International Civil Aviation Organization

WORKING PAPER

ASSEMBLY — 37TH SESSION

EXECUTIVE COMMITTEE

Agenda Item 17: Environmental protection

PRESENT AND FUTURE AIRCRAFT NOISE AND EMISSIONS TRENDS

(Presented by the Council of ICAO)

EXECUTIVE SUMMARY

As requested by Assembly Resolution A36-22, Appendix A, the Council's Committee on Aviation Environmental Protection (CAEP) has assessed "the present and future impact of aircraft noise and aircraft engine emissions" and has approved tools for this purpose that permit the consideration of interrelationships between aircraft noise, emissions that affect local air quality (LAQ), and emissions that affect the global climate. Scenarios were evaluated for a baseline year of 2006 and for the future years 2016, 2026 and 2036. The full-flight fuel burn analysis also considered the year 2050. The evaluations were based on an unconstrained forecast and did not consider the effects of alternative fuels.

In absolute terms, the total global population exposed to aircraft noise, total global aircraft emissions that affect LAQ, and total global aircraft emissions that affect the global climate are expected to grow. Aviation's noise and emissions footprint is, however, predicted to grow at a rate slower than the demand for air travel and on a per-flight basis; efficiency is expected to improve throughout the period.

Action: The Assembly is invited to:

a) accept the global environmental trends as the basis for decision making on environmental matters during this session of the Assembly;
b) request the Council to continue work in this area with the support of States and to ensure that the next session of the Assembly is provided with an updated global environmental trends assessment; and
c) consider the information in this paper for the update of Assembly Resolution A36-22.

Strategic Objectives:	This working paper relates to Strategic Objective C, *Environmental Protection - Minimize the adverse effect of global civil aviation on the environment*.
Financial implications:	No additional resources required. The work involved for the Secretariat is expected to be undertaken within the resources included under the Draft Budget 2011-2013.
References:	A37-WP/24, *Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection - General Provisions, Noise and Local Air Quality* Doc 9938, *Report of the Eighth Meeting of the Committee on Aviation Environmental Protection* Doc 9902, *Assembly Resolutions in Force (as of 28 September 2007)*

1. INTRODUCTION

1.1 The Council's Committee on Aviation Environmental Protection (CAEP) evaluated models and developed future scenarios in noise, local air quality (LAQ), and greenhouse gas (GHG) emissions. Most of the models and expertise needed to undertake this evaluation are made available by States and international observer organizations.

1.2 In this paper, global results are presented for:

a) population exposed to aircraft noise (noise analysis);

b) NOx and particulate matter (PM) below 3,000 feet (LAQ analysis); and

c) full-flight fuel burn and commercial aircraft system's fuel efficiency (GHG analysis).

1.3 The results presented in this paper are based on the CAEP-produced, unconstrained, central forecast and are representative of the trends observed across the range of scenarios considered.

2. SCENARIOS

2.1 The operational data for 2006, the baseline year, includes global commercial aviation operations under Instrument Flight Rules (IFR). Detailed aircraft movement data were available for North America, Central America, and most of Europe, while aircraft manufactured in the Commonwealth of Independent States (CIS) were not included due to lack of data.

2.2 A range of scenarios were developed for the assessment of aircraft noise, emissions that affect local air quality (LAQ), and fuel burn, which is representative of greenhouse gas (GHG) emissions. Scenario 1 is the sensitivity case that assumes the operational improvements necessary to maintain current operational efficiency levels, including the planned introduction of NextGen and SESAR, but does not include any aircraft technology improvements beyond those available in current (2006) production aircraft. Since Scenario 1 is not considered a likely outcome, it is purposely depicted in all graphics with no line connecting the modelled results in 2006, 2016, 2026 and 2036. Scenario 1 is the same for each of the trends. The other scenarios assume increased implementation of both operational and technological improvements. Scenarios 2 and higher are assumed to be the most likely outcomes.

2.3 The CAEP central forecast predicts an annual passenger traffic growth rate of 4.8 per cent from 2006 to 2036.

3. NOISE RESULTS

3.1 Figure 1 provides results for the total global population exposed to aircraft noise above 55 DNL for 2006, 2016, 2026 and 2036. The 2006 baseline value is about 21.2 million people. In 2036, total population exposed ranges from about 26.6 million people with Scenario 4, to about 34.1 million people with Scenario 2.

