# Impact of Airport Capacity Expansion on $CO_2$ Emission: The Case of Hong Kong International Airport

## Summary of Findings
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Dr. Andrew Yuen
Associate Director
Aviation Policy and Research Centre

# Impact of airport capacity expansion on $CO_2$ emission: The case of Hong Kong International Airport

Andrew Yuen,
The Chinese University of Hong Kong

Janina Scheelhaase and Martin Schaefer
German Aerospace Center (DLR)

*(The results are preliminary)*

# Outline

1. Motivation and Objectives
2. Background
3. Methodology and Results
4. Other Issues – flight diversion
5. Quantifying the Carbon Costs

# 1. Motivation and objectives

- *Due to the increasing demand in air traffic, lots of airports considered capacity expansion*
- *Those expansion plans usually involves huge government investment*
- *The construction and the operation of the new capacities may have significant impacts to the surroundings*

# 1. Motivation and objectives

- *Cost-Benefit Analysis*

*Benefits of airport expansion*

- *Passengers' travel benefits*
- *Airport and airline*
- *Other related industries, such as tourism and logistics*

*Costs of airport expansion*

- *Infrastructure costs*
- *Environmental costs*

# 1. Motivation and objectives

Cost and Benefit analysis for New Runway in London Heathrow Airport

| | |
|---|---|
| Benefit to users (passengers and airlines) | £2.3 billion |
| Benefit to producers (airport operator) | £4.0 billion |
| Benefit to government (revenue from air passenger duty and putative carbon levy) | £5.2 billion |
| Carbon cost | £6.2 billion |
| Community costs (noise, blight, congestion, air pollution) | £2.5 billion |
| Infrastructure costs | £7.8 billion |
| NET COST | £5.0 billion |

Source: A New Approach to Evaluating Runway 3, New Economics Foundation, 2010

# 1. Motivation and objectives

Aviation and climate change

- 3% of the total man-made contribution (IPCC, 2007)

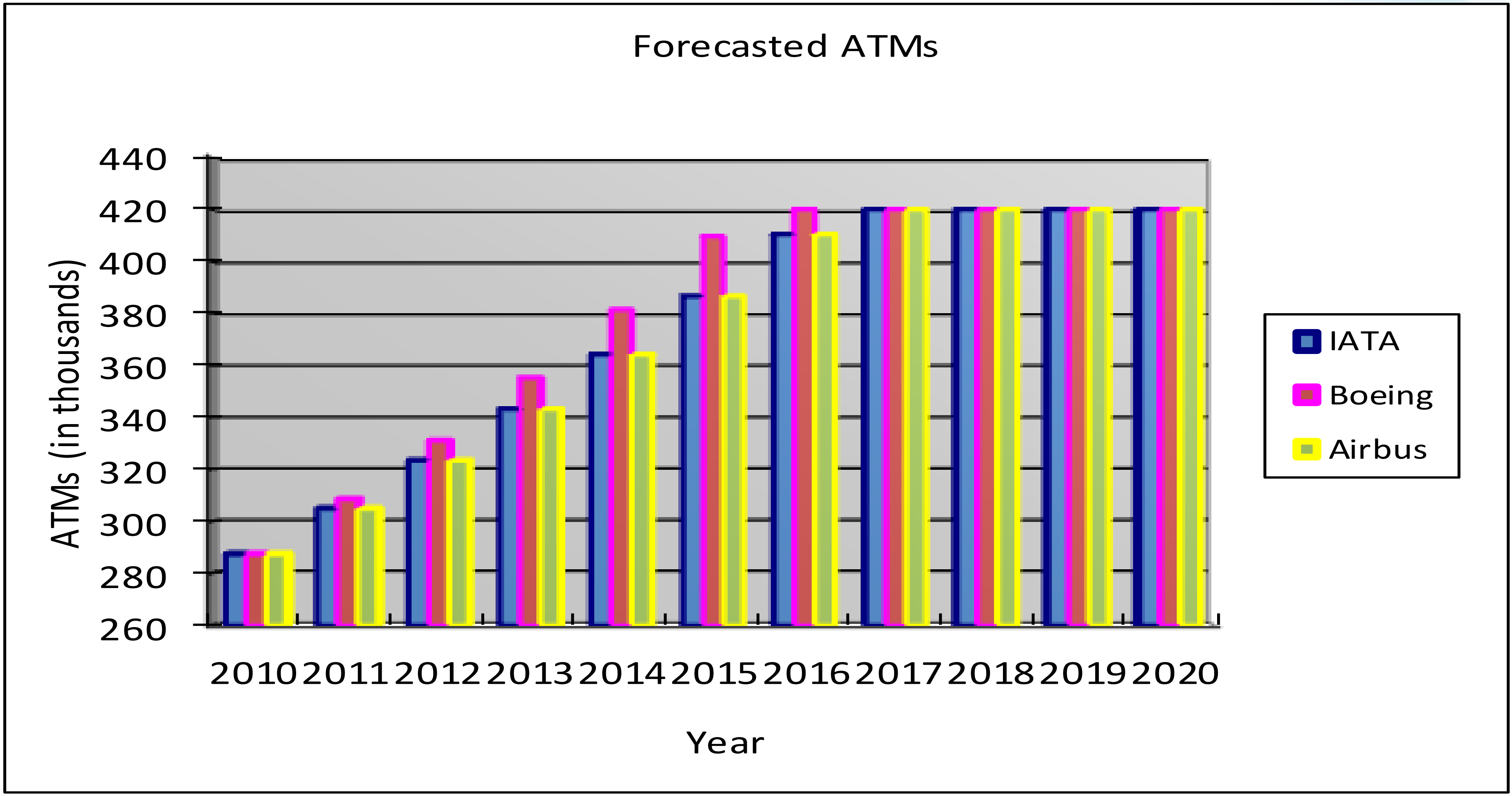
- Rapid Growth
  - $CO_2$ increased by a factor of about 1.5 from 1990-2000
  - projected continue to grow by around 3-4% annually

