Development and Validation —

August 2019

TABLE OF CONTENTS

GLOSSARY

AIP	Aeronautical Information Publication
AO	Aeroplane operator
ARP	Aerodrome Reference Points
BT	Block Time
CAEP	Committee on Aviation Environmental Protection
CCG	CORSIA CERT Group
CEMs	CO_2 Estimation Models
CERT	CO_2 Estimation and Reporting Tool
COFdb	CCG Operations and Fuel database
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSV	Comma-Separated Values
DPOs	Data Providing Organizations
EASA	European Union Aviation Safety Agency
EMP	Emissions Monitoring Plan
ER	Emissions Report
ERt	Emissions Report template
ETM	Environmental Technical Manual
FAA	Federal Aviation Administration
GCD	Great Circle Distance
ICAO	International Civil Aviation Organization
MDG	Modelling and Database Group
MRV	Monitoring, Reporting and Verification
MTOM	Maximum Take Off Mass
OLS	Ordinary Least Squares
PMM	Primary Monitoring Method
TCDS	Type Certificate Data Sheets
VB	Verification body
WG4	Working Group 4
WGS84	World Geodetic System 1984
WTC	Wake Turbulence Category

1. INTRODUCTION

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

The ICAO CORSIA CERT tool supports aeroplane operators in:

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

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

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

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

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

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

2.1 General overview

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

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

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

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

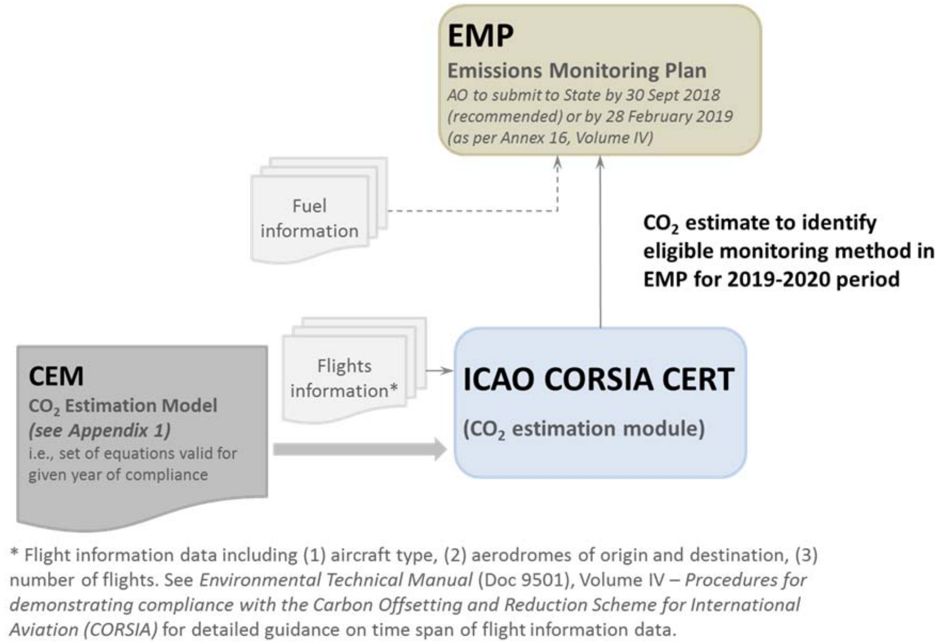

Figure 1: Architecture of CORSIA Emissions Monitoring Plan and reporting system (2018 or aeroplane operator year of entry into CORSIA)

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

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

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

---

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

eligibility to the use of the ICAO CORSIA CERT. The 2019 includes the monitoring and report generation functionality. The 2020 version is expected to generally have the same high-level functionality as the 2019 version of the ICAO CORSIA CERT. 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.

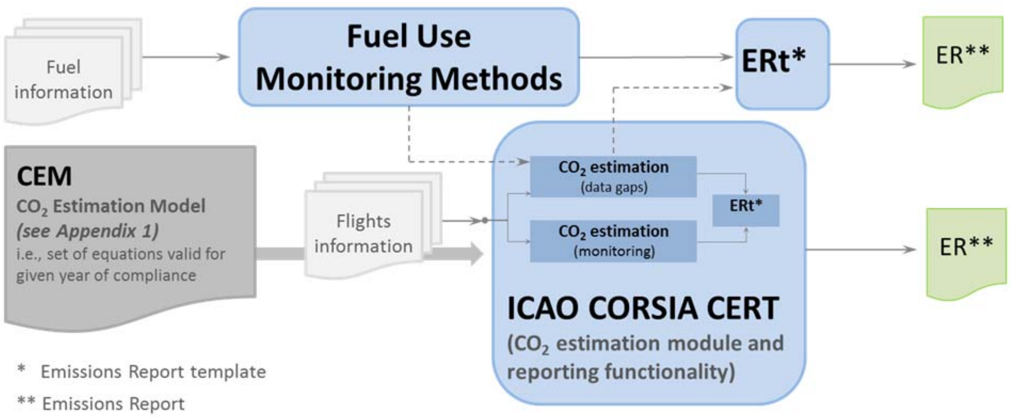

Figure 2: Architecture of CORSIA reporting system (2019 onward for compliance purposes)

	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 2019 version of the ICAO CORSIA CERT

Based on requirements from Annex 16, Volume IV, a more detailed architecture of the 2019 version of the ICAO CORSIA CERT was developed. First, potential and expected users of the ICAO CORSIA 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 2019 version of the ICAO CORSIA CERT

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 ICAO CORSIA 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 and subsequent versions

2.2.2 Proposed high-level architecture of the ICAO CORSIA CERT 2019 and subsequent versions

The ICAO CORSIA CERT 2019 version was built on the 2018 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 ICAO CORSIA CERT 2019 and subsequent versions, including:

- <u>Improvements of the ICAO CEMs based on Great Circle Distance:</u> existing ICAO CEMs based on Great Circle Distance (GCD) input embedded in the 2018 version of the ICAO CORSIA CERT were improved. In addition, additional ICAO CEMs for some aircraft types not yet covered by the 2018 version were developed. This enhancement was based on additional and updated flight level data from operators in accordance with Annex 16, Volume IV, Appendix 3. The expanded data collection was guided by: (1) additional Data Providing Organizations (DPOs) interested in contributing to the ICAO CORSIA CERT development; and (2) feedback on the review process and the identification of aircraft types that required additional attention.

- <u>Development of new ICAO CEMs based on Block Time Input:</u> the 2019 version of the ICAO CORSIA CERT required the enhancement of the ICAO CEMs to include Block Time input functionality. These additions relied on the collection of additional and specific data towards the development on the 2019 version of the COFdb.

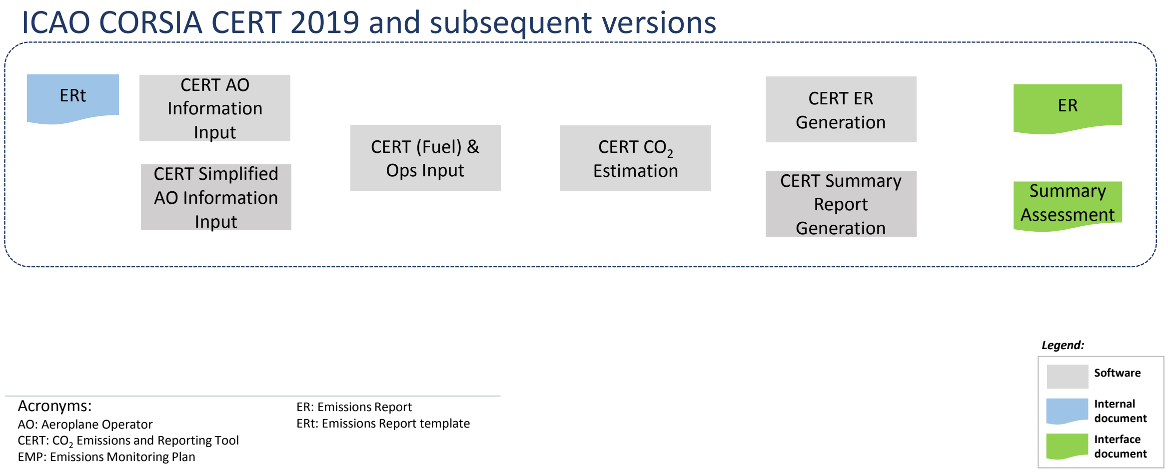

Figure 5: High level architecture of the ICAO CORSIA CERT 2019 and subsequent versions

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

2.2.3 Detailed use cases for the ICAO CORSIA CERT 2019 and subsequent versions

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.

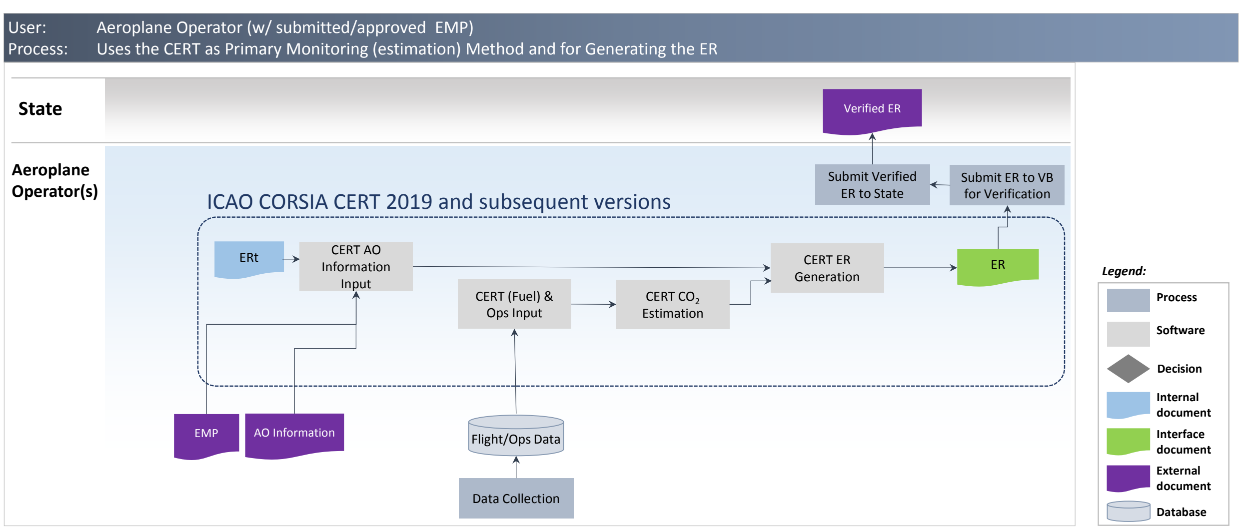

Figure 6: Mapping of processes supported by the ICAO CORSIA CERT 2019 and subsequent versions for an aeroplane operator with an approved EMP and using the ICAO CORSIA CERT as primary monitoring method and to generate its ER

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.

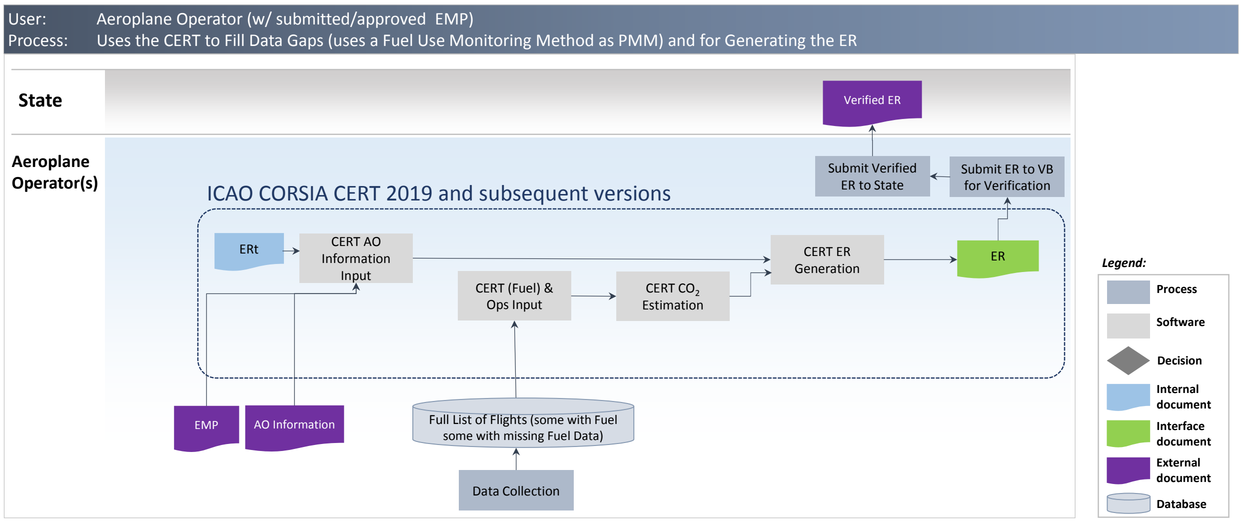

Figure 7: Mapping of processes supported by the ICAO CORSIA CERT 2019 and subsequent versions for an aeroplane operator with an approved EMP and using the ICAO CORSIA CERT to fill data gaps and generate its ER

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.

