



UNIVERSITY OF
CAMBRIDGE 8 0 0 Y E A R S
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Institute for Aviation
and the Environment



Aviation Integrated Modelling (AIM) Project



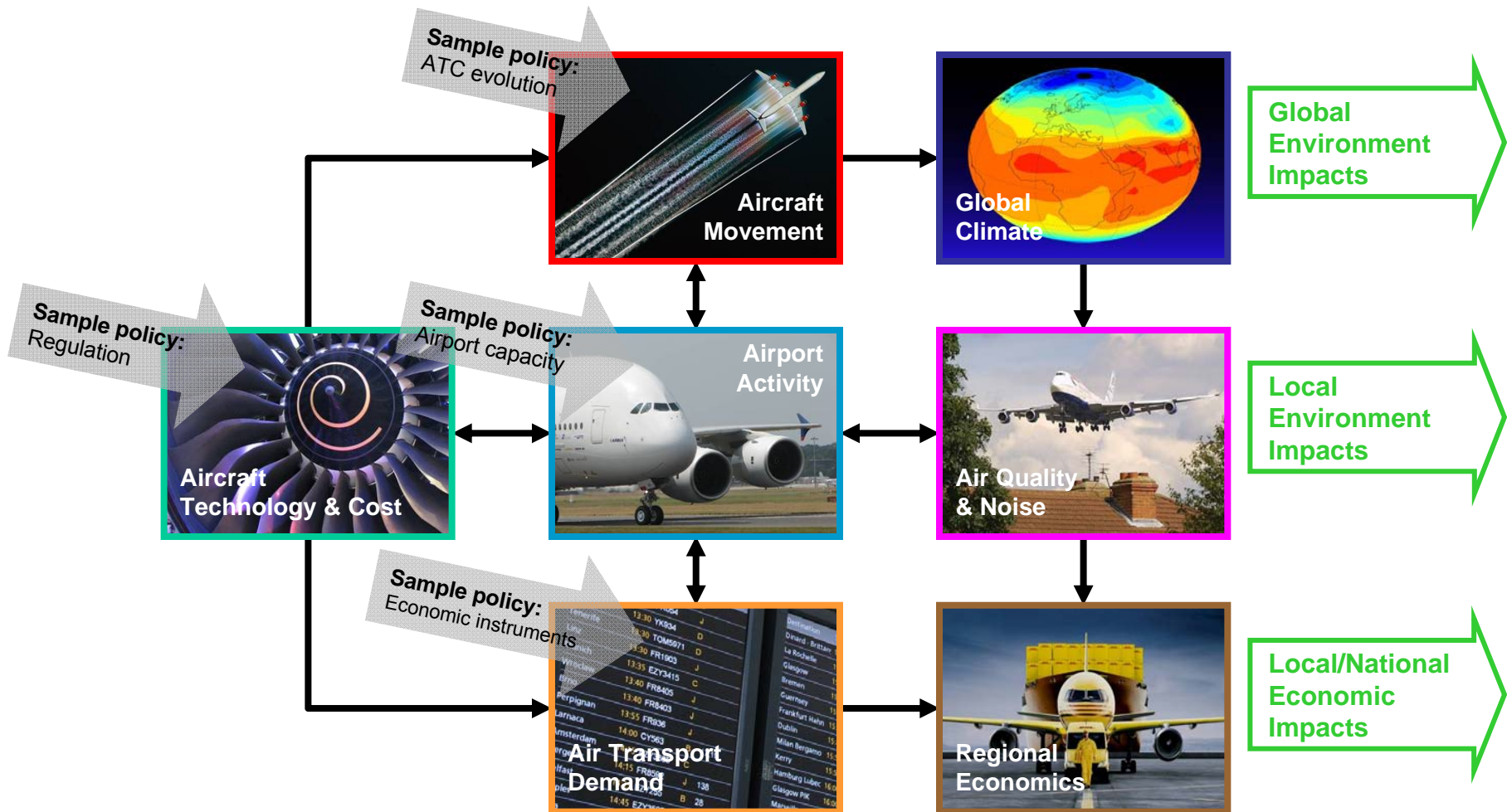
ANCAT MITG/12

The Hague, 19 May 2009

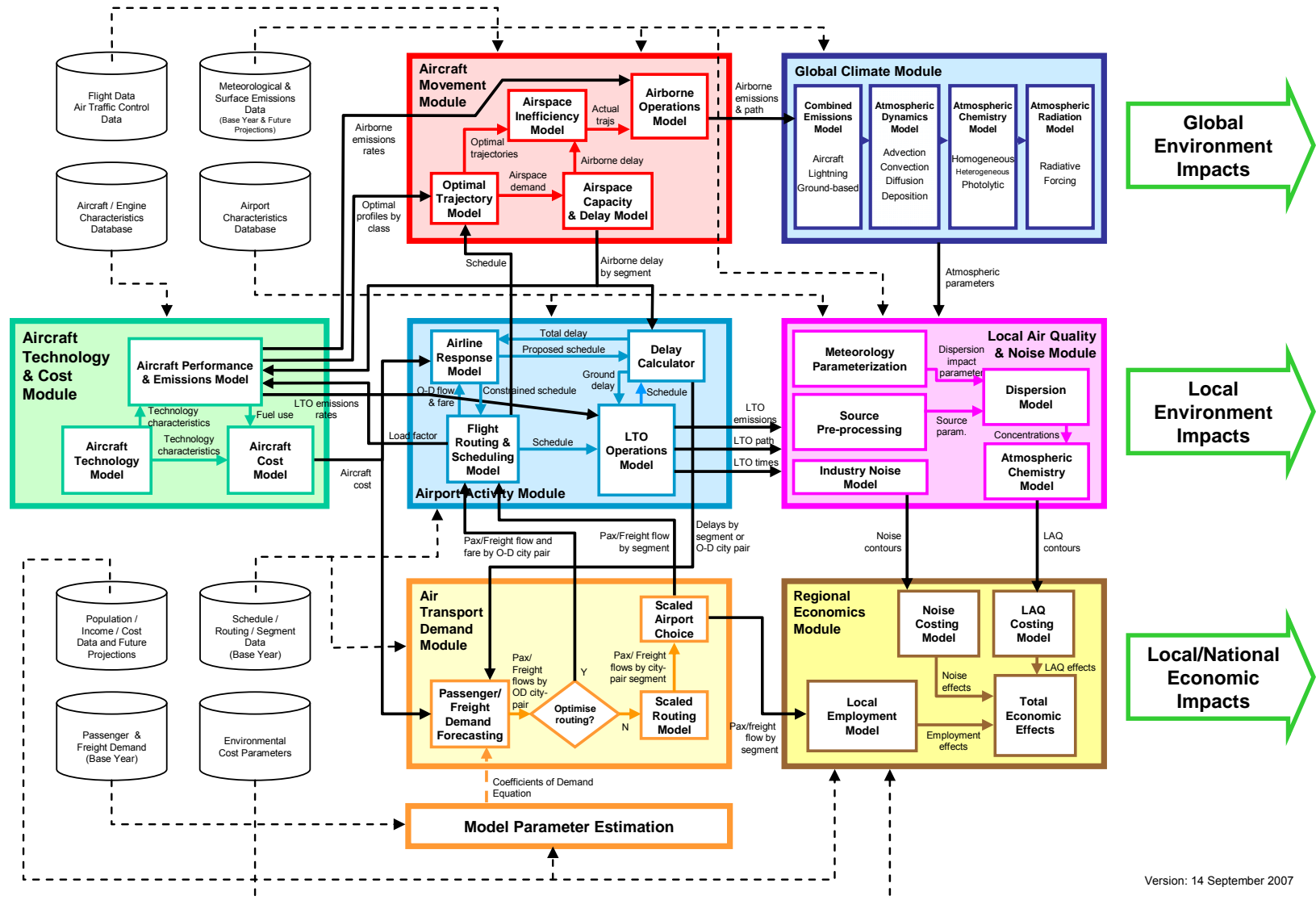
- Goal: Develop integrated assessment tool for aviation, environment & economic interactions at local & global levels, now and into the future
 - Assess policies to strike appropriate balances between economic benefits and environmental impact mitigation
 - Independent & transparent tool for mediating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

- Funding from:





AIM Detailed Architecture



- **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**

Core team:

- Dr. Andreas Schäfer (*Principal Investigator*)
- Steven Barrett (*Air Quality & Noise*)
- Dr. Lynnette Dray (*Air Transport Demand*)
- Antony Evans (*Airport Activity*)
- Dr. Helen Rogers (*Global Climate*)
- Dr. Maria Vera Morales (*Aircraft Technology and Cost*)

IAE co-investigators:

- Prof. Bill Dawes (*Engineering*)
- Dr. Chez Hall (*Engineering*)
- Prof. Peter Haynes (*DAMTP*)
- Prof. Roderic Jones (*Chemistry*)
- Prof. John Pyle (*Chemistry*)

