Modelling the Future Environmental Impact of Aviation

Antony D. Evans

Andreas Schäfer, Tom Reynolds, Steven Barrett, Lynnette Dray, Marcus Köhler, Helen Rogers, María Vera-Morales

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Outline

- Introduction to Aviation Integrated Modelling (AIM) project
- Overview of AIM capabilities
- Sample OR problem: Modelling airline response to constraints

Aviation Growth

- Steady growth of worldwide scheduled passenger air travel:
  - Average growth rate 1960 – 2005: over **8**% per year
  - Airbus and Boeing forecast to 2026: **5**% per year
  - Conservative estimates to 2050: **30-110**% x 2005 levels
  - More aggressive estimates to 2050: **10x** 2005 levels

- Aviation's contribution to anthropogenic CO_2 small, but increasing
  - Aviation contributes **~3**% of anthropogenic CO_2
  - Non-CO_2 effects potentially significant in aviation

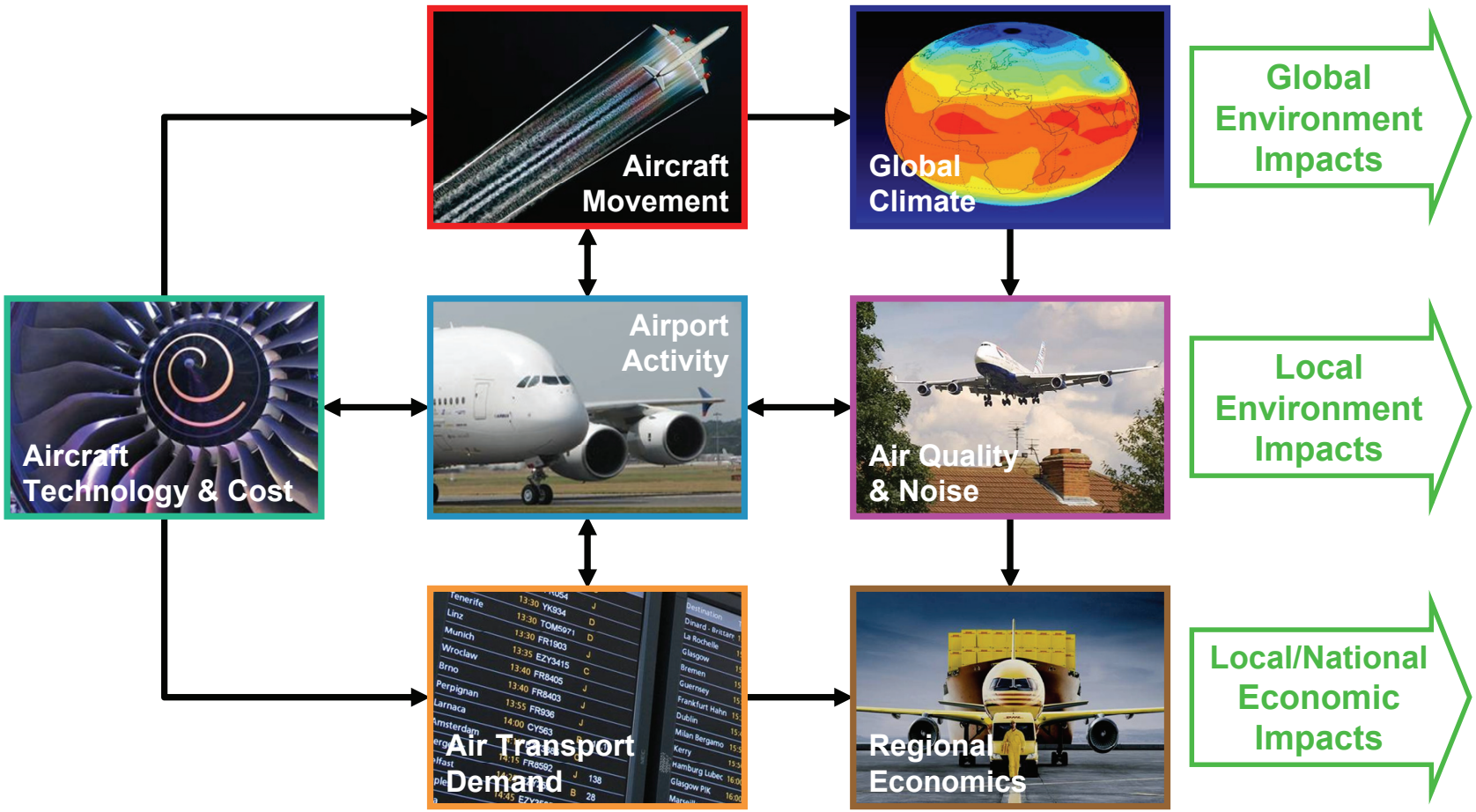
Aviation System-Wide Perspective

- Air transport system is large, complex and multi-disciplinary involving numerous stakeholders with different agendas
- Range of future trends
  - Developing regions (India, China,…)
  - Developing sectors (VLJ, SSBJ,…)
  - Developing technologies
- Increasing (and range of) environmental pressures
- Need for tools to analyse trade-offs & assist policymakers

Aviation Integrated Modelling
www.AIMproject.aero

Aviation Integrated Modelling Project

- **Goal:** Develop policy assessment tool for aviation, environment & economic interactions at local & global levels, now and into the future



