

INTERNATIONAL CIVIL
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FINAL REPORT OF THE INDEPENDENT EXPERT OPERATIONAL GOALS GROUP (IEOGG)

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Published in English only, by the
INTERNATIONAL CIVIL AVIATION ORGANIZATION
999 University Street, Montréal, Quebec, Canada H3C 5H7

For ordering information and for a complete listing of sales agents
and booksellers, please go to the ICAO website at www.icao.int

Doc 10021 *Final Report of the Independent Expert Operational Goals Group (IEOGG)*

Order Number: 10021

ISBN 978-92-9249-615-9

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FINAL REPORT OF THE INDEPENDENT EXPERT

OPERATIONAL GOALS GROUP (IEOGG)

1. INTRODUCTION

1.1 Operational improvements, in conjunction with aircraft technology improvements, are key elements that contribute to the achievement of ICAO environmental goals and the sustainability of the aviation sector. ICAO therefore requires the thorough assessment and definition of potential environmental goals.

1.2 The high-level purpose of operational goals is to inform decision makers of achievable environmental benefits if the potential improvements are implemented. In addition, these goals will provide valuable input into the ICAO Committee on Aviation Environmental Protection (CAEP)'s environmental trend assessment process through its Modelling and Databases Group (MDG).

2. BACKGROUND

2.1 Past ICAO Independent Expert (IE) Reviews

2.1.1 The Independent Expert (IE) review process was originated back to during the CAEP/7 cycle (2004-2007), when the first IE group was established under CAEP WG3 to develop medium-term and long-term technology goals for NO_x emissions. Various IE review groups and processes were established during the CAEP/8 cycle (2007-2010), including noise technology goals IE review under WG1, second NO_x technology goals IE review under WG3, fuel burn technology goals IE review under WG3 and operational goals IE review process under WG2.

2.2 The CAEP/9 Cycle Independent Expert Operational Goals Group (IEOGG) Review

2.2.1 During the CAEP/8 cycle, the Independent Expert Operational Goals Group (IEOGG) was established through CAEP-Memo/72. IEOGG met in December 2008 and produced its report for the Modelling Task Force (MODTF, now called MDG) in February 2009. This short timescale was mainly due to the late IE process kick-off and was also dictated by the needs of the Group on International Aviation and Climate Change (GIACC). The IEOGG report was subsequently submitted to Steering Group in June 2009. The report was not published because of concerns from the CAEP Steering Group, which included the lack of time devoted to IEOGG discussion and information gathering. As a result of these issues, the Operational Goals Review was therefore conducted a second time under the CAEP/9 cycle (2010-2013).

2.3 **Difference between Operational and Technology Reviews**

2.3.1 As previously mentioned, various environmental goal setting processes under Independent Experts (IEs) have been established by the ICAO CAEP to cover aircraft ‘technology’ goals for fuel burn, noise and NOx emissions (engines and airframes). However, significant differences between operational and technology reviews have to be taken into account:

- Operational performance improvements are in part achieved via multi-sector plans and agreements. The relative complexity of Operations arises in part from the range of public and private stakeholders actively involved in delivering operational performance improvements, including governments, regulators, international institutions, professionals and their associations, air navigation service providers (ANSPs), airport and aircraft operators, research institutes, airframe, engine and air traffic management (ATM) technology manufacturers and communication system providers. This wide range of operational goal interests and delivery mechanisms results in some key differences between CAEP technology goals and operational goals in the scope, the process and the type of experts required.
- When IE reviews of technology plans were analyzed to develop recommended technology goals for CAEP, active employees of the relatively limited ‘goal applicable’ sector (i.e. manufacturers) were not eligible to serve as an IE because they were not considered to be independent. However, if the same approach is utilized for operational goals IE selection, the potential pool of “independent” experts would be extremely limited due to the multiplicity of sectors involved in operational improvements. In addition, no single organization or sector is capable of delivering an operational goal individually. Having a balanced representation of all stakeholders in the IE group therefore would implicitly facilitate collective independence. While ensuring the independence of IEOGG consensus, operationally active experts have therefore been eligible as IEs for the operational goals analysis.