# 1. Motivation and objectives

- *To provide a scientific methodology to estimate the $CO_2$ emissions due to airport expansion*
- *To understand issues in estimating $CO_2$ emissions related to capacity expansion*
- *To use HK airport expansion as a case to illustrate the related issues in estimation*

# 2. Background

Capacity constraint (ATM:420,000) at the Hong Kong Airport



# 2. Background

- In June 2011, the Airport Authority of Hong Kong (AAHK) has held a public consultation for its *Hong Kong International Airport (HKIA) Master Plan 2030*.

- Option 1: Two-Runway System
  - practical maximum annual (air traffic movement) ATMs is 420,000
  - The maximum capacity is expected to be reached in 2017

- Option 2: Three-Runway System
  - practical maximum annual ATMs would be 620,000
  - The maximum capacity is expected to be met by 2030

# 2. Background

- During the consultation (June–Sep 2011), a lot of public arguments on environmental issues were raised and could not reach a consensus

- Environmental groups and politicians complained that HKIA  failed to provide a full information of the environment impacts

# 2. Background

- Hong Kong Environmental Impact Assessment (EIA)
  - Complained by NGOs that the requirements are not fulfilled the international standards
  - Mainly concerned about local impacts; thus $CO_2$ is not included in the assessment

# 3. Methodology

- To calculate $CO_2$ emissions by all flights to/from HKIA under cases with and without 3rd runway

| Case I | Case II |
|---|---|
| Two runway | Third runway |

# 3. Methodology

- Limitations
  - Passenger flights are only considered in the study (the total can be calculated by assuming fixed ratio between passenger and cargo flights)
  - Each airline’s market share will keep constant in the study period
  - The effects of other emission control measures is not taken into account, like EU ETS.

# 3. Methodology

Project flight schedule between 2010-2030

↓

Fleet forecast between 2011-2030

↓

Fuel consumption between 2010-2030

↓

CO2 emissions between 2010-2030

# Flight Movements Forecast 2010-2030

- Obtain the flight plan in 2010, which includes all OD markets from/ to HKIA
- Have forecasted growth rates in each region from 2011 – 2030
- Forecast the flight movement for each OD markets from 2011-2030
- Take into account the capacity constraint for 1st case

# Data Sources

## 1. Flight schedule in 2010

- OAG (O-D pair information; Cargo and Passenger; Frequency; aircraft type)

| | | | | | | |
|---|---|---|---|---|---|---|
| Bangkok (Intl) Thailand | HKG | Hong Kong(Intl) China | CX | Cathay Pacific Airways | 744 | BOEING 747-400 |
| Bangkok (Intl) Thailand | HKG | Hong Kong(Intl) China | CX | Cathay Pacific Airways | 330 | AIRBUS INDUSTRIE A330 |
| Bangkok (Intl) Thailand | HKG | Hong Kong(Intl) China | CX | Cathay Pacific Airways | 777 | BOEING 777 |
| Bangkok (Intl) Thailand | HKG | Hong Kong(Intl) China | CX | Cathay Pacific Airways | 773 | BOEING 777-300 |
| Bangkok (Intl) Thailand | HKG | Hong Kong(Intl) China | CX | Cathay Pacific Airways | 343 | AIRBUS INDUSTRIE A340-300 |
| Bangkok (Intl) Thailand | HKG | Hong Kong(Intl) China | EK | Emirates Airlines | 773 | BOEING 777-300 |

## 2. Forecasted growth rate

- IATA, Boeing and Airbus (Regional growth rates)

# Fleet Forecast 2010 - 2030

Approach for Simplified Fleet Forecast (DLR):

- Based on typical aircraft lifetimes (retirement curves) and assumptions on aircraft production periods.