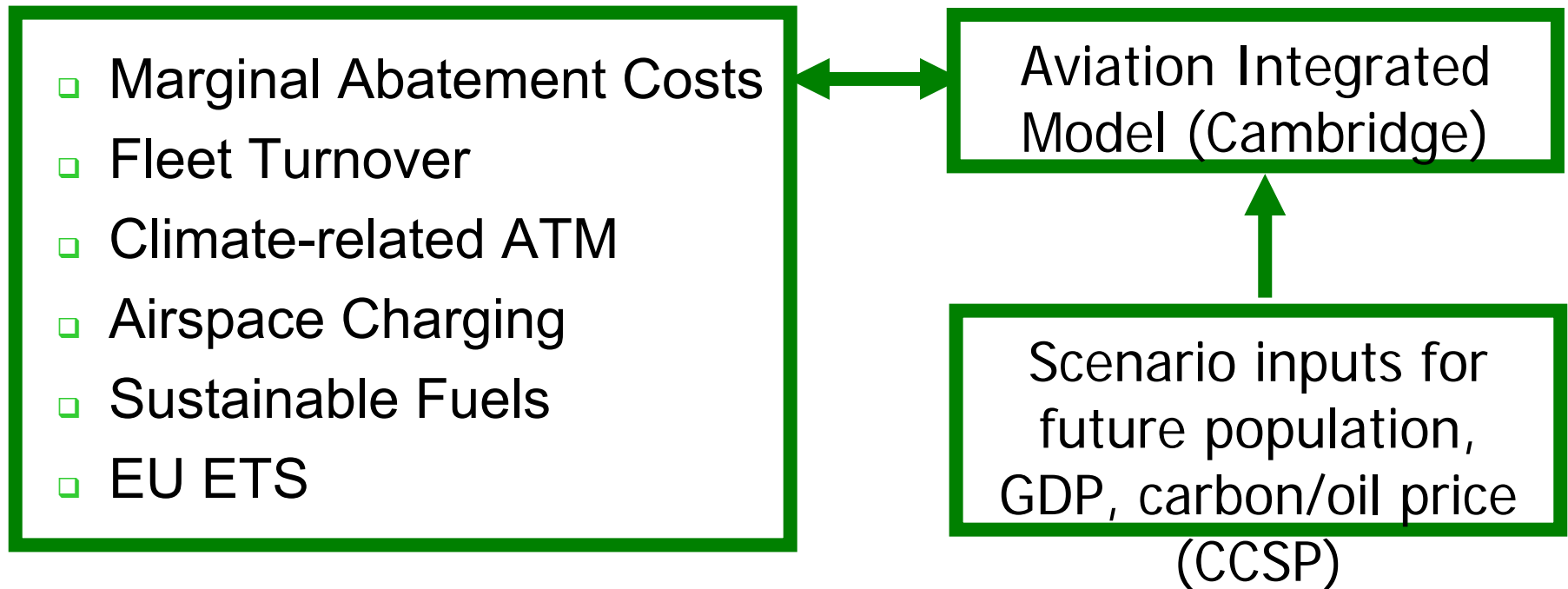
Affiliated researchers:

