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# **Overview of the Institute for Aviation and the Environment & Aviation Integrated Modelling Project**

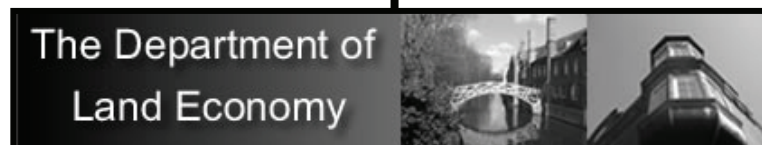
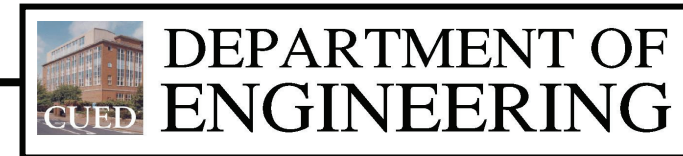
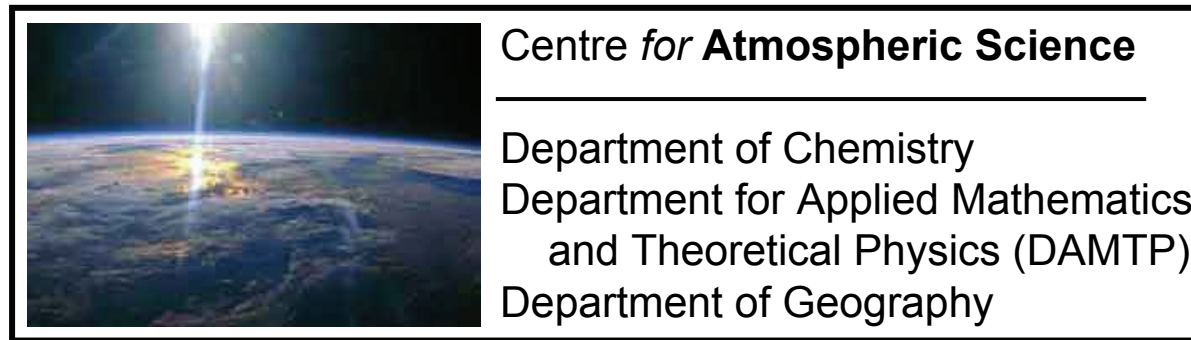
**Tom G. Reynolds**

Presentation to the PARTNER Advisory Board Meeting  
Transport Canada, Ottawa, 25-26 March 2008

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# Background

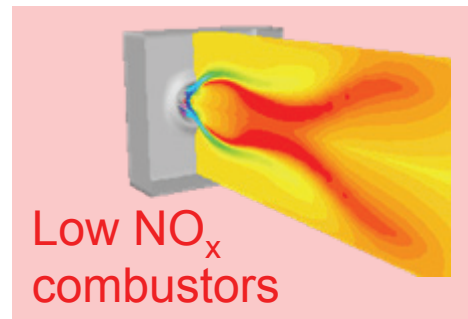
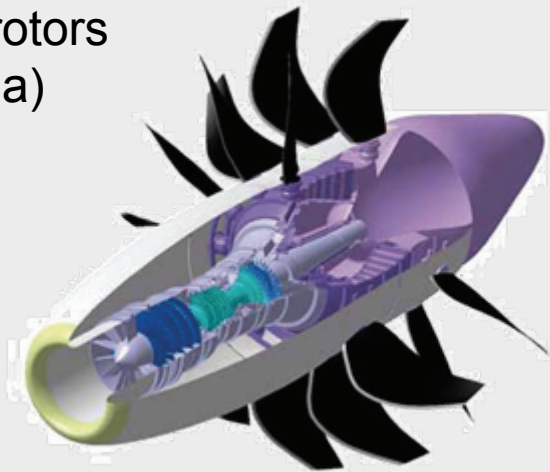
- University expertise in topics related to impact of aviation on the environment brought together by formation of IAE in 2004



# IAE-Related Activities: Technology

- Airframe/engine engineering for reduced environmental impact
- Aircraft operations for reduced environmental impact

Open rotors  
(Omega)



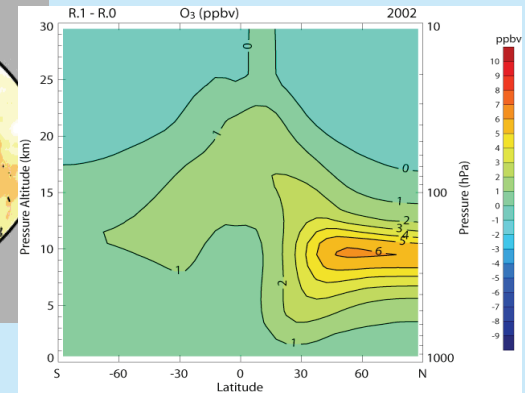
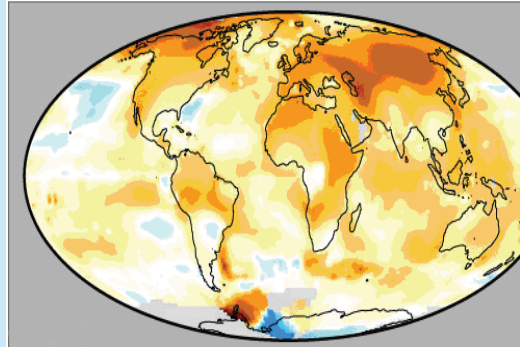
Laminar flow aircraft



