Quantifying the Environmental Design Trades for a State-of-the-Art Turbofan Engine

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Background

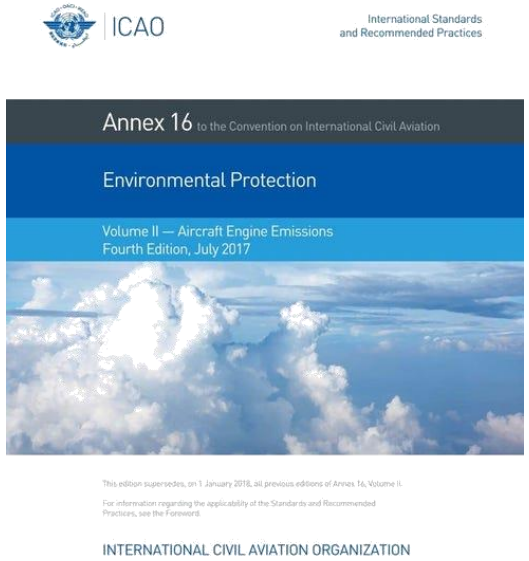
Emissions: Noise and LTO NOx

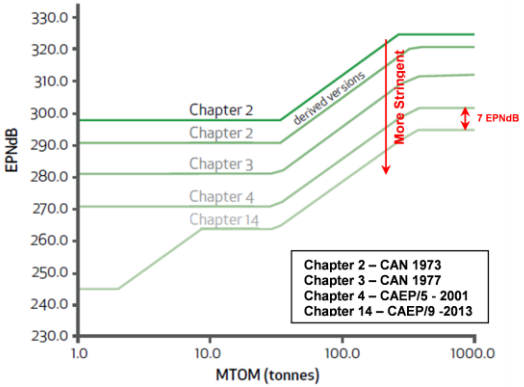
Noise:

- Human health, e.g. cardiovascular disease and sleep disturbance
- ICAO Chapter 14 noise standard

NOx emissions:

- Climate and Local air quality
- Annex 16 Volume II



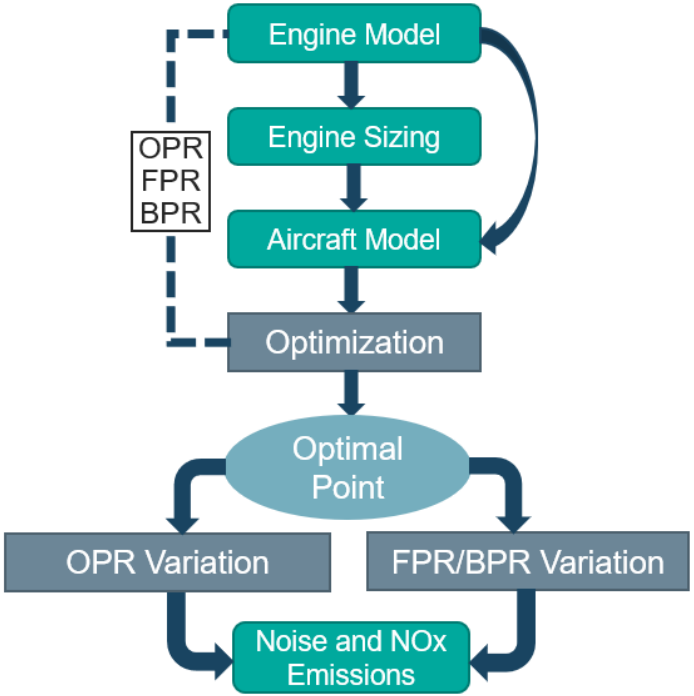


Source: https://www.icao.int/environmental-protection/Pages/default.aspx

Methodology

Aim: How early design choices influence trades between CO_2, NOx and Noise

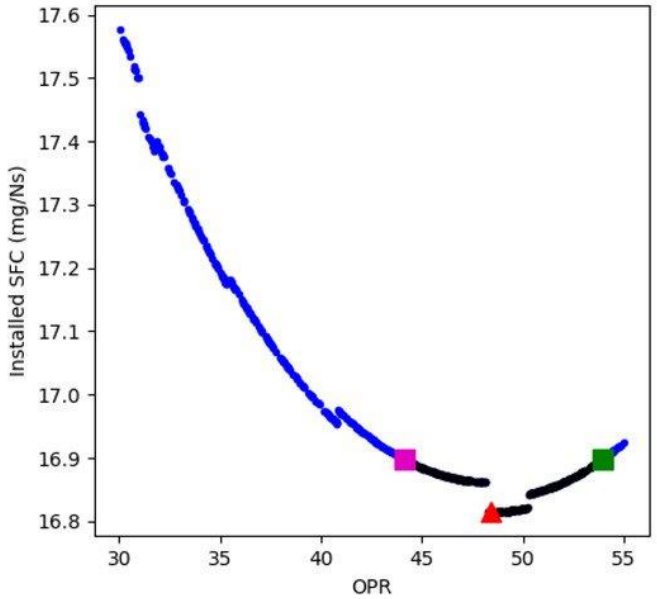
- Principle: Around an optimum point the function experiences insignificant variation
- Intention: Quantify this region for minimum installed SFC → Trade Space
- Model: Single aisle thrust class turbofan engine
- Parameter variation: OPR, FPR, BPR
- Noise and NOx emissions evaluation