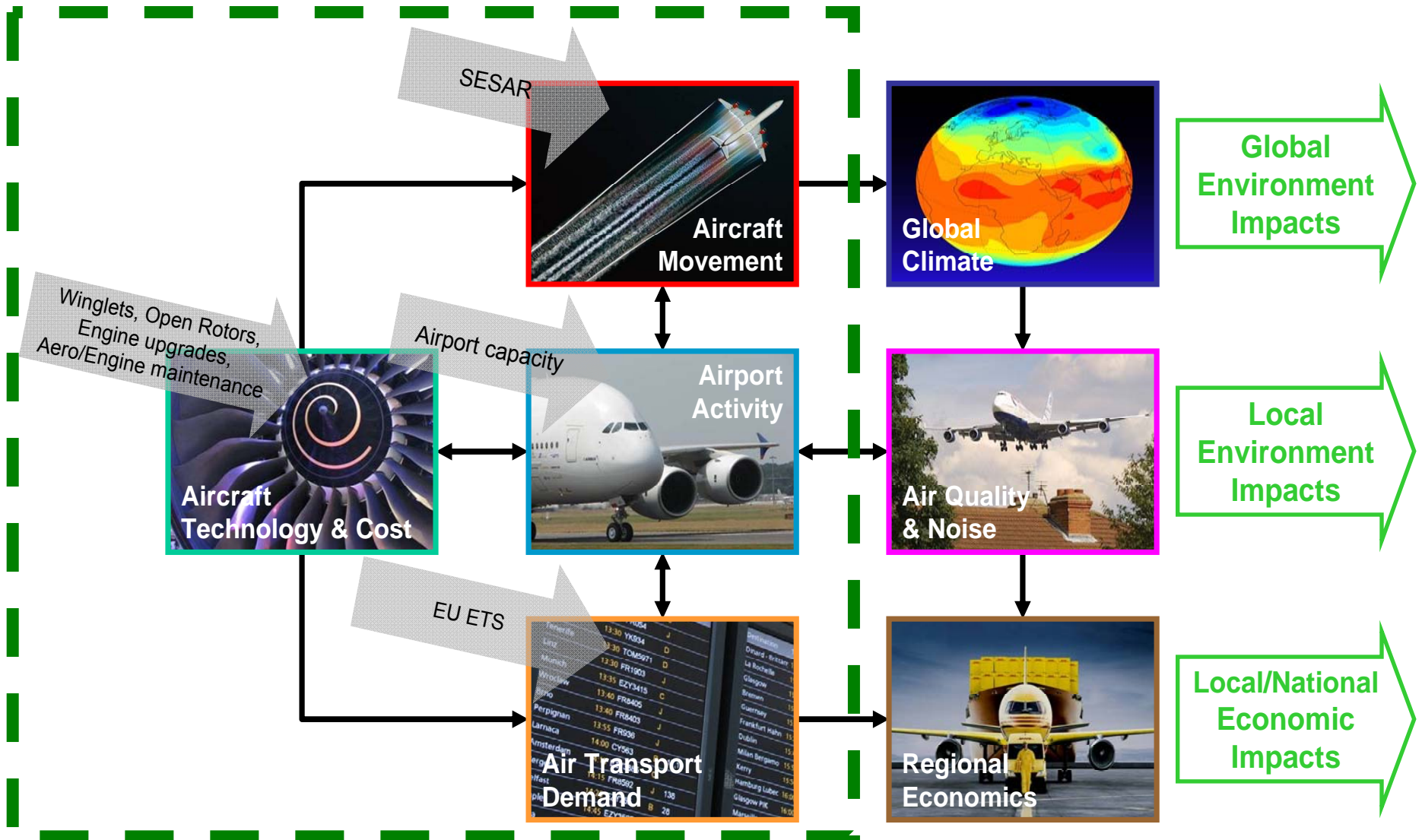
- Prof. Rex Britter (*Air Quality, MIT*)
- Dr. Marcus Köhler (*Global Climate, King's College London*)
- Dr. Tom Reynolds (*Air Traffic Control/Management, MIT/Lincoln Labs*)
- Dr. Zia Wadud (*Regional Economics, Bangladesh University of Engineering and Technology*)

- Output: Journal publications, Conference papers, PhD theses
- Collaborations
 - Omega projects (2 lead, 3 partner)
 - PARTNER (2 workshops)
 - MIT
 - IIT Bombay
 - FP7
 - UK Climate Change Committee
- Recent Research:
 - Omega Integration Study: Opportunities for Reducing Aviation-Related GHG Emissions – a Systems Analysis for Europe
 - PhD Research – Antony Evans: Modelling Airline Responses to Policy Measures and Constraints that may alter the Environmental Impact of Aviation

- Omega Project 41, “Opportunities for Reducing Aviation-Related GHG Emissions – a Systems Analysis for Europe”
- Use modular AIM structure to interface with the results of other Omega projects
- Goals:
 - Investigate interaction between different technological, operational and economic CO₂ emission mitigation measures
 - Assess which measures would be most useful in achieving aviation CO₂ emission reductions

- How might different policies/scenarios interact?
 - Simulate by combining a range of Omega study results with a systems model for European Aviation:



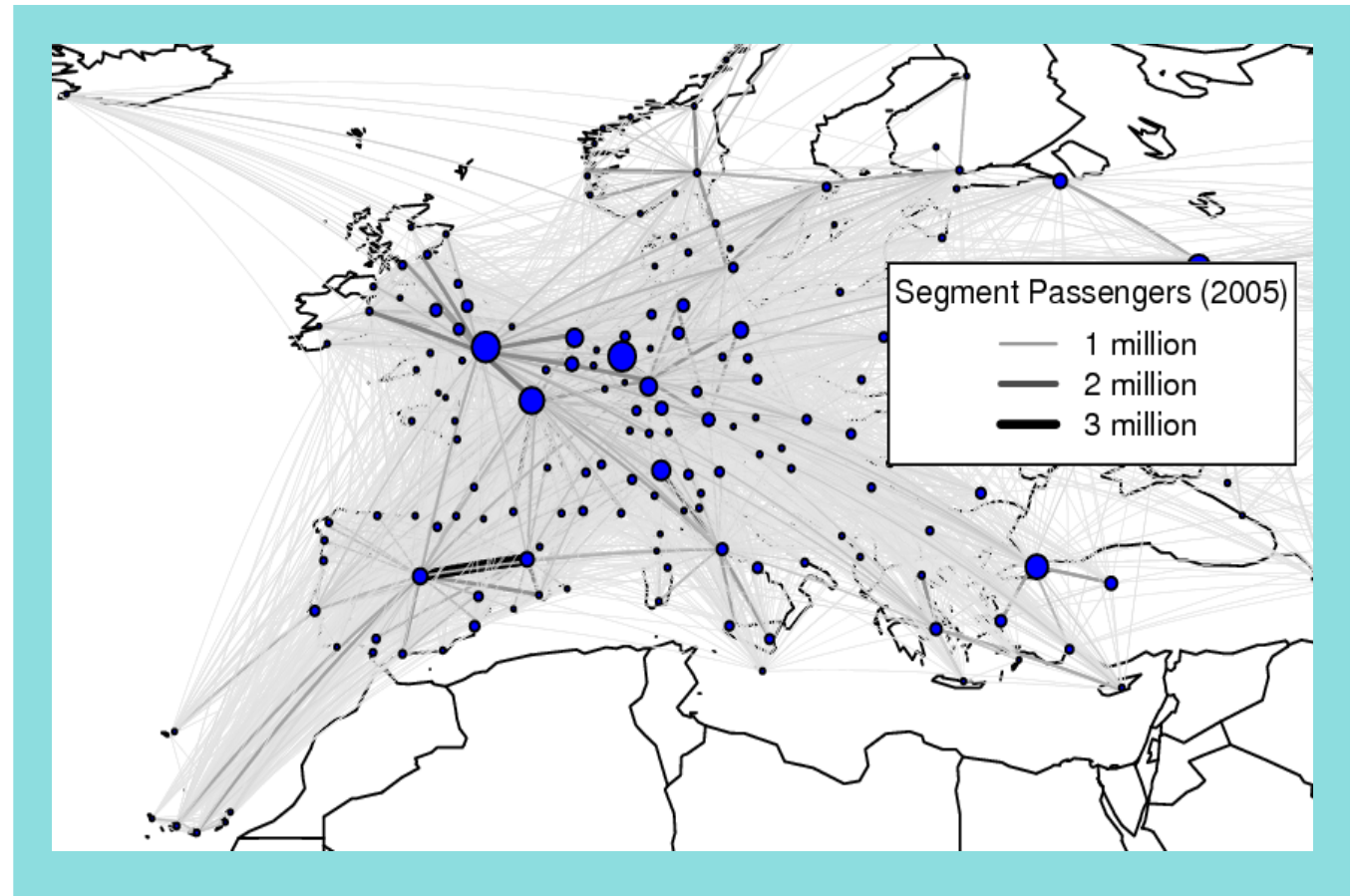


Future Scenarios
(CCSP 2007):

