Environmental effects of city airports on urban areas: management of airport ground operations to reduce carbon emissions

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Outline

- Aviation and climate change - Motivation of this work
- The LTO cycle
- Measures
- Methodology
- Objective
- Case study
- Results
- Conclusions
Air Transport Impacts

A brief history of fuel burn and emissions reduction...

A continuous fuel burn and CO₂ reduction since early 50s:
-80% since the jet age
(source: Airbus, modified by authors)
Motivation

- For the next 20 years, 4.5% global annual air traffic growth;
- European passengers are forecast to grow 3.7% per year between 2015 and 2035

(Source: Airbus, Global Market Forecast 2016-2035)
Aviation and Climate Change

Percentage of anthropogenic CO$_2$ emissions

- Aviation: 2%
- Other Sources: 85%
- Other Transportation Sources: 13%

5% of this 2% is attributable to airports (i.e. 0.1% of total emissions)

Source: IPCC, “Aviation and the Global Atmosphere”
Aviation goes greener: IATA Carbon Offset and Reduction Scheme for International Aviation
(source: www.iata.org)

1. Improve fleet fuel efficient by 1.5% per year from now until 2020
2. Cap net emissions from 2020 through carbon neutral growth
3. By 2050, net aviation carbon emissions will be half what they were in 2005.
“ACI EUROPE and its members commit to reduce carbon emissions from airport operations fully within their own control with the ultimate target to become carbon neutral.”

Source: ACI Europe

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The LTO cycle

Taxi times increase at higher rates than demand, because of airport congestion

Reference LTO cycle (Source: European Aviation Safety Agency (EASA), 2017)
The LTO cycle: CO₂ emissions

- Aircraft contribute to local air pollution during the LTO cycle

<table>
<thead>
<tr>
<th>Source</th>
<th>(% CO₂ values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Induced vehicular traffic</td>
<td>(35 %)</td>
</tr>
<tr>
<td>2. Electric energy</td>
<td>(5 %)</td>
</tr>
<tr>
<td>3. Energy produced in airport from ng</td>
<td>(1 %)</td>
</tr>
<tr>
<td>4. Energy produced in airport from diesel</td>
<td>(1 %)</td>
</tr>
<tr>
<td>5. Aircraft LTO cycle</td>
<td>(57 %)</td>
</tr>
<tr>
<td>6. Handling ground equipment</td>
<td>(1 %)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>(100 %)</td>
</tr>
</tbody>
</table>

*computed as in Postorino and Mantecchini (2014), based on data provided by Bologna Airport, year 2016
Measures to reduce taxi emissions

- Operational
- Technological:
  - Alternative AGPS:
    - Internal AGPS (electrified taxi)
    - External AGPS (dispatch towing)

Conventional and alternative taxi-out procedures:

Source: WheelTug 2017
Source: TaxiBot 2013
TaxiBot is a semi-robotic towbarless tractor, specifically designed for dispatch towing. It is diesel fuelled and exists in two variants.

**TaxiBot specs**

<table>
<thead>
<tr>
<th>TaxiBot variant</th>
<th>NB</th>
<th>WB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitable aircraft</td>
<td>Airbus A320 family, Boeing 737, 757, McDonnel Douglas MD80, MD90</td>
<td>Airbus A330 to A380, Boeing 767, 777, 747, McDonnel Douglas MD11</td>
</tr>
<tr>
<td>Diesel engine</td>
<td>2x294 kW (2x394 HP) SCANIA DC9 engines V5</td>
<td>2x566 kW (2x760 HP) SCANIA DC16 engines V8</td>
</tr>
<tr>
<td>Average fuel consumption</td>
<td>6 gallons/hour (22.7 l/h)</td>
<td>22 gallons/hour (83.3 l/h)</td>
</tr>
</tbody>
</table>
Objective

- Identify and assess the benefits resulting from the introduction of an alternative taxi-out procedure at large regional airport.

Actual taxi times estimation

Emissions and fuel consumption reduction
Case study: Bologna Airport

- Annual traffic (FY 2016)
  - Almost 70,000 movements
  - More than 7.6 million pax

- RWY 12/30
  - Up to 24 movements/hour (rwy 12 - ILS cat III)
  - RWY 30 only for ILS CAT I operations

- 3 aprons
- 34 aircraft stands
- 10 taxiways

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Current taxi-out scenario and Taxibot scenario

«Traditional» taxi-out

- Push-back
- Taxi-out with engines on
- Warm-up
- APU
- Detachment

To be compared with the standard taxi scenario

«Alternative» taxi-out

Detachment point

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Evaluation of taxi time

\[ T_A = \sum_{i=1}^{n} (T_{Hi} + T_{Ai} + T_W) \cdot N_{Ai} \]

For each apron «i»

- \( N_{Ai} \) is the number of movements;
- \( T_{Hi} \) is the tug operating time for each taxi-out operation;
- \( T_{Ai} \) is the taxiing-out time, i.e. the time the aircraft needs to self-taxi onto the runway head;
- \( T_W \) is the warm-up time for each aircraft movement.