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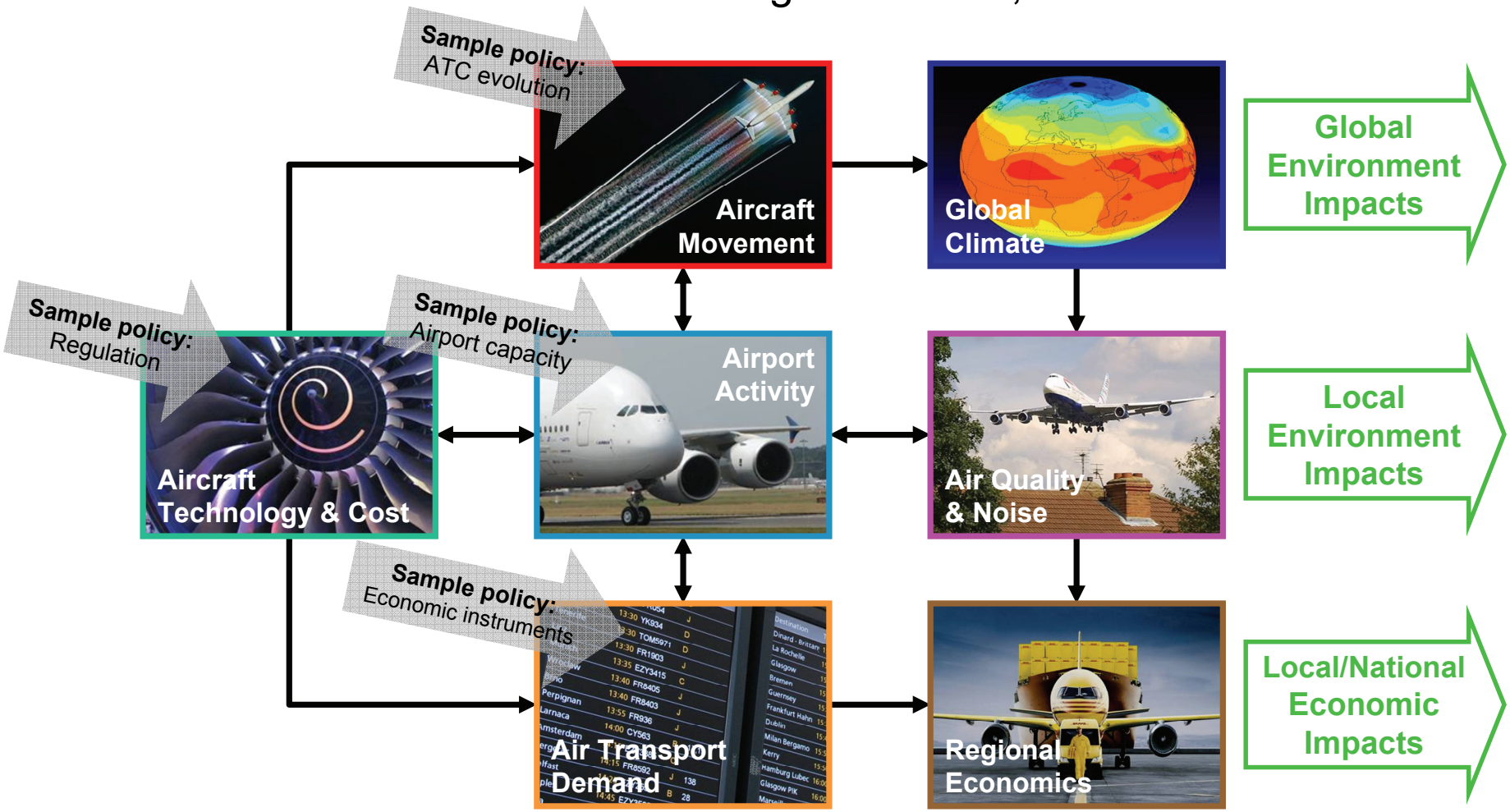
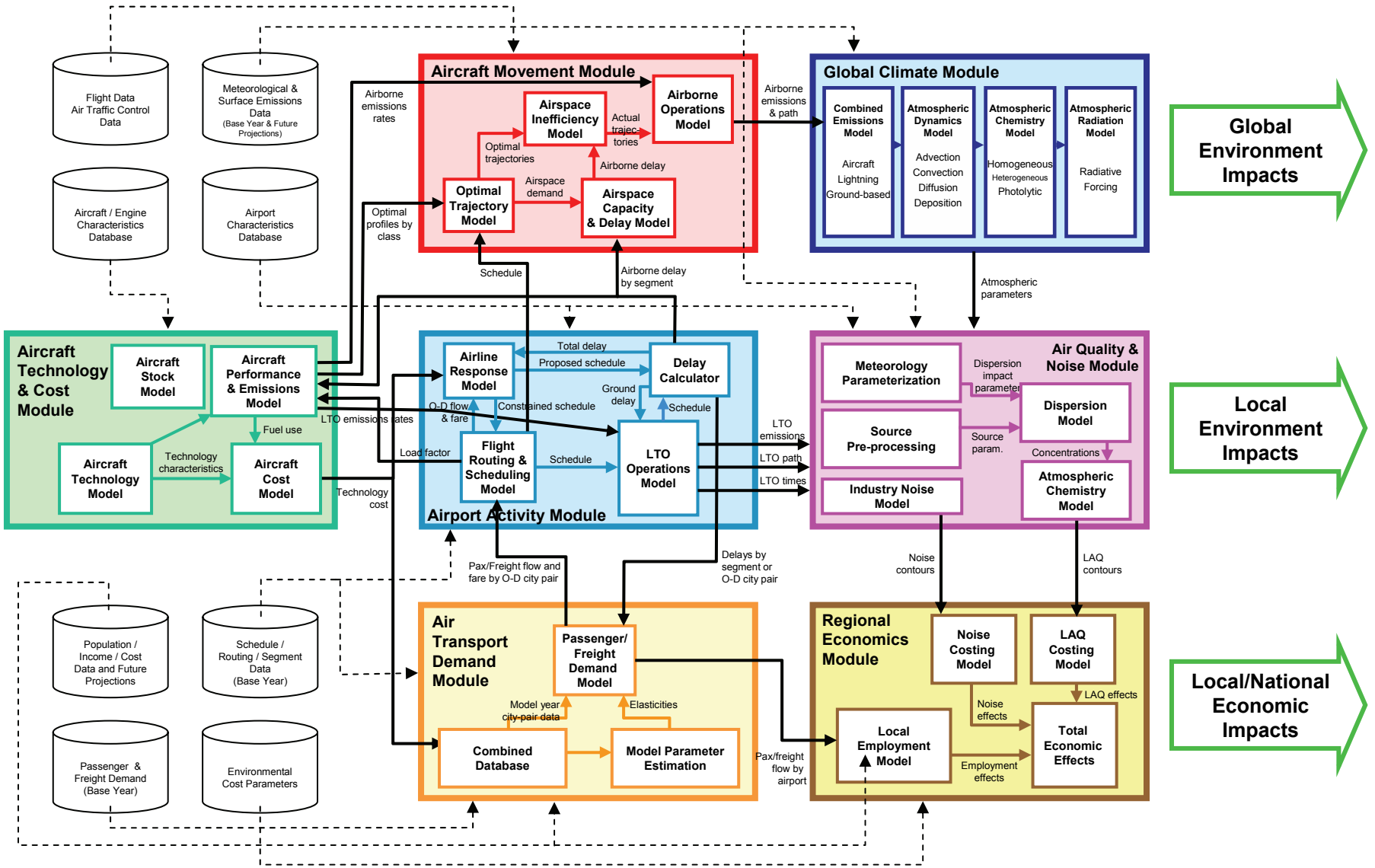


