# LOCAL AIR QUALITY - OVERVIEW
## BY ICAO SECRETERIAT

Since the late 1970s ICAO has been developing measures to reduce the impact of aircraft emissions on Local Air Quality (LAQ). These measures focus on the effects of aircraft engine emissions released below 3,000 feet (915 metres) and emissions from airport sources, such as airport traffic, ground service equipment, and de-icing operations. One of the principal results arising from the work of ICAO is the development of the ICAO Standards and Recommended Practices (SARPs) on engine emissions contained in Volume II of Annex 16 to the *Convention on International Civil Aviation* (the "*Chicago Convention*") and related guidance material and technical documentation. These SARPs aim to address potential adverse effects of air pollutants on LAQ, primarily pertaining to human health and welfare. Among other issues, these provisions address: liquid fuel venting, smoke, and the main gaseous exhaust emissions from jet engines, namely; hydrocarbons (HC), oxides of nitrogen (NOx), and carbon monoxide (CO). Specifically, the Annex 16 engine emissions Standards set limits on the amounts of gaseous emissions and smoke allowable in the exhaust of most civil aircraft engine types.

The certification process for aircraft engine emissions is based on the Landing Take Off (LTO) cycle, shown in **Figure 1**, for aircraft engine emissions which is representative of the emissions emitted in the vicinity of airports. The LTO cycle contains four modes of operation, which involve a thrust setting and a time-in mode. These are as follows:

- **Take-off:** (100% available thrust) for 0.7 minutes;
- **Climb:** (85% available thrust) for 2.2 minutes;
- **Approach:** (30% available thrust) for 4.0 minutes;
- **Taxi:** (7% available thrust) for 26 minutes.

The engine certification process itself is performed on a test bed where the engine is run at each thrust setting in order to generate fuel flow and emissions the data for each of the modes of operation. The submission of these data are mandated as part of the engine emissions certification. All of these data are stored in the publically available ICAO emissions databank.

Over the past three years work has been conducted by CAEP to continue to ensure the validity of the technical basis underpinning the ICAO SARPs associated with reducing the impact of civil aviation on LAQ. This work has included, inter alia: development of a non-volatile Particulate Matter (nvPM) Standard, an industry led combustion technology review, the update to ICAO SARPs to ensure their currency, and an overview of the current state of the science regarding LAQ. The CAEP/10 meeting recommended the first nvPM standard for aircraft engines and this will be considered by the ICAO Council for adoption in the early part of 2017.

