Calculation Methodology Document

1 AWG background

The Aviation Working Group (see www.awg.aero, **AWG**) is a non-profit entity chaired by Airbus and Boeing, and comprised of the world's major aviation manufacturers, leasing companies and banking and other financial institutions. AWG works on regulations and practices to facilitate international aviation financing and leasing. It is widely considered a leader on the link between finance and aviation, and a specialist on their relation and interplay with regulation.

2 ESG subgroup

In January 2020, AWG created a focused environmental, social and governance (**ESG**) subgroup. The purpose of the ESG subgroup is to "*assess, provide information, and potentially take action on, ESG geared to the context of aviation financing and leasing*".

Based on limited availability of quality data on, and the consistency and complexity of alternative methods of calculating, carbon emissions in aviation, the ESG subgroup proposed to create a foundational tool, available to the industry, for the purposes of calculating carbon dioxide (**CO2**) emissions for aircraft and aircraft portfolios based on original equipment manufacturer (**OEM**) source data, which is widely acknowledged to represent the best source data for aircraft CO2 emissions performance. The initial participating OEMs are Airbus, ATR, Boeing and Embraer.

The work of the ESG subgroup has resulted in the creation of the "AWG Carbon Calculator" tool (the **ACC Tool**), the only aircraft CO2 emissions tool to use OEM source data. The ACC Tool will enable its users to perform advanced calculations to generate reliable and consistent CO2 emissions information for aircraft and aircraft portfolios based on aircraft-specific operational information that is generally available to airlines, aircraft lessors, aircraft financiers, and other aviation investors.

This document sets out the basis on, and the methodology for, which CO2 emissions are calculated for aircraft and aircraft portfolios using the ACC Tool.

3 ACC Tool calculations

The ACC Tool will be available to participants in the aviation financing and leasing sector.

3.1 User Inputs

In respect of any aircraft for which carbon emissions are to be calculated, the ACC Tool requires the user to (a) select the relevant aircraft model, (b) input the number of flight hours per annum and cycles per annum for that aircraft, and (c) confirm whether a degradation factor should apply (for example, where the aircraft model is out-of-production or an engine on the relevant aircraft is close to overhaul). Where flight hours per annum and cycles per annum are not known by the user, the user can select to apply default utilisation data provided by the OEM for that aircraft model (**OEM Default Utilisation**). Together, these data inputs are referred to as the **User Inputs**.

3.2 OEM Data

The ACC Tool calculates the estimated annual CO2 emissions of an aircraft by reference to the User Inputs and data provided by the OEM in respect of that aircraft model (**OEM Data**). The OEMs will provide their own CO2 emissions data in respect of each aircraft model within their fleet at the following mission lengths.

For Turboprop and Regional Jet aircraft, the OEMs will provide CO2 emissions data for low (0.5 hour), medium (1.5 hour), and high (3 hour) mission lengths. For Single-Aisle aircraft, the OEMs will provide CO2 emissions data for low (1 hour), medium (2 hour), and high (4 hour) mission lengths. For Widebody aircraft, the OEMs will provide CO2 emissions data for low (2 hour), medium (4 hour), and high (10 hour) mission lengths.

Notwithstanding the foregoing, the CO2 emissions data for (a) the Embraer ERJ140 and Embraer ERJ145 aircraft will be provided for low (0.5 hour), medium (1.5 hour), and high (2 hour) mission lengths and (b) the Airbus A310-300F and Airbus A300F4-600RF aircraft will be provided for low (1 hour), medium (2 hour), and high (4 hour) mission lengths, as the selected mission lengths for the applicable aircraft type are not appropriate in the context of the operational range or use for these aircraft models.

The OEM Data is discussed further in paragraph 4 (*OEM Data*).

3.3 ACC Tool calculation

Where the User Inputs correspond to a mission length other than those mission lengths provided for in the OEM Data, the ACC Tool will either (a) use linear interpolation and extrapolation of the OEM Data to calculate an approximated figure for the annual CO2 emissions for that mission length or (b) return an error message where the User Inputs are outside the specified range.

The ACC Tool will (a) where a mission length corresponding to User Inputs falls within the range of the specified low and medium mission lengths, apply linear interpolation using the low and medium mission length OEM Data to determine the approximated annual CO2 emissions for such mission length, (b) where a mission length corresponding to User Inputs falls within the range of the specified medium and high mission lengths, apply linear interpolation using the medium and high mission length OEM Data to determine the approximated annual CO2 emissions for such mission length, and (c) where a mission length corresponding to User Inputs falls within the range of the specified high mission length and the cut-off limit above the specified high mission length as determined by the OEM, apply linear extrapolation using the medium and high mission length OEM Data to determine the approximated annual CO2 emissions for such mission length. Where a mission length corresponding to User Inputs falls below the specified low mission length or above the cut-off limit above the specified high mission length as determined by the OEM, the ACC Tool will return an error message.