Detailed Architecture



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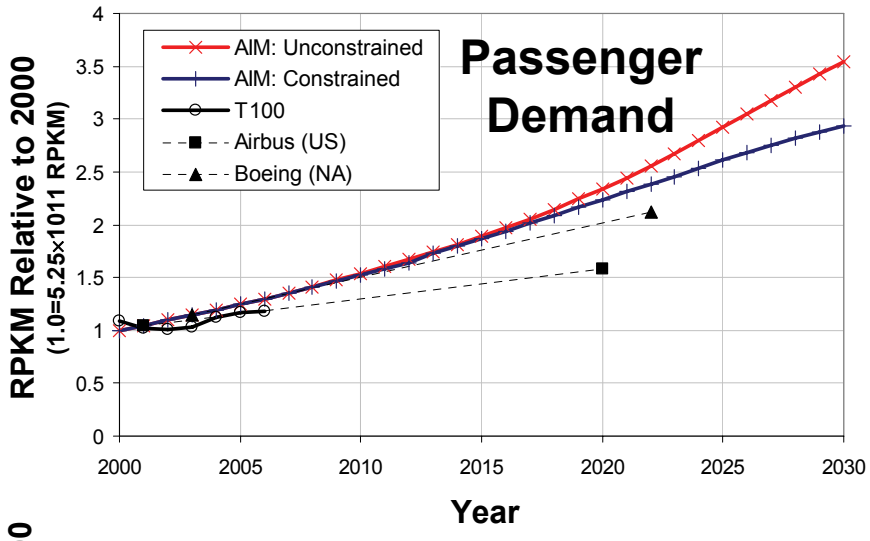
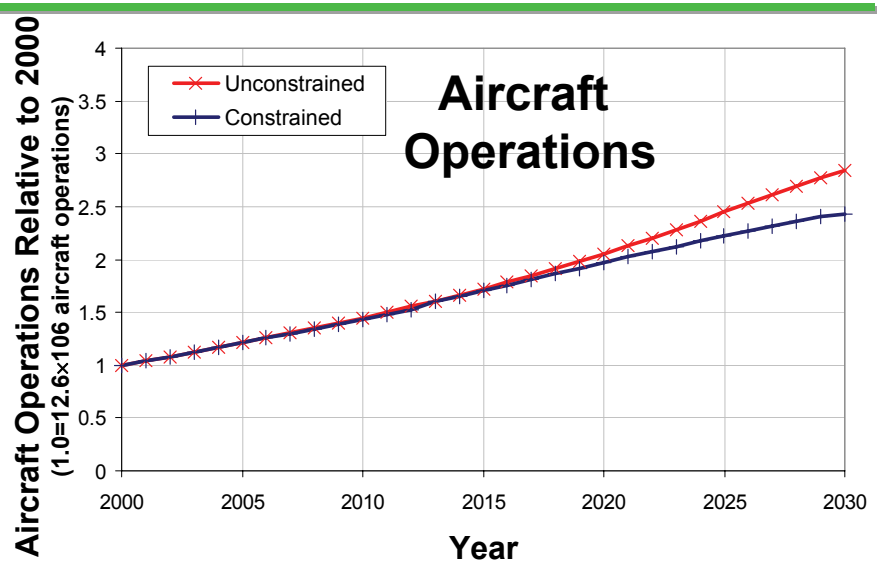
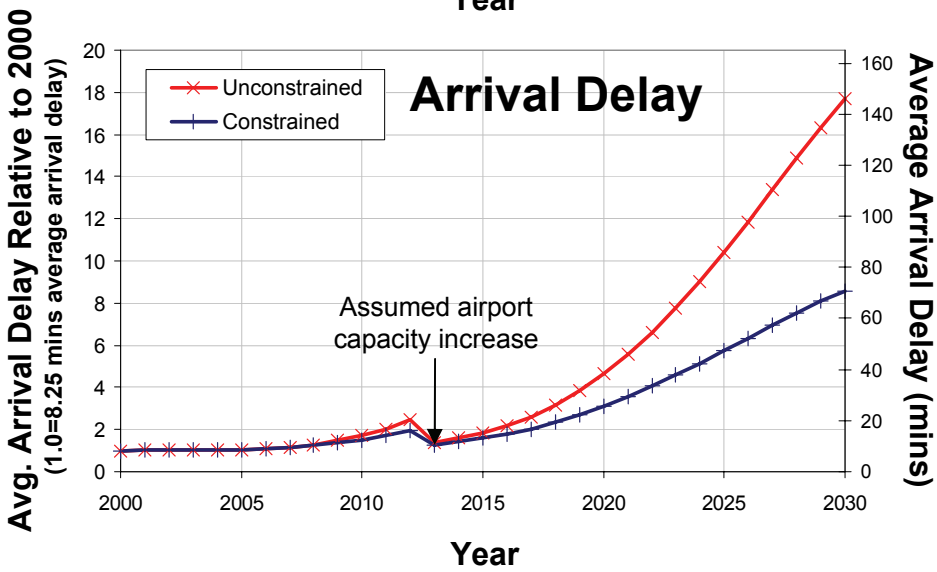
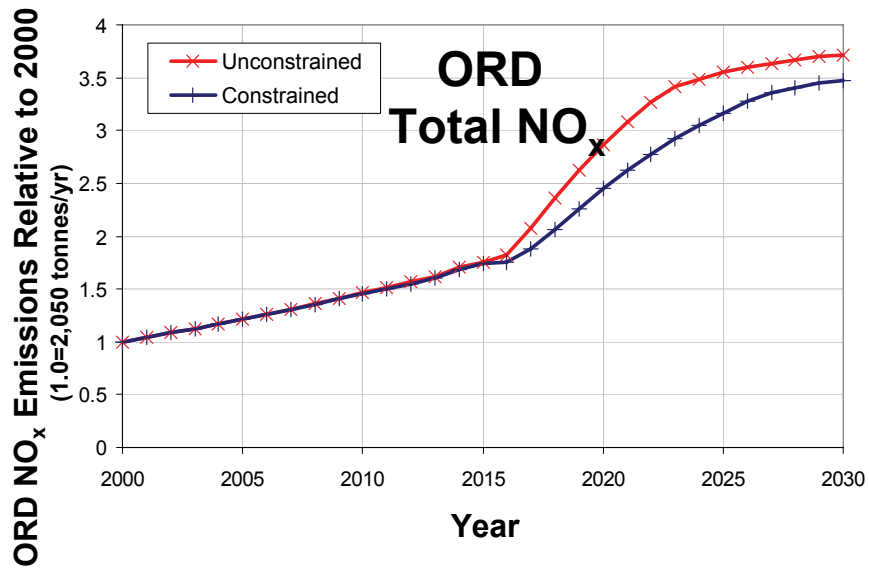
Overview of Capabilities: US Case Study