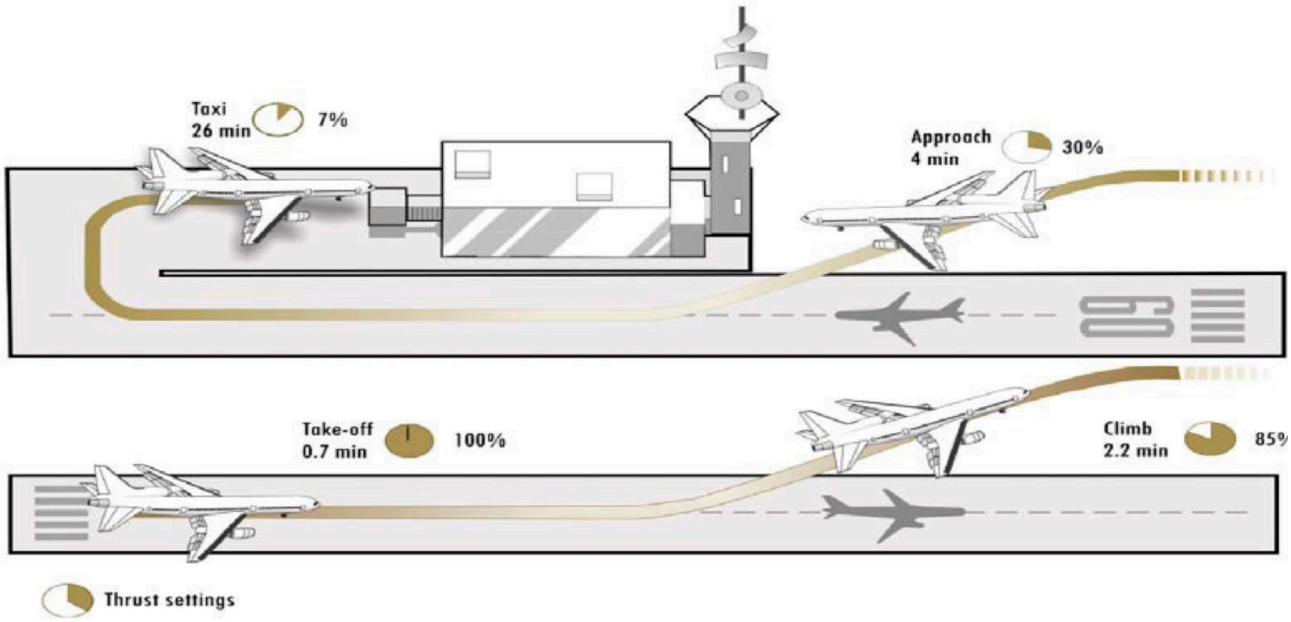


Figure 1. Illustration of ICAO emissions certification procedure in the LTO cycle.

## Emissions Standards and Technology

Technological innovations in aviation continue to lead the way towards effective and efficient measures in support of ICAO's environmental goals of limiting or reducing the impact of aircraft emissions on LAQ. The objective of ICAO engine emissions standards is to encourage the use of the latest technology in engine designs. Therefore the setting of standards is closely linked to understanding the research and development of technology. To complement the standard-setting process, CAEP developed, with the assistance of a panel of independent experts, medium- and long-term NOx technology goals (10 and 20 years, respectively). While CAEP did not conduct a NOx technology review in the past three years (the most recent IE review was published in 2010), an industry-led combustion technology review was performed and was presented to CAEP. This industry-led review provided an assessment of advances in engine combustor design technologies for subsonic aircraft and the degree to which these technologies could influence gaseous emissions, and particulate matter, including the potential interdependencies and trade-offs with emissions and noise, and the likely timescales for introduction. The advances in engine combustor design technologies were considered in the context of the existing mid- and long- term CAEP goals. To provide the latest state of technology, currently CAEP is working on an integrated independent expert technology goals assessment and review for engines and aircraft which aims to be delivered to the CAEP/11 meeting in February 2019.

### MEDIUM- AND LONG-TERM NOX TECHNOLOGY GOALS

Medium Term (MT) goal for NOx positioned at CAEP/6 NOx Standard minus 45% +/- 2.5% at Operating Pressure Ratio (OPR) of 30 by 2016. The Long Term (LT) NOx goal is CAEP/6 NOx Standard minus 60% +/- 5% by 2026.

## Developing a New Standard for Particulate Matter

Aircraft engines burning hydrocarbon-based fuels emit gaseous and particulate matter (PM) emissions as by-products of combustion. At the engine exhaust, particulate emissions mainly consist of ultrafine soot or black carbon emissions. Such particles are called "non-volatile" PM (nvPM). They are present at the high temperatures at the engine exhaust. Compared to traditional diesel engines, gas turbine engine non-volatile particles are typically smaller in size. Their geometric mean diameter ranges roughly from 15 nanometres (nm) to 60nm (0.06 micrometres; 10nm = 1/100,000 of a millimetre). These particles are ultrafine and are invisible to the Human eye.

During the CAEP/10 meeting, CAEP recommended a new standard for nvPM. The nvPM Standard, which will apply to engines manufactured from 1 January 2020, is for aircraft engines with rated thrust greater than 26.7kN and is the first of its kind. It includes a full standardized certification procedure for the measurement of nvPM, with the regulatory limit for the nvPM mass concentration set at the current ICAO smoke visibility limit. The new nvPM Standard is recommended as an amendment to Annex 16, Volume II and is currently being considered for adoption by the ICAO Council. Further details on the work on nvPM can be found in the article on the *Development of a Particulate Matter Standard for Aircraft Gas Turbine Engines*, Chapter 3 in this report.

## Future ICAO Work

ICAO continues to develop measures aimed at mitigating the impact of aviation on air quality in the vicinity of airports, and to support this ICAO continues to develop international standards, guidance material, and technical documentation as appropriate for the needs of the international community. This includes the maintenance of Annex 16, the environmental technical manuals, and the ICAO engine emissions databank.

Based on the success of recommending the first nvPM requirement, the work of CAEP will now involve the further development of a more stringency nvPM mass and number standard during CAEP/11, which will consider technical feasibility, economic reasonableness, environmental benefit and interdependencies. CAEP will also continue to monitor and review technology developments, including combustion technologies and advances in engine combustor design, with a view to understanding how these technologies may impact the production of gaseous emissions and particulate matter in the future.

### Sustainable Development Goals