Where an error message is provided in respect of User Inputs, the user will have the option to either (a) apply OEM Default Utilisation for the relevant aircraft model or (b) contact the OEM for carbon emissions information in this range. The relevant cut-off limit above the specified high mission length as determined by the OEM for an aircraft model will be available within the ACC Tool.

3.4 User Outputs

The ACC Tool will, in respect of any output, confirm the User Inputs so that such User Inputs can be verified. The ACC Tool will then, in respect of such User Inputs, confirm (a) CO2 emissions per annum, (b) CO2 emissions per flight hour, and (c) CO2 emissions per mission/cycle (together, the **User Outputs**).

The ACC Tool calculates the CO2 emissions per flight hour and CO2 emissions per mission/cycle by dividing the calculated CO2 emissions per annum by the corresponding User Inputs (or, where OEM Default Utilisation has been selected, the relevant default utilisation information).

The ACC Tool will provide CO2 emissions in metric units, but this can be converted to imperial units using the ACC Tool.

User Outputs from the ACC Tool for specific User Inputs can be saved and labelled as individual aircraft (**Aircraft**) by the user (for example, by reference to a manufacturer serial number and a specific year).

3.5 Portfolios

Users of the ACC Tool will be able to combine saved Aircraft within a portfolio (a **Portfolio**). The ACC Tool will, in respect of a Portfolio, confirm (a) details of the relevant User Outputs for each Aircraft, (b) the corresponding User Inputs for each Aircraft, and (c) the aggregate annual CO2 emissions (together, the **Portfolio Information**).

3.6 Reports, graphical outputs and certificates

Users of the ACC Tool will be able to generate a report for a Portfolio. The report will confirm the Portfolio Information and provide tabular and graphical outputs based on aircraft type, aircraft model and selected Aircraft. Users of the ACC Tool will also be able to generate a comparison report in respect of two Portfolios. The report will confirm the Portfolio Information for each Portfolio and provide tabular and graphical outputs of the Portfolio Information based on aircraft type and aircraft model for comparison purposes.

Graphical outputs will be presented in various forms to aid users of the ACC Tool in visualising the relevant Portfolio Information, and such forms will include bar chart, pie chart, radar chart, scatter chart and bubble chart. Users of the ACC Tool will be able to produce certificates confirming annual CO2 emissions for selected Aircraft or aggregate annual CO2 emissions for selected Portfolios.

Aircraft and Portfolio data will be exportable in CSV format, graphical outputs will be exportable in JPEG or PNG format, and certificates will be exportable in PDF format.

4 OEM Data

4.1 OEM Data assumptions

The OEM Data has been prepared based on the following assumptions:

a. Turboprop aircraft are configured in a typical single-class interior layout.

   This assumption has been selected as it reflects the configuration of most of the Turboprop fleet as at the time of development.

b. Regional Jets are configured in a typical single-class interior layout for small Regional Jets (ERJ135/ERJ145/CRJ200) and a typical two-class interior layout for large Regional Jets (E1/E2/CRJ700).

   These assumptions have been selected as they reflect the configuration of most of the small and large Regional Jet fleets as at the time of development.

c. Single-Aisle aircraft are configured in a typical two-class interior layout.

   This assumption has been selected as to reflect both (i) the configuration of most of the Single-Aisle fleet as at the time of development and (ii) the typical configuration in which such aircraft are marketed by the OEMs.

d. Widebody aircraft are configured in representative interior layouts.

This assumption has been selected to reflect both (i) the configuration of most of the Widebody fleet as at the time of development and (ii) the typical configuration in which such aircraft are marketed by the OEMs.

e. Typical Express Freight payload for Single-Aisle and medium Widebody freighter aircraft.

   This assumption has been selected as it reflects the typical use for Single-Aisle and medium Widebody freighter aircraft.

f. Typical General Freight payload for large Widebody freighter aircraft.

   This assumption has been selected as it reflects the typical use for large Widebody freighter aircraft.

g. OEM assumed Operating Empty Weight for each configuration.

   This assumption has been selected so that it is then consistent with the assumptions regarding configuration referred to above.

h. The relevant aircraft operator operated each flight with 100% passenger occupancy.

   This assumption has been selected to represent a conservative approach to the possible understatement of CO2 emissions for aircraft. Note: passenger occupancy does not represent a significant difference in the CO2 emissions for aircraft for the purposes of the ACC Tool.

i. Where a Single-Aisle or Widebody aircraft model has multiple engine options, the best performing engine option has been selected.

   This assumption has been selected as it often reflects the most common engine selection and to ensure consistency in comparison. Note: engine selection does not represent a significant difference in the CO2 emissions for aircraft for the purposes of the ACC Tool.

j. If selected in the User Inputs, a performance degradation will be applied in accordance with a percentage selected by the relevant OEM.

   The percentage for performance degradation has been selected based on OEM performance analysis.

k. The emissions factor is 3.16.