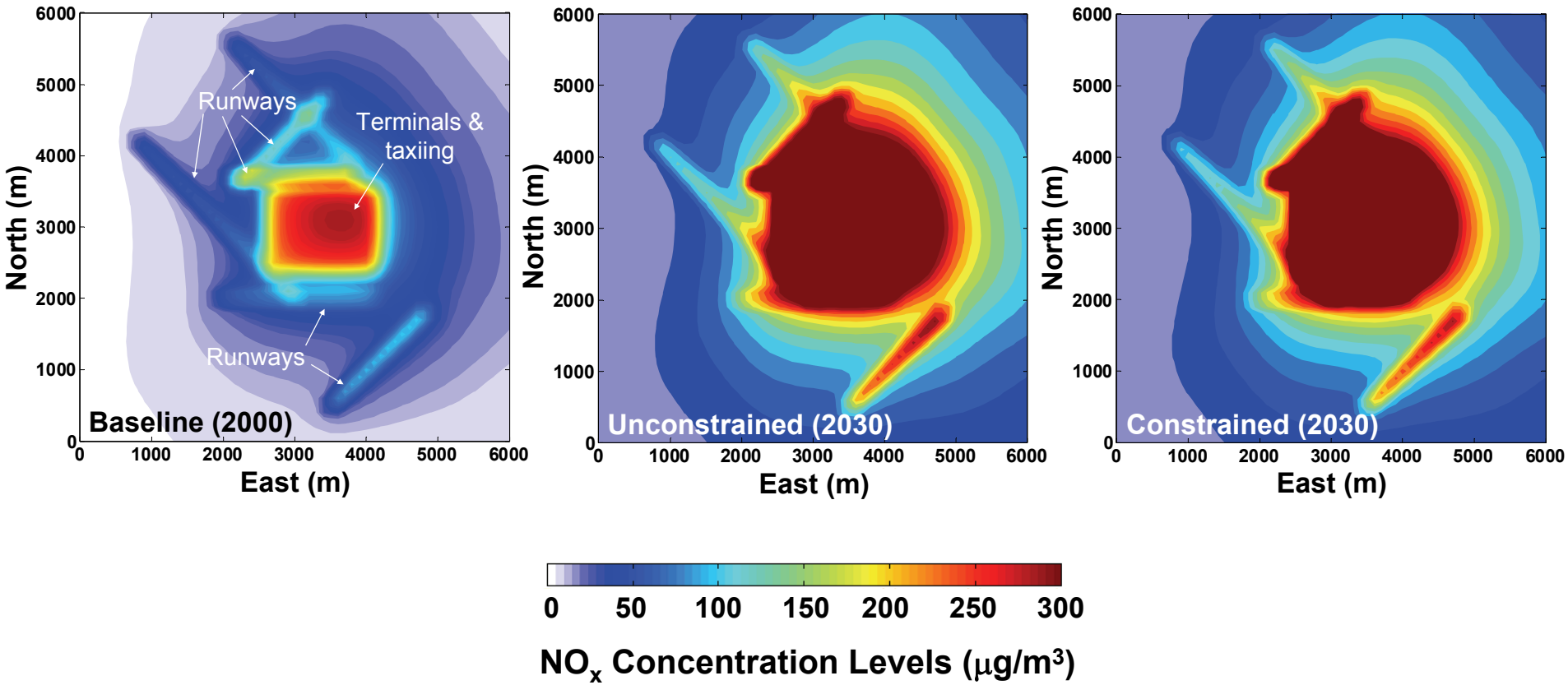




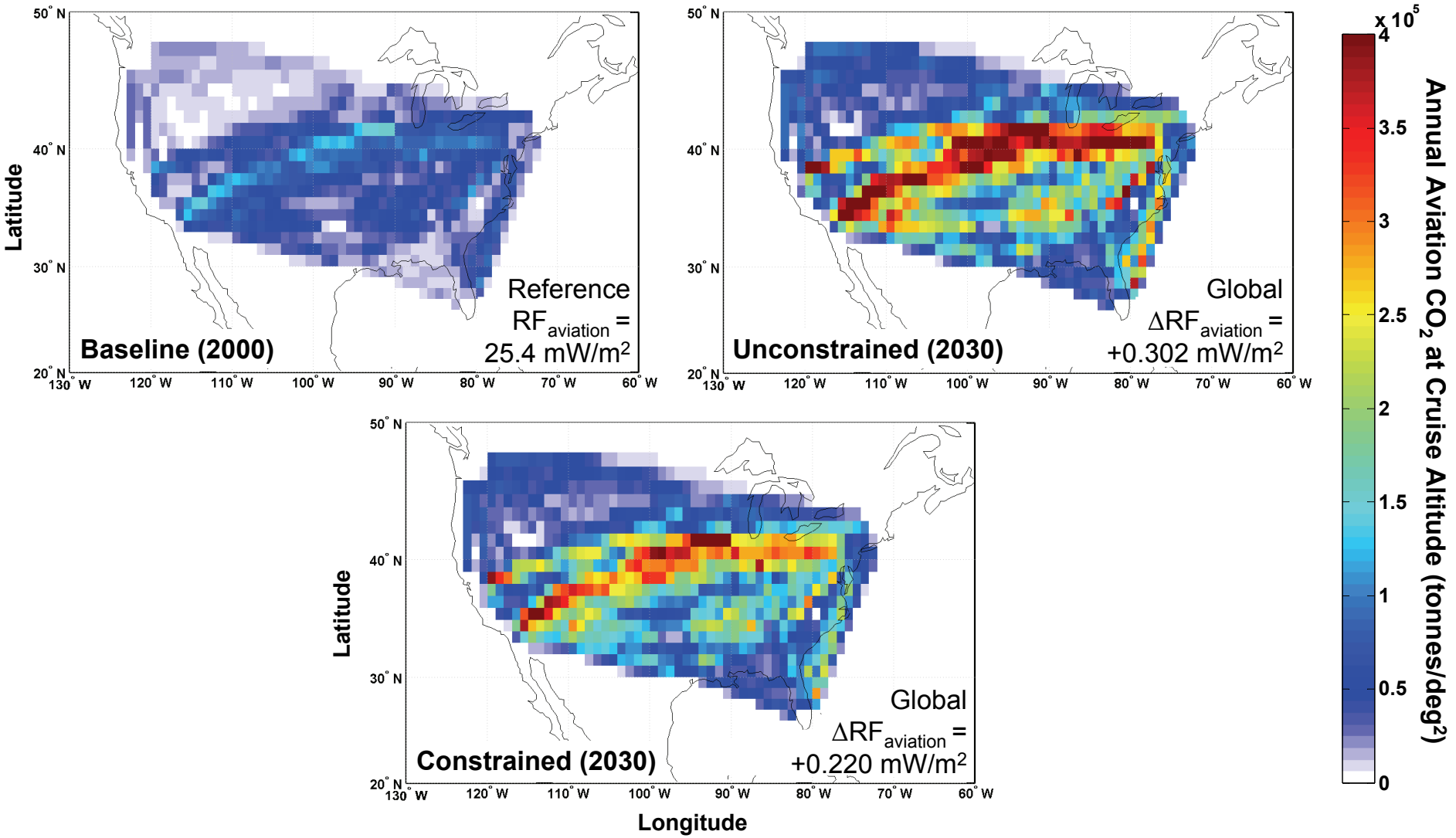




ORD Annual Average NO_x Results



En Route CO_2/Global RF Results



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  - Constraints may include: airport capacity, regulatory constraints (e.g. Noise limits), imposed costs (e.g. ETS)