2.4 **Remit and Terms of Reference**

2.4.1 The CAEP/9 cycle work programme contains an operational goals task designed to conduct a more robust IE review. The primary tasks include:

- Using the IE process, carry out a robust air traffic operational review and make recommendations for operational goals for noise and fuel burn in the mid term (10 years) and the long term (20 years), (Task O.01.01);
- Develop an action plan and schedule to address issues raised by the 2009 CAEP Steering Group (SG) and to conduct a more robust IE process (Task O.01.02); and
- Provide overall facilitation of the IE Operational review including i) generate the guidance, information and material needed for the IE process; ii) hold a workshop and the IE Review; iii) facilitate the IE assessment and formulation of findings and report (Task O.01.03).

2.4.2 The CAEP/8 meeting (February 2010) also decided that the time-frame for all the IE goals (technology and operational) should be harmonized to the years 2020 and 2030.

2.4.3 The proposed terms of reference and CAEP Memo for recruitment were discussed and refined at the 2010 CAEP SG. The IEOGG objectives were set and approved as follows:

- Review and summarize available information on relevant areas of planned regional and global operational improvements and research on operational improvements;
- As a basis for goal setting, consider the worldwide potential "pool" for operational improvements (i.e. total inefficiency in today's system);
- Develop a base-case scenario against which to measure future benefit delivery – harmonizing to the extent possible with timelines used for related goals (e.g. other IE groups and/or GIACC);
- Based on the initial Operational Goals report submitted to CAEP/8 (CAEP/8-WP/12) and addressing the concerns raised by CAEP/8 SG in Salvador in 2009, develop challenging and aspirational Operational Environmental Goals for the medium-term (2020) and long-term (2030), for consideration by CAEP/9; if possible providing an interim report to MDG during 2011;
- Ensure that their proposed goals are sufficiently robust to allow for their publication and for the subsequent trend assessment activities of MDG;
- Highlight any uncertainties or anticipated range of accuracy of the goals and likelihood of success;
- Identify weakness and gaps in available knowledge and information and advise ICAO where these should be addressed to inform future goal setting activities; and
- Establish a framework for the consistent periodic iteration of the operational goal setting activity in the future.

2.4.4 The full IEOGG Terms of Reference are included in Appendix C.

3. ADMINISTRATION AND SUPPORT

3.1 Support from the Operational Goals Planning Committee (OGPC)

3.1.1 The IEOGG process is designed to deliver operational goals for use by CAEP and CAEP working arrangements (primarily MDG) for the CAEP/9 meeting (February 2013). To support this review, the Operational Goals Planning Committee (OGPC) was established within WG2 to elaborate on the terms of reference and timeline of activities of IEOGG, develop initial plans and material, support the IE nomination process and organize an initiation workshop.

3.2 Part of the recommendations made by the CAEP/8 meeting was the close coordination with other IE groups, in particular the WG3 fuel burn reduction technologies goal process. In defining the proposed IEOGG plan and terms of reference, sharing of information between WG2-OGPC and the WG3 Fuel Burn Reduction Technology Goals team was therefore undertaken. This has helped to ensure consistency and to avoid the risk of overlap.

3.3 Recruitment Process and Membership

3.3.1 CAEP-Memo/79 was sent on 22 November 2010 to Members and Observers to call for nomination of the IEs. In March 2011, six experts had been nominated and in April 2011 one of the original nominations was withdrawn. Two new nominations were made and accepted after the Steering Group meeting in September 2011. In August 2012, the IATA member resigned and a replacement was identified in October 2012. The group of experts was set as described in Table 1. Full accounting of membership attendance is shown in Appendix D.

Table 1: CAEP/9 IEOGG Membership

IE Name	Nominating Body	Relevant Knowledge (selected elements only)
Michael Ball	U.S. (FAA)	Air Traffic performance, systems and operations.
Lee Merry Brown (Chairperson)	U.S. (FAA)	Air Traffic Operations and Airspace Design
Teresa Di Lallo	Italy (ENAV)	CNS/ATM performance metrics and Functional Airspace Blocks
Dirk Kugler	Germany (DLR)	CNS/ATM, Navigation Systems
Robert Goldman (replaced Grady Boyce)	IATA	Airline Operations
Richard Marchi	ACI	Airport operations and management. ICAO goal setting.
Mohamed Osman Alata Soliman	ACAC	Public relations, air transport and international affairs; and in, airport environmental management.
Anton Walsdorf	ICCAIA	Aircraft Systems Engineering, SESAR, NextGen, Security and Military

3.4 Conduct of the IEOGG Kick-off Workshop

3.4.1 Part of the action plan to facilitate the IE review, as outlined in Task O.01.02, was to hold a workshop and establish the IE Review group.