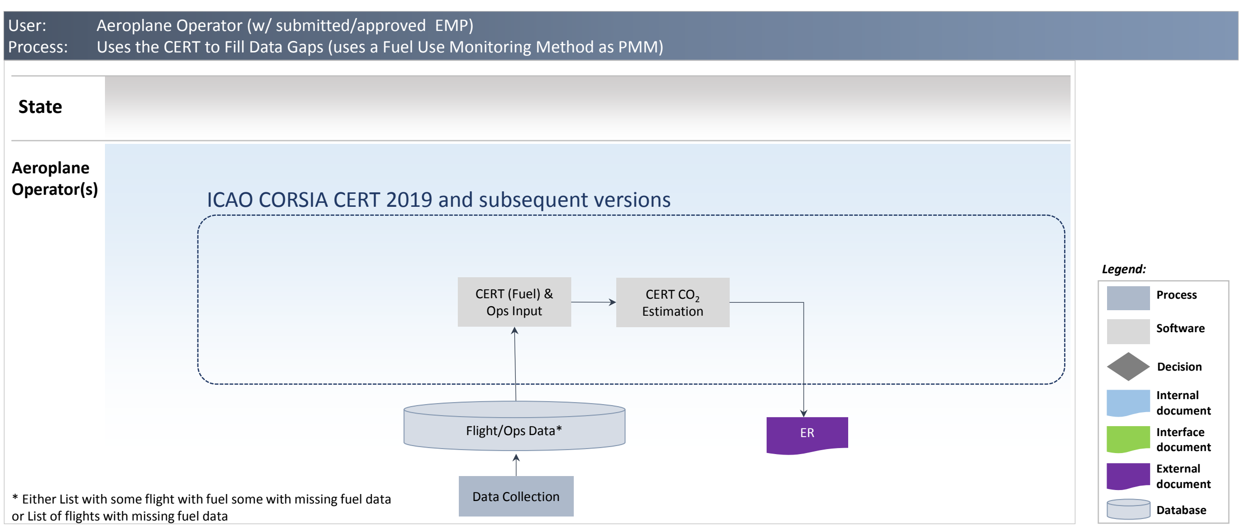

Figure 8: Mapping of processes supported by the ICAO CORSIA CERT 2019 and subsequent versions for an aeroplane operator using the ICAO CORSIA CERT only to fill data gaps

Figure 9 shows the processes expected to be followed by an aeroplane operator to determine the applicability of CORSIA and eligibility to use the ICAO CORSIA CERT.

Note. - This process is similar to the use of the 2018 version of the ICAO CORSIA CERT.

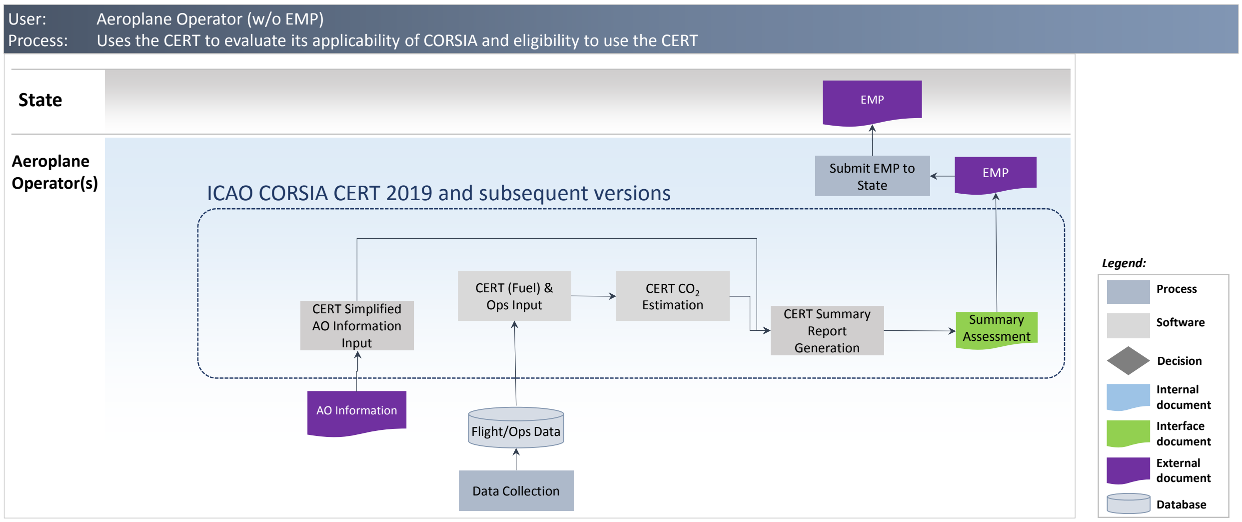

Figure 9: Mapping of processes supported by the ICAO CORSIA CERT 2019 and subsequent versions for an aeroplane operator to determine the applicability of CORSIA and eligibility to user the ICAO CORSIA CERT

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

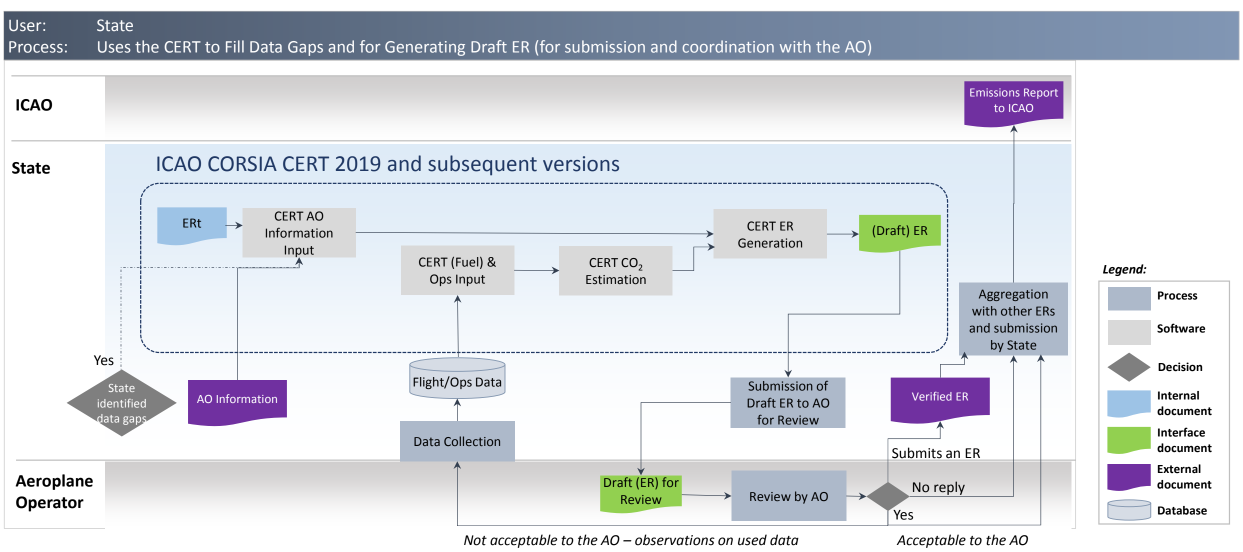

Figure 10: Mapping of processes supported by the ICAO CORSIA CERT 2019 and subsequent versions for a State to fill data gaps

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

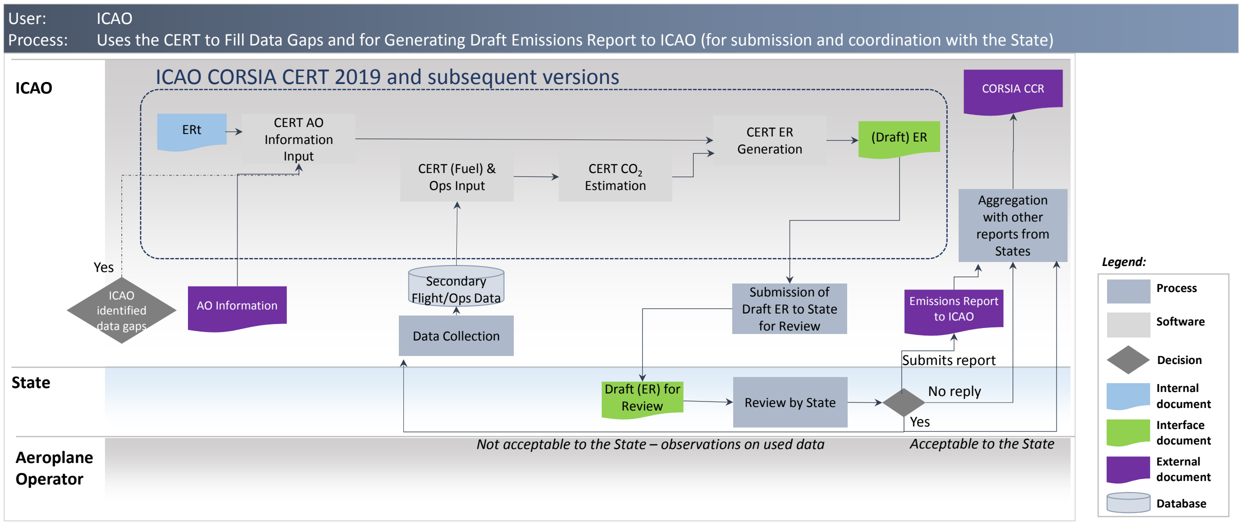

Figure 11: Mapping of processes supported by the ICAO CORSIA CERT 2019 and subsequent versions for ICAO to fill data gaps

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.

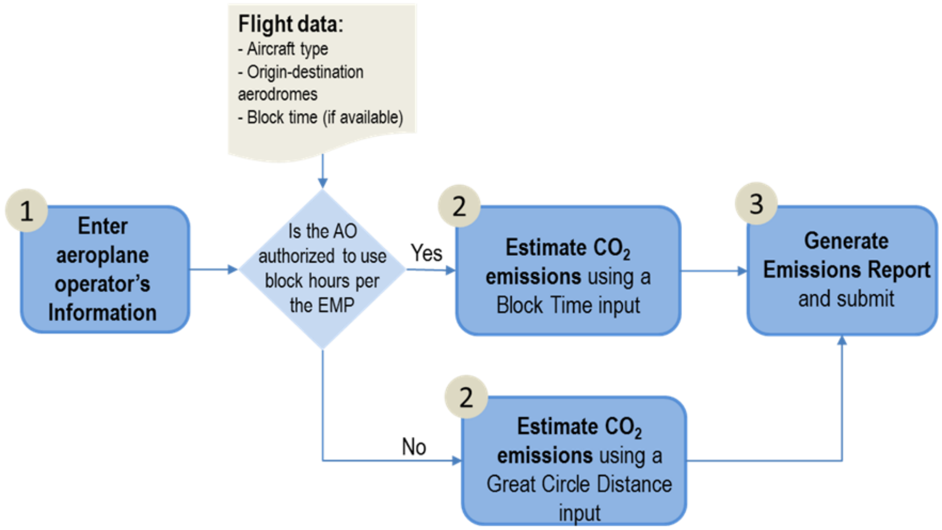

Figure 12: Overview of the high-level functions of the potential CORSIA CO_2 Estimation and Reporting Tool

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

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

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

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

(4) Finally, if an aircraft type is missing an ICAO CEM after steps 1 to 3, a set of generic equations can be developed using the methodology described in section 3.2.6, generic equations from which an ICAO CEM for such aircraft type can then be derived. This approach is used for aircraft types that, not being included in the tables of Appendix A-1 and A-2 which list all the aircraft types included in the ICAO CORSIA CERT aeroplane database, can be entered into the ICAO CORSIA CERT as Custom Aeroplane.

Note. - For an aircraft type included in the ICAO CORSIA CERT aeroplane database, the ICAO CORSIA CERT shall always estimate the CO_2 emissions using the ICAO CEM obtained for it after steps 1 to 3, even when a Custom Aeroplane has been defined for such aircraft type and an ICAO CEM derived for it by the ICAO CORSIA CERT from the set of generic equations.

