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Evaluation of climate impacts of aviation technology targets

B. Owen, D.S. Lee and L. Lim

Dalton Research Institute, Department of Environmental and Geographical Sciences, Manchester Metropolitan University, United Kingdom (b.owen@mmu.ac.uk)

The International Civil Aviation Organization (ICAO) through the aegis of its Committee on Aviation Environmental Protection (CAEP), has suggested trialling the use of long term technology goals (LTTG) to reduce NOx emissions from aircraft. Any reduction in NOx emissions at cruise conditions is assumed to have a beneficial effect on climate, as radiative forcing of O3 is at its most effective in the upper troposphere and lower stratosphere.

However, 'reductions' of NOx under the CAEP regulatory regime are not straightforward. The CAEP standards allow for higher NOx emissions for higher pressure-ratio engines. The metric is termed Dp/foo, which is, grams of NOx per kN of maximum rated thrust at static sea-level test conditions versus over-all pressure ratio of the engine (OPR). The goal-setting process was undertaken by the Long-Term Technology Goal Task Group, ICAO- CAEP Working Group 3. The LTTG exercise specified medium and long-term goal 'lines', i.e. levels of Dp/foo versus OPR, in line with the current CAEP NOx regulatory regime. However, CAEP did not consider the resultant global emissions that compliance with such a regime might imply, nor the improvements that they may represent over some defined 'business as usual' scenario.

This study provides global forecasts of aviation NOx and CO2 emissions for 2020, 2030 and 2050, based on the LTTG long-term and medium-term goals using a global aviation emissions model, FAST such that the benefits of the technology goals can be quantified in terms of emissions.

The overall methodology of assessing the potential benefits to be realized from achieving the goals was to scale engine emission indices according to the goals specifications and applying them to forecasted operations of the future fleet. Having consulted industry, it was assumed that changes in NOx Dp/Foo are directly proportional to changes in the EINOx. This assumption ignores any change in NOx emission characteristics that future technologies might produce.

The scenarios to be assessed also required a consideration of the likely fuel efficiency improvements in the future fleet resulting from an assumed increase in OPR. Three base case scenarios were devised in order to account for both NOx and fuel efficiency improvements in addition to the 2 goals cases (i.e. the medium term and long term goals).The impacts of the goals and trends in fuel efficiency improvement on the fleet EINOx, the total NOx emissions and the total CO2 emissions were evaluated by comparison of the base and goal cases up to 2050.

In addition, a climate response model tailored for aviation emissions was used to calculate the benefits of technology improvements in terms of radiative forcing. The LinClim model is a linear climate response model that has been formulated to calculate radiative forcing (RF) and the temperature response for aviation's effects on the global atmosphere. The model includes CO2, a parameterized methodology for O3 from aviation NOx, a reduction in the CH4 RF from aviation NOx, contrails, sulphate and black carbon aerosols. From these RFs, temperature responses may be calculated from individual effects in order to determine their relative importance by applying published values for efficacies for the individual effects, thereby allowing comparison of the different climate effects of the fuel efficiency improvements and NOx emission changes.