3.4.2 The objective of this two-day workshop was to inform the IEs of substantial inputs related to IEOGG activities, including the clarification on terms of reference, lessons learned by other IE processes, expectation from CAEP MDG, relevant information on various initiatives such as NextGen, SESAR, AIRE and ASPIRE, and other inputs from stakeholders.

3.4.3 WG2 and the IEOGG therefore thoroughly reviewed the terms of reference as supplied in CAEP-Memo/79. Presentations were made from key stakeholders and colleagues whose work is considered significant to the IEOGG task. In addition, the IEOGG elected a chair and took control of the remaining work program with WG2 providing support as needed. The workshop concluded with the election of Lee Brown from the U.S. as Chair of the IEOGG.

3.4.4 Although presentations were thorough, relevant, and reflected current experience in operational efficiency calculations, they also reflected the limitations of geographical representation. Presentations primarily considered performance and benefits modeling for the U.S. and Europe and the models and databases dealt mostly with fuel rather than noise.

4. SCOPE AND TECHNICAL CONSIDERATIONS

4.1 The Terms of Reference defines Operations to “...encompasses the direct facilitation of the utilisation of civil aircraft in any phase of the Gate-to-Gate regime, both in the air and on the ground.” The IEOGG has further refined this definition to broadly include changes from an initiative that involves how, when or where an airframe is utilized. This definition includes three classes of operational changes: Air Traffic Management (ATM) Operations, Airport Operations, and Aircraft Operations.

- ATM Operations include those initiatives that directly impact the path (in all dimensions) and how airspace is used. Examples would include Performance-Based Navigation Routing, Optimized Profiles, Flexible Airspace, and Functional Airspace Blocks. Collaborative decision making techniques would also be considered in this category.
- Airport Operations include those initiatives in and around the airfield. Examples include Improved Surface Management, Minimum Engine Taxi, and Enhanced Ground-Movement Information Sharing.
- Aircraft Operations include initiatives specific to the aircraft but not associated with technologies. Scheduling and operating procedures could also be considered in this category. Examples include Aircraft Type, Auxiliary Power Unit Use, and Relaxation of Take-off Speed Limitations.

4.2 Future activities that do not directly affect gate-to-gate operations were not included in the IEOGG analyses. However, the IEOGG has attempted to put the potential impact of these actions in the context of other in-scope activities (e.g. trade-offs between noise and emissions impacts). The IEOGG notes that congestion management techniques (e.g. slot restrictions, or minimum aircraft size requirements) and land use restrictions may influence and produce operational effects.

4.3 The Terms of Reference identifies the IEOGG environmental scope to develop goals for fuel consumption (an efficiency metric) and operational noise mitigation. The analysis approaches for fuel consumption and noise are described in separate sections of this report.

4.4 The IEOGG’s scope includes a baseline of 2010, with two target goal years 2020 (mid-term) and 2030 (long-term). At the inaugural workshop, the IEOGG was asked to consider adding an additional year, 2040, to coincide with the MDG modelling timeframes planned for CAEP/10. This report includes 2020, 230, and 2040 goals. The longer-range goals, i.e. 2040 do not have the same rigor as the 2020 and 2030 goals.

5. TECHNICAL COORDINATION

5.1 The IEOGG had one coordination teleconference with the Chair of the Modelling and Database Group (MDG). Subsequently, the IEOGG received 2006 global operations data and a draft 2036 global operations forecast.

5.2 Richard Marchi (IEOGG member and FESG member) provided the IEOGG with the FESG traffic and passenger forecasts from May 2012 for the route groups. The IEOGG used these two data sets to construct its required traffic forecasts for 2020, 2030, 2040.

5.3 At its February 2012 meeting, the IEOGG received a briefing of the Aviation System Block Upgrades (ASBUs) from Steve Bradford from the U.S. FAA. The briefing acquainted the group with the ASBUs, and the IEOGG will be using this material in its deliberations. The IEOGG has received the most recent draft/version of the ASBU document.

5.4 The IEOGG also received a briefing from ICCAIA at its February 2012 meeting. The briefing included several proposals for operational improvement in both emissions and noise. The IEOGG used the information in its deliberations.