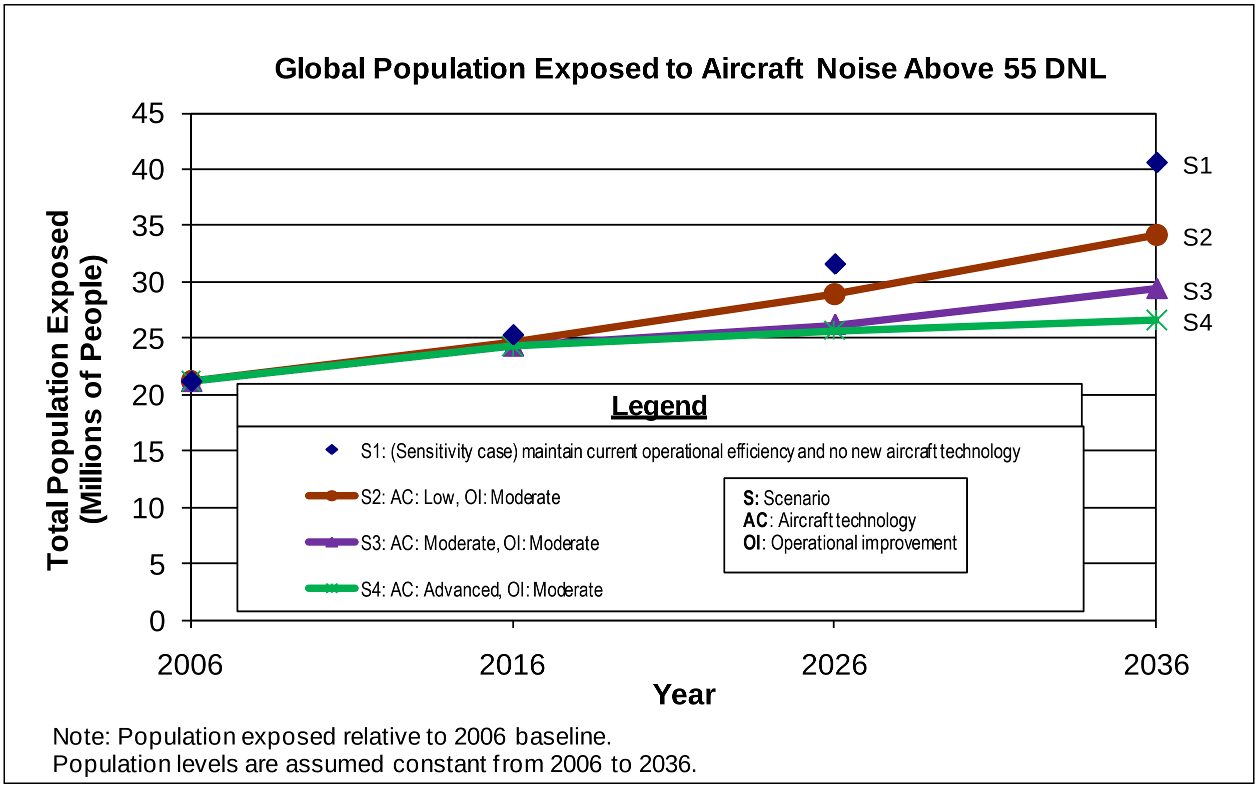

Figure 1. Total Global Population Exposed to Aircraft Noise Above 55 DNL.

<u>**Noise (Scenarios 2 – 4)**</u>

- **Scenario 2** is the low aircraft technology and moderate operational improvement case that assumes noise improvements of 0.1 decibels of effective perceived noise level (EPNdB) per annum for all aircraft entering the fleet from 2013 to 2036.
- **Scenario 3** is the moderate aircraft technology and operational improvement case that assumes a 0.3 EPNdB per annum for all aircraft entering the fleet from 2013 to 2020, 0.1 EPNdB from 2020 to 2036.
- **Scenario 4** is the advanced aircraft technology and moderate operational improvement case that assumes a 0.3 EPNdB per annum for all aircraft entering the fleet from 2013 to 2036.

