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EXECUTIVE COMMITTEE

Agenda Item 20: Environmental protection – Aircraft Noise
Agenda Item 21: Environmental protection – Aircraft Engine Emissions affecting Local Air Quality
Agenda Item 22: Environmental Protection – International Aviation and Climate Change – Policy, Standardization and Implementation Support

CIVIL AVIATION AND THE ENVIRONMENT

(Presented by the Council of ICAO)

EXECUTIVE SUMMARY

This paper reports on progress made by ICAO since the 38th Session of the Assembly on issues related to civil aviation and the environment. Activities undertaken by the Secretariat, its cooperation with other organizations and the work of the Committee on Aviation Environmental Protection (CAEP) are presented.

Action: The Assembly is invited to:

a) acknowledge the substantial progress made by the Organization in addressing the impact of noise, local air quality and global emissions, and in particular, on the development of new Standards and Recommended Practices (SARPs) on non-volatile Particulate Matter and CO_2;
b) support the continued work of the ICAO Secretariat and CAEP and on all key areas relating to civil aviation and the environment; and
c) consider the information contained in this paper for the update of Assembly Resolutions A38-17 and A38-18.

Strategic Objectives:	This working paper relates to Strategic Objective E – *Environmental Protection.*
Financial implications:	The activities referred to in this paper will be undertaken subject to the resources available in the 2017–2019 Regular Programme Budget and/or from extra-budgetary contributions.
References:	A39-WP/52, *Consolidated statement of continuing ICAO policies and practices related to environmental protection – Global Market-based Measure (MBM) scheme* A39-WP/49, *Consolidated statement of continuing ICAO policies and practices related to environmental protection – Climate change* A39-WP/48, *Consolidated statement of continuing ICAO policies and practices related to environmental protection – General provisions, noise and local air quality* A39-WP/39, *A Comprehensive Strategy for Air Navigation: Endorsement of the Updated Global Air Navigation Plan* Doc 10069, *Report of the Tenth Meeting of the Committee on Aviation Environmental Protection*

1. INTRODUCTION

1.1 With a view to minimizing the adverse effects of international civil aviation on the environment, the Organization formulates policies, develops and updates Standards and Recommended Practices (SARPs) on aircraft noise and aircraft engine emissions, and conducts outreach activities. These activities are conducted by the Secretariat, with technical support provided by the Committee on Aviation and Environmental Protection (CAEP). In pursuing its activities, ICAO also cooperates with other United Nations bodies and international organizations.

1.2 Significant advances have been made in reducing the amount of noise and emissions produced by international civil aviation. For example, significant technological progress has resulted in aircraft produced today being approximately 75 per cent quieter and 80 per cent more fuel efficient per passenger kilometre than in the 1960s. A summary of the latest progress achieved by international civil aviation is provided in Appendix A.

2. MODELLING ACTIVITIES

2.1 In support of a data-driven decision making process, significant modelling and analysis exercise has been conducted during the triennium. An updated set of noise, local air quality, and global climate trends was delivered (see A39-WP/55, *Present and Future Trends in Aircraft Noise and Emissions).* Additional key deliverables for which modelling and analysis was conducted are described below.

3. BASKET OF MEASURES TO REDUCE CO_2 EMISSIONS FROM INTERNATIONAL AVIATION

3.1 Aeroplane CO_2 Standard

3.1.1 Following six years of technical work by ICAO, during the CAEP/10 meeting, a recommendation was finalized on an aeroplane CO_2 emissions certification Standard. This new Standard, the first global Standard for CO_2 emissions of any sector, will apply to new aeroplane type designs from 2020 and to aeroplane type designs that are already in-production in 2023. This means that if an in-production aeroplane design is changed after 2023, the aeroplane would be required to comply with the CO_2 emissions Standard. In 2028, there is a production cut-off, meaning that in-production aeroplanes that do not meet the Standard from 2028 can no longer be produced, unless the designs are modified to comply with the Standard. The new CO_2 emissions Standard is recommended for inclusion in a new Volume to Annex 16 (Annex 16, Volume III – *Aeroplane CO_2 Emissions*). The Secretariat is currently progressing the new Standard through the SARP adoption process which will conclude in early 2017.

