Greener Aircraft Taxiing: Single-Engine Taxi-out Evaluations

Giuseppe Pillirone
Air France
Aviation Commitment to Environmental Sustainability

• Aviation’s contribution to man-made greenhouse gas emissions is 2 - 3%
• The Aviation Industry is aware of its environmental impact, and is committed to reducing it further in its mission to "bring people and cargo all over the world" ...
• Airlines continue to invest into more efficient aircraft, more efficient operations, and the development of sustainable aviation fuels
  • Key figures for AF-KLM Group (Source: AF-KLM Sustainability Report 2019)

  - 30% lower CO2 emissions per passenger/km compared to 2005
  - 22 new, quieter, more efficient aircraft added to the fleet
  - 32% less CO2 emissions by ground operations compared to 2018
  - 43% noise reduction per movement compared to 2000
  - 31% less non-recycled waste compared to 2011

• Focusing on Flight Operations
  • Fuel-efficient procedures are constantly studied and applied in operations whenever possible: Flight plan precision, Speed adjustments and Optimized procedures, Landing configurations, and, on the ground, Taxiing with one engine off
Single-Engine Taxiing

- Aircraft taxiing operations are a significant source of energy consumption and emissions at airports.

- Moving on ground ("taxiing") is a short part of a flight, but in this phase jet engines are not at their optimal use.
  - Several measures can reduce fuel-burn during ground operations.
    - "wait on stand" thanks to A-CDM/TSAT, minimize usage of APU, optimum taxi speed, ...

- One improvement is to taxi with one (or several) engine shut down, since "n–1" engines provide enough power to move the aircraft on the ground.

- Terminology
  - "Single" engine-off (one-of-two, one- or two-of-four, etc.) vs "All" engines-off (towing)
  - Distinguish Taxi-out (at departure) and Taxi-in (at arrival)
Impact? Possible Gains?

• Estimates on the exact impact of taxiing are variable
  • no direct systematic measurement available yet from AFR

• Orders of magnitude given in the literature:
  • "Taxiing accounts for 10 to 30% of total flight time in Europe"
    • taxi times vary by airport, but certainly exceed engine warmup/cooldown times
  • "Taxiing uses 10~13 kg fuel per minute for A320 family"
  • Single-engine taxiing has the potential to...
    • "reduce fuel burn and carbon dioxide emissions by 20% to 40%"
    • "reduce emissions of nitrogen oxides by 10% to 30%"

• Nevertheless: on the many flights operated every day, multiplying small quantities by many occurrences, will bring benefit

<table>
<thead>
<tr>
<th>a/c type</th>
<th>saved fuel kg/min</th>
<th>typical cooldown time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A320</td>
<td>5</td>
<td>180</td>
</tr>
<tr>
<td>B737</td>
<td>5</td>
<td>180</td>
</tr>
<tr>
<td>E190</td>
<td>4</td>
<td>120</td>
</tr>
<tr>
<td>A330</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>AT70</td>
<td>2</td>
<td>120</td>
</tr>
<tr>
<td>B777</td>
<td>13</td>
<td>180</td>
</tr>
</tbody>
</table>

potential fuel saving per a/c type when taxiing with one engine off

UNLESS the engine is cold (2hrs stop)
Observed Taxi Times

- **Taxi-OUT tends to be longer than Taxi-IN**
- **Both are quite variable**

**CODA Taxi-IN Times - Winter 2018**

- Most medians around 5 minutes

**CODA Taxi-OUT Times - Winter 2018**

- Most medians above 10 minutes
- 80% of the values spread over ~13 min

**Source:**
Eurocontrol CODA Database
Extraction of ~50 European airports

**NB:**
The two lists contain the same airports, but are sorted differently (by growing Median)
Less simple than it may appear

- Single-engine taxiing requires many points of attention
  - Need to respect engine warmup and cooldown timing (plus fire hazard at departure)
  - Need to respect max parameters of the running engine
  - Changes manoeuvrability and balance of the a/c
  - Not possible for certain taxiways (turns, slope, cross active rwy, ...)
  - Simply forbidden at certain airports
  - Not possible depending on rain / wind / visibility ...
  - Not straightforward on certain a/c (power syst. architecture)
  - Workload for single-engine taxi-out at departure is higher than for taxi-in at arrival, because of the engine start procedure

- Widely used on Arrivals
  - (estimated at ~50%, which is probably most of the "allowed" circumstances)

- ...quite infrequent on Departures
  - (estimated at less than 10% of all departures – not a recommended procedure in most airlines)
Challenges of Single-Engine Taxi-Out

- "Can we encourage our pilots to perform Single-engine Taxi-OUT more often?"

- Uncertainty about the "available minutes" to taxi-out discourages pilots to apply S.E. Taxi-out
  - Operational Flight Plans give "statistical" taxi times, that do not reflect the real conditions
    - Exact taxiways path, congestion of the platform, Runway pressure, ...
    - An accurate reliable indication of the time until takeoff would give confidence in the decision making, and allow to start the second engine not too late, not too early
  - \( \rightarrow \) "How can we provide accurate departure info to the cockpit ..."

- This information exists on ground side (eg. DMAN, or A-CDM...)
- "Information sharing" should be commodity nowadays (ground-ground and ground-aircraft)
- A reliable way to estimate this (TTOT? EXOT?) needs to be discussed with ATM and ACDM-communities
  - Tower ATCOs may need to perform final sequence optimization, eg. based on wake turbulence
  - A-CDM implementation is not generalized, and practices are not identical on different platforms
  - \( \rightarrow \) Absolute accuracy is not a prerequisite, a minimum available time must be known

- Best Ground-Aircraft communication: Voice? Acars? Gatelink? EFB? Display at the gate? ground staff? ...
Conclusion

• Every measure to reduce environmental impact is good to take

• Single-engine Taxiing can bring a reduction of fuel-burn and emissions at the airport
  • but Safety comes first!

• Taxi-OUT appears to have some unexploited potential
  • but it also has specific challenges

• Additional work can be done by Airlines, ATM, Airports, to explore the conditions to encourage wider usage of this technique in standard operations