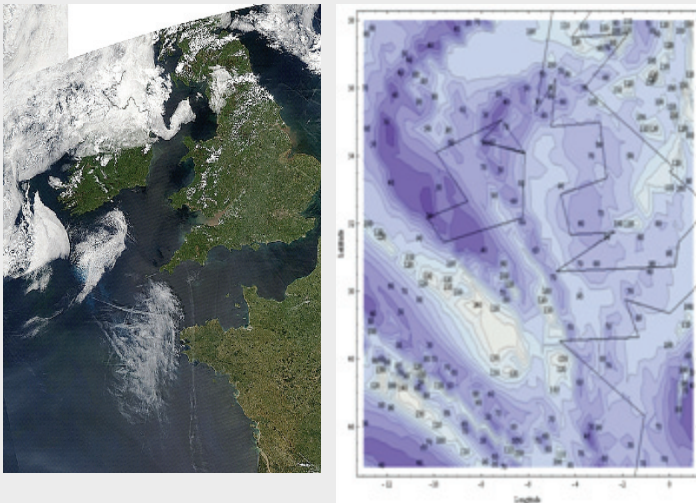
# IAE-Related Activities: Atmosphere

- Atmospheric chemistry, radiation & transport modelling
- Atmospheric observation

## Atmospheric modelling



## Contrail modelling



## Atmospheric observation



FAAM  
BAe146



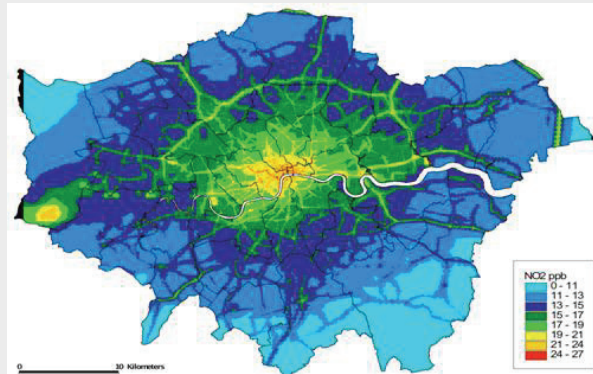
MOZAIC  
A340s



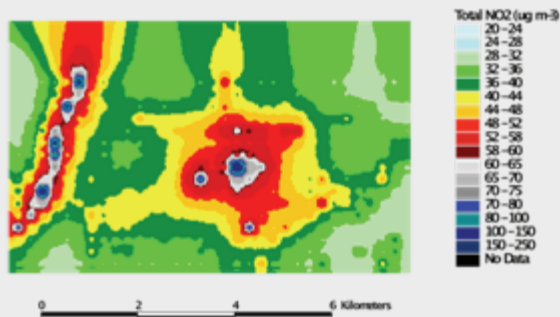
# IAE-Related Activities: Impact Prediction