3.2 Global Market-Based Measures (MBM) Scheme for International Aviation

3.2.1 ICAO has been developing recommendations for technical design elements of a global MBM scheme, namely on monitoring, reporting and verification (MRV) system, emissions unit criteria (EUC) and registries. The Secretariat, in coordination with CAEP, have also undertaken technical analyses on various approaches for distribution of offsetting requirements under a global MBM scheme. The work of ICAO on future emissions trends and alternative fuels also supported the development of design elements for a global MBM scheme (see A39-WP/52, *Consolidated statement of continuing ICAO policies and practices related to environmental protection – Global Market-based Measure (MBM) Scheme*).

3.3 Operational Improvements

3.3.1 Recognizing that many of the improvements defined in the Global Air Navigation Plan (GANP) (see A39-WP/39, *A Comprehensive Strategy for Air Navigation: Endorsement of the Updated Global Air Navigation Plan*) offer the potential to deliver fuel and CO_2 emissions reductions, an analysis

of environmental benefits from the implementation of the Aviation System Block Upgrade (ASBU) Block 0 was conducted.

3.4 Improved operations and Air Traffic Management (ATM) offer potential improvements in efficiency and CAEP analysis has shown that full implementation of the aviation system block upgrade (ASBU) Block 0 could achieve 0.7 to 1.4 per cent fuel saving in 2018 compared to 2013.

3.5 Sustainable Alternative Fuels for Aviation

3.5.1 The Secretariat continued to support States and stakeholders in their effort to develop and deploy alternative fuels. This included regular updates to the Global Framework for Aviation Alternative Fuels (GFAAF) (see A39-WP/56, *Sustainable Alternative Fuels for Aviation*). CAEP's work on alternative fuels Life Cycle Assessment (LCA) methodology supported the technical work on the monitoring, reporting, and verification (MRV) system of a global MBM scheme and the updated CO_2 emissions trends presented in A39-WP/55, *Present and Future Trends in Aircraft Noise and Emissions*.

3.6 Outreach

3.6.1 In September of 2014 and 2015, ICAO convened the Fuelling Aviation with Green Technology Seminar and the Global Aviation Partnerships on Emissions Reductions (E-GAP) Seminar, respectively. In addition, ICAO's fourth Environmental Report which focuses on the issue of aviation and climate change was published in July 2016 and it is available on the ICAO public website (http://www.icao.int/environmental-protection/Pages/ENV2016.aspx).

4. AIRCRAFT NOISE

4.1 The recommendations to amend Annex 16, Volume I - *Aircraft Noise* included general maintenance to keep the environmental SARPs up to date and relevant. The Secretariat is currently progressing the amendments to Annex 16, Vol. I through the Standards and Recommended Practices (SARPs) adoption process. In addition, the Environmental Technical Manual (ETM) on the use of Procedures in the Noise Certification of Aircraft (Doc 9501) was updated and will be published as an amendment to the current Doc 9501, Volume I.

4.2 The important work continued on monitoring noise technology and understanding the progress towards the ICAO noise goals. This is part of the continued effort to ensure that the latest available noise reduction technology is incorporated into aircraft designs. ICAO also continued its work on the development of a new supersonic noise Standard for future aircraft, and understanding the current state of sonic boom knowledge, research and supersonic aeroplane projects. It is anticipated that the certification of a supersonic aeroplane could occur in the 2020-2025 timeframe.

5. AIRCRAFT ENGINE EMISSIONS AFFECTING LOCAL AIR QUALITY

5.1 Aircraft engines burning hydrocarbon-based fuels emit gaseous and particulate matter (PM) emissions. At the engine exhaust, particulate emissions mainly consist of ultrafine soot or black carbon emissions, also known as non-volatile PM (nvPM). During the CAEP/10 meeting, the first nvPM Standard for aircraft engines greater than 26.7kN was recommended. The nvPM Standard, which will apply to engines manufactured from 1 January 2020, is the first of its kind. The new nvPM Standard is recommended as an amendment to Annex 16, Volume II - *Aircraft Engine* Emissions.