IGSM: High GDP growth, high oil price

MERGE: medium GDP growth and oil price, higher carbon price

MiniCAM: low GDP growth, low oil price



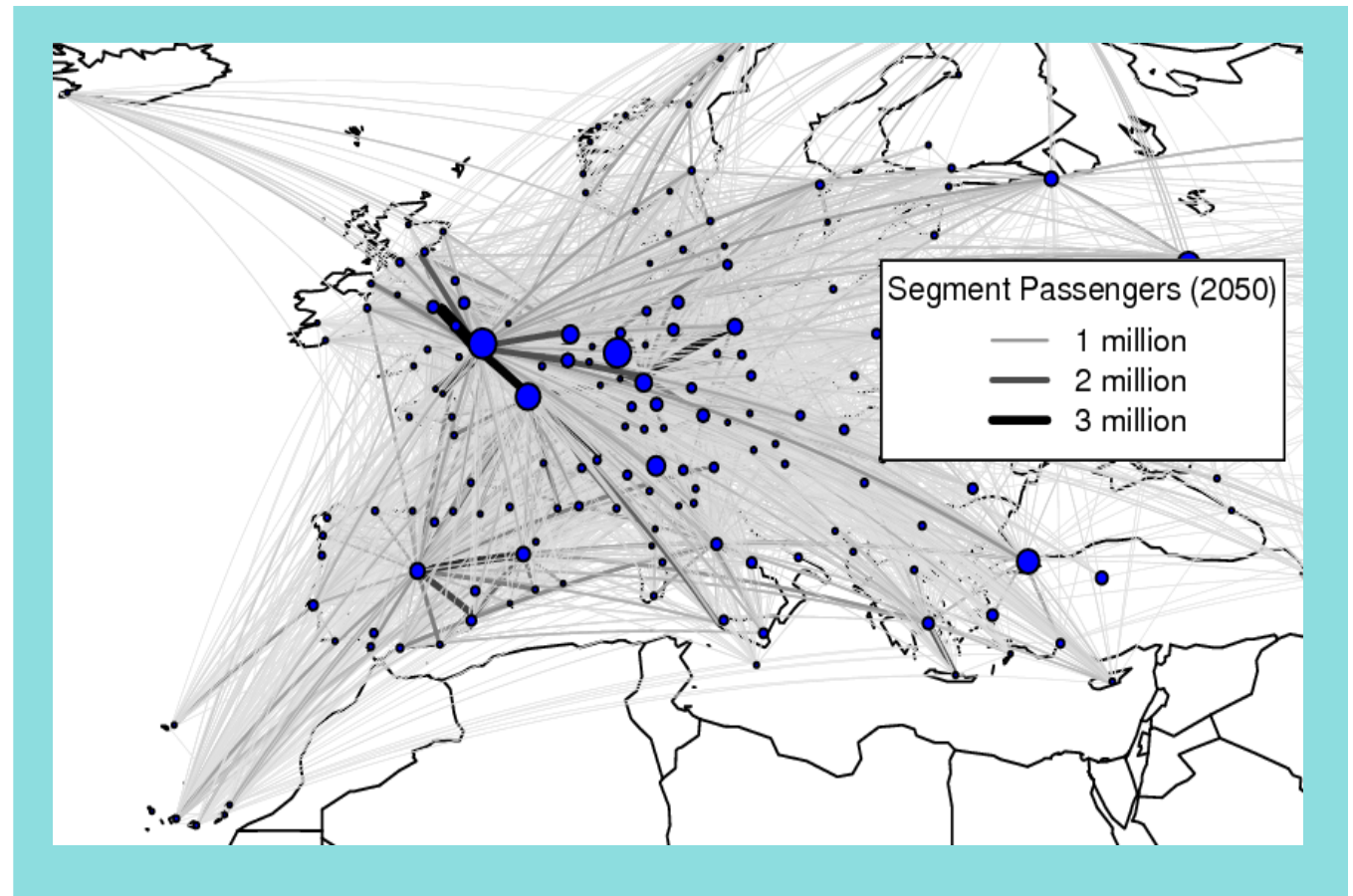