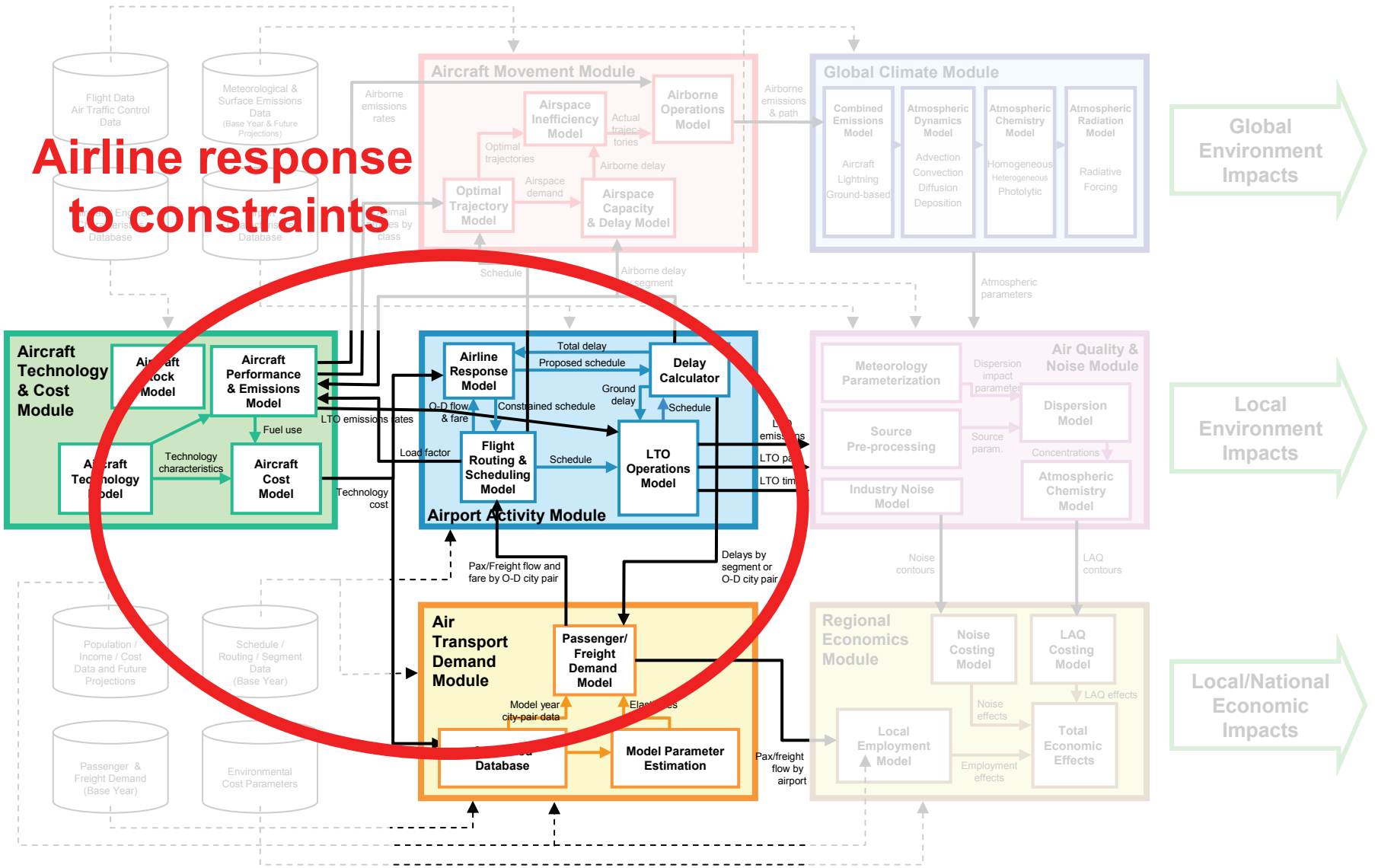
Modelling Airline Response to Constraints

- **Approach:** Maximize airline system profit while endogenously modeling impact of constraints (airport capacity)

$$\max\left(\sum_{i,j}\sum_{p\in Itin_{i,j}}\overline{Fare}_{i,j}\cdot Pax^{p}_{i,j}-\sum_{m,n,k}Cost_{f\,m,n,k}\cdot Fltfreq_{m,n,k}-\sum_{i,j}\sum_{p\in P_{i,j}}Cost_{p\,i,j}\cdot Pax^{p}_{i,j}\right)$$