4. NOX AND PARTICULATE MATTER (PM) RESULTS BELOW 3,000 FT

4.1 Figure 2 provides results for global NOx emissions below 3,000 feet above ground level (AGL) for 2006, 2016, 2026 and 2036. The 2006 baseline value is about 0.25 million metric tonnes (Mt, 1kg x 10^9). In 2036, total NOx ranges from 0.52Mt, with Scenario 3, to 0.72 Mt with Scenario 2. Across the size spectrum of airports, aircraft emissions contribute between 70 to 80 per cent of total airport NOx emissions.

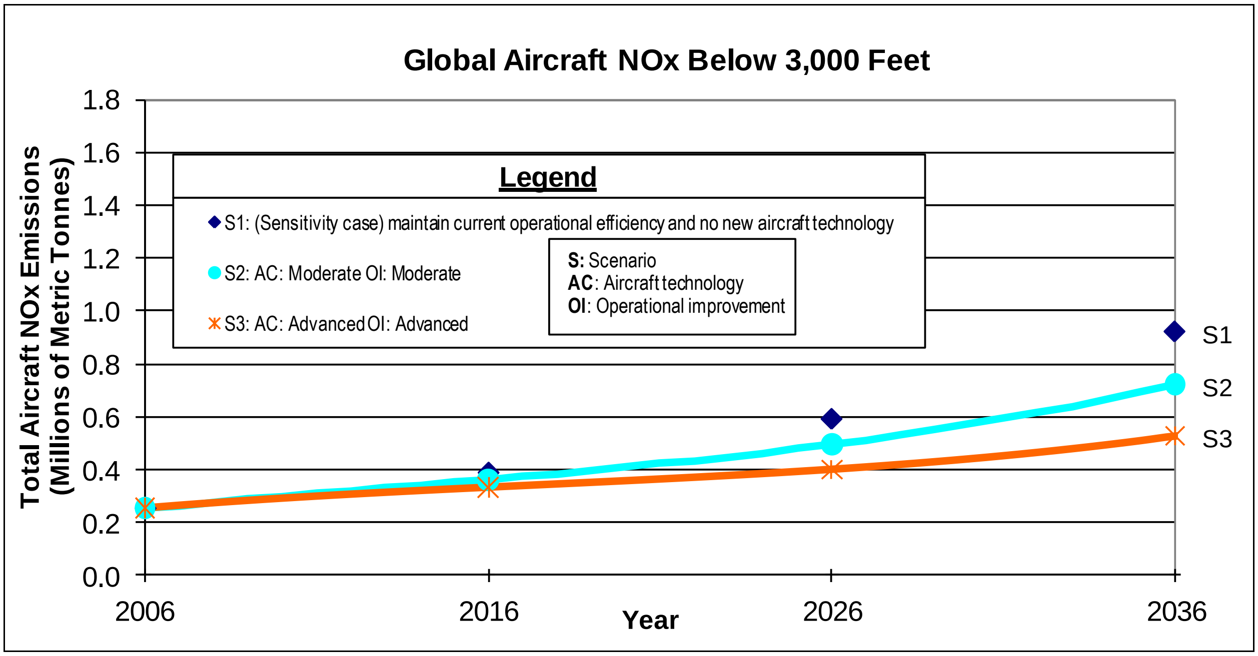

Figure 2. Total Global Aircraft NOx Below 3,000 Feet AGL.

NOx (Scenarios 2 and 3, Below and Above 3,000 ft)

- **Scenario 2** is the moderate aircraft technology and operational improvement case that assumes aircraft NOx improvements based upon achieving 50% of the reduction from the current NOx emission levels to the NOx emissions levels by CAEP/7 NOx Independent Expert goals review (-60% +/-5% of current CAEP/6 NOx Standard) for 2026, with no further improvement thereafter. This scenario also includes fleet-wide moderate operational improvements by region.

- **Scenario 3** is the advanced aircraft technology and operational improvement case that assumes aircraft NOx improvements based upon achieving 100% of the reduction from the current NOx emission levels to the NOx emissions levels by CAEP/7 NOx Independent Expert goals review for 2026, with no further improvement thereafter. This scenario also includes fleet-wide advanced operational improvements by region that are considered to be an upper bound of those improvements.