MERGE 2005

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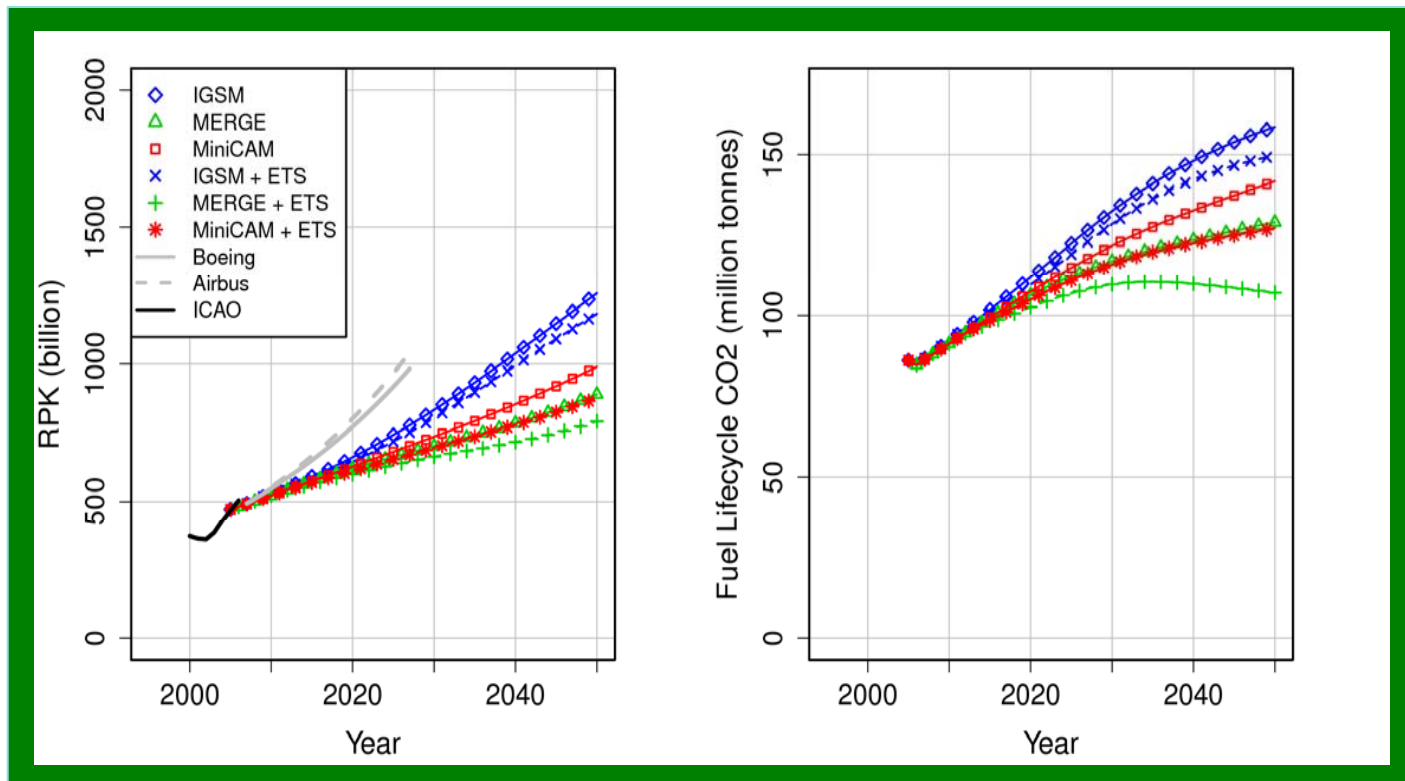
MERGE: medium GDP growth and oil price, higher carbon price