- Aircraft types are changed iteratively by a software module such that target market shares of aircraft types are reached.

# Calculation of Fuel Burn and $CO_2$ Emissions

DLR VarMission Aircraft Performance Software

Approach for Emissions Calculation:

- Bottom-Up Approach: Simulation of each individual flight for the purpose of emissions estimation.

- Aircraft Models:
  - Current aircraft types from EUROCONTROL BADA v3.9
  - Aircraft of the near future: Models and assumptions from Schaefer (2012)

1kg fuel consumption = 3.155kg CO2 emission

# 3. Results – Fuel consumption

Comparison between BAU and 3rd runway cases in fuel consumption

| Year | Difference (tons) | %Difference |
|---|---|---|
| 2017 | 32,038 | 0.4% |
| 2018 | 235,900 | 3.1% |
| 2019 | 367,800 | 4.8% |
| 2020 | 516,922 | 6.8% |
| 2021 | 676,081 | 8.9% |
| 2022 | 770,172 | 10.1% |
| 2023 | 875,520 | 11.5% |
| 2024 | 1,034,079 | 13.6% |
| 2025 | 1,191,909 | 15.7% |
| 2026 | 1,251,568 | 16.4% |
| 2027 | 1,352,755 | 17.8% |
| 2028 | 1,438,636 | 18.9% |
| 2029 | 1,537,876 | 20.2% |
| 2030 | 1,612,115 | 21.2% |

# 3. Results -$CO_2$ emission

Comparison between BAU and 3rd runway cases

| Year | Difference (tons) | %Difference |
|---|---|---|
| 2017 | 100,921 | 0.4% |
| 2018 | 743,086 | 3.1% |
| 2019 | 1,158,571 | 4.8% |
| 2020 | 1,628,304 | 6.8% |
| 2021 | 2,129,655 | 8.9% |
| 2022 | 2,426,041 | 10.1% |
| 2023 | 2,757,889 | 11.5% |
| 2024 | 3,257,349 | 13.6% |
| 2025 | 3,754,512 | 15.7% |
| 2026 | 3,942,440 | 16.4% |
| 2027 | 4,261,180 | 17.8% |
| 2028 | 4,531,705 | 18.9% |
| 2029 | 4,844,311 | 20.2% |
| 2030 | 5,078,163 | 21.2% |

# 4. Further Issues

1. Flight diversion
   - No capacity; flights diverted to other airports

2. Airlines' responses to limited capacity constraint
   - Increases the aircraft size

# 4. Issues -Flight diversion

# 4. Issues -Flight diversion

- Explore the impacts of flight diversion on the $\Delta$Emissions with and without 3rd runway
- Previously, we considered the extreme case with 0% flight diversion – the air traffic will disappear if no capacity.
- Three more cases to consider: 30%, 50% and 80%

# 4. Issues -Flight diversion

| | % Difference | | | |
|---|---|---|---|---|
| Year | 0% diverted | 30% diverted | 50% diverted | 80% diverted |
| 2017 | 0.4% | 0.3% | 0.2% | 0.1% |
| 2018 | 3.1% | 2.2% | 1.5% | 0.6% |
| 2019 | 4.8% | 3.4% | 2.4% | 1.0% |
| 2020 | 6.8% | 4.8% | 3.4% | 1.4% |
| 2021 | 8.9% | 6.2% | 4.4% | 1.8% |
| 2022 | 10.1% | 7.1% | 5.1% | 2.0% |
| 2023 | 11.5% | 8.1% | 5.8% | 2.3% |
| 2024 | 13.6% | 9.5% | 6.8% | 2.7% |
| 2025 | 15.7% | 11.0% | 7.8% | 3.1% |
| 2027 | 16.4% | 11.5% | 8.2% | 3.3% |
| 2028 | 17.8% | 12.4% | 8.9% | 3.6% |
| 2029 | 18.9% | 13.2% | 9.5% | 3.8% |
| 2030 | 20.2% | 14.1% | 10.1% | 4.0% |

If 30% flights diverted, $\Delta$Emissions with and without 3rd runway is 14.1%

# 5. Quantifying the emissions

- Monetarize the emission costs

| | Method | US $ |
|---|---|---|
| Australian | Carbon Tax | 22 |
| EU | Trading price | 10 |
| US EPA | Cost of Damage | 39 |
| Stern Review (2007) | Cost of Damage | 30 |
| CX Offset Prog | Abatement Cost | 3 |

# 5. Quantifying the emissions

- Additional annual $CO_2$ Costs due to third runway in 2030 and afterwards

| | US million$ |
|---|---|
| Australian | 111.7 |
| EU | 50.8 |
| US EPA | 198.0 |
| Stern Review (2007) | 152.3 |
| CX Offset Prog | 15.2 |

Thank you!