5.5 On Day 1 of the June 2012 meeting, the IEOGG met with David Knorr, Senior U.S. FAA Representative in Paris. Mr. Knorr is a primary author on many performance assessment studies that the IEOGG has used in its deliberations. The IEOGG discussed several studies with Mr. Knorr for understanding of assumptions and interpretation of results.

5.6 At the CAEP SG3 meeting held in July 2012, several participants volunteered additional data and support. Information received and utilized by the IEOGG in its August meeting included a preview of recent performance assessment reports from Australia, delay and diversion data from Brazil, CARATS project material from Japan, PBN project data in UAE from ARAC, Hudson Bay ADS-B project data from Canada, and noise contour data from MDG and WG1.

5.7 A special teleconference was held in July 2012 with Tim Rees, Airservices Australia, to discuss recent performance assessment studies.

5.8 At the August 2012 meeting, the IEOGG held a coordination teleconference was held with Dennis Huff, the Noise IE Chairperson. Assumptions on feasibility of steeper approaches were discussed at this meeting.

6. REVIEW OF RELEVANT RESEARCH, STUDIES AND DEMONSTRATION PROJECTS

6.1 The IEOGG informed its deliberations using the results of several studies, research papers and demonstration projects. This work generally either describes a “theoretically available” benefit pool or describes benefits that can be achieved using a certain technology or operational process. It is also the case that the results typically apply to a specific geographic region, e.g. North Atlantic and to a specific phase of flight, e.g. terminal area/descent. As discussed later, the IEOGG analysis was generally organized along these lines. In this section the relevant work reviewed by the IEOGG is listed. The application of specific results to the IEOGG analysis is discussed later in this report.

6.2 While the work of the IEOGG took a “bottom-up” approach, earlier “top-down” studies were considered to provide context and validation. These include, the CAEP/8 IEOGG report (CAEP/8 2010), the CANSO goals (CANSO 2008) and the IATA sponsored NLR study (Brok and Hoogerbrugge, 2000). As identified in the IEOGG Terms of Reference, the IEOGG used the CAEP/8 IEOGG Report as a starting point for its deliberations. The IEOGG used resource documents and studies that were referenced by the CAEP/8 IEOGG.

6.3 Several broad studies and demonstration projects provided the IEOGG with input and information across multiple dimensions. These include the U.S./Europe ATM performance study (Performance Review Commission and the Air Traffic Organization, Strategy and Performance Business Unit, 2009, Gulding et al 2009), the AIRE project (Aguilar 2020, Forsberg 2009, Bourgin, and Renou, 2010, Delain et al 2010, Lachance 2011, Maier 2011, RETA-CDA Consortium, 2010) and the ASPIRE project (ASPIRE 2009, ASPIRE 2010).

6.4 As discussed later in this report, the IEOGG analysis of operational fuel and atmospheric emissions goals is broken down by phase of flights: taxi-out, climb, cruise, descent and taxi-in.

6.5 The U.S./Europe ATM performance study provided a starting point in estimating benefit pools for taxi-in and taxi-out. Specific references on virtual queuing, which has the potential to substantially reduce taxi-out emissions in the U.S. include Bhadra et al 2011, Brinton et al 2011, Deonandan and Balakrishnan 2010 and Simaiakis et al 2011.

6.6 Estimates for the climb pool employed Robinson and Kamgarpour 2009 and Performance Review Commission 2008. Additional insights were provided by Mitchell and Ekstrang 2011, which also explored noise/emissions tradeoffs.

6.7 Basic estimates of the enroute benefit pool used the U.S./Europe ATM performance study, Lovegren and Hansman 2011, Fujisaki 2012, and Palopo and Windhorst 2009. The AIRE and ASPIRE project also provided specific validation and insights. Additional insight was provided by Malwitz et al 2007.

6.8 References used to estimate the descent benefit pool include CAEP/7 2007, Dinges 2007, Knorr et al 2011, Robinson and Kamgarpour 2009, Shresta et al 2009. Insights into mechanisms to achieve these benefits were provided in Shresta et al 2011, Swenson et al 2011, Churchill and Hall 2012.

6.9 Ryerson et al 2011 provides insights on the relationship between various flight characteristics and fuel usage, which were useful in validating certain ideas and estimates.

6.10 References used in estimating the noise goals include: Airservices Australia 2007, Clarke 2000, Clarke et al 2004, Dinges 2007, Graham et al, 2009, ICAO 2007, Lissek 2011, Mitchell and Ekstrand 2011, Reynolds et al 2007

6.11 The SESAR and NextGen program plans have been used for determining the timing and feasibility of any specific operational enhancements, technologies, or procedures in Europe and the United States. The Aviation System Block Upgrade draft materials have been used to estimate similar capability availability for other parts of the world.