- Near-airport pollution
- Climate change

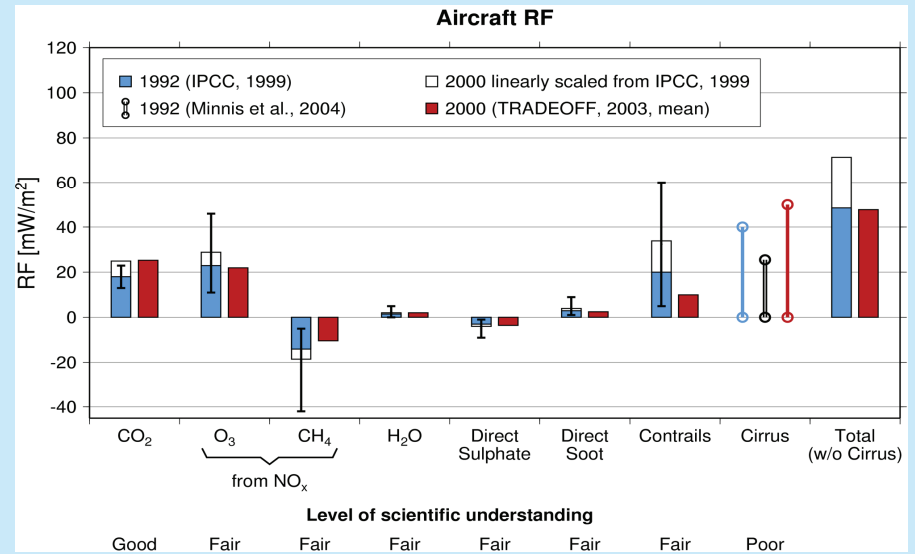
## Local air quality modelling



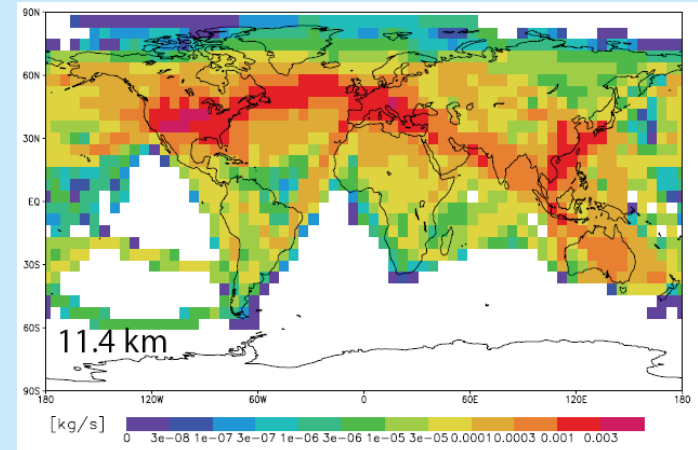
## PSDH



## Climate change

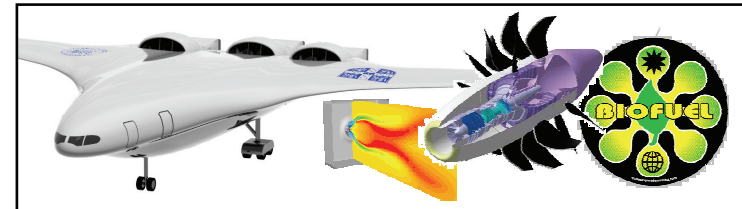


## IPCC update



# IAE-Related Activities: Policy Assessment

- 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 environmental pressures
- Need for tools to assist policymakers



- **Goal:** Develop policy assessment tool for aviation, environment & economic interactions at local & global levels, now and into the future
  - ❑ Assess policies to strike appropriate balances between economic benefits and environmental impact mitigation
  - ❑ Independent & transparent tool for mediating between stakeholders
- 3-year “Phase 1” initiated in October 2006

- Funding from:   NATURAL ENVIRONMENT RESEARCH COUNCIL 

## Core team:

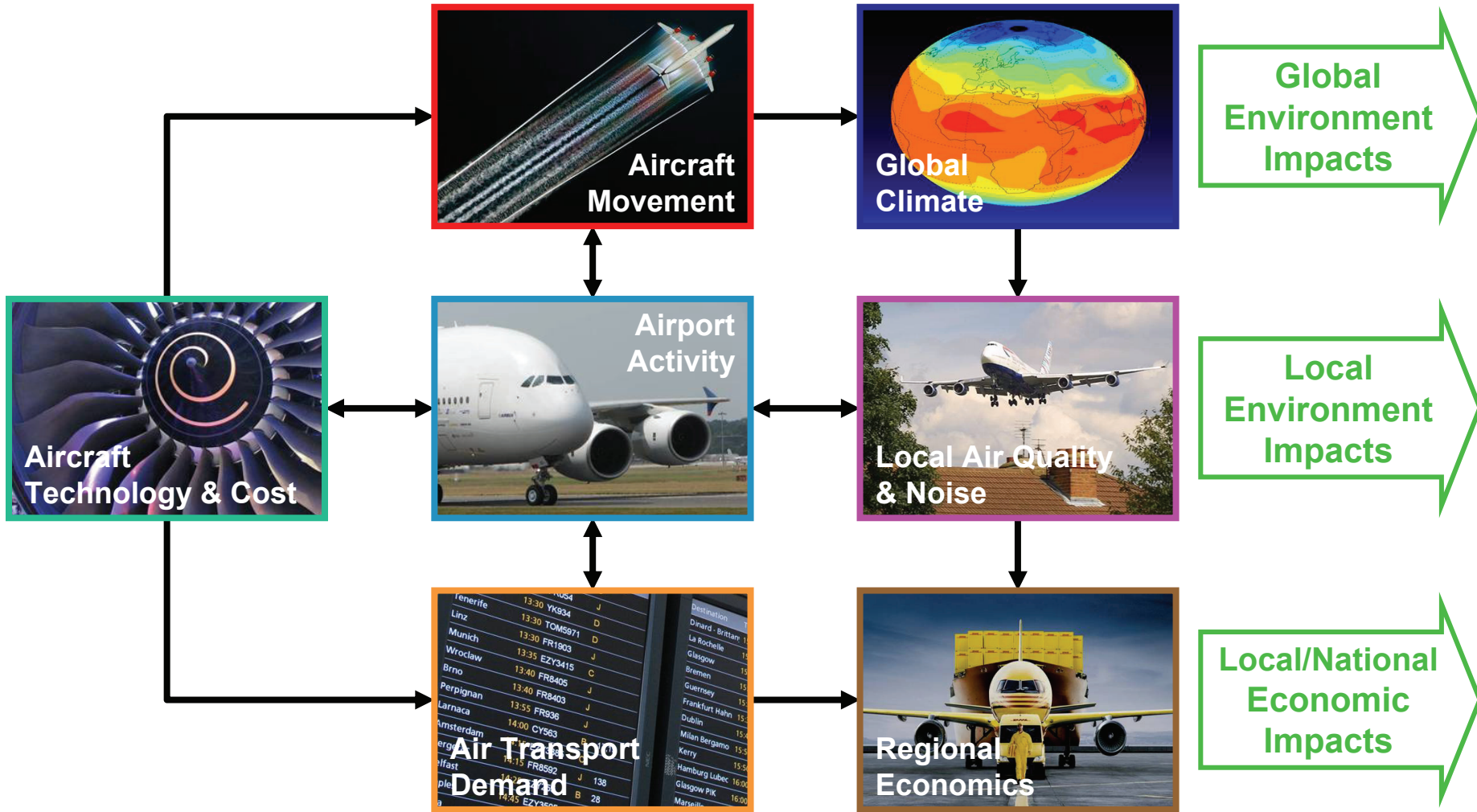
- Dr. Andreas Schäfer (*Principal Investigator*)
- Steven Barrett (*Local Air Quality & Noise*)
- Dr. Lynnette Dray (*Air Transport Demand*)
- Antony Evans (*Airport Activity*)
- Dr. Marcus Köhler (*Global Climate*)
- Dr. Tom Reynolds (*Project Manager & Aircraft Movement*)
- Dr. Maria Vera Morales (*Aircraft Technology and Cost*)
- Dr. Zia Wadud (*Regional Economics*)