5.2 Further general maintenance amendments to Annex 16, Volume II were recommended to keep the environmental SARPs up to date and relevant. In addition, the Environmental Technical Manual (ETM) on the use of Procedures in the Emissions Certification of Engines (Doc 9501) was updated and will be published as an amendment to Doc 9501, Volume II. The Secretariat is currently progressing the amendments to Annex 16, Vol. II, including the new nvPM Standard, through the SARP adoption process.

6. ENVIRONMENTAL GUIDANCE AT AIRPORTS

6.1 In the context of the growing demand for international air transport, the CAEP/10 meeting recommended the publication of an updated Doc 9184, *Airport Planning Manual*, Part 2, *Land-use and Environmental Control*. This Document will contribute to enhancing States' preparedness for new environmental challenges and integrates the latest environmental management practices at and around airports.

6.2 A Circular on community engagement for aviation environmental management was also recommended by the CAEP/10 meeting, in light of the potential impact of community reactions on aviation activities.

7. ENVIRONMENTAL TOOLS TO SUPPORT QUANTIFICATION

7.1 The Secretariat is currently developing an update to expand the scope of the ICAO Carbon Emissions Calculator to allow users to estimate the CO_2 emissions associated with shipments by air cargo, consistent with the methodology that was recommended by CAEP/10.

7.2 The Doc 9988, *Guidance on the Development of States' Action Plans on CO_2 Emissions Reduction Activities* was updated by the Secretariat to include "Rules of Thumb" that can be used to estimate the benefits from the elements of the ICAO Basket of Measures to address CO_2 emissions from international aviation. A companion software tool, known as the Environmental Benefits Tool (EBT) was developed to automate the application of these "Rules of Thumb." The combination of the revised Doc 9988 and EBT aims to ensure that all States are able to submit an action plan with quantified results (see A39-WP/54, *States' Voluntary Action Plans on CO_2 Emissions Reduction Activities*).

8. COOPERATION WITH OTHER UN BODIES

8.1 Of note during this triennium was ICAO's intense cooperation within the UN system including the United Nations Framework Convention on Climate Change (UNFCCC), the International Maritime Organization (IMO), the United Nations Environment Programme (UNEP) and participation in the Sustainable Development Goals (SDGs) development process.

8.2 United Nations Framework Convention on Climate Change (UNFCCC)

8.2.1 Of particular note was ICAO's continuing cooperation with the UNFCCC process, by following developments and regularly providing information and perspectives relating to international aviation. Since the last ICAO Assembly, Parties to the UNFCCC undertook important negotiations, leading to the adoption of the Paris Agreement at the 21st Session of the Conference of the Parties (COP21) to the UNFCCC, held in Paris, France, in December 2015.

8.2.2 The Paris conference was attended by over 36,000 delegates from governments, UN bodies, other international organizations and civil society organizations. The negotiations were in particular on draft text related to the overall objectives of the agreement, the scope of Intended Nationally Determined Contributions (INDCs) by each country, and the differentiation between developed and developing countries, such as the levels of financial and other means of implementation support from developed countries to developing counties.

8.2.3 ICAO participated in COP21, providing statements and speeches, and holding more than 20 bilateral meetings with high-level representatives, in order to highlight ICAO's efforts and its leadership role on international aviation matters, as contained in the ICAO Council's Declaration on

International Aviation and Climate Change, dated 18 November 2015[1]. The COP21 conference adopted the Paris Agreement and associated decision[2]. The COP21 outcome was reviewed during the ninth meeting of the 207th Session of the Council in March 2016, where the Council decided on further actions to follow up the COP21 outcome.