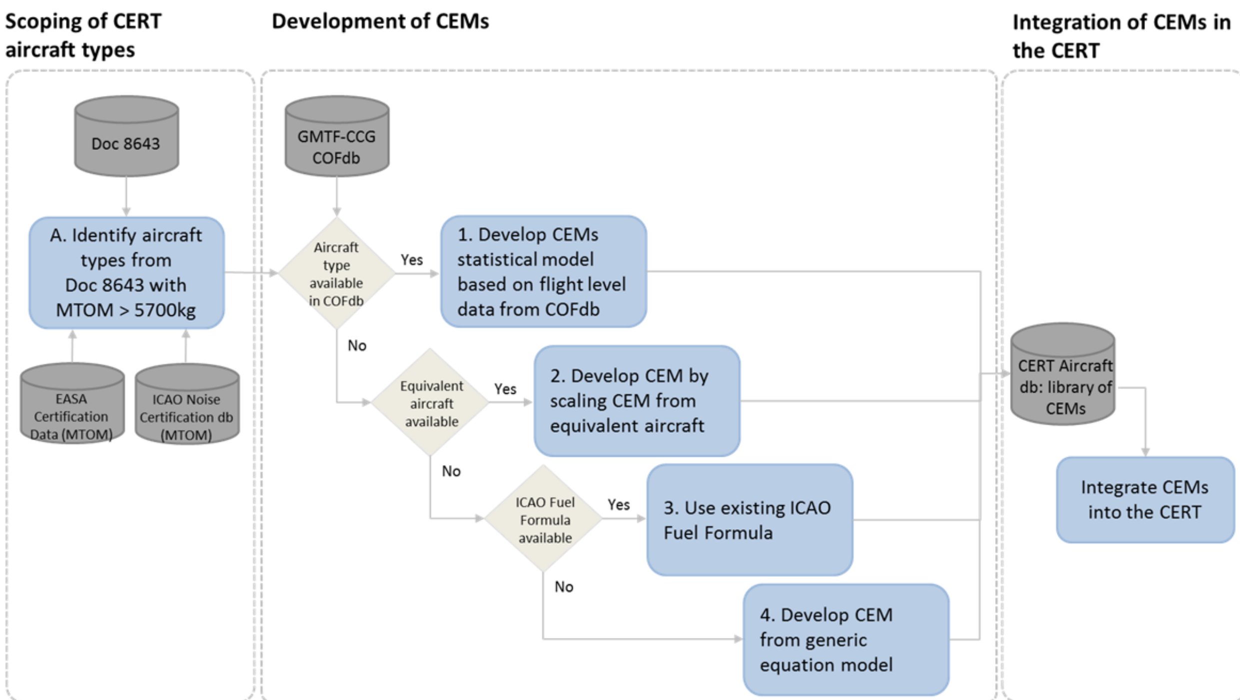

Figure 13: Summary of process for developing ICAO CO_2 Emissions Estimation Models (CEMs)

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 2019 version of the ICAO CORSIA CERT is based on the version of Doc 8643 that was last updated on 9 October 2018.

- Maximum Take Off Mass (MTOM):
    - o The following version of the EASA Noise Certification Databases (www.easa.europa.eu/document-library/noise-type-certificates-approved-noise-levels) were used to obtain MTOM data by aircraft type.
        - ▪ EASA approved noise levels (Heavy propeller driven aeroplanes), Issue 29, last updated: 14 November 2018
        - ▪ EASA approved noise levels (Jet aeroplanes), Issue 31, last updated: 15 November 2018
        - ▪ EASA approved noise levels (Light propeller driven aeroplanes), Issue 28, last updated: 14 November 2018
    - o 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
    - o Complementary data sources were also used when needed, including the U.S. Federal Aviation Administration (FAA) Type Certificate Data Sheet (TCDS), available at: http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgMakeModel.nsf/Frameset?OpenPage

Methodology

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

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

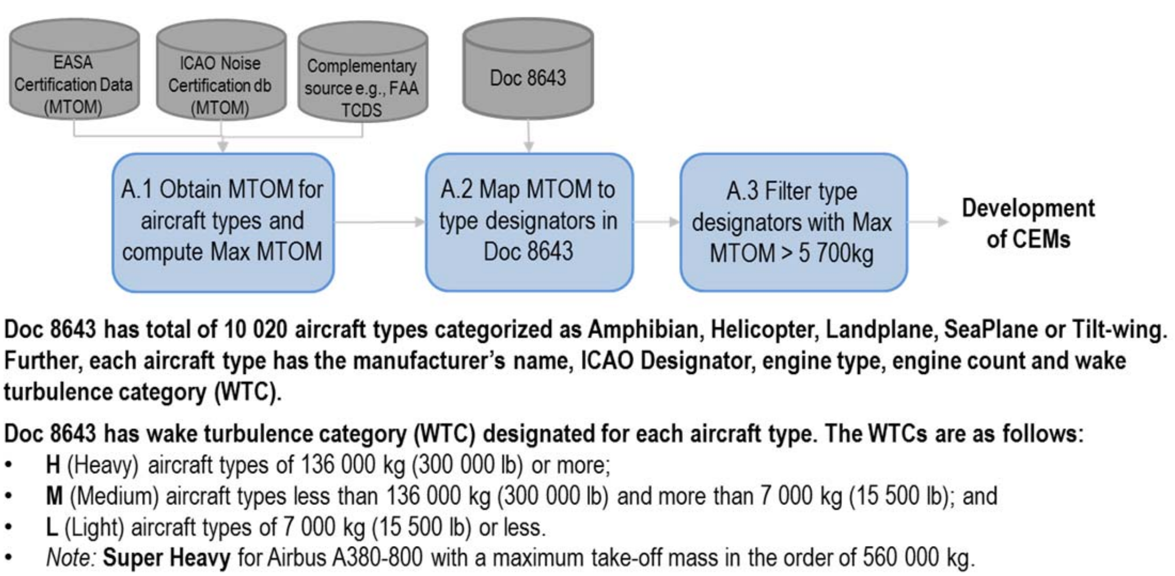

Figure 14: Development of list of aircraft types with MTOM>5 700kg for the ICAO CORSIA CO_2 Estimation and Reporting Tool development process

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

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

Overview of the CCG Operations and Fuel database (COFdb)

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

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

Data collection and validation processes

When providing data to CAEP, DPOs are responsible for:

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

- excluding from the provided data records for which:
  - 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 2019 version of the ICAO CORSIA CERT

For the 2019 version of the ICAO CORSIA CERT, the COFdb version 2019_2.2 as of January 20, 2019 was used. This 2019 version 2.2 of the COFdb includes data from approximately 4 million flights for 98 aircraft types by ICAO Type Designator. Data ranged from 2010 to 2018 with about 78% of the data coming from 2014 to 2018.

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).

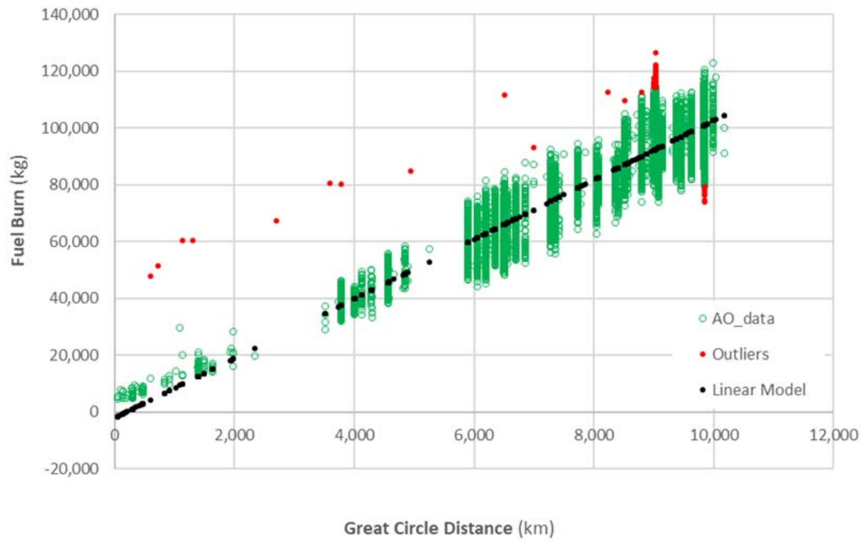

Figure 15: Illustration of sample data used to generate ICAO CEMs, including outlier data removed from the process of generating the ICAO CEM

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.

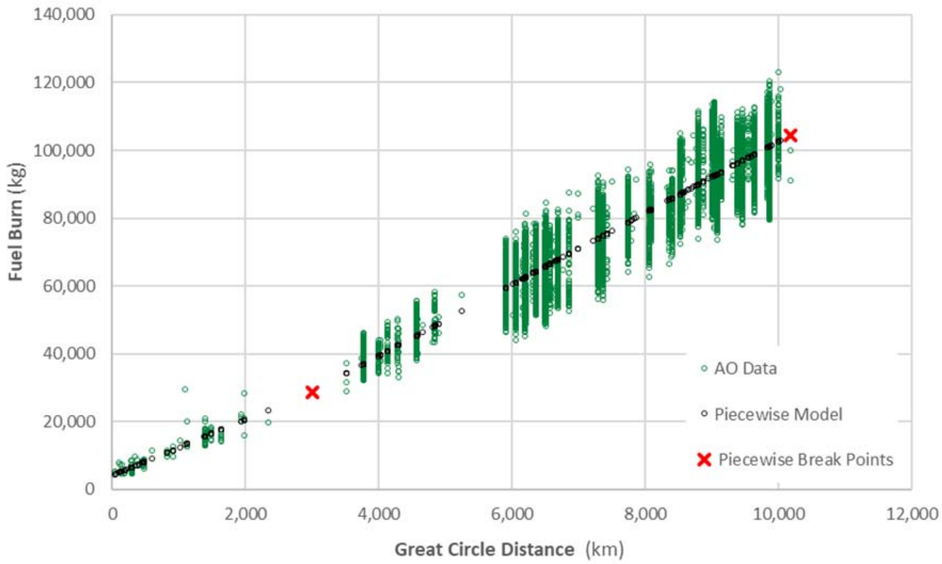

Figure 16: Illustration of fuel burn statistical method model formulation (GCD Model)

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, i.e. an aircraft type not included in the tables of Appendix A-1 and A-2 which relate to the ICAO CORSIA CERT aeroplane database, that a user may need to enter and use towards the estimation of its emissions.

Note. - For an aircraft type included in the ICAO CORSIA CERT aeroplane database, the ICAO CORSIA CERT shall always estimate the CO_2 emissions using the CEM obtained for it after steps 1 to 3, even when a Custom Aeroplane has been defined for such aircraft type and an ICAO CEM derived for it by the ICAO CORSIA CERT from the set of generic equations.

For each linear regression-based model the fuel is calculated on specific distances, to determine the coefficients of the generic equations based on Great Circle Distance, and on specific block time values, to determine the coefficients of the generic equations based on Block Time. Those are determined to ensure a sufficient level of granularity and account for the possible variation of the piecewise breakpoints.

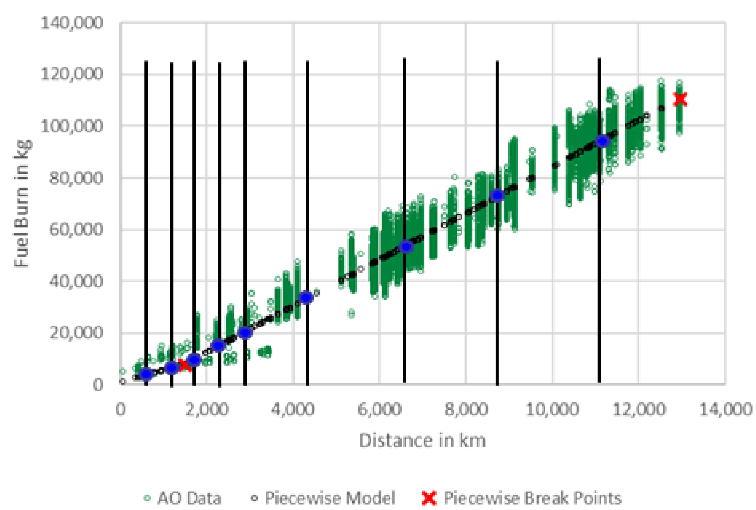

Figure 17: Illustration of process for binning data for developing generic equation

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.