## IAE co-investigators:

- Prof. Rex Britter (*Engineering*)
- Prof. Bill Dawes (*Engineering*)
- Dr. Chez Hall (*Engineering*)
- Prof. Peter Haynes (*DAMTP*)
- Prof. Roderic Jones (*Chemistry*)
- Dr. Matthew Juniper (*Engineering*)
- Prof. John Pyle (*Chemistry*)
- Dr. Helen Rogers (*DAMTP*)

## Affiliated students:

- Pablo Bolgeri (*Politecnico di Milano*)
- Henry Hallam (*Engineering*)
- Richard Hunsley (*Engineering*)



- **Integration**

- Captures interdependencies, data transfer & feedback
- Examination of trade-offs (e.g. local environment vs. global environment vs. economic impacts)

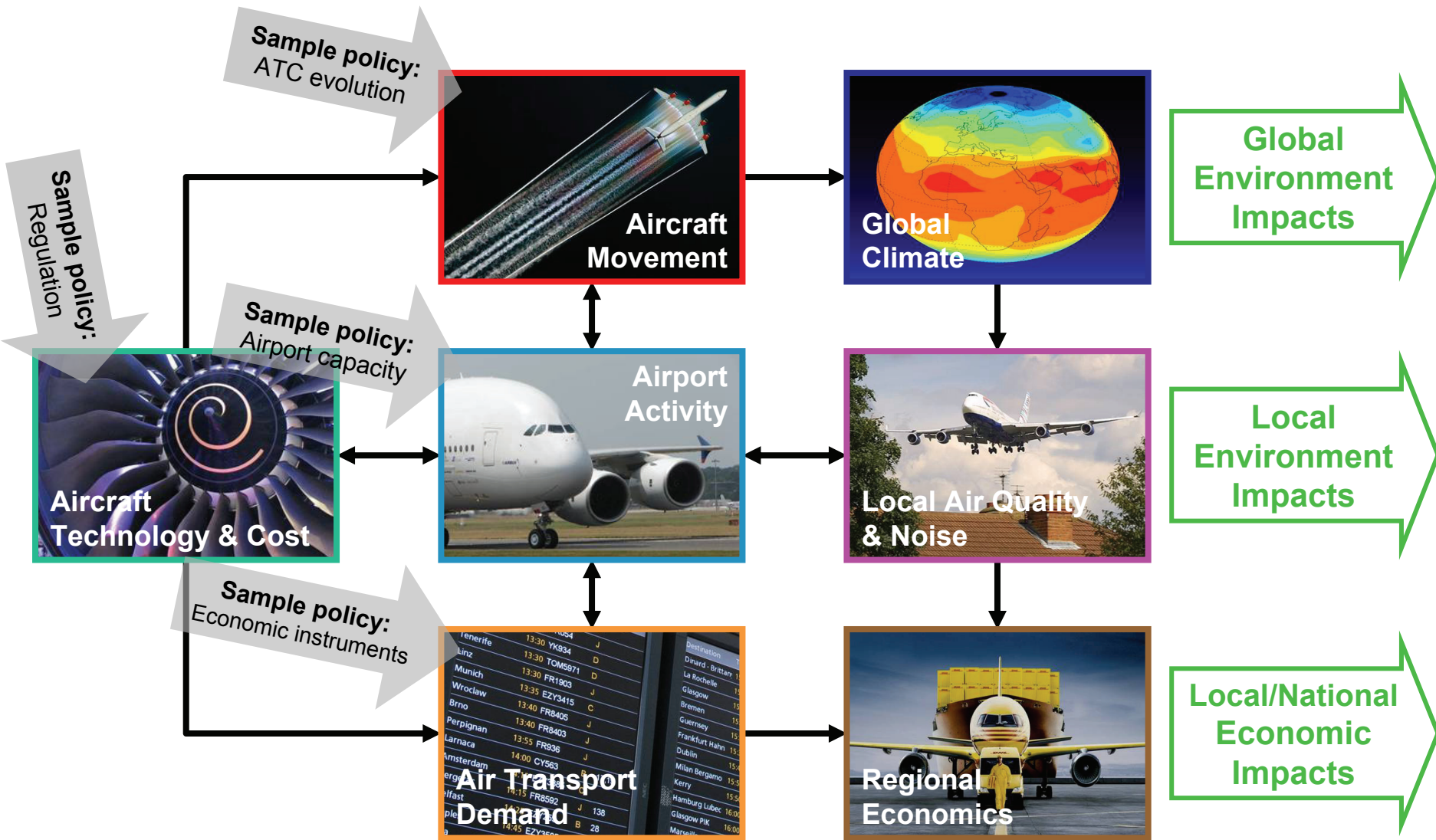
- **Modularity**

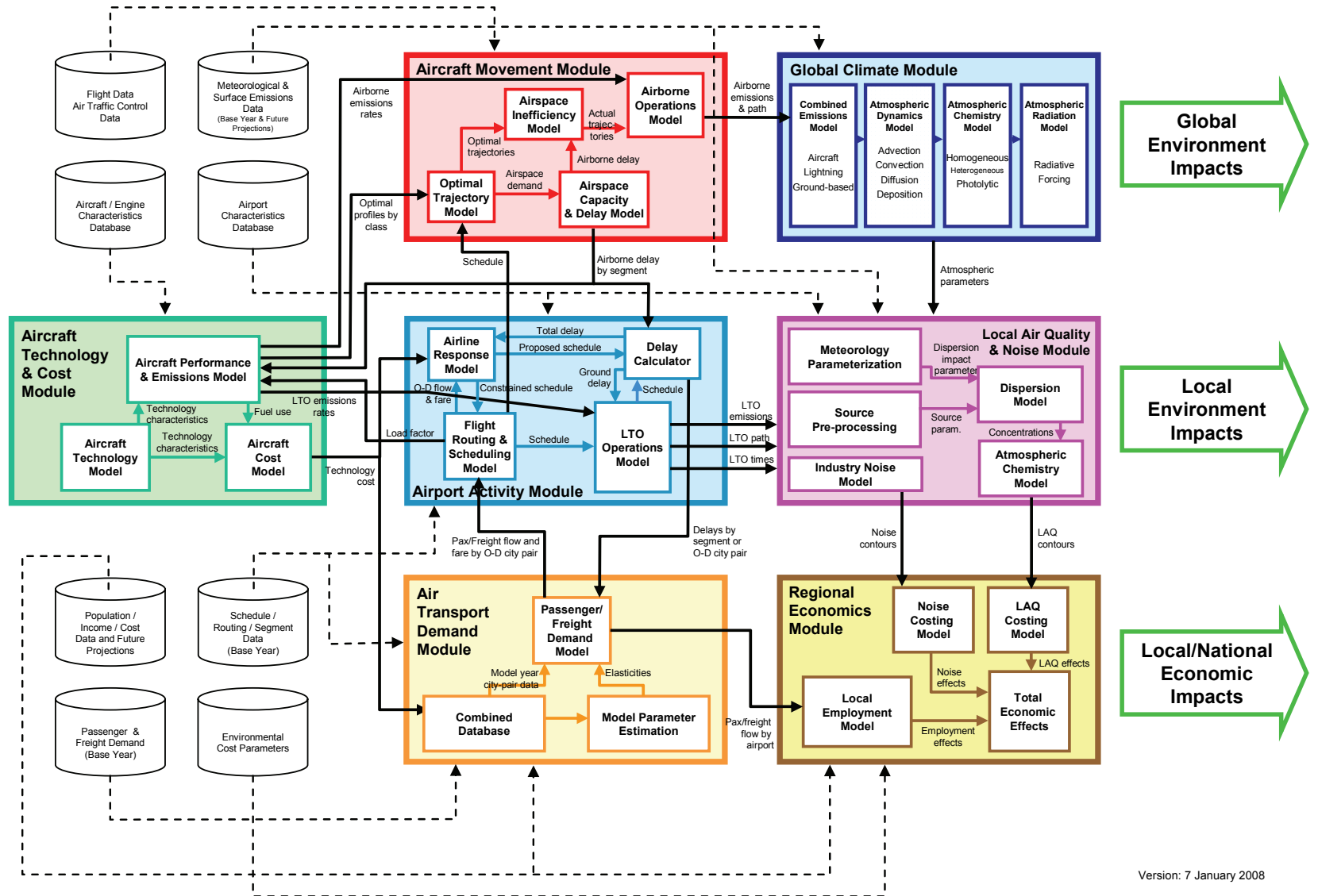
- Resolution of modules tailored to application
- Subset of modules run independently
- Substitution of models from other groups