4.2 The results for PM emissions below 3,000 feet follow the same trends as those for NOx. The 2006 baseline value is 2,200 metric tonnes. In 2036, total global PM is projected to be about 5,800 metric tonnes with Scenario 2.

4.3 The contribution of airport emissions to the overall emissions loading in the vicinity of airports is dependent upon the emission sources surrounding the airport. For a typical urban environment, airport emissions represent approximately 10 per cent of total regional emissions in the vicinity of airports, whereas in more rural environments airport emissions would tend to be a higher percentage. The region referred to here should not be confused with the ICAO regions as it refers to the local communities surrounding the airport, e.g., 50 km x 50 km.

4.4 Mass emissions, measured in units such as total tonnes of NOx or total tonnes of PM, from airport sources are only a metric for comparison purposes. To understand the influence on ambient air quality, airport mass emissions must be converted to ambient concentrations, measured in units such as micrograms per cubic meter (μg/m^3) or parts per million (PPM) of NOx or PM. The incremental contribution in ambient pollutant concentrations from airport emissions decreases the further one travels away from the airport. Each airport's contribution is unique, given the surrounding urbanization/industrialization and meteorological conditions within the vicinity of the airport.

5. NOX RESULTS ABOVE 3,000 FT

5.1 The scenarios assessed for NOx above 3,000 ft are identical to those for NOx below 3,000 ft. As shown in Figure 3, the 2006 baseline value is about 2.5 Mt. In 2036, total NOx ranges from about 4.6 Mt with Scenario 3, to about 6.3 Mt with Scenario 2.

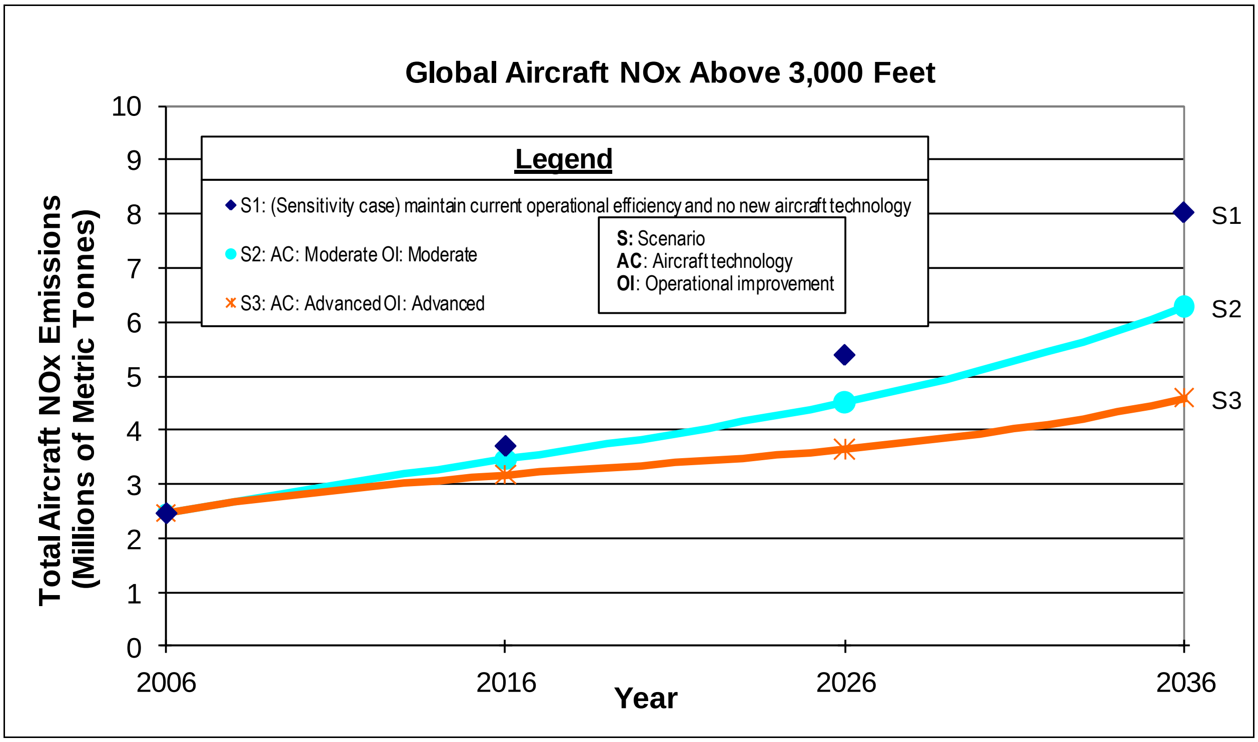

Figure 3. Total Global Aircraft NOx Above 3,000 Feet AGL.