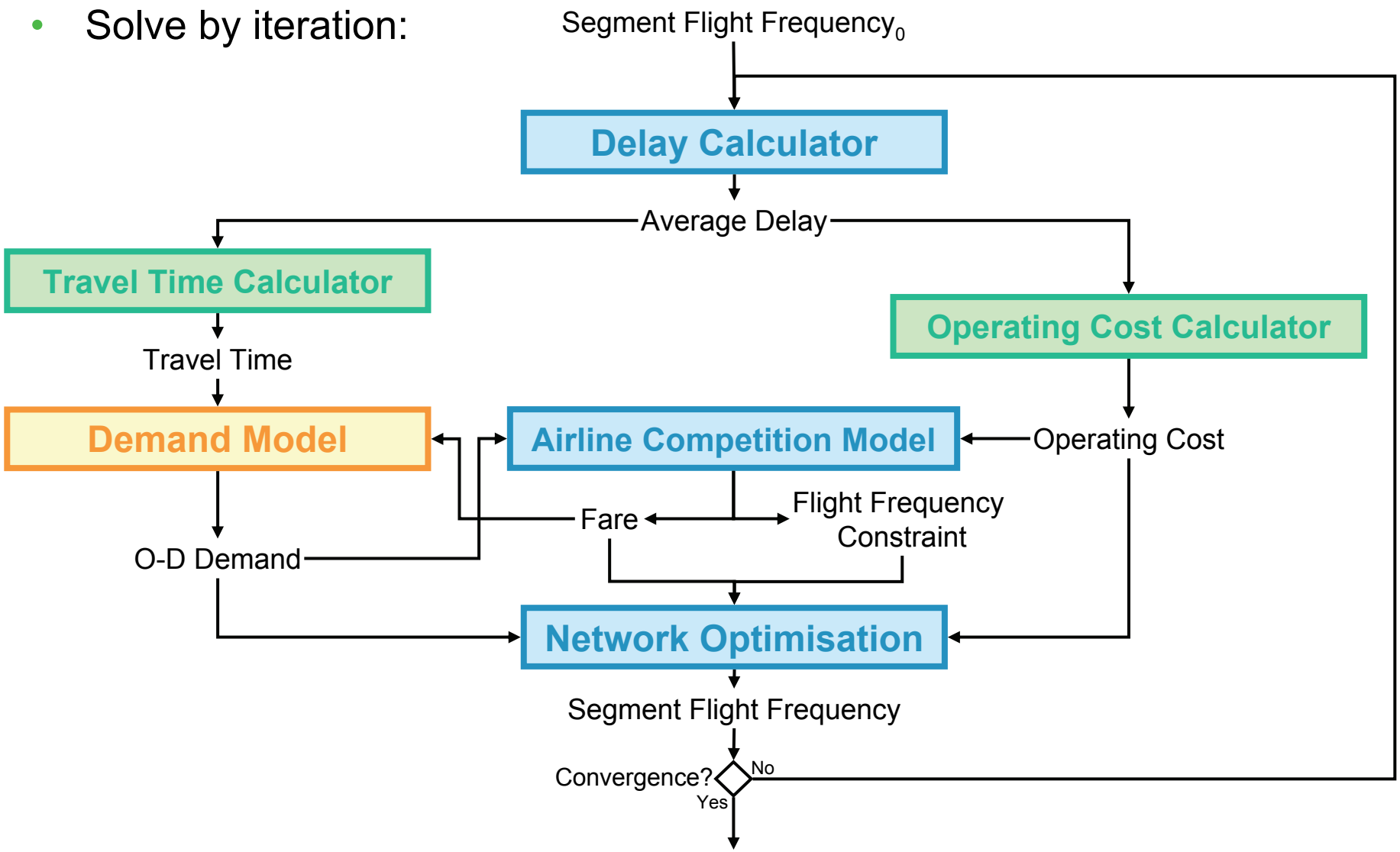
- Passenger demand (Pax) a function (among others) of delay (travel time) and fare ($Fare$) – modelled by a Demand Model
- Operating cost ($Cost_f$ & $Cost_p$) a function (among others) of delay – modeled by an Operating Cost Calculator