8.2.4 The Paris Agreement will enter into force after 55 Parties to the UNFCCC accounting in total for at least an estimated 55 per cent of global greenhouse gas emissions have deposited their instruments of ratification, acceptance, approval or accession. As of 8 June 2016, 177 Parties signed the Paris Agreement, of which 17 Parties deposited instruments of ratification, acceptance, approval or accession.

8.2.5 Following the Paris conference, the first meeting of the UNFCCC was held in May 2016 in Bonn, Germany, to undertake initial discussion on issues requested by the Paris Agreement and associated decision. ICAO provided its statement and submission related to recent developments on international aviation and climate change, and the Bonn meeting took note of the information and invited the ICAO Secretariat to continue to report at future meetings.

8.2.6 As part of its cooperation with the UNFCCC Secretariat, the ICAO Secretariat has been developing aviation methodologies under the UNFCCC Clean Development Mechanism (CDM). Methodologies on “electric taxiing systems for airplanes” and “solar power for domestic aircraft at-gate operations” were approved by the CDM Executive Board, extending the CDM programme to include aviation-related projects for the first time.

8.3 Climate Neutral United Nations Initiative

8.3.1 In September 2014, the UN Secretary-General proposed that the UN system should attain climate neutrality[3] by 2020, and the UN Chief Executives Board (CEB) endorsed this proposal in April 2015.

8.3.2 Regarding the first step in attaining climate neutrality (i.e. reduce emissions to the extent possible), the Organization has employed various measures. The ICAO Headquarters building was the first to receive the Leadership in Energy and Environmental Design for Existing Buildings (LEED-EB) Gold Certification in Canada. ICAO implemented integrated print-on-demand, reducing the inventory of printed documents by 65 per cent, and has been moving towards a paperless process for document distribution. The Organization is considering the second step in attaining climate neutrality (i.e. offsetting the emissions that remain).

8.3.3 The ICAO Carbon Emissions Calculator is the official tool used to estimate the air travel-related portion of UN agencies’ carbon inventories. ICAO continued to work with the United Nations Environment Programme (UNEP) and other UN agencies to support the generation of emissions inventories from air travel, and the integration of the ICAO Calculator into travel systems and a GHG reporting software common to all UN organizations.

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[1] ICAO outreach material at COP21 is available at: http://www.icao.int/environmental-protection/Pages/cop21.aspx
[2] COP21 decision and Paris Agreement is available at: http://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf[3] In this context, “climate neutrality” means that the net GHG emissions of the UN system should be zero, to be attained by reducing emissions to the extent possible and by offsetting the emissions that remain.
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APPENDIX

LATEST PROGRESS ACHIEVED BY AVIATION

1. AIRCRAFT TECHNOLOGY TO REDUCE CO_2 EMISSIONS

1.1 Significant technological progress has been made in the aviation sector on fuel efficiency, with aircraft produced today being about 80 per cent more fuel efficient per passenger kilometre than in the 1960s. This is the result of airframe, aero-engine, and aircraft systems manufacturers continuous drive to develop new and innovative technologies. The industry estimate that each new generation of aircraft brings around 15-20% savings in fuel and CO_2 compared with the aircraft it replaces [Source: ATAG]. Progress continues to be made today in, *inter alia*, advanced aerodynamics, aircraft systems, lighter airframe structures, and improved propulsive efficiency. The new aeroplane CO_2 emissions Standard plays an important role in reducing the sectors fuel burn by ensuring that these latest fuel efficiency technologies are being employed in the latest aeroplane designs.

1.2 Lower fuel consumption has been achieved in new aircraft type designs through the utilization of high By Pass Ratio (BPR) engines, and lighter and high temperature materials which contribute to increased propulsive efficiency.

1.3 The combination of lighter weight materials and innovative structural technologies result in lower weight airframes and, therefore, lower fuel consumption. More recent technological developments have increased the use of composite materials to over 50 per cent by weight in the latest aeroplane designs, and this is shown in Figure 1 for the Airbus A350 and Boeing 787.