6. FUEL BURN AND CASFE FULL-FLIGHT RESULTS

6.1 Figure 4 provides results for global full-flight fuel burn for 2006, 2016, 2026, 2036 and 2050. These results are for both domestic and international traffic combined. As shown in Figure 5, the 2006 baseline value is 187 Mt of fuel, with domestic traffic representing approximately 38 per cent of this total and international traffic representing 62 per cent.

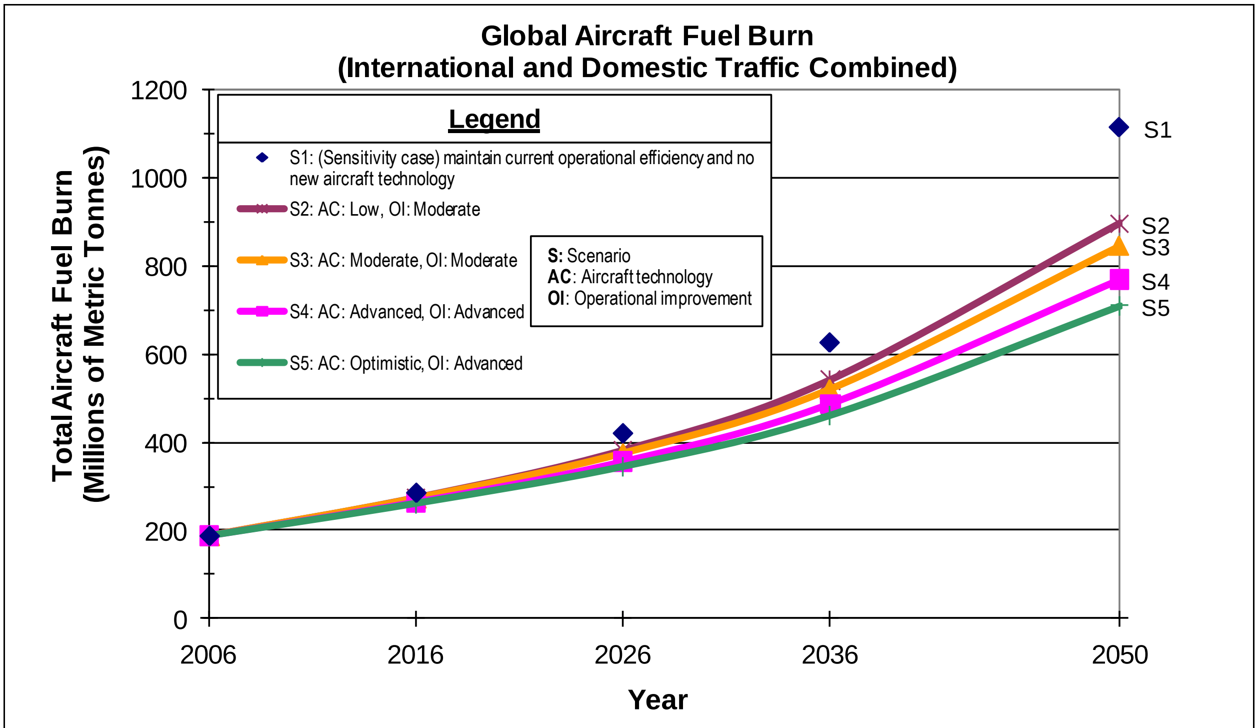

Figure 4. Total Global Aircraft Fuel Burn 2006 to 2050.

<u>Full-Flight Fuel Burn and CASFE (Scenarios 2-5)</u>

- **Scenario 2** is the low aircraft technology and moderate operational improvement case that in addition to including the improvements associated with the migration to the latest operational initiatives, e.g., those planned in NextGen and SESAR (Scenario 1), includes fuel burn improvements of 0.96 per cent per annum for all aircraft entering the fleet after 2006 and prior to 2015, and 0.57 per cent per annum for all aircraft entering the fleet beginning in 2015 out to 2036. It also includes additional fleet-wide moderate operational improvements by region.