- Delay a function (among others) of airport capacity and flight frequency ($FltFreq$) – modeled by a Delay Calculator
- Fare ($Fare$) and flight frequency ($FltFreq$) constrained by competition – modeled by an Airline Competition Model

Detailed Architecture



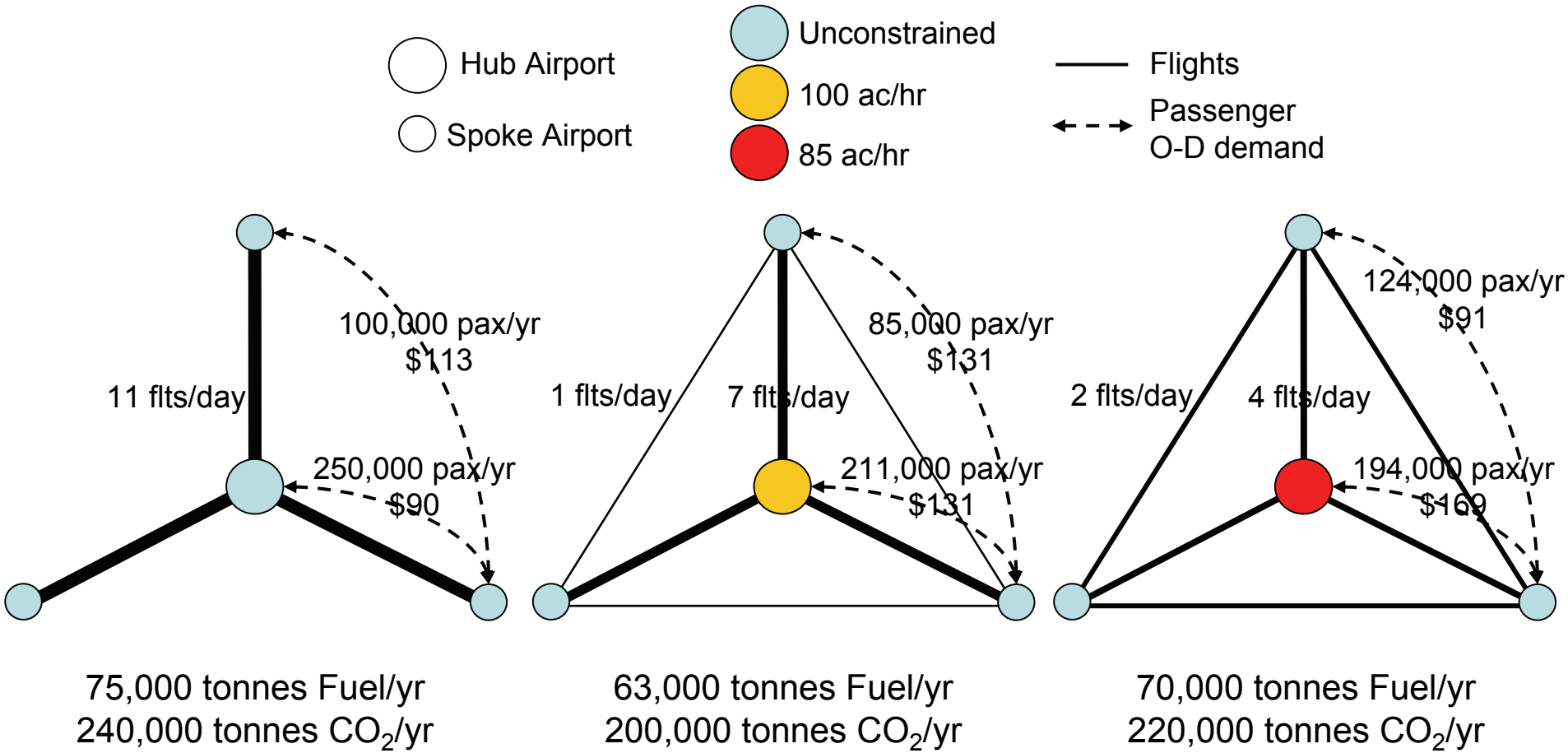
Passenger and Airline Response to Airport Capacity Constraints