- **Extendability**

- Natural expansion in sophistication or number of modules

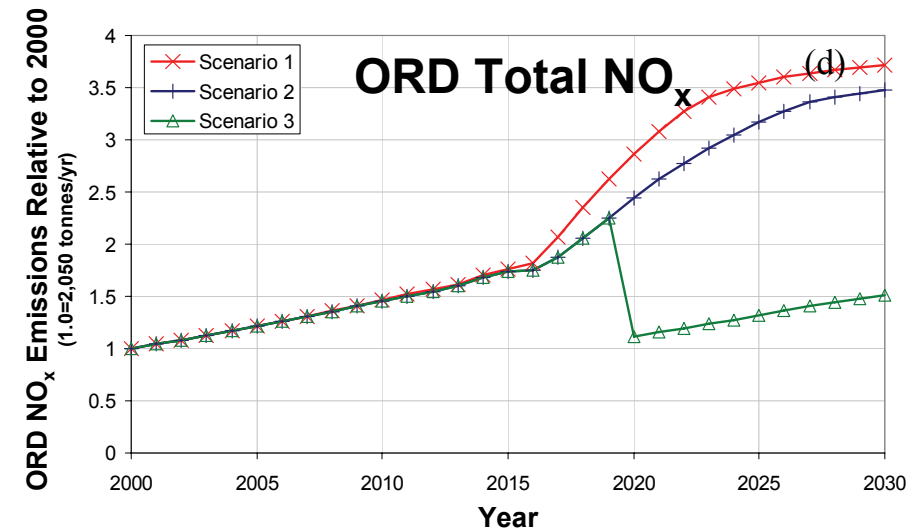
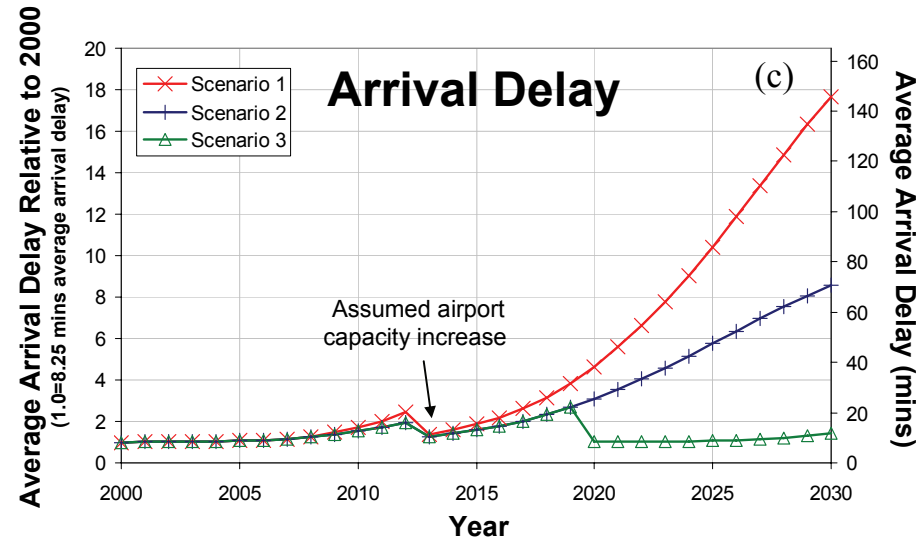
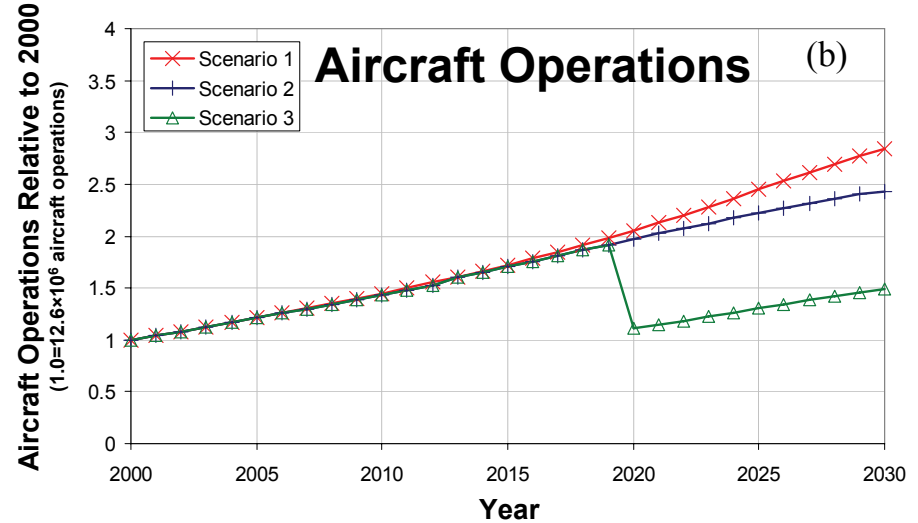
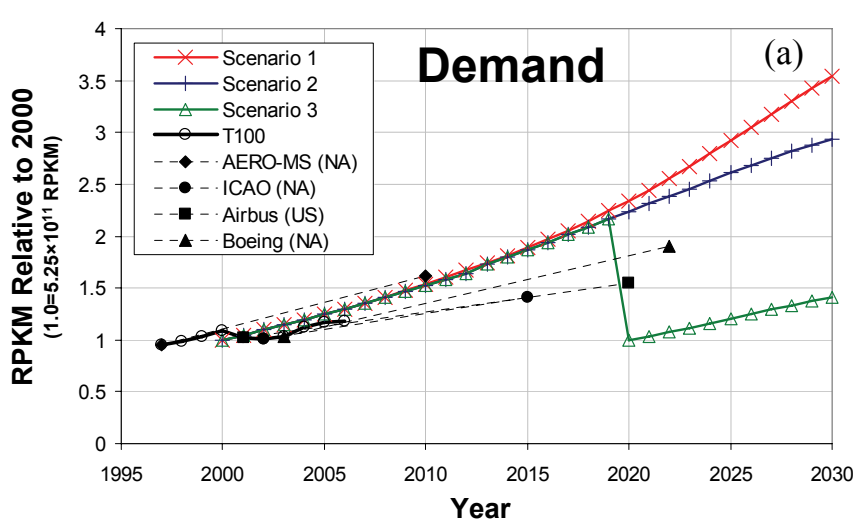
- **Policy assessment potential**