[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 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.

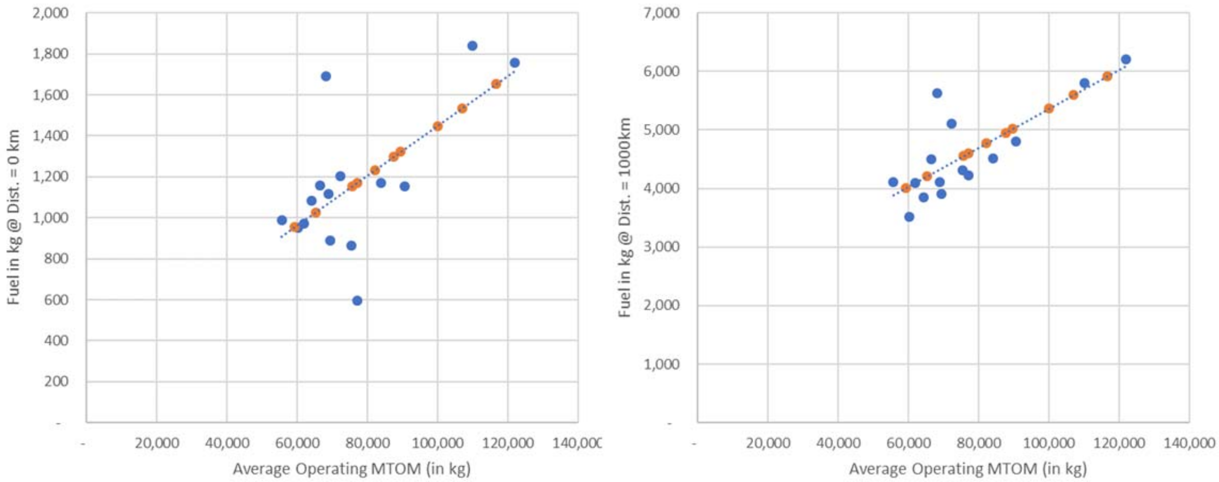

Figure 18: Illustration of generic aeroplane fuel burn-MTOM based regressions for a given distance

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 19).

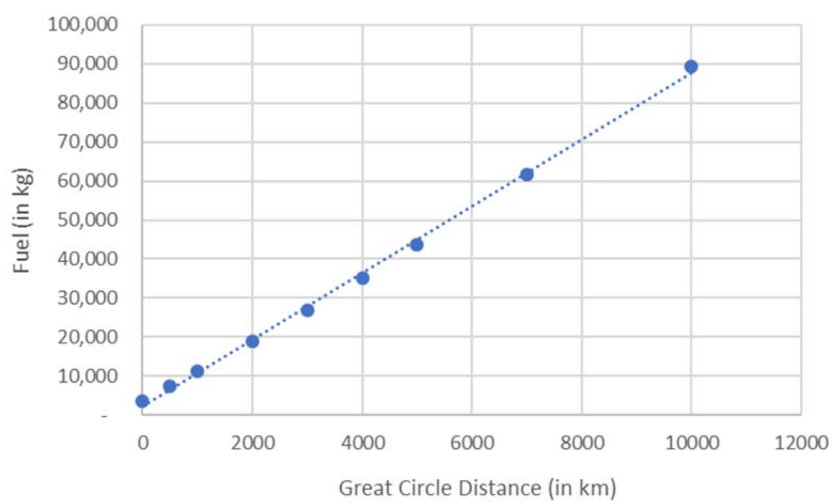

Figure 19: Illustration of generic aeroplane ICAO CEM

4. IMPLEMENTATION OF THE 2019 VERSION OF THE ICAO CORSIA CERT

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

The ICAO CORSIA CERT version 2019 was developed to include two key functionalities:

a) Summary of assessment of applicability of CORSIA and eligibility to use the ICAO CORSIA CERT in 2020; and

b) CO_2 Estimation and Reporting for 2019.

4.1 Summary of assessment of applicability of CORSIA and eligibility to use the ICAO CORSIA CERT in 2020

The ICAO CORSIA CERT version 2019 was developed to take the user through a simple three steps process where the user:

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

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

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

4.1.1 Aeroplane operator identification

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

4.1.2 Calculation of CO_2 emissions

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

4.1.3 Loading and entering data into the ICAO CORSIA CERT

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

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

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

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

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

Entering custom aeroplane codes

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

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

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

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

d) Turboprop.

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

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

The following coefficients are used in the 2019 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	1132.004429	0.004303424	3.467456998	1.72332E-05
Jet with certified MTOM >= 60 000 kg and < 136 000 kg	377.5570001	0.008578731	1.668450972	2.30871E-05
Jet (Heavy) with certified MTOM < 60 000 kg	241.6529817	0.011941157	0.184649426	4.96668E-05
Turboprop	-66.66768268	0.01531235	0.354234095	4.76301E-05

Figure 20: Coefficients used in the 2019 version of the ICAO CORSIA CERT to generate generic equations (as a function of entered Average MTOM) for aircraft types entered as custom aeroplane

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

Entering custom aerodrome codes

If needed, the user can enter custom aerodrome codes in order to allow for the calculation of CO_2 emissions for each flight entered. The user is prompted to enter aerodrome latitude using WGS84 coordinates. In the 2019 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 2019. 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 2020.

The summary assessment includes:

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

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

- Total annual estimated CO_2 emissions (international). It should be noted that emissions are for all international State pairs. For the 2021 version of the ICAO CORSIA CERT, this total will be split 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 2019, 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 2019

The CO_2 Estimation and Reporting functionality of the ICAO CORSIA CERT version 2019 was developed to take the user through each step of the Emissions Report generation process where the user:

(1) Enters aeroplane operator identification and description of activities;

(2) Enters underlying basic information of the Emissions Report;

(3) Enters aeroplane fleet and fuel types;

(4) Selects Fuel density;

(5) Selects the level of aggregation of the information reported;

(6) Loads its operations (and fuel) data to estimation CO_2 emissions;

(7) Completes the prefilled “Reporting - State pairs” report; or

(8) Completes the prefilled “Reporting - Aerodrome pairs”;

(9) Completes the prefilled “Data gaps” information; and

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

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

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

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

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

Entering custom aeroplane codes

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

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

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

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

d) Turboprop.

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

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

The following coefficients are used in the 2019 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	1132.004429	0.004303424	3.467456998	1.72332E-05
Jet with certified MTOM >= 60 000 kg and < 136 000 kg	377.5570001	0.008578731	1.668450972	2.30871E-05
Jet (Heavy) with certified MTOM < 60 000 kg	241.6529817	0.011941157	0.184649426	4.96668E-05
Turboprop	-66.66768268	0.01531235	0.354234095	4.76301E-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	-221.7941714	-0.020274258	44.8886798	0.000295552
Jet with certified MTOM >= 60 000 kg and < 136 000 kg	1246.262888	-0.018110701	9.132799849	0.000426552
Jet (Heavy) with certified MTOM < 60 000 kg	249.7020267	-0.005251951	2.997853225	0.000584315
Turboprop	-60.75673809	0.008854764	0.332295895	0.00044357

Figure 21: Coefficients used in the 2019 version of the ICAO CORSIA CERT to generate generic equations (as a function of entered Average MTOM) for aircraft types entered as custom aeroplane

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

Entering custom aerodrome codes

Note. – The Custom Aerodrome functionality for the "CO_2 Estimation and Reporting for 2019" functionality is identical to the Custom Aerodrome functionality for the "Summary of assessment of applicability of CORSIA and eligibility to use the ICAO CORSIA CERT in 2020". See section 4.1.4 for details.

4.3 Data entry error and plausibility of input data

The ICAO CORSIA CERT 2019 version also includes a number of new functionalities that allow 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

The ICAO CORSIA CERT 2019 version builds on the 2018 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 was added in the 2019 version, including

- Improvements of the ICAO CEMs based on Great Circle Distance: The ICAO CEMs based on Great Circle Distance (GCD) input embedded in the 2018 version of the ICAO CORSIA CERT were improved. In addition, additional ICAO CEMs for aircraft types not yet covered by the 2018 version were developed. These enhancements are based on additional and updated flight level data from operators who volunteered to provide data.
- Development of New ICAO CEMs based on Block Time Input: The 2019 version of the ICAO CORSIA CERT includes the ICAO CO_2 Estimation Models (CEMs) based on Block Time input.

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

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

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

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 2021 version of the ICAO CORSIA CERT, this total will be split between State pairs with offsetting requirements and State pairs not subject to offsetting requirements (see Annex 16, Volume IV, Chapter 3 for details).
   - Total annual number of flights during the reporting period (international). It should be noted that flights are for all international State pairs. For the 2021 version of the ICAO CORSIA CERT, this total will be split 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 "CO2 Emissions Estimation & Data Gap Filling" section, the ICAO CORSIA CERT automatically generated the list of State Pairs including: State of departure, State of arrival, whether the CO_2 emissions were estimated by the ICAO CORSIA CERT, total number of flights, fuel type, total mass of fuel, fuel conversion factors, total CO_2 emissions. In the 2021 version, the ICAO CORSIA CERT will indicate 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 2021 version of the ICAO CORSIA CERT, this total will be split between State pairs with offsetting requirements and State pairs not subject to offsetting requirements (see Annex 16, Volume IV, Chapter 3 for details).
- Total annual number of flights during the reporting period (international). It should be noted that flights are for all international State pairs. For the 2021 version of the ICAO CORSIA CERT, this total will be split 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 "CO2 Emissions Estimation & Data Gap Filling" section, the ICAO CORSIA CERT automatically generates the list of Aerodrome Pairs including; ICAO aerodrome code and State for the Departure, ICAO aerodrome code and State for the Arrival, whether the CO_2 emissions were estimated by the ICAO CORSIA CERT, total number of flights, fuel type, total mass of fuel, fuel conversion factors, total CO_2 emissions. In the 2021 version, the ICAO CORSIA CERT will indicate whether the Aerodrome Pair is subject to offsetting requirements.

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

- Based on input and calculations in the "CO2 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 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 2019, 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 "CO2 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 2020 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 2019 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 2019 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
A20N	A-320neo	Yes				
A21N	A-321neo	Yes				
A306	A-300B4-600	Yes				
A310	A-310	Yes				
A318	A-318	Yes				
A319	A-319	Yes				
A320	A-320	Yes				
A321	A-321	Yes				
A332	A-330-200	Yes				
A333	A-330-300	Yes				
A343	A-340-300	Yes				
A346	A-340-600	Yes				
A359	A-350-900 XWB	Yes				
A388	A-380-800	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				
B38M	737 MAX 8	Yes				
B462	BAe-146-200	Yes				
B463	BAe-146-300	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				
B744	747-400 (international, winglets)	Yes				
B748	747-8	Yes				
B752	757-200	Yes				
B753	757-300	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				
C550	550 Citation 2	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
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				
D328	328	Yes				
DH8D	Dash 8 (400)	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				
E35L	EMB-135BJ Legacy	Yes				
E55P	EMB-505 Phenom 300	Yes				
F100	100	Yes				
F2TH	Falcon 2000	Yes				
F50	50 Maritime Enforcer	Yes				
F70	70	Yes				
F900	Falcon 900	Yes				
FA50	Falcon 50	Yes				
FA7X	Falcon 7X	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				
MD11	MD-11	Yes				
MD82	MD-82	Yes				
MD88	MD-88	Yes				
MD90	MD-90	Yes				
RJ85	RJ-85 Avroliner	Yes				
SF34	SF-340	Yes				