<table>
<thead>
<tr>
<th>Apron</th>
<th>( N^* ) take-off (*)</th>
<th>Conventional taxi-out time for each movement (min)</th>
<th>Alternative taxi-out time for each movement (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13,954</td>
<td>9.68</td>
<td>2,297</td>
</tr>
<tr>
<td>2</td>
<td>6,244</td>
<td>9.1</td>
<td>863</td>
</tr>
<tr>
<td>3</td>
<td>1,059</td>
<td>8.2</td>
<td>116</td>
</tr>
<tr>
<td>Total</td>
<td>21,257</td>
<td>3,343 (hours)</td>
<td>3,278 (hours)</td>
</tr>
</tbody>
</table>

(*) Reference year 2016

Taxi times are almost the same
CO₂ emission comparison

\[ E = \sum_{i=1}^{n} (T_{Ai}+T_W) \cdot N_{Ai} \cdot f \cdot e + \sum_{i=1}^{n} T_{Hi} \cdot N_{Ai} \cdot f' \cdot e' = E_A + E_{HV} \]

For each apron «i»

- \( e, e' \) are emission factors (measured in amount of CO₂ per liter of fuel burnt);
- \( f, f' \) are specific consumption factors (measured in liter/t, t being the reference time unit), to compute the fuel burnt respectively by aircraft and tug vehicles during taxi-out;
- \( E_A \) and \( E_{HV} \) are the expected emissions due respectively to the aircraft and to the tug vehicle.

<table>
<thead>
<tr>
<th>CO₂ Tons (Annual) *</th>
<th>Conventional taxi-out</th>
<th>Alternative taxi-out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft-related taxi-out</td>
<td>13,652</td>
<td>4,340</td>
</tr>
<tr>
<td>Tug-related taxi-out</td>
<td>88</td>
<td>228</td>
</tr>
</tbody>
</table>

| Fuel consumption (litres)** | | |
|-----------------------------| | |
| Aircraft-related taxi-out   | 4,320,349             | 1,373,312           |
| Tug-related taxi-out        | 29,388                | 85,572              |

*Average emission factors: \( e = 3.16 \) kg CO₂/l; \( e' = 2.67 \) kg CO₂/l

**Average consumption factors: \( f = 540 \) l/h; \( f' = 22.7 \) l/h
Results and discussion

- 67% \( \text{CO}_2 \) saved in taxi-out
- Almost 3,000,000 liters of jet fuel saved

Overall effects on airport carbon footprint

Financial benefits for airlines

<table>
<thead>
<tr>
<th>Airline</th>
<th>Fuel Saved</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR FRANCE</td>
<td>88,000 kg</td>
<td>$88,000</td>
</tr>
<tr>
<td>BRITISH AIRWAYS</td>
<td>46,000 kg</td>
<td>$46,000</td>
</tr>
<tr>
<td>LUFTHANSA</td>
<td>77,500 kg</td>
<td>$77,500</td>
</tr>
<tr>
<td>RYANAIR</td>
<td>310,500 kg</td>
<td>$310,500</td>
</tr>
<tr>
<td>KLM ROYAL DUTCH AIRLINES</td>
<td>46,000 kg</td>
<td>$46,000</td>
</tr>
<tr>
<td>ALITALIA</td>
<td>80,000 kg</td>
<td>$80,000</td>
</tr>
<tr>
<td>AUSTRIAN AIRLINES</td>
<td>50,000 kg</td>
<td>$50,000</td>
</tr>
</tbody>
</table>

Estimation on 2016 traffic data - only fuel saved at current market price
Conclusions

Motivation of the study
- Aviation fuel burnt and related emissions are expected to grow at high rate if not properly managed
- Aircraft engine emissions are the main source of pollutants at airports during LTO cycle

Objective of the study
- Assess the potential benefits from an alternative taxi procedure
- The introduction of a new taxi procedure can gradually lead to
  - Environmental benefits for airports
  - Financial benefits for airlines

Further research
- Micro-simulation of aircraft taxi-out to test effect of congestion under heavy traffic
- Cost benefit analysis to evaluate financial sustainability of proposed solution
Thank you! Questions?

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