Imperial College London

Impact of single-engine taxiing on NO_x emissions from aircraft engines at London Heathrow Airport

Kar Chun LEE

Department of Civil and Environmental Engineering, Imperial College London.

Introduction

In London Heathrow Airport (LHR), nitrogen oxides (NO_x) are the main chemical compounds affecting the local air quality (HAL, 2011). To tackle this problem, single-engine taxiing (SET) is adopted by airport operators. Conventionally, aircraft tended to use all of its engines to manoeuvre on the ground at an airport. The new practice requires pilots to use only half the number of its aircraft engines to taxi. As this is a measure that has been implemented since 2011, there is an interest on the impact of SET on emissions at LHR. The aim for this project is to quantify the change in NO_x emission at LHR between SET and twin-engine taxiing (TET).

Methodologies

BOSS (ATM data) and QAR (second-by-second aircraft data) from air traffic movements (ATMs) by British Airways' Airbus A319 were used for this project. These are used to estimate emission by ICAO sophisticated approach (2011), which requires to base on actual ATMs and aircraft data to carry out the estimation. Figure 1 is the flow chart for estimating engine emissions.

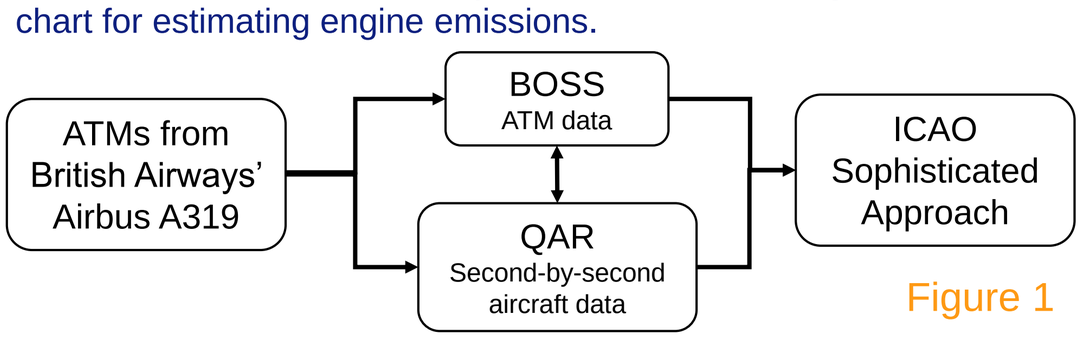
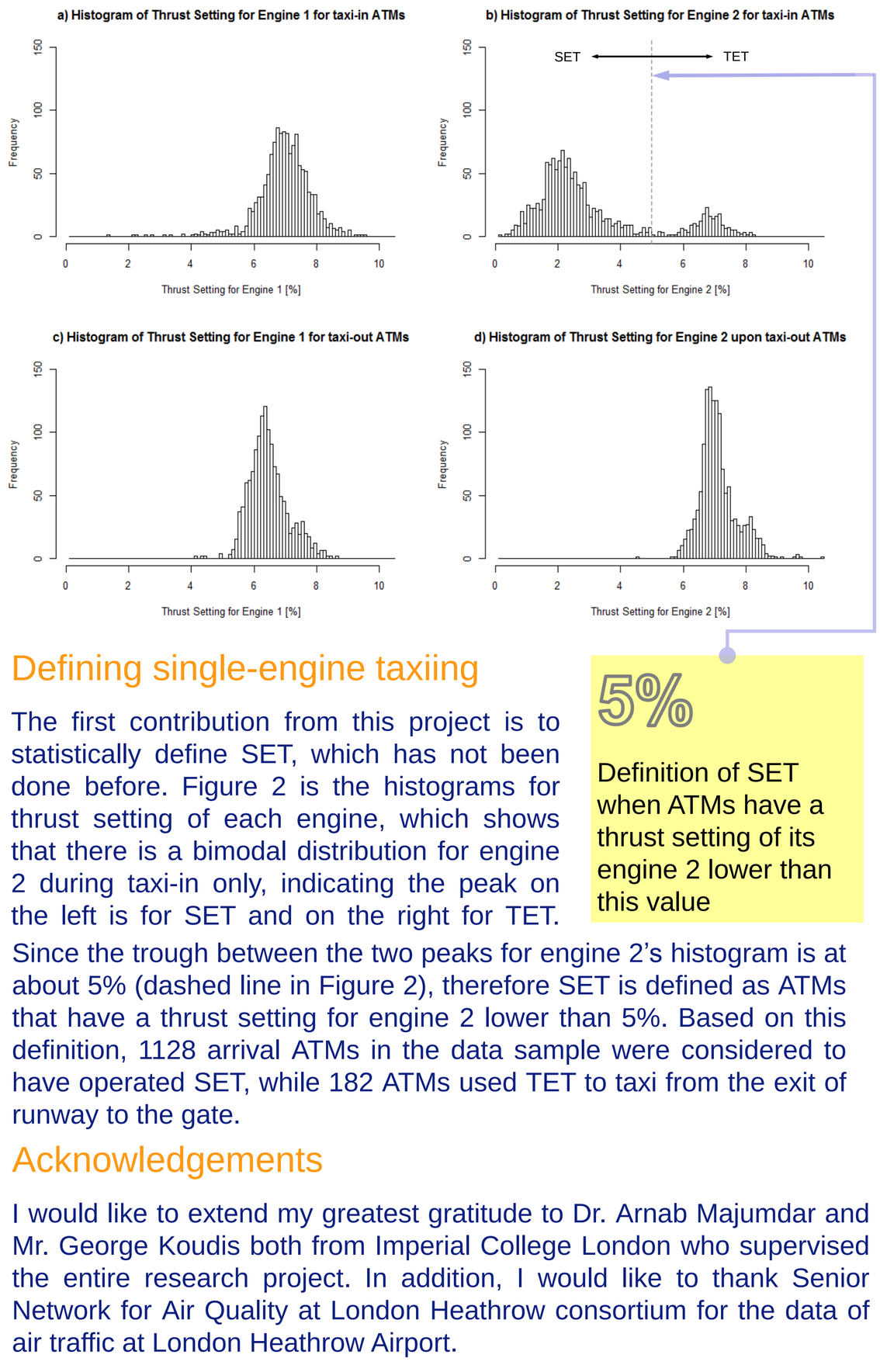