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

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

Type Designator	Example of Model*	CEM based on AO data (from COFdb)	CEM based on Equivalent Aircraft Type		CEM based on ICAO Fuel Formula	
		Source of CEM	Source of CEM	Type Designator of Equivalent Aircraft	Source of CEM	ICAO Aircraft Code
A30B	A-300B2		Yes	A306		
A342	A-340-200		Yes	A343		
A345	A-340-500		Yes	A346		
A35K	A-350-1000 XWB		Yes	A359		
AN30	An-30		Yes	AN26		
AN32	An-32		Yes	AN26		
AT73	ATR-72-211		Yes	AT72		
B37M	737 MAX 7		Yes	B38M		
B39M	737 MAX 9		Yes	B38M		
B461	BAe-146-100		Yes	B462		
B712	717-200		Yes	MD88		
B732	737-200		Yes	B733		
B741	747-100		Yes	B744		
B742	747-200		Yes	B744		
B743	747-300		Yes	B744		
B74R	747SR		Yes	B744		
B74S	747SP		Yes	B744		
B78X	787-10 Dreamliner		Yes	B789		
C25C	525C Citation CJ4		Yes	C550		
C525	525 Citation CJ1		Yes	C550		
C55B	550B Citation Bravo		Yes	C550		
C560	560 Citation 5		Yes	C550		
DH8A	Dash 8 (100)		Yes	DH8D		
DH8B	Dash 8 (200)		Yes	DH8D		
DH8C	Dash 8 (300)		Yes	DH8D		
DHC7	DHC-7 Dash 7		Yes	DH8D		
E75L	ERJ-170-200 (long wing)		Yes	E170		
E75S	ERJ-170-200 (short wing)		Yes	E170		
FA8X	Falcon 8X		Yes	FA7X		
H25A	HS-125-1		Yes	H25B		
H25C	Hawker 1000		Yes	H25B		
LJ25	25		Yes	LJ40		
LJ35	35		Yes	LJ40		
LJ55	55		Yes	LJ45		
LJ70	70		Yes	LJ45		
LJ75	75		Yes	LJ45		
MD81	MD-81		Yes	MD82		
MD83	MD-83		Yes	MD82		
MD87	MD-87		Yes	MD88		
RJ1H	RJ-100 Avroliner		Yes	B463		
RJ70	RJ-70 Avroliner		Yes	RJ85		

* 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
A124	An-124 Ruslan				Yes	A4F
A140	IRAN-140 Faraz				Yes	A40
A148	An-148				Yes	A81
A748	748				Yes	HS7
AN12	An-12				Yes	ANF
AN24	An-24				Yes	AN4
AN28	An-28				Yes	A28
AN72	An-72				Yes	AN7
ATP	ATP				Yes	ATP
B701	707-100				Yes	70M
B721	727-100				Yes	721
BA11	BAC-111 One-Eleven				Yes	B11
BE20	Super King Air (200)				Yes	BE2
BELF	SC-5 Belfast				Yes	SHB
C130	L-100 Hercules				Yes	LOH
C212	C-212 Aviocar				Yes	CS2
CN35	CN-235				Yes	CS5
CVLP	Convairliner				Yes	CVR
D228	Dornier 228				Yes	D28
DC10	DC-10				Yes	D10
DC3	DC-3				Yes	DC3
DC6	DC-6				Yes	DC6
DC85	DC-8-50				Yes	D8T
DC86	DC-8-60				Yes	D8L
DC87	DC-8-70				Yes	D8Q
DC91	DC-9-10				Yes	D91
DC92	DC-9-20				Yes	D92
DC93	DC-9-30				Yes	D93
DC94	DC-9-40				Yes	D94
DC95	DC-9-50				Yes	D95
DHC6	DHC-6 Twin Otter				Yes	DHT
E110	EMB-110 Bandeirante				Yes	EMB
E120	EMB-120 Brasilia				Yes	EM2
F27	F-27				Yes	F27
F28	F-28 Fellowship				Yes	F28
FA10	Falcon 10				Yes	DF2
G159	G-159 Gulfstream 1				Yes	GRS
I114	Il-114				Yes	I14
IL18	Il-18				Yes	IL8
IL62	Il-62				Yes	IL6
IL76	Il-76				Yes	IL7
IL86	Il-86				Yes	ILW
IL96	Il-96				Yes	IL9
J328	Dornier 328JET				Yes	FRJ
JS31	BAe-3100 Jetstream 31				Yes	J31
JS32	BAe-3200 Jetstream Super 31				Yes	J32
JS41	BAe-4100 Jetstream 41				Yes	J41
L101	L-1011 TriStar				Yes	L10
L188	Electra (L-188)				Yes	LOE
L410	L-410 Turbolet				Yes	L4T
N262	N-262 Frégate				Yes	ND2
S601	SN-601 Corvette				Yes	NDC

* 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 (cont.). 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
SB20	2000				Yes	S20
SC7	SC-7 Skyliner				Yes	SHS
SH33	SD3-30				Yes	SH3
SH36	360				Yes	SH6
SW2	SA-26 Merlin 2				Yes	SWM
T134	Tu-134				Yes	TU3
T154	Tu-154				Yes	TU5
T204	Tu-204				Yes	T20
WW24	1124 Westwind				Yes	WWP
YK40	Yak-40				Yes	YK4
YK42	Yak-42				Yes	YK2
YS11	YS-11				Yes	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 2019 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
A20N	603	2,225	3,543	4,861	6,179	7,497	8,815	10,133	11,451	12,769	14,087	15,405	16,723				
A21N	839	2,081	3,497	5,102	6,707	8,312	9,917	11,522	13,127	14,732	16,337	17,942	19,547	22,757			
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	1,579	4,434	7,289	10,145	13,000	15,855	18,710	21,565	24,420	27,276	30,131	32,986	35,841	41,552	47,262	52,972	
A318	1,052	2,462	3,849	5,233	6,617	8,000	9,384	10,767	12,151	13,535	14,918	16,302	17,685				
A319	865	2,628	4,064	5,393	6,854	8,315	9,776	11,237	12,698	14,159	15,620	17,081	18,542				
A320	975	2,698	4,211	5,725	7,238	8,751	10,496	12,241	13,986	15,731	17,476	19,221					
A321	688	2,965	4,767	6,569	8,371	10,173	11,975	13,777	15,579	17,381	19,183	20,985	22,787				
A332	2,045	5,252	8,018	10,784	13,550	16,843	20,261	23,679	27,096	30,514	33,932	37,350	40,768	47,603	54,439	61,275	68,110
A333	1,813	5,970	9,936	13,248	16,561	19,873	23,186	26,498	29,811	33,123	36,436	39,748	43,061	49,686	56,311	62,936	69,561
A343	2,789	6,689	10,589	14,200	17,811	21,422	25,033	28,644	32,255	35,866	39,479	43,756	48,032	56,585	65,138	73,691	82,244
A346	4,424	8,226	12,027	15,829	19,630	23,431	28,700	33,969	39,238	44,507	49,776	55,045	60,314	70,852	81,390	91,928	102,466
A359	3,416	6,572	9,727	12,883	16,038	19,194	22,349	25,505	28,689	32,324	35,960	39,595	43,231	50,502	57,773	65,044	72,315
A388	4,474	11,646	18,818	25,990	33,162	40,334	47,506	54,678	61,850	69,022	76,194	83,366	90,538	104,882	119,226	136,767	154,922
AN26	228	1,736	2,944	3,701	4,458	5,215											
AT43	99	718	1,267	1,816	2,365	2,913	3,462	4,011	4,560	5,109	5,658						
AT45	98	857	1,488	2,119	2,750	3,381	4,012										
AT46	199	863	1,527														
AT72	185	863	1,541	2,219	2,897												
AT75	202	875	1,588	2,301													
AT76	177	917	1,616														
B190	97	446	795	1,144	1,493	1,842											
B38M	750	2,079	3,409	4,739	6,069	7,399	8,728	10,058	11,388	12,718	14,048	15,377	16,707				
B462	746	2,400	4,053	5,706	7,360	9,013											
B463	667	2,543	4,420	6,296	8,172	10,048											
B722	975	4,337	7,049	9,760	12,472	15,183	17,895	20,606	23,318	26,029	28,741	31,452					
B733	1,119	2,500	3,984	5,547	7,111	8,674	10,238	11,801	13,365	14,928	16,492	18,055	19,619				
B734	704	2,797	4,525	6,177	7,830	9,483	11,136	12,789	14,442	16,095	17,748	19,401	21,054	24,359	27,665	30,971	34,277
B735	982	2,515	4,047	5,580	7,112	8,645	10,177	11,710	13,242	14,775	16,307	17,840	19,372	22,437	25,502	28,567	
B736	1,086	2,300	3,515	4,804	6,112	7,420	8,728	10,036	11,344	12,652	13,960	15,268	16,576	19,192			
B737	794	2,399	3,871	5,342	6,814	8,285	9,757	11,228	12,700	14,171	15,643	17,114	18,586				
B738	655	2,639	4,201	5,762	7,323	8,885	10,446	12,007	13,568	15,130	16,691	18,252					
B739	1,215	2,874	4,534	6,193	7,853	9,513	11,172	12,832	14,491	16,151	17,811						
B744	6,221	11,435	16,648	21,862	27,076	32,290	37,728	43,675	49,621	55,568	61,514	67,460	73,407	85,300	98,281	113,677	129,072
B748	6,391	11,634	16,878	22,121	27,365	32,608	37,852	43,095	48,339	53,582	58,826	64,069	69,574	82,354	95,134	107,914	120,694
B752	1,520	3,627	5,733	7,840	9,861	11,793	13,725	15,657	17,589	19,521	21,453	23,385	25,317	29,181	33,045		
B753	1,443	3,863	6,283	8,702	11,122	13,542	15,962	18,381	20,801	23,221	25,641	28,061	30,480	35,320	40,159		
B762	1,457	4,302	7,148	9,993	12,838	15,683	18,529	21,374	24,219	27,065	29,910	32,755	35,601	41,291	46,982	52,672	
B763	1,650	4,440	7,230	10,020	12,809	15,599	18,389	21,179	23,969	27,060	30,294	33,528	36,763	43,231	49,700	56,168	62,637
B764	1,883	4,889	7,895	10,901	13,907	16,913	19,919	22,925	25,930	28,936	31,942	34,948	37,954	43,966	49,977	55,989	62,001
B772	3,137	6,911	10,685	14,459	18,233	22,007	25,781	29,555	33,329	37,103	40,877	44,651	48,425	55,971	65,216	74,461	83,706
B773	3,765	8,064	12,363	16,662	20,961	25,260	29,844	34,463	39,082	43,701	48,320	52,939	57,558	66,796	76,034	85,272	94,510
B77L	3,309	7,275	11,240	15,206	19,171	23,137	27,102	31,068	35,034	40,416	45,797	51,179	56,560	67,323	78,089	86,071	94,053
B77W	4,807	8,738	12,670	16,601	20,533	24,464	28,396	32,328	37,385	42,443	47,500	52,558	57,615	67,730	77,850	86,991	96,132
B788	2,324	4,864	7,404	9,944	12,483	15,356	18,230	21,103	23,977	26,850	29,724	32,597	35,471	41,218	46,965	52,712	58,459
B789	2,235	5,163	8,091	11,019	13,947	16,875	19,803	22,731	25,660	28,896	32,132	35,368	38,604	45,076	51,548	58,020	64,492
C550	190	617	945	1,270	1,596	1,921	2,246	2,571									
C56X	207	758	1,103	1,447	1,792	2,136	2,481	2,826									
C68A	385	970	1,429	1,866	2,304	2,742	3,179	3,617	4,055	4,493	4,930	5,368	5,806				
CL30	336	980	1,579	2,050	2,521	2,992	3,463	3,934	4,405	4,876	5,347	5,818					
CL35	288	1,020	1,476	1,932	2,397	2,898	3,399	3,900	4,401	4,902	5,403	5,904					
CL60	347	1,084	1,677	2,270	2,862	3,455	4,047	4,640	5,232	5,825	6,417	7,010	7,602	8,788			
CRJ1	459	1,224	1,980	2,659	3,338	4,017	4,696	5,375	6,054	6,733	7,412	8,091	8,770				
CRJ2	247	1,201	2,037	2,872	3,708	4,544	5,379	6,215	7,050	7,886	8,721	9,557	10,393				
CRJ7	499	1,670	2,652	3,634	4,616	5,598											
CRJ9	545	1,745	2,779	3,801	4,822	5,843											
CRJX	517	1,853	2,905	3,956	5,006												
D328	141	674	1,208	1,741													
DH8D	303	1,117	1,931	2,746	3,560												
E135	388	1,219	1,893	2,567	3,241	3,915	4,591	5,103	5,615								