Figure 1: Examples of increased use of composite materials in Airbus A350 and Boeing 787 designs [Source: ICCAIA].

1.4 New aircraft types also incorporate a high level of electrical systems and controls that contribute to a low operating weight and help further enhance the operating efficiency of the aircraft.

2. OPERATIONAL MEASURES TO REDUCE CO_2 EMISSIONS

2.1 The Global Air Navigation Plan (GANP) presents a framework for harmonising avionics capabilities and the required air traffic management (ATM) ground infrastructure as well as automation. The framework is the Aviation System Block Upgrades (ASBUs). The ASBUs provide a roadmap to assist air navigation service providers in the development of their individual strategic plans and investment decisions with a goal of global aviation system interoperability.

2.2 Improved operations and Air Traffic Management (ATM) offer potential improvements in efficiency and CAEP analysis has shown that full implementation of the aviation system block upgrade (ASBU) Block 0 could achieve 0.7 to 1.4 per cent fuel saving in 2018 compared to 2013. Modules within Block 0 include, amongst others, Optimised Approach Procedures including vertical guidance, improved operations through enhanced en-route trajectories, and improved flexibility and efficiency in descent profiles using Continuous Descent Operations (CDO). For example, as per the Rules of Thumb developed by CAEP, it is estimated that 60 kg of fuel or 189.6 kg of CO_2 are saved for each Continuous Descent Operation.

2.3 Environmental assessment tools developed by ICAO have allowed States to successfully assess the environmental benefit of implementing the various operation measures. To assist the States to estimate fuel savings in a manner consistent with the models approved by CAEP and aligned with the Global Air Navigation Plan, the ICAO Fuel Savings Estimation Tool (IFSET) has been developed by the Secretariat with support from States and international organizations. IFSET is not intended to replace the use of detailed measurement or modelling of fuel savings, where those capabilities exist. Rather, it is provided to assist those States without such facilities to estimate the benefits from operational improvements in a harmonized way.

3. AIRCRAFT TECHNOLOGY TO REDUCE LOCAL AIR QUALITY EMISSIONS

3.1 Engine manufacturers continue to make progress in combustor design to reduce emissions that impact Local Air Quality (LAQ) in the vicinity of airports. While Standards have been developed for Hydrocarbon (HC), Carbon Monoxide (CO) and smoke, and most recently for non-volatile Particulate Matter (nvPM), much of the focus of international efforts has been on the reduction of NOx. The ICAO engine emissions standards ensure that the most efficient local air quality emissions reduction technologies are being employed in the production of aircraft engines.

3.2 New type engines with Rich Quench Lean (RQL) combustion technologies continue to demonstrate reductions in NOx emissions. Some advanced RQL and staged lean burn combustion technologies from medium and large engines (i.e. those larger than 89 kN thrust) have already met the ICAO NOx medium term goal[4]. The NOx emissions reductions are being achieved through a combination of engine cycle and advanced combustion technology.

3.3 In addition to demonstrating significant reductions in NOx emissions, staged lean burn combustion technologies may also provide reductions in nvPM emissions when the engine is operating in the lean burn mode. The use of alternative fuels has also been shown to potentially result in substantial reductions in nvPM emissions.

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[4] ICAO Doc 9953, Report of the Independent Experts to CAEP/8 on the Second Review and the Establishment of Medium and Long Term Technology Goals for NOx, ICAO, 2010.

4. AIRCRAFT NOISE

4.1 Aircraft and engine manufacturers have worked aggressively to reduce aircraft noise levels, with aircraft produced today being about 75 per cent quieter than in the 1960s. Major advances in airframe and propulsion system (engine and nacelle) designs combined with improvements in aircraft performance have further contributed to reducing aircraft noise. Major advances have also been made that reduced the noise of propeller-driven regional aircraft. For example, Figure 2 shows the effect of the difference between the noise certification limits of the various Annex 16, Vol. I chapters (and it therefore shows the effect of improvements in technology). It illustrates the areas that are exposed to noise levels greater than 80 dB during one landing and take-off for aircraft that just meet the various Chapter limits [European Aviation Environmental Report, EASA, 2016].