- **Scenario 3** is the moderate aircraft technology and operational improvement case that in addition to including the improvements associated with the migration to the latest operational initiatives, e.g., those planned in NextGen and SESAR (Scenario 1), includes fuel burn improvements of 0.96 per cent per annum for all aircraft entering the fleet after 2006 out to 2036, and additional fleet-wide moderate operational improvements by region.

- **Scenario 4** is the advanced aircraft technology and operational improvement case that in addition to including the improvements associated with the migration to the latest operational initiatives, e.g., those planned in NextGen and SESAR (Scenario 1), includes fuel burn improvements of 1.16 per cent per annum for all aircraft entering the fleet after 2006 out to 2036, and additional fleet-wide advanced operational improvements by region.

- **Scenario 5** is the optimistic aircraft technology and advanced operational improvement case that in addition to including the improvements associated with the migration to the latest operational initiatives, e.g., those planned in NextGen and SESAR (Scenario 1), includes an optimistic fuel burn improvement of 1.5 per cent per annum for all aircraft entering the fleet after 2006 out to 2036, and additional fleet-wide advanced operational improvements by region. This scenario goes beyond industry-based recommendations for potential improvements.

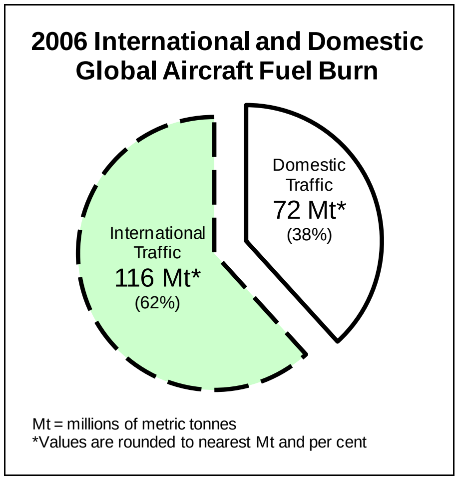

Figure 5. Percentage of Global Aircraft Full-Flight Fuel Burn in 2006 Attributed to International and Domestic traffic.

6.2 In 2036, total fuel burn ranges from about 461 Mt with Scenario 5, to about 541 Mt with Scenario 2. These results are presented in terms of fuel consumption and not GHG. Without considering the effects of alternative fuels, assuming that 3.16 kg CO_2 is produced for every kg of fuel burnt gives a baseline value of 591 Mt CO_2 in 2006 to between 1,450 and 1,710 Mt CO_2 in 2036.

6.3 The baseline value of 187 Mt in 2006 only includes fuel burn from the main aircraft engines of IFR flights. It does not include fuel burn from auxiliary power units, from aviation-related operations (e.g., ground support equipment) or from visual flight rules (VFR) flights. Non-scheduled flights in regions for which radar data are not available were also not accounted for. Fuel burn from aviation-related operations, VFR flights and non-scheduled flights may together amount to approximately 10 to 12 per cent additional fuel burn.

6.4 Figure 6 presents the global CASFE results for the years 2006, 2016, 2026 and 2036. The 2006 baseline value is 0.32 kg/tonne-km. In 2036, global CASFE ranges from about 0.25 with Scenario 2, to about 0.21 with Scenario 5. Lower CASFE values represent more efficient operations. Also depicted in Figure 6, by a dashed line, is an approximation of the effects of the ICAO CO_2 Aspirational Goal.