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

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	**0**	**500**	**1000**	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**5500**	**6000**	**7000**	**8000**	**9000**	**10000**
E145	257	1,248	1,934	2,620	3,306	3,992	4,678	5,364	6,050								
E170	467	1,714	2,743	3,904	5,085	6,266	7,446										
E190	510	2,100	3,335	4,586	5,957	7,327	8,698	10,069	11,439	12,810	14,180	15,551	16,922	19,663	22,404		
E195	541	2,129	3,466	4,803	6,140	7,477	8,814	10,151	11,488	12,825	14,162	15,499	16,836	19,510	22,184		
E35L	379	1,286	1,908	2,529	3,151	3,772	4,394	5,015	5,637	6,258	6,880	7,501	8,123	9,366			
E55P	205	668	934	1,200	1,466	1,732	1,998	2,264									
F100	539	2,178	3,526	4,874	6,222	7,570	8,918	10,266	11,615								
F2TH	329	1,012	1,528	2,044	2,560	3,076	3,592	4,109	4,589	5,070	5,550	6,031	6,511	7,472			
F50	123	865	1,487	2,108	2,730	3,351	3,972	4,594	5,215	5,837	6,458	7,080	7,701				
F70	642	1,962	3,106	4,250	5,394	6,538	7,682										
F900	338	1,050	1,659	2,269	2,878	3,488	4,097	4,707	5,316	5,926	6,535	7,145	7,754	8,973	10,192		
FA50	313	1,061	1,641	2,147	2,652	3,158	3,663	4,169	4,674	5,180	5,685	6,191	6,696				
FA7X	378	1,313	1,975	2,636	3,298	3,959	4,620	5,282	5,943	6,604	7,266	7,927	8,588	9,911	11,234	12,556	13,879
G280	326	862	1,397	1,933	2,469	3,005	3,398	3,732	4,066	4,400	4,735	5,069	5,403				
GL5T	751	1,812	2,679	3,546	4,413	5,280	6,147	7,014	7,881	8,748	9,615	10,483	11,350	13,084	14,818	16,552	
GLEX	659	1,863	2,733	3,602	4,472	5,341	6,211	7,080	7,950	8,820	9,689	10,559	11,428	13,167	14,906	16,645	18,385
GLF4	508	1,832	2,519	3,207	4,020	4,841	5,663	6,484	7,306	8,127	8,949	9,770	10,592	12,235			
GLF5	690	1,673	2,488	3,304	4,119	4,935	5,750	6,566	7,381	8,196	9,012	9,827	10,611	12,109	13,608	15,107	16,605
GLF6	528	1,774	2,568	3,362	4,156	4,950	5,744	6,538	7,332	8,126	8,920	9,714	10,508	12,096	13,683	15,271	16,859
H25B	236	803	1,233	1,664	2,094	2,525	2,955	3,386	3,816	4,247							
LJ31	118	595	889	1,183	1,477	1,771											
LJ40	126	610	993	1,377	1,760	2,144	2,527										
LJ45	76	657	1,010	1,364	1,717	2,071	2,424	2,778	3,131								
LJ60	209	648	1,026	1,404	1,782	2,160	2,538	2,916	3,294	3,672	4,050						
MD11	2,169	6,837	11,505	16,174	20,842	25,510	30,179	34,847	39,515	44,184	48,852	53,521	58,189	67,526	76,862	86,199	95,536
MD82	820	2,867	4,915	6,962	9,010	11,057	13,105	15,152	17,200	19,247							
MD88	1,756	3,691	5,625	7,560	9,782	12,146	14,510	16,874									
MD90	688	3,115	5,099	6,835	8,571	10,308	12,044	13,780									
RJ85	551	2,365	4,180	5,995	7,810	9,625	11,440	13,255									
SF34	154	612	1,069	1,527	1,984	2,442											

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	2,628	5,400	8,172	10,945	13,717	16,489	19,262	22,034	24,806	27,578	30,351	33,123	35,895	41,440	46,984		
A342	2,736	6,562	10,388	13,931	17,473	21,016	24,558	28,101	31,643	35,186	38,730	42,926	47,121	55,512	63,903	72,293	80,684
A345	4,480	8,329	12,179	16,029	19,878	23,728	29,062	34,398	39,733	45,069	50,405	55,740	61,076	71,747	82,418	93,089	103,760
A35K	3,912	7,525	11,138	14,751	18,364	21,978	25,591	29,204	32,817	36,431	41,176	45,339	49,501	57,827	66,153	74,478	82,804
AN30	218	1,664	2,821	3,547	4,272	4,998											
AN32	256	1,953	3,312	4,164	5,015	5,867	6,719										
AT73	190	887	1,584	2,281	2,978												
B37M	701	1,945	3,189	4,432	5,676	6,920	8,164	9,407	10,651	11,895	13,139	14,383	15,626	18,114			
B39M	804	2,230	3,656	5,081	6,507	7,933	9,359	10,785	12,211	13,637	15,063	16,489	17,915				
B461	674	2,167	3,660	5,153													
B712	1,386	2,912	4,439	5,854	7,719	9,585	11,450	13,316									
B732	991	2,213	3,526	4,910	6,294	7,678	9,062	10,445	11,829	13,213	14,597						
B741	5,370	9,870	14,371	18,871	23,372	27,434	32,566	37,699	42,832	47,965	53,098	58,231	63,364	71,546	84,835		
B742	5,853	10,757	15,662	20,567	25,472	30,377	35,493	41,087	46,682	52,276	57,870	63,464	69,058	80,247	92,459	106,942	121,426
B743	5,861	10,773	15,685	20,597	25,509	30,421	35,545	41,148	46,750	52,352	57,955	63,557	69,159	80,364	92,595	107,099	121,603
B74R	5,117	9,406	13,695	17,983	22,272	26,143	31,035	35,926	40,818	45,709	50,600	55,492	60,383	68,181	80,845	93,509	106,172
B74S	5,003	9,196	13,389	17,581	21,774	25,559	30,341	35,123	39,905	44,687	49,469	54,251	59,033	66,656	79,037	91,418	103,798
B78X	2,254	5,208	8,161	11,115	14,068	17,022	19,975	22,929	25,882	29,148	32,412	35,676	38,941	45,469	51,997	58,526	65,054
C25C	235	763	1,170	1,573	1,976	2,378	2,781	3,184	3,587								
C525	173	566	863	1,160	1,458	1,755											
C55B	205	667	1,022	1,373	1,725	2,077	2,428	2,780									
C560	224	727	1,114	1,497	1,881	2,264	2,648	3,031									
DH8A	165	611	1,056	1,501	1,946												
DH8B	171	631	1,091	1,550													
DH8C	201	743	1,285	1,827	2,369												
DHC7	208	769	1,330														
E75L	492	1,807	2,893	4,117	5,362	6,607	7,852										
E75S	477	1,752	2,805	3,992	5,200	6,407	7,614										
FA8X	395	1,370	2,059	2,749	3,439	4,128	4,818	5,508	6,198	6,887	7,577	8,267	8,956	10,336	11,715	13,094	14,474
H25A	217	738	1,134	1,530	1,926	2,322	2,718	3,114	3,509	3,905	4,301						
H25C	261	890	1,367	1,844	2,322	2,799											
LJ25	90	436	710	985	1,259	1,533	1,807										
LJ35	110	532	867	1,201	1,536	1,870	2,205	2,539	2,874	3,208							
LJ55	74	645	992	1,339	1,687	2,034	2,381										
LJ70	76	658	1,012	1,367	1,721	2,075	2,429	2,783									
LJ75	78	674	1,036	1,399	1,762	2,124	2,487	2,849									
MD81	784	2,742	4,699	6,657	8,614	10,572	12,530	14,487	16,445	18,402	20,360						
MD83	892	3,118	5,345	7,572	9,799	12,025	14,252	16,479	18,705	20,932	23,159	25,385	27,612	32,066			
MD87	1,597	3,356	5,115	6,874	8,896	11,045	13,195	15,345	17,495	19,644	21,794	23,944	26,094				
RJ1H	693	2,642	4,592	6,541	8,490	10,440	12,389	14,338	16,288								
RJ70	556	2,388	4,221	6,054	7,886												

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
A124	9,659	18,979	28,299	37,619	46,939	56,259	65,579	74,899	84,219	93,539	102,859						
A140	314	963	1,612	2,261	2,909	3,558	4,207										
A148	783	1,732	2,681	3,630	4,579	5,528	6,477	7,427									
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														
AN72	783	1,732	2,681	3,630	4,579	5,528	6,477	7,427	8,376								
ATP	282	865	1,447	2,029	2,612	3,194	3,777	4,359	4,942								
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							
BA11	558	2,209	3,861	5,512	7,164	8,815	10,467	12,118	13,770	15,421							
BE20	46	142	237	333	428	524	619	715									
BELF	397	3,910	6,502	9,094	11,686	14,278	16,870	19,462	22,054	24,646	27,238	29,830	32,422	37,606	42,790		
C130	869	2,664	4,459	6,254	8,049	9,844	11,639	13,434									
C212	138	423	707	992													
CN35	210	642	1,075	1,507	1,940	2,372	2,805	3,237	3,670								
CVLP	20	1,294															
D228	115	353	590	828	1,065	1,303											
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		
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			
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	
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										
DC95	821	2,680	4,538	6,397													
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							
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										
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										
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
J328	183	968	1,484	2,000													
JS31	120	369	618														
JS32	129	394	659														
JS41	177	544	910	1,276	1,642	2,008	2,375	2,741									
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
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														
S601	184	407	630	853	1,076	1,299											
SB20	829	1,391	1,954	2,517	3,080	3,643											
SC7	87	267	448														
SH33	166	508	850	1,193													
SH36	177	544	910	1,276													
SW2	124	380	636	892	1,148	1,403	1,659	1,915									
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				
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								
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 2019 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
A20N	A-320neo	Yes				
A21N	A-321neo	Yes				
A306	A-300B4-600	Yes				
A310	A-310	Yes				
A318	A-318	Yes				
A319	A-319	Yes				
A320	A-320	Yes				
A321	A-321	Yes				
A332	A-330-200	Yes				
A333	A-330-300	Yes				
A343	A-340-300	Yes				
A346	A-340-600	Yes				
A359	A-350-900 XWB	Yes				
A388	A-380-800	Yes				
AN26	An-26	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				
B38M	737 MAX 8	Yes				
B462	BAe-146-200	Yes				
B463	BAe-146-300	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				
B744	747-400 (international, winglets)	Yes				
B748	747-8	Yes				
B752	757-200	Yes				
B753	757-300	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				
C550	550 Citation 2	Yes				
C56X	560XL Citation Excel	Yes				
C68A	680A Citation Latitude	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
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				
D328	328	Yes				
DH8D	Dash 8 (400)	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				
E35L	EMB-135BJ Legacy	Yes				
E55P	EMB-505 Phenom 300	Yes				
F100	100	Yes				
F2TH	Falcon 2000	Yes				
F50	50 Maritime Enforcer	Yes				
F70	70	Yes				
F900	Falcon 900	Yes				
FA50	Falcon 50	Yes				
FA7X	Falcon 7X	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				
MD11	MD-11	Yes				
MD82	MD-82	Yes				
MD88	MD-88	Yes				
MD90	MD-90	Yes				
RJ85	RJ-85 Avroliner	Yes				
SF34	SF-340	Yes				

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

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

Type Designator	Example of Model*	CEM based on AO data (from COFdb)	CEM based on Equivalent Aircraft Type		CEM based on ICAO Fuel Formula	
		Source of CEM	Source of CEM	Type Designator of Equivalent Aircraft	Source of CEM	ICAO Aircraft Code
A30B	A-300B2		Yes	A306		
A342	A-340-200		Yes	A343		
A345	A-340-500		Yes	A346		
A35K	A-350-1000 XWB		Yes	A359		
AN30	An-30		Yes	AN26		
AN32	An-32		Yes	AN26		
AT43	ATR-42-300		Yes	AT45		
AT73	ATR-72-211		Yes	AT72		
B37M	737 MAX 7		Yes	B38M		
B39M	737 MAX 9		Yes	B38M		
B461	BAe-146-100		Yes	B462		
B712	717-200		Yes	MD88		
B732	737-200		Yes	B733		
B741	747-100		Yes	B744		
B742	747-200		Yes	B744		
B743	747-300		Yes	B744		
B74R	747SR		Yes	B744		
B74S	747SP		Yes	B744		
B78X	787-10 Dreamliner		Yes	B789		
C25C	525C Citation CJ4		Yes	C550		
C525	525 Citation CJ1		Yes	C550		
C55B	550B Citation Bravo		Yes	C550		
C560	560 Citation 5		Yes	C550		
DH8A	Dash 8 (100)		Yes	DH8D		
DH8B	Dash 8 (200)		Yes	DH8D		
DH8C	Dash 8 (300)		Yes	DH8D		
DHC7	DHC-7 Dash 7		Yes	DH8D		
E75L	ERJ-170-200 (long wing)		Yes	E170		
E75S	ERJ-170-200 (short wing)		Yes	E170		
FA8X	Falcon 8X		Yes	FA7X		
H25A	HS-125-1		Yes	H25B		
H25C	Hawker 1000		Yes	H25B		
LJ25	25		Yes	LJ40		
LJ35	35		Yes	LJ40		
LJ55	55		Yes	LJ45		
LJ70	70		Yes	LJ45		
LJ75	75		Yes	LJ45		
MD81	MD-81		Yes	MD82		
MD83	MD-83		Yes	MD82		
MD87	MD-87		Yes	MD88		
RJ1H	RJ-100 Avroliner		Yes	B463		
RJ70	RJ-70 Avroliner		Yes	RJ85		

