Following six years of development, ICAO’s Committee on Aviation Environmental Protection (CAEP) at its tenth meeting (CAEP/10) recommended an Aeroplane Carbon Dioxide (CO₂) Emissions Certification Standard. This new standard is part of the ICAO “basket of measures” to reduce greenhouse gas emissions from the air transport system, and it is the first global technology Standard for CO₂ emissions for any sector with the aim of encouraging more fuel efficient technologies into aeroplane designs.

This technology-based approach is similar to the current ICAO Annex 16 Standards on engine emissions for local air quality (Volume II) and aircraft noise (Volume I). The recommended CO₂ Standard has been developed at the aeroplane level, and therefore has considered all technologies associated with the aeroplane design (e.g. propulsion, aerodynamics and structures). Once adopted by the ICAO Council, the Aeroplane CO₂ Emissions Certification Standard will be published as a new Annex 16, Volume III.

The framework for the CO₂ Standard consists of a certification requirement and regulatory limit, as shown in Figure 1, and the work to develop the CO₂ Standard was divided into two phases. Phase 1, which was completed at the ninth meeting of the CAEP (CAEP/9) in February 2013, resulted in the approval of some of the details regarding the applicability of the Standard, the CO₂ Metric System and the development of a CO₂ Standard certification requirement. Phase 2 involved the development of the regulatory limit lines and the applicability requirements such as scope and date.

In the ICAO Environmental Report 2013, a summary was provided of the work that had been completed during Phase 1. This new article provides an overview of both phases over the past six years, the lead up to the CAEP/10 meeting and the recommendation from the CAEP/10 meeting on the first ICAO Aeroplane CO₂ Emissions Certification Standard.

**Phase 1 work- The Development of Certification Requirement**

An important Phase 1 milestone in the development of the CO₂ Standard was the agreement on a CO₂ metric system to measure the aeroplane fuel burn, and therefore CO₂ emissions, performance. The intent of this CO₂ metric system is to equitably reward advances in aeroplane technologies (e.g. propulsion, aerodynamics and structures) that contribute to reductions in aeroplane CO₂ emissions, and differentiate between aeroplanes with different generations of these technologies. As well as accommodating the full range of technologies and designs which manufacturers can employ to reduce CO₂ emissions, the CO₂ metric system has been designed to be common across different aeroplane categories, regardless of aeroplane purpose or capability. An overview of the CO₂ Metric System can be found in Figure 2.
To establish the fuel efficiency of the aeroplane, the CO₂ metric system uses multiple test points to represent the fuel burn performance of an aeroplane type during the cruise phase of flight. Specifically, there are three averaged (i.e. equally weighted) points representing aeroplane high, middle and low gross masses, which are calculated as a function of Maximum Take-Off Mass (MTOM). Each of these represents an aeroplane cruise gross mass seen regularly in service. The objective of using three gross mass cruise points is to make the evaluation of fuel burn performance more relevant to day-to-day aeroplane operations.

The metric system is based on the inverse of Specific Air Range (i.e. 1/SAR), where SAR represents the distance an aeroplane travels in the cruise flight phase per unit of fuel consumed. In some aeroplane designs, there are instances where changes in aeroplane size may not reflect changes in aeroplane weight, for example when an aeroplane is a stretched version of an existing aeroplane design. To better account for such instances, not to mention the wide variety of aeroplane types and the technologies they employ, an adjustment factor was used to represent aeroplane size. This is defined as the Reference Geometric Factor (RGF), and it is a measure of aeroplane cabin size based on a two-dimensional projection of the cabin. This improved the performance of the CO₂ metric system, making it fairer and better able to account for different aeroplane type designs.

The overall capabilities of the aeroplane design is represented in the CO₂ metric system by the certified MTOM. This accounts for the majority of aeroplane design features which allow it to meet market demand.

Based on the CO₂ metric system, CAEP developed procedures for the certification requirement including, inter alia, the flight test and measurement conditions; the measurement of SAR; corrections to reference conditions; and the definition of the RGF used in the CO₂ emissions metric. CAEP utilised manufacturers’ existing practices in measuring aeroplane fuel burn in order to understand how current practices could be used and built upon for the new Standard. Based on this information, the ICAO Annex 16 Volume III CO₂ Standard certification requirement was developed; and, pending some future work, this was initially approved by the CAEP/9 meeting in February 2013. This was a crucial component in the CO₂ Standard development and allowed CAEP to move onto Phase 2 of the work.

**Phase 2 Work – Setting the Regulatory Limit**

ICAO environmental Standards are designed to be environmentally effective, technically feasible, economically reasonable, while considering environmental interdependencies. These four tenets of CAEP guided Phase 2 work, which involved carrying out a comprehensive assessment of the costs and benefits of all the options which could be selected to form the CO₂ Standard. This involved defining an analytical space within which CAEP would work to investigate the options available. This included the development of options for the regulatory limit line, applicability options and dates, and all the associated assumptions which allowed the CAEP working groups to perform the cost-effectiveness analysis required to make an informed decision on the Standard at the CAEP/10 meeting. The foundation of the CAEP/10 recommendation on the CO₂ emissions Standard was supported by this significant data informed process, involving input from ICAO member states and stakeholders. The modelling exercise involved several analytical tools, including fleet evolution modelling, environmental benefits, recurring costs, non-recurring costs, costs per metric tonne of CO₂ avoided, certification costs, applicability scenarios and various sensitivity studies to inform the decision-making process. This work allowed CAEP to conduct an analysis, with the aim of providing a reasonable assessment of the economic costs and environmental benefits for a potential CO₂ standard in comparison with a “no action” baseline.
CHAPTER 4
GLOBAL EMISSIONS

A WIDE COVERAGE OF AEROPLANES
The standard is most stringent for larger aeroplanes with an MTOM of greater than 60 tonnes. This accounts for more than 90% of international aviation emissions.

The Contribution of the CO2 Standard to Reducing CO2 Emissions from International Aviation
It is complex to fully understand the impact of the CO2 Standard due to potential unknown market driven responses to the regulation, and the fact that the CO2 Standard cost-effectiveness analysis was a comparative investigation of regulatory limit lines. However, it is clear that the new standard will have direct effects by increasing the importance of fuel efficiency in the design process such that an aeroplane type not just meets the regulatory limit but also has good relative product positioning in terms of a margin to the limit.

The Next Steps and Consideration by the ICAO Council
The CAEP/10 recommended CO2 Standard is currently going through the adoption process within ICAO. This involves a review for the Air Navigation Commission (ANC), a consultation process with all the 191 ICAO Member States, before being considered by the Council for adoption during early 2017. Following this the First Edition of Annex 16, Volume III should become applicable during the latter part of 2017.

References
ICAO Circular 337 - CAEP/9 agreed certification requirement for the aeroplane CO2 emissions standard
ICAO Doc 10069 - Report of CAEP/10
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