   This factor is a chemical constant relating the mass of CO2 produced by stoichiometric combustion of a known mass of jet fuel, rounded to three significant figures.

l. CO2 emissions in respect of taxi-in and taxi-out are not included.

   This assumption has been selected to accurately reflect that both OEM Data and User Inputs reference flight hours, rather than block hours.

4.2 OEM Data mission length

The OEMs have confirmed that CO2 emissions increase on a linear basis relative to the mission length, provided that such mission lengths fall within the range of the specified low mission length and the cut-off limit above the specified high mission length as determined by the OEM. Accordingly, CO2 emissions

data is provided for low, medium and high mission lengths within generally expected operational ranges for Turboprop, Regional Jet, Single-Aisle and Widebody aircraft. A medium mission length has been included to improve accuracy. The mission lengths have also been selected as they represent the best fit for interpolation and extrapolation purposes within the ACC Tool.

4.3 OEM Default Utilisation

The OEM Default Utilisation for an aircraft model represents the number of flight hours and cycles that the relevant OEM would typically expect an aircraft of that model to incur on an annual basis.

5 ACC Tool accuracy

There are many factors which may cause actual aircraft CO2 emissions to vary from the data provided by the ACC Tool. These include but are not limited to the following:

a. The aircraft's actual model, operation or condition is different to that suggested by the User Inputs.

b. The de-rate factor at which the aircraft is operated.

c. The environmental conditions in which the aircraft is operated.

d. The aircraft can be operated on varying mission lengths.

e. The aircraft's actual configuration or condition.

f. The aircraft's actual payload and/or passenger occupancy.

g. The weight of any spare fuel carried by the aircraft.

6 Definitions/Glossary

ACC Tool has the meaning given to it in paragraph 2 (*ESG subgroup*).

Aircraft has the meaning given to it in paragraph 3.4 (*User Outputs*).

aircraft type means, for the purposes of the ACC Tool, either Turboprop, Regional Jet, Single-Aisle or Widebody.

AWG has the meaning given to it in paragraph 1 (*AWG background*).

CO2 has the meaning given to it in paragraph 2 (*ESG subgroup*).

cycle means one take-off and landing of an aircraft.

ESG has the meaning given to it in paragraph 2 (*ESG subgroup*).

flight hour means each hour or part of an hour elapsing from the moment the wheels of an aircraft leave the ground on take-off until the wheels of the aircraft next touch the ground.

mission length means the number of flight hours elapsed per cycle for an aircraft.

OEM has the meaning given to it in paragraph 2 (*ESG subgroup*).

OEM Data has the meaning given to it in paragraph 3.2 (*OEM Data*).

OEM Default Utilisation has the meaning given to it in paragraph 3.1 (*User Inputs*).

Operating Empty Weight means the empty weight of the aircraft including all fluids, equipment, crew and crew baggage required for operation, but excluding fuel.

Portfolio has the meaning given to it in paragraph 3.5 (*Portfolios*).

Portfolio Information has the meaning given to it in paragraph 3.5 (*Portfolios*).

Regional Jet means, for the purposes of the ACC Tool, each of the following aircraft models: Embraer ERJ 140, Embraer ERJ 145, Embraer E170, Embraer E175, Embraer E190, Embraer E195, Embraer E175-E2, Embraer E190-E2 and Embraer E195-E2.

Single-Aisle means, for the purposes of the ACC Tool, each of the following aircraft models: Airbus A220-100, Airbus A220-300, Airbus A319-neo, Airbus A320neo, Airbus A321neo, Airbus A319-100, Airbus A320-200, Airbus A321-100, Airbus A321-200, Boeing 737-700W, Boeing 737-800W, Boeing 737-900ERW, Boeing 737-7, Boeing 737-8, Boeing 737-9 and Boeing 737-10.

Turboprop means, for the purposes of the ACC Tool, each of the following aircraft models: ATR 72-600, ATR 72-500, ATR 42-600, ATR 42-500, ATR 72-200 and ATR 42-300.

User Inputs has the meaning given to it in paragraph 3.1 (*User Inputs*).

User Outputs has the meaning given to it in paragraph 3.4 (*User Outputs*).

Widebody means, for the purposes of the ACC Tool, each of the following aircraft models: Airbus A330-800neo, Airbus A330-900neo, Airbus A340-300, Airbus A340-500, Airbus A340-600, Airbus A350-900 XWB, Airbus A350-1000 XWB, Airbus A380-800, Airbus A330-200, Airbus A330-300, Airbus A330-200F, Airbus A310-300F, Airbus A300F4-600RF, Boeing 767-300ER, Boeing 787-8, Boeing 787-9, Boeing 787-10, Boeing 777-200ER, Boeing 777-300ER, Boeing 747-8I.

NOTE: The inclusion of aircraft within the definitions of Turboprop, Regional Jet, Single-Aisle and Widebody is made solely for the purposes of calculations on the ACC Tool, and such inclusion and definitions neither signals, nor permits inferences relating to, any classification, categorisation or distinctions for any other purpose.