7. LIMITATIONS AND ASSUMPTIONS

7.1 This section includes a list of issues and concepts that could constitute limitations on the IEOGG analysis approach. The IEOGG has made assumptions and simplifications concerning these areas in order to support its conduct of the analyses.

7.1.1 Fuel Efficiency: As recognized by the CAEP/8 IEOGG the relationship between operational efficiency and fuel efficiency/CO₂/NO_x is complex. The challenges faced during the CAEP/8 processes have not yet been resolved. Thus, the IEOGG approach to emissions reduction is to assume emissions are linearly related to fuel usage so that an X% reduction in fuel usage corresponds to an X% reduction in emissions. The IEOGG believes that this approach is consistent with its broad goal-setting mission, while recognizing that in the specific case of NO_x emissions, there are some specific measures that can be taken to reduce NO_x that do not correspond to similar reductions in fuel usage.

7.1.2 Operational Goals May Require Technology Investments: The IEOGG goals represent savings that can be achieved by new operational practices. However, in many cases these require new technology investments on the part of both ANSP's and flight operators, such as those associated with NextGen and SESAR. Very specifically, it is important to note that achieving the goals require

substantial reduction in taxi-in and taxi-out emissions through efficient queuing and through the eventual use of electric taxi systems.

7.1.3 Goals May Require Policy Changes: The goals, at least in part, may require changes in policies and practices, not only of ANSP's but also of flight operators and national states. For example, achieving certain cruise benefits may require flight operators to give higher priority to the use of fuel efficient speeds. Flight operators may also have to avoid practices that lead to excess airport congestion. Also, some cruise benefits may require that national states provide additional access to special use airspace, e.g. airspace currently reserved for military purposes.

7.1.4 Goal Interpretation: The emissions/fuel efficiency goals refer to improvement in the operational efficiency on a per-flight basis. To illustrate, the IEOGG 2040 goal could be interpreted as follows: on the average, an equivalent flight, e.g. a B737-800 from KATL to KORD, should use 9% less fuel in 2040 than the same flight would use in 2010. Specifically, these goals do not account for growth in the overall number of flights and the characteristics of a "average" flight, which likely will become longer and use a larger aircraft. This is discussed in more detail later in the report.

7.1.5 Business Case of Stakeholders: the economic impact of implied operational changes on the various stakeholders has not been taken into account. Certain means to improve the benefit or mitigate the negative environmental impact of the air transport management system could compromise the operational business case of stakeholders, even leading to a loss of the "livelihood of a stakeholder". Such potential outcomes would certainly make the implementation of such operational changes a public policy challenge.

7.1.6 New-Air-Transport-Concepts: the current assumptions are based on current air travel technologies of commercial transport aircraft, e.g. fixed wing aircraft, where in the long-term new air transport solutions/concepts, e.g. lighter than air, autonomous traffic/UAV, etc. could provide even more significant reduction of environmental impact.

7.1.7 Governances: the potential evolution in air transportation business models and systems, e.g. in regional/leisure aircraft, military aviation or new security requirements, has not been taken into account. These could further impose constraints on the ATM system. Today, the current ATM system is mainly driven and designed by state authorities and under civil/economical boundary conditions. New methods for providing ATM services, e.g. privatization of ANSP services, could have a substantial impact the issues addressed in this report.

7.1.8 Inter-Transport-Modes"-Effects: the underlying forecasts have not taken into account the potential shift in long-term transportation needs, through changes in social requirements or demands imposed through living environments, e.g. Mega-Cities. Further, the potential reduction in passenger or freight transport demand by the development into a more information driven society has not been taken into account.

7.1.9 Climate Change: Constraints imposed by emerging climate changes were not taken into account.

7.1.10 Policies Constraints: Constraints imposed by local, regional or global policies facilitating or hampering traffic growth/efficiency in operation were not taken into account.

7.1.11 Noise Impacts: The IEOGG focus is on operational measures having the potential to reduce noise through ATM operational changes of the type that are being contemplated in SESAR and NextGen. The IEOGG did not consider actions to reduce noise impacts through non-operational measures, such as land use measures, aircraft operating restrictions, curfews, up-gauging or other