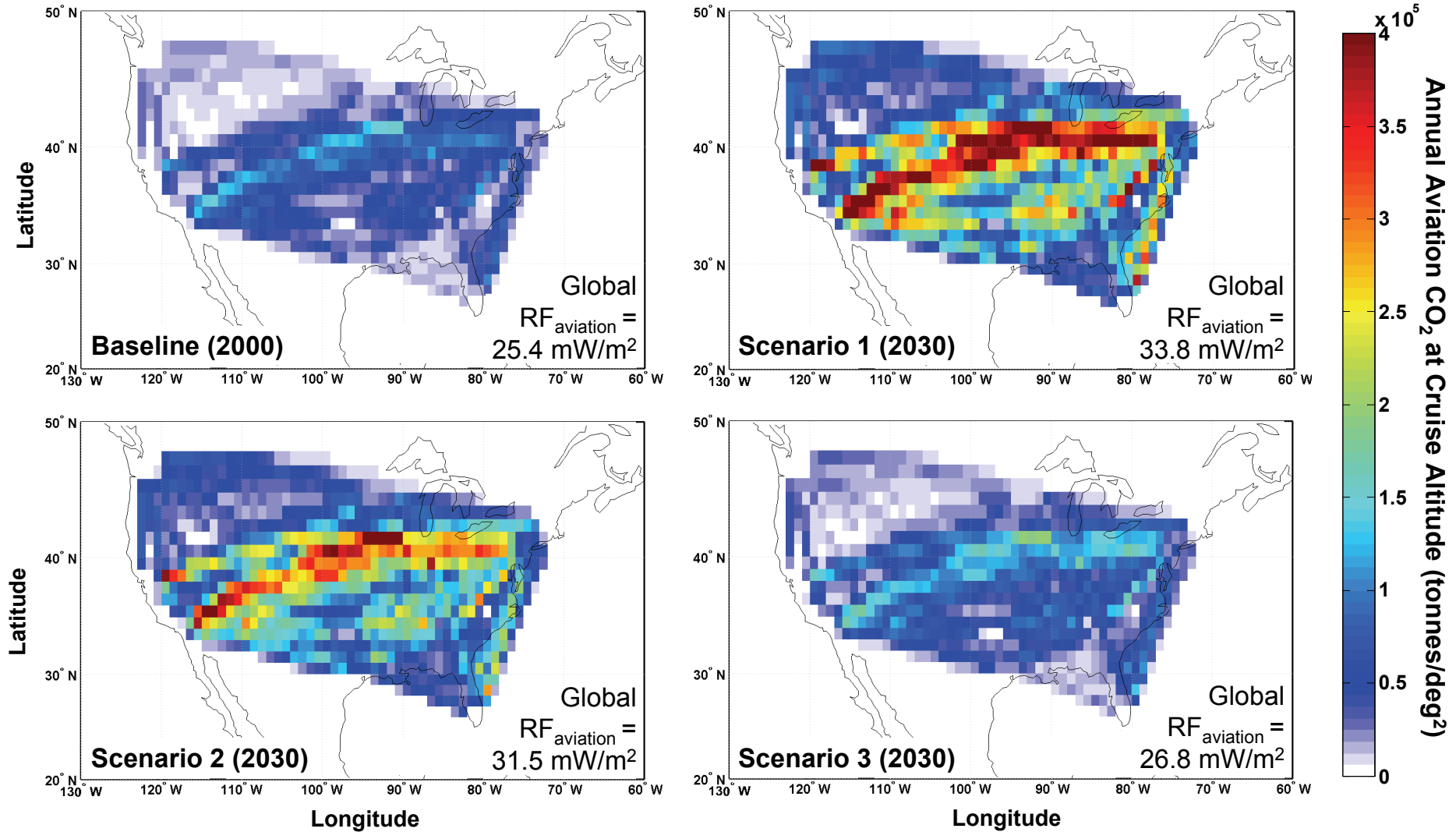




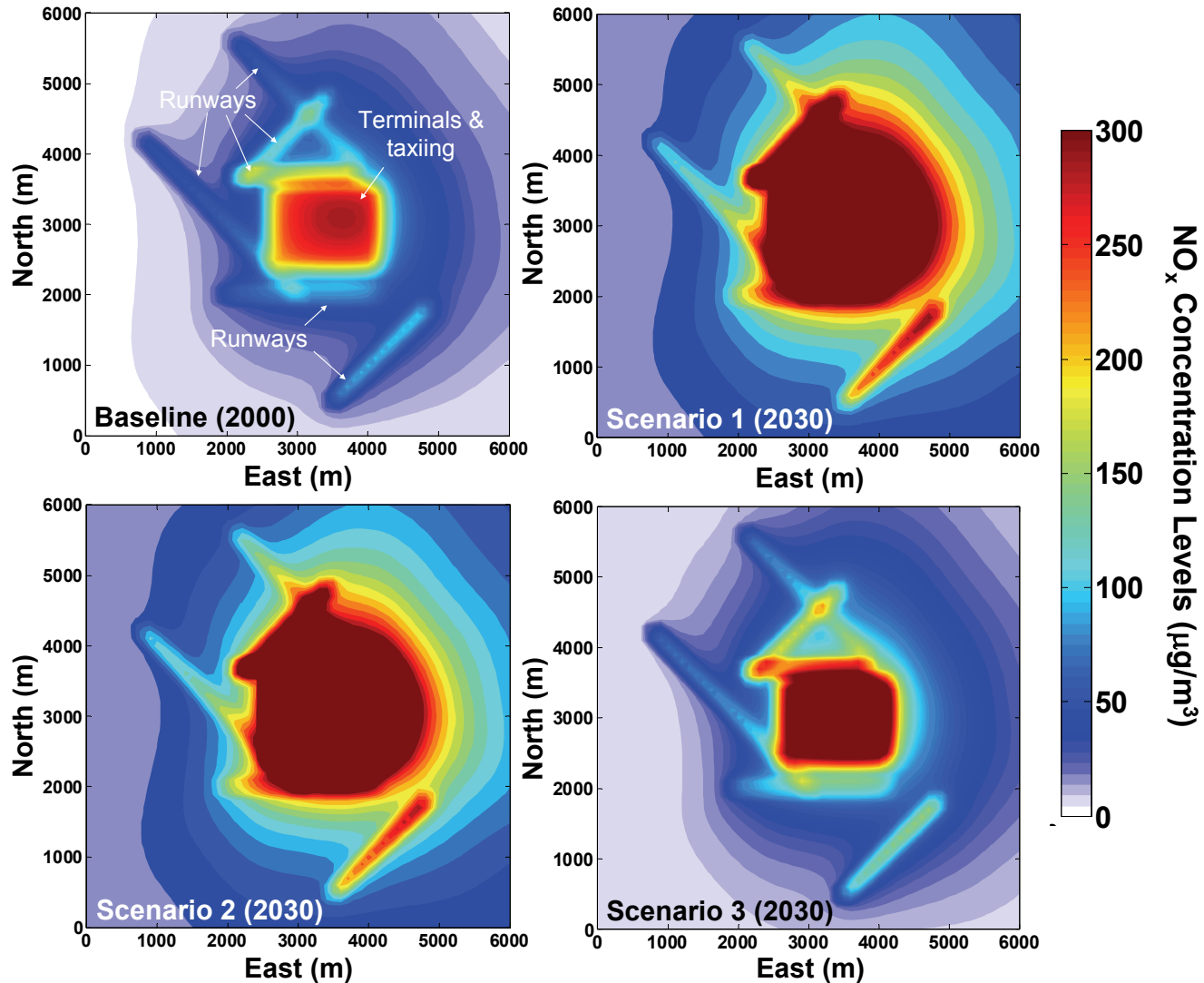
- Developed for AIAA Aviation Technology, Integration and Operations (ATIO) Conference
  - ❑ Belfast, Northern Ireland, September 2007
  - ❑ Paper No. AIAA-2007-7751
- Intended as technology demonstrator
  - ❑ Demonstrates fully integrated AIM model
  - ❑ Applies only basic prototypes of each module
  - ❑ Not necessarily producing realistic forecasts & behaviours
- Each module under continued development