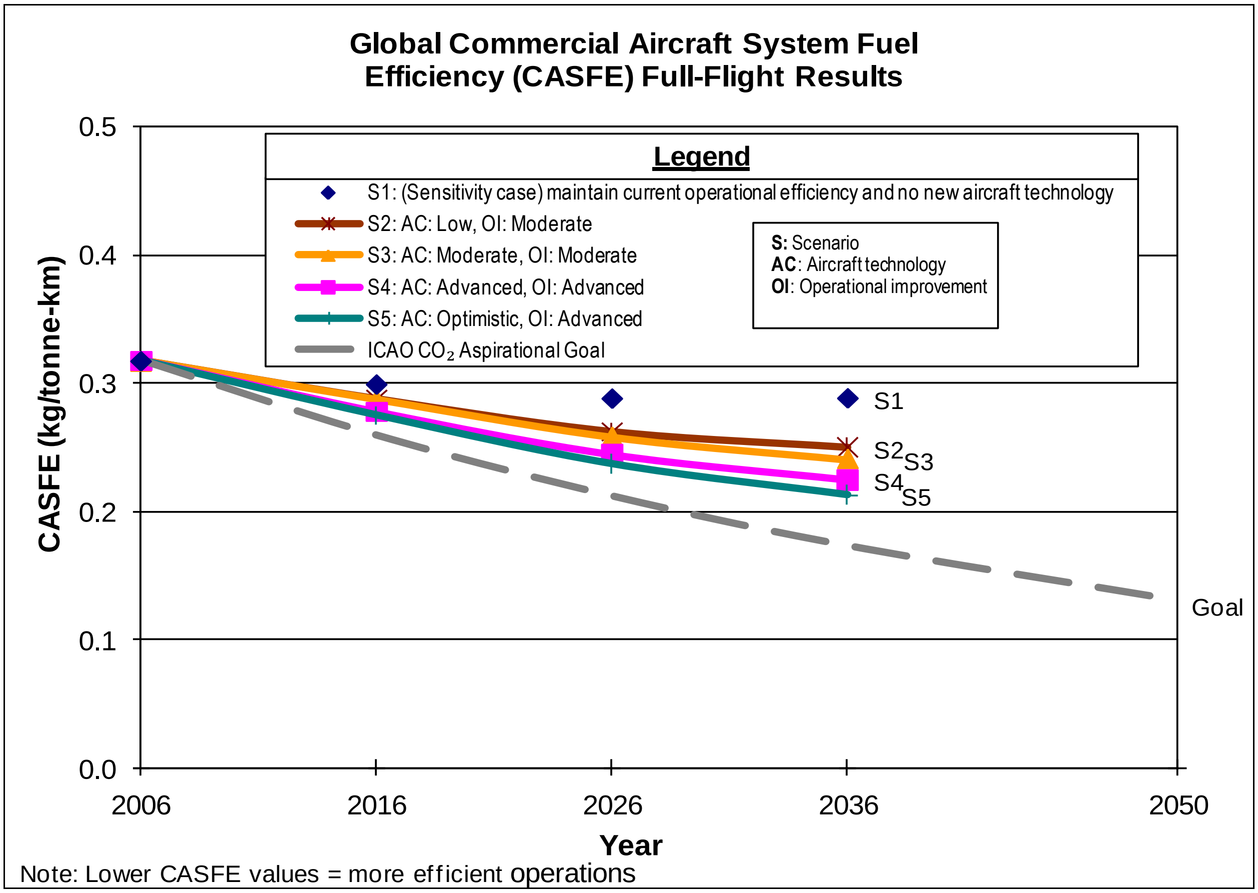

Figure 6. Commercial Aircraft System Fuel Efficiency (CASFE) Full-Flight Results.

7. CONCLUSIONS

7.1 Harmonization of assumptions and the use of common airport, fleet and operations input data across the three modelling domains (noise, LAQ, and GHG) provided ICAO, for the first time, the ability to study the interrelationships between them.

7.2 Based on the unconstrained CAEP central forecast, passenger traffic is expected to grow, on average, at 4.8 per cent per year between 2006 and 2036. Over the same period, the global population exposed to noise above 55 DNL is expected to grow at between 0.7 to 1.6 per cent, aircraft NOx emissions below 3,000 feet are expected to grow at between 2.4 and 3.5 per cent, and aircraft fuel consumption is expected to grow at between 3.0 and 3.5 per cent per year.

7.3 Environmental standards set by ICAO and the investments in technology and improved operational procedures are allowing aviation’s noise, LAQ, and GHG footprints to grow at a rate slower than the demand for air travel.

7.4 Regarding CO_2 emissions, while on a per flight basis, efficiency is expected to continue to improve, an emissions “gap” could exist in absolute terms, relative to 2006 or earlier, that would require a form of intervention to allow for sustainable growth.

— END —