* 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
A124	An-124 Ruslan				Yes	A4F
A140	IRAN-140 Faraz				Yes	A40
A148	An-148				Yes	A81
A748	748				Yes	HS7
AN12	An-12				Yes	ANF
AN24	An-24				Yes	AN4
AN28	An-28				Yes	A28
AN72	An-72				Yes	AN7
ATP	ATP				Yes	ATP
B701	707-100				Yes	70M
B721	727-100				Yes	721
B722	727-200				Yes	72A
BA11	BAC-111 One-Eleven				Yes	B11
BE20	Super King Air (200)				Yes	BE2
BELF	SC-5 Belfast				Yes	SHB
C130	L-100 Hercules				Yes	LOH
C212	C-212 Aviocar				Yes	CS2
CN35	CN-235				Yes	CS5
CVLP	Convairliner				Yes	CVR
D228	Dornier 228				Yes	D28
DC10	DC-10				Yes	D10
DC3	DC-3				Yes	DC3
DC6	DC-6				Yes	DC6
DC85	DC-8-50				Yes	D8T
DC86	DC-8-60				Yes	D8L
DC87	DC-8-70				Yes	D8Q
DC91	DC-9-10				Yes	D91
DC92	DC-9-20				Yes	D92
DC93	DC-9-30				Yes	D93
DC94	DC-9-40				Yes	D94
DC95	DC-9-50				Yes	D95
DHC6	DHC-6 Twin Otter				Yes	DHT
E110	EMB-110 Bandeirante				Yes	EMB
E120	EMB-120 Brasilia				Yes	EM2
F27	F-27				Yes	F27
F28	F-28 Fellowship				Yes	F28
FA10	Falcon 10				Yes	DF2
G159	G-159 Gulfstream 1				Yes	GRS
I114	Il-114				Yes	I14
IL18	Il-18				Yes	IL8
IL62	Il-62				Yes	IL6
IL76	Il-76				Yes	IL7
IL86	Il-86				Yes	ILW
IL96	Il-96				Yes	IL9
J328	Dornier 328JET				Yes	FRJ
JS31	BAe-3100 Jetstream 31				Yes	J31
JS32	BAe-3200 Jetstream Super 31				Yes	J32
JS41	BAe-4100 Jetstream 41				Yes	J41
L101	L-1011 TriStar				Yes	L10
L188	Electra (L-188)				Yes	LOE
L410	L-410 Turbolet				Yes	L4T
N262	N-262 Frégate				Yes	ND2

* 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 (cont.). 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
S601	SN-601 Corvette				Yes	NDC
SB20	2000				Yes	S20
SC7	SC-7 Skyliner				Yes	SHS
SH33	SD3-30				Yes	SH3
SH36	360				Yes	SH6
SW2	SA-26 Merlin 2				Yes	SWM
T134	Tu-134				Yes	TU3
T154	Tu-154				Yes	TU5
T204	Tu-204				Yes	T20
WW24	1124 Westwind				Yes	WWP
YK40	Yak-40				Yes	YK4
YK42	Yak-42				Yes	YK2
YS11	YS-11				Yes	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 2019 of the ICAO CORSIA CERT

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

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

	Fuel (in kg) for given Block Hour (in min)																
Type Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
A20N	317	1,811	3,814	5,818	7,943	10,191	12,438	14,685									
A21N	291	1,762	4,218	6,763	9,308	11,854	14,399	16,944	19,489								
A306	603	4,836	9,070	13,303	17,536	21,769	26,002	30,236	34,469								
A310	388	3,215	7,537	11,899	16,261	20,623	24,985	29,347	33,709	38,071	42,433	46,795					
A318	147	2,112	4,076	6,041	8,005	9,969	11,934	13,898	15,862								
A319	290	2,209	4,378	6,547	9,014	11,482	13,949	16,417	18,884								
A320	342	2,307	4,614	7,133	9,819	12,513	15,208										
A321	55	2,615	5,335	8,312	11,422	14,532	17,642	20,751									
A332	154	4,408	8,663	14,058	19,452	24,847	30,241	36,083	42,148	48,214	54,279	60,345	66,410	72,475	78,541	84,606	
A333	297	4,745	9,193	14,508	19,927	25,346	31,566	37,810	44,055	50,299	56,543	62,788	69,032	75,276			
A343	138	5,158	10,818	16,477	22,137	27,796	34,786	42,042	49,298	56,553	63,809	71,065	78,321	85,576	92,832	100,088	
A346	1,452	6,978	12,504	18,031	24,812	34,103	43,394	52,685	61,976	71,267	80,558	89,849	99,140	108,431	117,722	127,012	136,303
A359	3,193	5,456	9,038	15,259	21,479	27,700	33,921	40,142	46,362	52,583	58,804	65,025	71,245	77,466	83,687	89,908	96,128
A388	4,939	10,878	20,871	30,864	40,857	50,850	63,978	78,534	93,089	107,645	122,201	136,757	151,313	165,869	180,425	194,981	209,537
AN26	97	984	1,872	2,760													
AT45	102	552	1,126	1,702													
AT46	49	564															
AT72	37	552	1,067														
AT75	49	679															
AT76	87	582															
B190	-	299	601	902													
B38M	305	2,442	4,579	6,716	8,968	11,258	13,549	15,839									
B462	290	1,810	3,785	5,759													
B463	169	1,928	3,686	5,445													
B733	673	2,190	4,426	6,663	8,900	11,136	13,373	15,610									
B734	314	2,418	4,727	7,078	9,428	11,779	14,129	16,480	18,830	21,180	23,531	25,881	28,232	30,582			
B735	61	2,133	4,204	6,275	8,347	10,418	12,490	14,561	16,632	18,704	20,775	22,846					
B736	391	1,897	3,813	5,729	7,646	9,562	11,478	13,395	15,311								
B737	343	2,130	4,190	6,503	8,815	11,186	13,765	16,345									
B738	50	2,074	4,614	7,155	9,695	12,235	14,776										
B739	553	2,294	4,752	7,448	10,144	12,840	15,536										
B744	1,741	8,850	15,960	23,070	34,330	45,590	56,851	68,111	79,371	90,632	101,892	113,152	124,413	135,673	146,933	158,194	169,454
B748	983	7,728	15,764	25,167	34,570	43,973	53,376	62,936	74,782	86,627	98,472	110,317	122,162	134,007	145,852	157,697	169,542
B752	82	2,950	5,927	9,123	12,318	15,513	18,709	21,904	25,099	28,295	31,490						
B753	148	3,156	6,555	10,504	14,453	18,403	22,352	26,301	30,250	34,199							
B762	1,218	4,025	7,519	12,384	17,249	22,115	26,980	31,845	36,710	41,576	46,441	51,306					
B763	968	3,676	7,776	12,166	16,555	20,945	25,334	30,525	36,341	42,158	47,975	53,792	59,608	65,425	71,242	77,059	
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	-	5,349	10,699	16,254	23,205	30,156	37,108	44,059	51,010	58,295	66,495	74,695	82,895	91,096	99,296	107,496	115,696
B773	2,800	7,055	11,471	18,928	26,386	33,438	40,112	46,786	53,459	60,133	66,807	73,481	80,155	86,828	93,502	100,176	
B77L	421	5,516	12,085	19,253	26,420	33,588	40,756	48,615	57,953	67,290	76,628	85,965	95,302	104,640	113,977	123,315	132,652
B77W	55	5,658	11,261	19,173	27,483	35,793	44,103	52,413	60,724	69,034	77,344	85,654	93,964	102,274	110,585	118,895	
B788	958	4,220	7,482	11,659	16,751	21,843	26,935	32,027	37,119	42,211	47,303	52,394	57,486	62,578	67,670	72,762	77,854
B789	554	4,070	7,586	11,861	17,654	23,446	29,238	35,031	40,823	46,616	52,408	58,201	63,993	69,786	75,578	81,371	87,163
C550	103	547	939	1,320	1,701												
C56X	45	769	1,265	1,761	2,257												
C68A	31	1,022	1,687	2,351	3,016	3,680	4,345	5,009									
CL30	70	892	1,714	2,536	3,358	4,180	5,002										
CL35	73	1,020	1,716	2,463	3,245	4,027	4,810										
CL60	52	875	1,823	2,770	3,717	4,664	5,611	6,559	7,506								
CRJ1	171	1,117	2,062	3,008	3,954	4,900	5,846	6,791									
CRJ2	9	936	2,080	3,224	4,368	5,512	6,656	7,800									
CRJ7	27	1,367	2,902	4,222													
CRJ9	94	1,507	3,037	4,568													
CRJX	171	1,649	3,126														
D328	82	473	864														
DH8D	53	872	1,791														
E135	296	1,294	2,293	3,291	4,290												
E145	70	1,041	2,013	2,985	3,956	4,928											
E170	247	1,443	3,029	4,616													

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 Block Hour (in min)																
Type Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
E190	235	1,791	3,658	5,703	7,754	9,805	11,856	13,908	15,959	18,010							
E195	-	1,767	3,827	5,887	7,948	10,008	12,069	14,129	16,190	18,250							
E35L	-	999	1,998	2,997	3,996	5,054	6,139	7,159	7,805								
E55P	46	681	1,081	1,482	1,883												
F100	27	1,871	3,775	5,699	7,623	9,547											
F2TH	180	1,070	1,904	2,737	3,570	4,403	5,236	6,070	6,903								
F50	96	543	1,085	1,628	2,171	2,713	3,256	3,799									
F70	136	1,640	3,341	5,043													
F900	73	996	1,920	2,852	3,884	4,915	5,947	6,979	8,010	9,042	10,074						
FA50	64	993	1,923	2,852	3,781	4,711	5,640	6,570									
FA7X	82	1,201	2,321	3,440	4,559	5,679	6,798	7,917	9,037	10,156	11,275	12,395	13,514				
G280	20	796	1,571	2,346	3,122	3,897	4,672	5,448									
GL5T	462	1,714	2,966	4,379	5,915	7,451	8,987	10,522	12,058	13,594	15,130	16,666					
GLEX	443	1,842	3,240	4,639	6,097	7,653	9,209	10,764	12,320	13,876	15,432	16,988	18,544	20,100			
GLF4	257	1,576	2,851	4,037	5,398	6,846	8,294	9,742	11,190								
GLF5	380	1,743	3,106	4,469	5,833	7,196	8,559	9,922	11,285	12,648	14,011	15,375	16,738	18,101	19,464	20,827	22,190
GLF6	10	1,491	2,973	4,454	5,936	7,417	8,898	10,380	11,861	13,343	14,824	16,305	17,787	19,268	20,750	22,231	
H25B	68	840	1,499	2,157	2,816	3,475											
LJ31	88	487	950	1,414													
LJ40	81	597	1,180	1,763													
LJ45	36	591	1,097	1,603	2,109												
LJ60	122	674	1,227	1,779	2,331	2,884	3,436										
MD11	1,738	5,474	12,063	20,344	28,626	36,907	45,189	53,470	61,752	70,033	78,314	86,596	94,877	103,159	111,440	119,722	128,003
MD82	173	2,805	5,615	8,602	11,590	14,577											
MD88	160	2,965	5,769	8,446	9,846												
MD90	624	2,613	5,068	7,678	10,288												
RJ85	617	2,072	3,526	4,980	6,434												
SF34	113	373	634	894													