- Solve by iteration:



Application to Theoretical Hub and Spoke Network

- Sample results for effects of delay on a simple hub and spoke network with **varying hub capacity constraints**

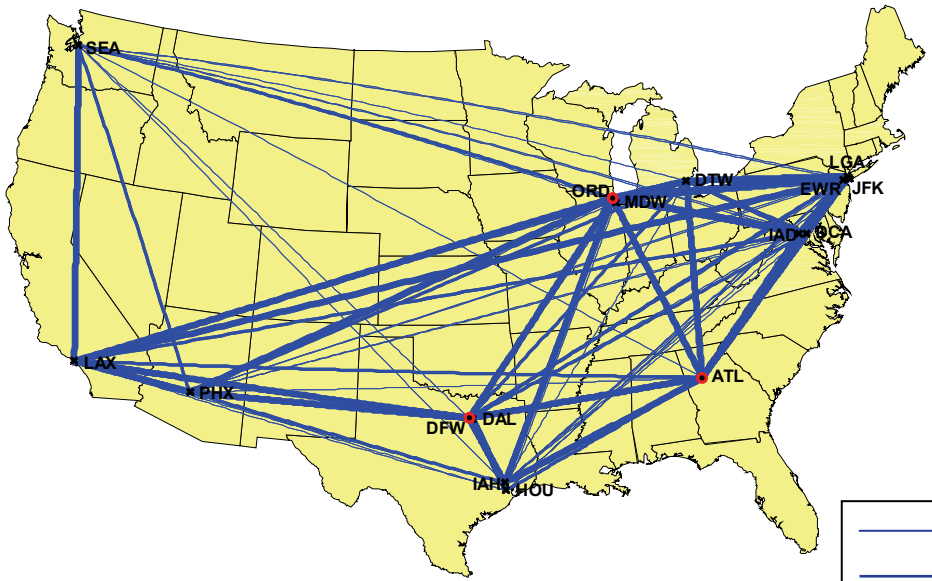


75,000 tonnes Fuel/yr
240,000 tonnes CO_2/yr

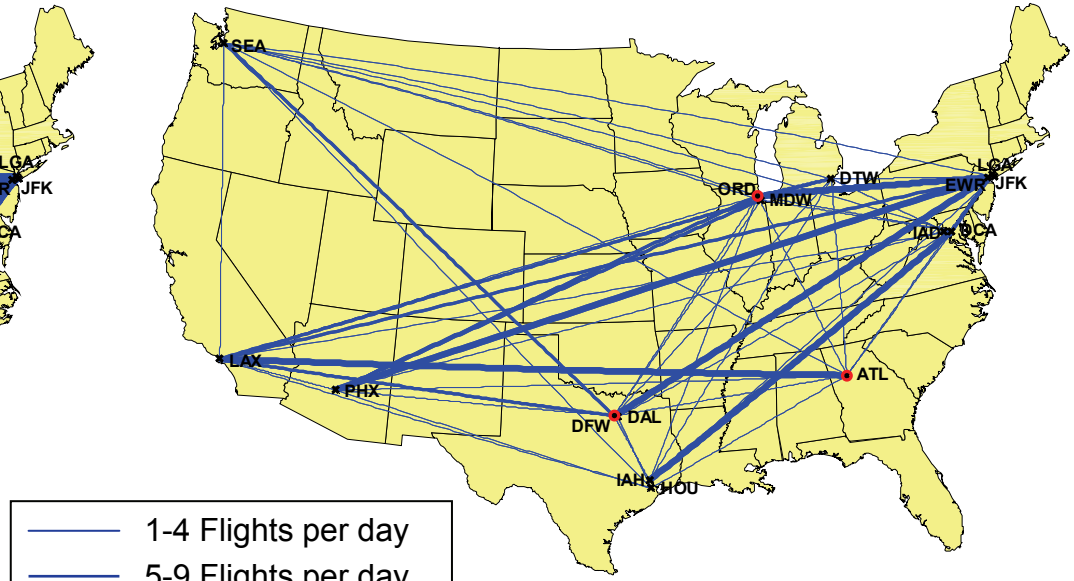
63,000 tonnes Fuel/yr
200,000 tonnes CO_2/yr

70,000 tonnes Fuel/yr
220,000 tonnes CO_2/yr

Application to Subset of US Airports



Actual Data
2005



Model Results
2005

1-4 Flights per day
5-9 Flights per day
10-14 Flights per day
>15 Flights per day

	Avg. % deviation by O-D market/segment
Flight Frequency	36% low
Fare	12% low
O-D pax demand	6% high

Summary

- AIM project developing a policy assessment tool for aviation, environment and economic effects
- Capabilities of AIM approach presented
- Breadth and depth of model presented
- Further enhancements planned
  - Improve modelling of airline response to constraints
- Further geographical expansion planned

Acknowledgements

- Funding bodies:

- AIM website: www.AIMproject.aero