Figure 1

Figure 2



Defining single-engine taxiing

The first contribution from this project is to statistically define SET, which has not been done before. Figure 2 is the histograms for thrust setting of each engine, which shows that there is a bimodal distribution for engine 2 during taxi-in only, indicating the peak on the left is for SET and on the right for TET. Since the trough between the two peaks for engine 2's histogram is at about 5% (dashed line in Figure 2), therefore SET is defined as ATMs that have a thrust setting for engine 2 lower than 5%. Based on this definition, 1128 arrival ATMs in the data sample were considered to have operated SET, while 182 ATMs used TET to taxi from the exit of runway to the gate.

5%

Definition of SET when ATMs have a thrust setting of its engine 2 lower than this value

Acknowledgements

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Estimating emissions

There are four variables affecting the estimation of emissions from aircraft engines in the ICAO sophisticated approach: fuel flow rate, thrust settings, time in mode (TIM) and emission indices (EIs). EIs is a variable depends on the engine type and therefore outside the scope of this project; the remaining three variables are varied by flight operators such as pilots and air traffic controllers (ATCs). Table 1 is a summary of mean values for different variables during taxi-in with TET and SET, and their differences.

TABLE 1

Variables	Taxi-in - TET	Taxi-in - SET	Percentage Difference
Fuel Flow Rate (kg/s)	0.2171	0.1573	↓ 27.54 %
Thrust Settings (%)	6.387	4.712	↓ 26.23 %
NO_x emission rate (g/s)	1.005	0.717	↓ 28.80 %
Time in mode (TIM) (s)	333.5	433.1	↑ 29.87 %
Fuel Consumption (kg)	73.5254	66.1822	↓ 10.00 %
Total NO_x emissions (g)	328.1	303.1	↓ 7.62 %

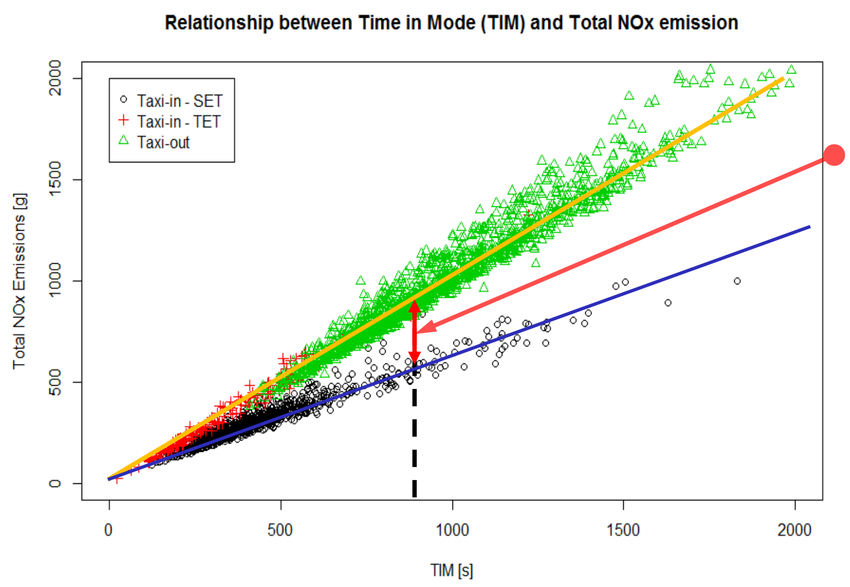
7.62%

Reduction in mean total NO_x emissions when SET is adopted during taxi-in comparing to TET

Key findings

Generally, there is a reduction from each variable mentioned in Table 1 in the SET scenario except TIM, which is due to some ATMs that encountered traffic during taxi-in. Despite this observation, the total NO_x emission, a quantity that TIM has a big influence in, is still reduced by 7.62 % comparing to TET.

Figure 3



27%

Approximate reduction of mean total NO_x emissions if SET is implemented with a taxi-out time of 15 minutes

Total NO_x emissions against Time in mode (TIM)

SET has a shallower gradient than TET in the scatter plot for total NO_x emission against TIM (Figure 3), indicating that the NO_x emission rate is lower for SET than TET. Furthermore, if SET is implemented for departing ATMs, it is estimated by linear regression model that the total NO_x emission can be reduced by around 27 % as compared to TET when the TIM is 15 minutes.

Conclusions

SET is proved to reduce the total fuel consumption and NO_x emission when compared to TET. Still, they are also depends heavily on the TIM. There will be quite a substantial decrease in total NO_x emission if taxi-out adopts SET as the TIM for departures is longer than arrivals.

References

Heathrow Airport Limited (HAL) (2011) *Heathrow Airport Air Quality Strategy 2011-2020*. London, United Kingdom: Available at: http://www.heathrowairport.com/static/Heathrow/Downloads/PDF/air-quality-strategy_LHR.pdf.

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