- Importance of feedback of delay effects
  - 20% reduction in demand in 2030 with Scenario 2
  - 15% reduction in operations in 2030 with Scenario 2
    - Less than demand reduction: higher proportion of smaller aircraft
  - 50% reduction in average arrival delay in 2030 with Sc. 2
    - Highly non-linear behaviour of delay with operations, especially when close to capacity
- Tax “shock” analysis provides interesting insights
  - High per-km tax required to reduce demand to 2000 levels
    - 7.7 cents/km equates to \$300 extra New York-Los Angeles
  - Demand falls to 2000 levels but operations fall less
    - Short haul demand less sensitive to price increases (business pax)
    - Higher proportion of short-haul traffic after tax “shock”



- Compared to Baseline emissions:
  - Large increase in Scenario 1 en route emissions
    - Concentration in heavily-travelled trans-continental routes
  - Smaller increase in Scenario 2 en route emissions
    - From dampened demand and operations due to delay effects
  - Evidence of emissions increase in Scenario 3
    - Demand creeps back 10 years after tax “shock”
- Global radiative forcing perturbation analysis shows similar trends
  - Scenario 1 up 8.4 mW/m<sup>2</sup> by 2030, Scenario 2 up 6.1 mW/m<sup>2</sup>, Scenario 3 up 1.4 mW/m<sup>2</sup> relative to 25.4 mW/m<sup>2</sup> baseline in 2000



- Rapidity of LAQ algorithm allows a large number of airports to be modelled – case study focus on ORD
  - NO<sub>x</sub> concentrations reflect prevailing winds and current/predicted runway usage
  - Taxi and terminal area emissions dominate over runway emissions as delays increase
- Probability of violating current regulations in Scenario 1 and 2
  - Policy measures may be required to avoid this
  - Emissions increase due to greater operations and delays: planned capacity increases only provide temporary relief

- Update on US case study (2008)
  - Higher fidelity module definitions
  - Capture wider range of feedbacks
- India case study (2008)
  - Representative of rapidly developing world region
  - Collaboration with IIT Bombay
- Ultimately extend to world case studies (2009)
- Systematic policy assessment scenarios (2009 on)

# Omega Background

- Government (HEFCE) funded Knowledge Transfer Network to address the future sustainability of civil aviation

- 9 university partners:



- Collaborative partners: **Stakeholders**

- ❑ Manufacturers, airlines, airports & ATM
- ❑ Relevant central government departments
- ❑ Local government & development agencies
- ❑ Non-Governmental Organisations
- ❑ Research funding agencies
- ❑ International organisations



# Omega-Funded IAE Projects

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- Alternative fuels project
  - Lead: University of Sheffield
  - Analysis of “drop-in” alternative aviation fuels
- Aircraft stock model project
  - Lead: Cranfield University
  - Analysis of fleet turnover drivers
- ATM impacts project
  - Lead: University of Cambridge
  - Analysis of current and future European ATM efficiency
- Environmental costs project
  - Joint post-doc (6 mths UCam, 6 mths MIT)
  - Systematic review of environmental costs of aviation and competing transportation modes

# Summary

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- IAE involved in wide range of relevant research activities
- AIM project bringing many strands together
- Keen to share knowledge and collaborate widely
- For more information:
  - Email: [tgr25@cam.ac.uk](mailto:tgr25@cam.ac.uk)
  - IAE website: [www.iae.damtp.cam.ac.uk](http://www.iae.damtp.cam.ac.uk)
  - AIM website: [www.AIMproject.aero](http://www.AIMproject.aero)