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

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
A30B	583	4,675	8,767	12,860	16,952	21,044	25,136	29,228	33,321	37,413							
A342	136	5,060	10,612	16,165	21,717	27,269	34,126	41,244	48,362	55,481	62,599	69,717	76,835	83,953	91,071	98,189	105,307
A345	1,470	7,066	12,662	18,259	25,126	34,534	43,942	53,351	62,759	72,167	81,576	90,984	100,392	109,801	119,209	128,617	138,026
A35K	3,656	6,247	10,349	17,472	24,595	31,718	38,841	45,964	53,087	60,210	67,334	74,457	81,580	88,703	95,826	102,949	110,072
AN30	93	943	1,794	2,645													
AN32	109	1,107	2,106	3,105	4,103												
AT43	93	499	1,020	1,542	2,064	2,586											
AT73	38	568	1,097														
B37M	285	2,284	4,283	6,281	8,388	10,530	12,672	14,815	16,957								
B39M	327	2,618	4,910	7,201	9,616	12,072	14,528	16,984									
B461	262	1,635	3,418														
B712	126	2,339	4,553	6,665	7,770												
B732	596	1,938	3,918	5,898	7,877	9,857	11,837										
B741	1,503	7,640	13,776	19,913	29,633	39,353	49,073	58,792	68,512	78,232							
B742	1,638	8,326	15,015	21,703	32,296	42,890	53,483	64,076	74,669	85,263	95,856	106,449	117,042	127,636	138,229		
B743	1,640	8,338	15,037	21,735	32,344	42,952	53,561	64,170	74,779	85,387	95,996	106,605	117,214	127,823	138,431	149,040	159,649
B74R	1,432	7,280	13,128	18,977	28,239	37,502	46,764	56,027	65,290	74,552	83,815	93,077	102,340				
B74S	1,400	7,117	12,835	18,552	27,608	36,663	45,719	54,774	63,830	72,885	81,940	90,996	100,051				
B78X	559	4,106	7,652	11,964	17,807	23,650	29,493	35,336	41,179	47,022	52,865	58,708	64,551	70,393	76,236	82,079	87,922
C25C	128	677	1,162	1,634	2,107												
C525	94	500	858	1,206													
C55B	111	591	1,015	1,427	1,839												
C560	122	645	1,107	1,556	2,006												
DH8A	29	477	979														
DH8B	30	493	1,012														
DH8C	35	581	1,192														
DHC7	37	601															
E75L	260	1,521	3,194	4,867													
E75S	253	1,475	3,098	4,720													
FA8X	85	1,253	2,420	3,587	4,755	5,922	7,089	8,256	9,424	10,591	11,758	12,926	14,093	15,260			
H25A	63	772	1,378	1,984	2,590	3,196	3,801										
H25C	76	931	1,661	2,392													
LJ25	58	427	843	1,260													
LJ35	70	521	1,029	1,537	2,046	2,554											
LJ55	35	580	1,077	1,574	2,071												
LJ70	36	592	1,099	1,606	2,113												
LJ75	37	606	1,125	1,644	2,163												
MD81	166	2,682	5,368	8,225	11,081	13,937	16,793										
MD83	188	3,051	6,106	9,355	12,604	15,853	19,102	22,350	25,599								
MD87	145	2,696	5,247	7,681	8,954	10,227	11,500	12,772									
RJ1H	176	2,003	3,830	5,657	7,484												
RJ70	623	2,092	3,560														

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

	Fuel (in kg) for given Great Circle Distance (in km)																
Type Designator	0	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900	960
A124	-	16,000	32,000	48,000	64,000	80,000	96,000										
A140	-	720	1,440	2,160													
A148	-	1,600	3,200	4,800	6,400												
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															
AN72	-	1,600	3,200	4,800	6,400	8,000											
ATP	-	646	1,293	1,939	2,586	3,232											
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											
B722	-	4,620	9,239	13,859	18,479	23,098	27,718										
BA11	-	3,057	6,114	9,172	12,229	15,286											
BE20	-	106	212	318	424												
BELF	-	2,880	5,760	8,640	11,520	14,400	17,280	20,160	23,040	25,920							
C130	-	1,992	3,984	5,976	7,968												
C212	-	316															
CN35	-	480	960	1,440	1,920	2,400											
CVLP	-																
D228	-	264	527	791													
DC10	-	8,921	17,843	26,764	35,686	44,607	53,528	62,450	71,371	80,293							
DC3	-	304	608														
DC6	-	1,082	2,165	3,247	4,330	5,412	6,494	7,577	8,659								
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						
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													
DC95	-	3,164	6,328														
DHC6	-	270															
E110	-	252	504														
E120	4	413															
F27	-	772	1,544	2,316	3,088	3,860											
F28	-	2,000	4,000	6,000	8,000	10,000											
FA10	-	760	1,520	2,280	3,040												
G159	-	720	1,440	2,160	2,880												
I114	-	880															
IL18	-	2,040	4,080	6,120													
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				
J328	-	872	1,744														
JS31	-	276															
JS32	-	294															
JS41	-	406	813	1,219	1,626												
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	
L188	-	2,319	4,638	6,958	9,277												
L410	-	320															
N262	-	302															
S601	-	376	752														
SB20	578	1,202	1,825	2,449													
SC7	-	200															
SH33	-	380															
SH36	-	406															
SW2	-	284	568	852	1,136												
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									
WW24	-	582	1,163	1,745	2,326	2,908											
YK40	-	816	1,632														
YK42	683	3,316	5,949	8,582	11,214												
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 2020 version of the ICAO CORSIA CERT

Type Designator	Manufacturer	Example of Model*
A124	ANTONOV	An-124 Ruslan
A140	ANTONOV	IRAN-140 Faraz
A148	ANTONOV	An-148
A158	ANTONOV	An-158
A20N	AIRBUS	A-320neo
A21N	AIRBUS	A-321neo
A225	ANTONOV	An-225 Mriya
A30B	AIRBUS	A-300B2
A342	AIRBUS	A-340-200
A345	AIRBUS	A-340-500
A359	AIRBUS	A-350-900 XWB
A35K	AIRBUS	A-350-1000 XWB
A3ST	AIRBUS	A-300ST Beluga
A743	ANTONOV	An-74-300
A748	AIL	748
AJET	AOI	Alpha Jet
AN12	ANTONOV	An-12
AN24	ANTONOV	An-24
AN26	ANTONOV	An-26
AN28	ANTONOV	An-28
AN30	ANTONOV	An-30
AN32	ANTONOV	An-32
AN38	ANTONOV	An-38
AN70	ANTONOV	An-70
AN72	ANTONOV	An-72
ASTR	GULFSTREAM AEROSPACE	1125 Astra
AT3	AIDC	AT-3 Tzu-Chung
AT43	ATR	ATR-42-300
AT44	ATR	ATR-42-400
AT73	ATR	ATR-72-211
AT75	ATR	ATR-72-500
ATP	BRITISH AEROSPACE	ATP
B350	BEECH	King Air 350
B38M	BOEING	737 MAX 8
B461	BRITISH AEROSPACE	BAe-146-100
B701	BOEING	707-100
B703	BOEING	707-300
B712	BOEING	717-200
B721	BOEING	727-100
B722	BOEING	727-200
B732	BOEING	737-200
B741	BOEING	747-100
B742	BOEING	747-200
B743	BOEING	747-300
B74D	BOEING	747-400 (domestic, no winglets)
B74R	BOEING	747SR
B74S	BOEING	747SP
B773	BOEING	777-300
B78X	BOEING	787-10 Dreamliner
BA11	BAC	BAC-111 One-Eleven
BCS1	BOMBARDIER	BD-500 CSeries CS100
BCS3	BOMBARDIER	BD-500 CSeries CS300
BE20	BEECH	Super King Air (200)
BE30	BEECH	300 Super King Air
BE40	BEECH	400 Beechjet
BELF	SHORT	SC-5 Belfast
BLCF	BOEING	747-400LCF Dreamlifter
C130	LOCKHEED	L-100 Hercules
C212	AIRBUS	C-212 Aviocar
C25B	CESSNA	525B Citation CJ3
C25C	CESSNA	525C Citation CJ4
C27J	ALENIA	Spartan (C-27J)
C295	AIRBUS	C-295
C525	CESSNA	525 Citation CJ1
C55B	CESSNA	550B Citation Bravo
C560	CESSNA	560 Citation 5
C650	CESSNA	650 Citation 3
C680	CESSNA	680 Citation Sovereign
C700	CESSNA	700 Citation Longitude
C750	CESSNA	750 Citation 10
CN35	AIRBUS	CN-235
CRJ2	CANADAIR	Challenger 800
CVLP	CONVAIR	Convairliner
CVLT	CANADAIR	Cosmopolitan
D228	DORNIER	Dornier 228
DC10	BOEING	DC-10
DC3	DOUGLAS	DC-3
DC6	DOUGLAS	DC-6
DC85	DOUGLAS	DC-8-50
DC87	DOUGLAS	DC-8-70
DC91	DOUGLAS	DC-9-10
DC92	DOUGLAS	DC-9-20
DC93	DOUGLAS	DC-9-30
DC94	DOUGLAS	DC-9-40
DC95	DOUGLAS	DC-9-50
DH8A	DE HAVILLAND CANADA	Dash 8 (100)
DH8B	DE HAVILLAND CANADA	Dash 8 (200)
DH8C	DE HAVILLAND CANADA	Dash 8 (300)
DHC6	DE HAVILLAND CANADA	DHC-6 Twin Otter
DHC7	DE HAVILLAND CANADA	DHC-7 Dash 7
E110	EMBRAER	EMB-110 Bandeirante
E120	EMBRAER	EMB-120 Brasilia
E195	EMBRAER	ERJ-190-200
E545	EMBRAER	EMB-545 Legacy 450
E550	EMBRAER	EMB-550 Legacy 500
E75L	EMBRAER	ERJ-170-200 (long wing)
E75S	EMBRAER	ERJ-170-200 (short wing)
F27	CONAIR	F-27
F28	FOKKER	F-28 Fellowship
FA10	DASSAULT	Falcon 10
FA20	DASSAULT	Falcon 20
FA8X	DASSAULT	Falcon 8X
G150	GULFSTREAM AEROSPACE	Gulfstream G150
G159	GRUMMAN	G-159 Gulfstream 1
GA5C	GULFSTREAM AEROSPACE	Gulfstream G500 (G-7)
GALX	GULFSTREAM AEROSPACE	Gulfstream G200
GLF2	GRUMMAN	Gulfstream 2
GLF3	GULFSTREAM AEROSPACE	Gulfstream 3
H25A	DE HAVILLAND	HS-125-1
H25C	BRITISH AEROSPACE	Hawker 1000
HA4T	HAWKER BEECHCRAFT	Hawker 4000
I114	ILYUSHIN	Il-114
IL18	ILYUSHIN	Il-18
IL62	ILYUSHIN	Il-62
IL76	ILYUSHIN	Il-76
IL86	ILYUSHIN	Il-86
IL96	ILYUSHIN	Il-96
J328	328 SUPPORT SERVICES	Dornier 328JET
JS31	BRITISH AEROSPACE	BAe-3100 Jetstream 31
JS32	BRITISH AEROSPACE	BAe-3200 Jetstream Super 31
JS41	AI(R)	BAe-4100 Jetstream 41
L101	LOCKHEED	L-1011 TriStar
L188	LOCKHEED	Electra (L-188)
L29B	LOCKHEED	L-1329 Jetstar 2
L410	AIRCRAFT INDUSTRIES	L-410 Turbolet
LJ24	GATES LEARJET	24
LJ25	GATES LEARJET	25
LJ35	GATES LEARJET	35
LJ55	GATES LEARJET	55
LJ70	LEARJET	70
LJ75	LEARJET	75
M28	PZL-MIELEC	M-28 Skytruck
MD81	BOEING	MD-81
MD82	BOEING	MD-82
MD83	BOEING	MD-83
MD87	BOEING	MD-87
MG15	AERO (2)	MiG-15
MRJ9	MITSUBISHI	MRJ-90
MU30	MITSUBISHI	MU-300 Diamond
N262	AEROSPATIALE	N-262 Frégate
PC24	PILATUS	PC-24
RJ1H	AI(R)	RJ-100 Avroliner
RJ70	AI(R)	RJ-70 Avroliner
S601	AEROSPATIALE	SN-601 Corvette
SB20	SAAB	2000
SBR1	NORTH AMERICAN	Sabreliner
SC7	SHORT	SC-7 Skyliner
SH33	SHORT	SD3-30
SH36	SHORT	360
SU95	SUKHOI	Superjet 100-95
SW2	SWEARINGEN	SA-26 Merlin 2
SW3	FAIRCHILD (1)	Merlin 3
SW4	FAIRCHILD (1)	Merlin 4
T134	TUPOLEV	Tu-134
T154	TUPOLEV	Tu-154
T204	TUPOLEV	Tu-204
T334	TUPOLEV	Tu-334
WW24	IAI	1124 Westwind
YK40	YAKOVLEV	Yak-40
YK42	YAKOVLEV	Yak-42
YS11	MITSUBISHI	YS-11

— END —