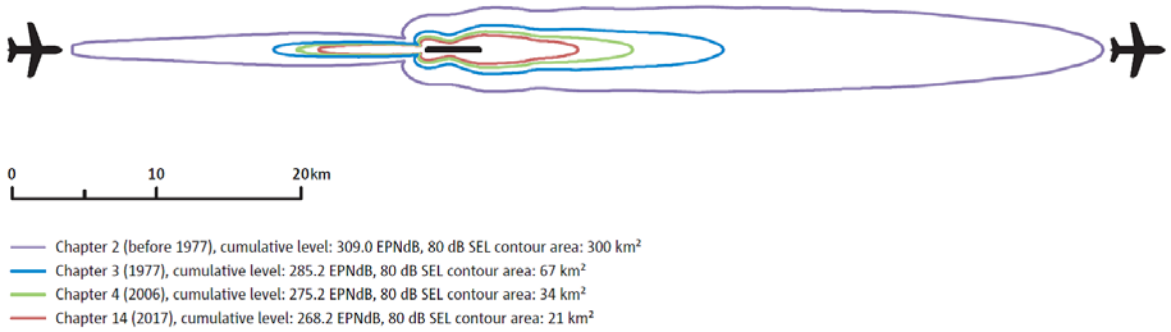

Figure 2: 80 dB Sound Exposure Level (SEL) contours for different aircraft that just meet the various ICAO Annex 16, Vol. I Chapter limits [Source: European Aviation Environmental Report, EASA, 2016].

4.2 Aircraft manufacturers continue to work to reduce all the significant sources of aircraft noise, in particular jet noise, fan noise, and airframe noise. Technology continues to play a significant role in reducing the noise around airports, and recent data has shown that new type aeroplanes with the latest noise reduction technologies on board meet the ICAO 2020 Mid-Term Technology Goals[5]. Concepts for reducing noise continue to be evaluated and developed, and efforts are ongoing to prove and implement these within aircraft designs.

4.3 In parallel with the development of technologies to reduce noise, it is crucial that the broader context of the *Balanced Approach to Aircraft Noise Management* is considered, which includes land-use planning and management, noise abatement operational procedures and operating restrictions, with the goal of addressing the noise problem in the most cost-effective manner. The aviation sector continues to develop noise abatement procedures which play an important role in minimizing community noise.

[5] ICAO Doc 10017, Report to CAEP by the CAEP Noise Technology Independent Expert Panel: Novel aircraft noise technology review and medium and long term noise reduction goals, ICAO, 2014

5. AIRPORTS

5.1 155 airports representing 33 per cent of global passenger traffic have engaged in Airport Carbon Accreditation, an airport-specific carbon mapping management standard. 123 airports are taking measures to reduce their own CO_2 emissions, including the use of clean energy. Amongst these, 21 airports are carbon neutral for the emissions under their direct and indirect control.

5.2 Airport operators have long been involved in local air quality management. Some of the most advanced air quality programme include elements such as behavioural change of the ground support staff, purchase of low-emitting ground support equipment, adoption of stand technology and operations and involvement in research projects. At Copenhagen Airport, such Air Quality Program has resulted in a reduction in mean levels of certain pollutants at the central apron area of about 50% in only 6 months.

5.3 Noise is indisputably the first cause of adverse community reactions. In addition to the implementation of the ICAO's Balanced Approach to aircraft noise management, airport operators are looking at community engagement as a complement to the four pillars of the Balanced Approach, namely reduction of noise at source, land-use planning, noise abatement procedures and operating restrictions. Build a trustful relationship with their communities, through dedicated community engagement activities and exploring the non-acoustic factors of adverse responses to aircraft noise is increasingly considered as a good practice, as documented in the ICAO Circular on Community Engagement for Aviation Environmental Management.

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