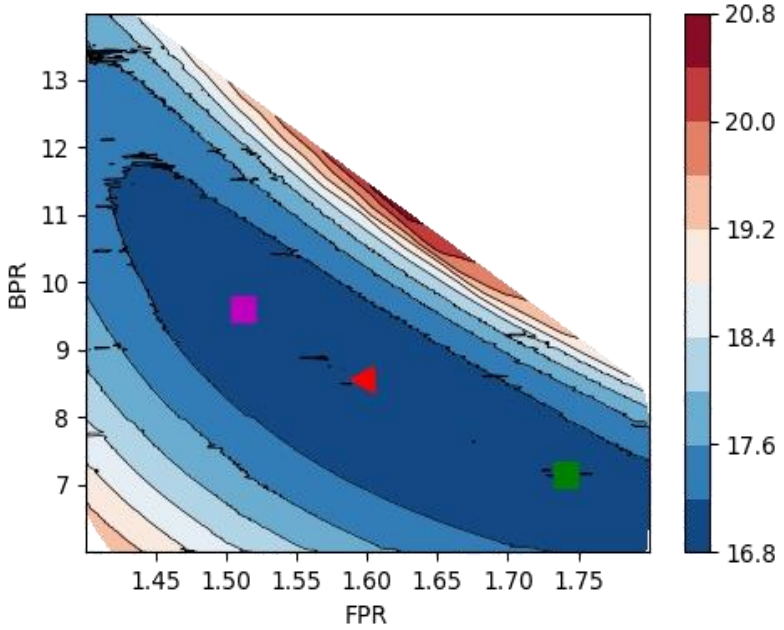
Trade Space

Study Cases

Core engine design space



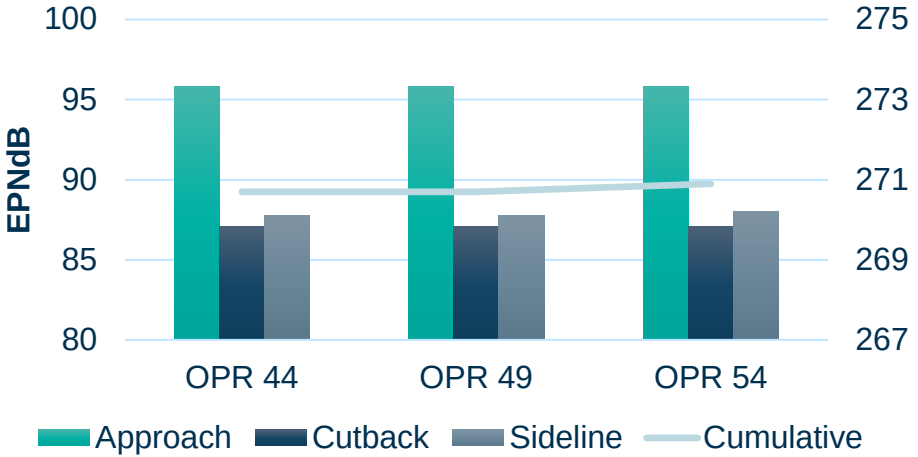
Low pressure system design space



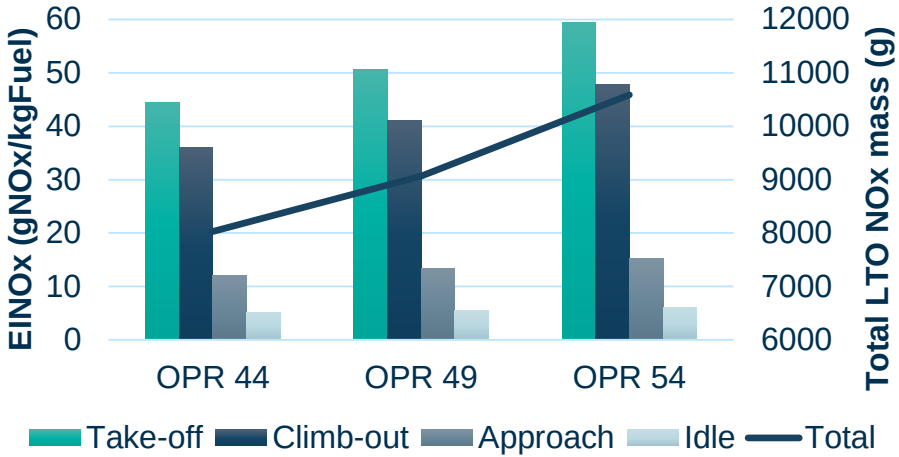
Multidisciplinary Trades

Study Case 1: OPR Variation

Noise



NOx

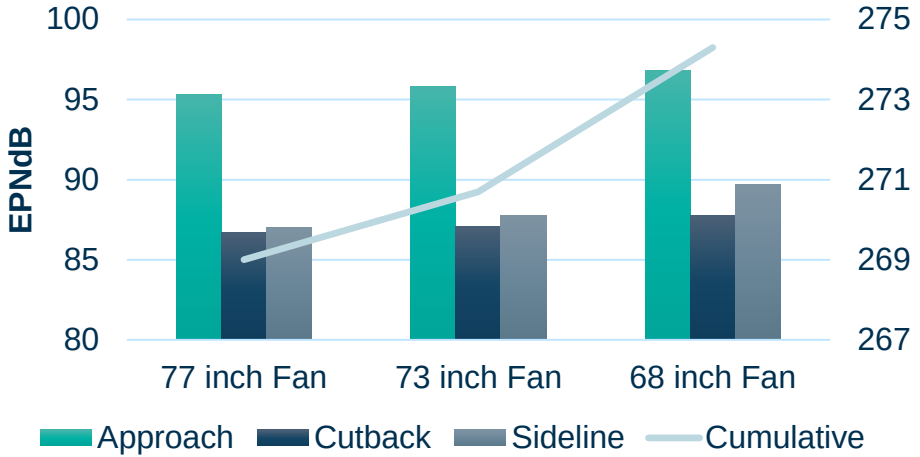


	OPR 44	OPR 49	OPR 54
Cruise Fuel flow (kg/s)	0.338	0.336	0.338

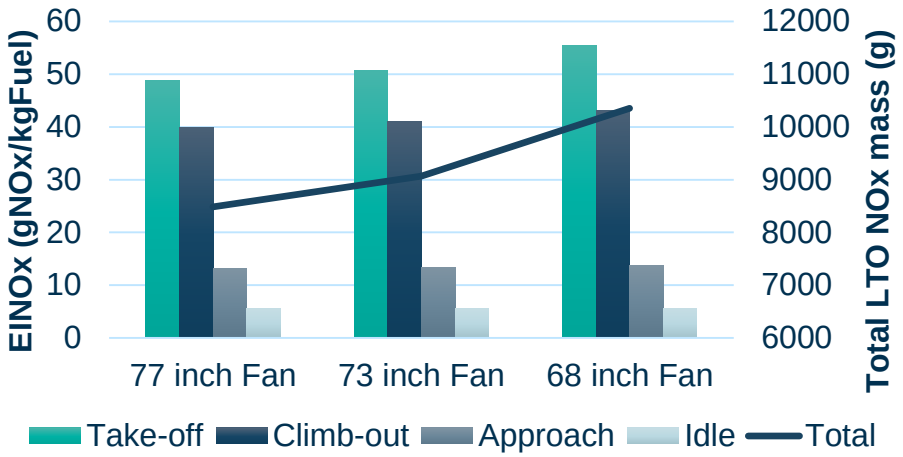
Multidisciplinary Trades

Study Case 2: Fan Diameter Variation

Noise



NOx



	77 inch Fan	73 inch Fan	68 inch Fan
Cruise Fuel flow (kg/s)	0.338	0.336	0.338

Conclusions

- A relatively large variation in cycle parameters is allowed with a modest effect on the installed SFC metric
- OPR variation is mostly relevant for improvement in NOx emissions
- Ranging the fan diameter results in reduction in cumulative noise
- Noise does not vary linearly with fan diameter and it largely depends on the engine technology level
- Further improvement could be achieved with increased fuel burn penalty

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