MiniCAM: low GDP growth, low oil price

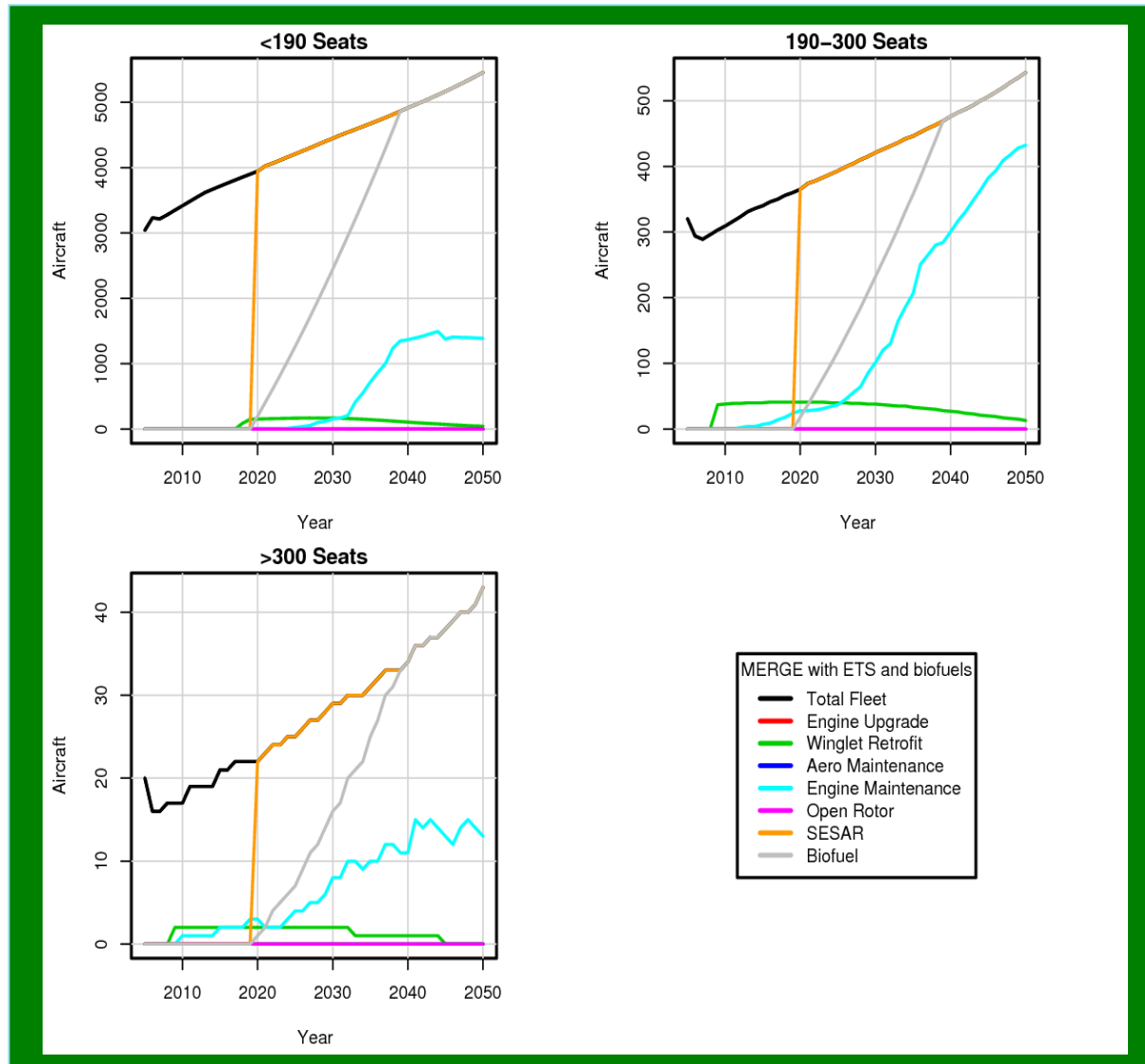


MERGE 2050

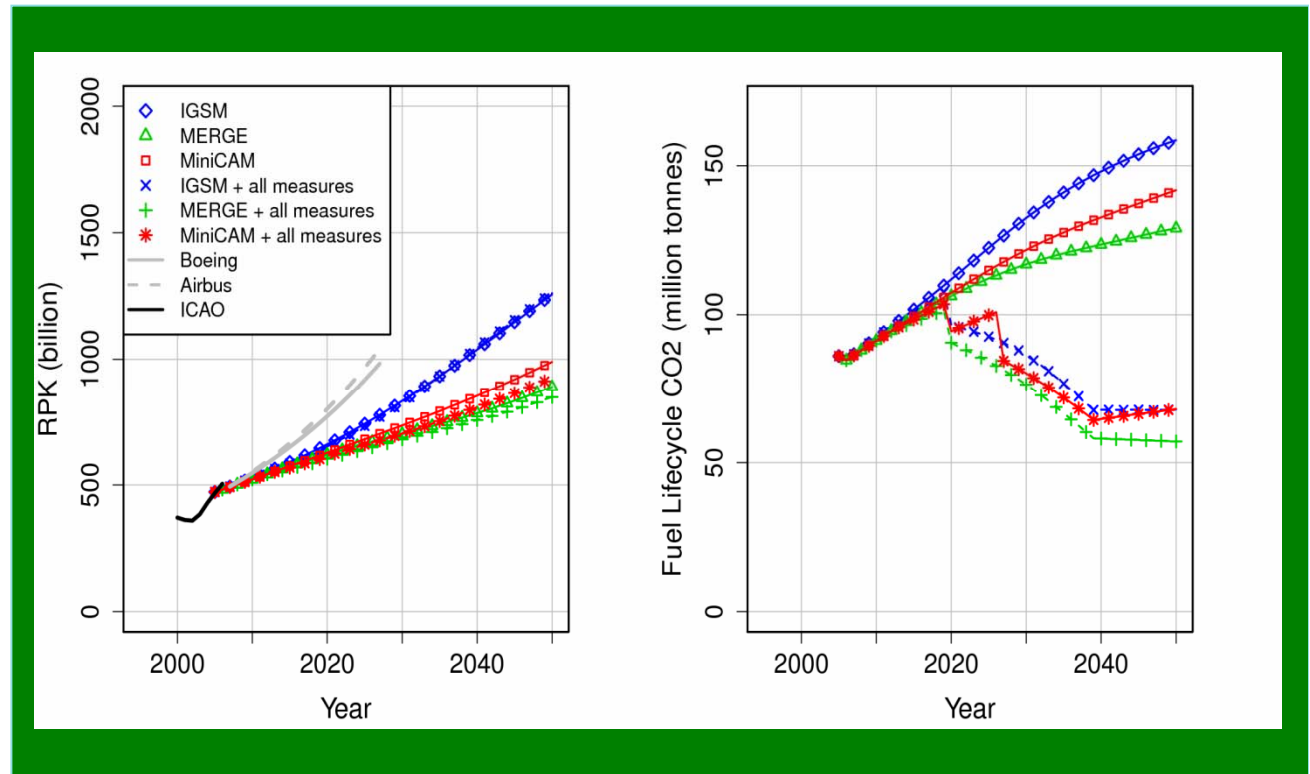
- Without other mitigation measures, emissions reductions come mainly from lowered demand
- Reference case demand requires ~doubling in capacity at LHR, CDG to 2050.



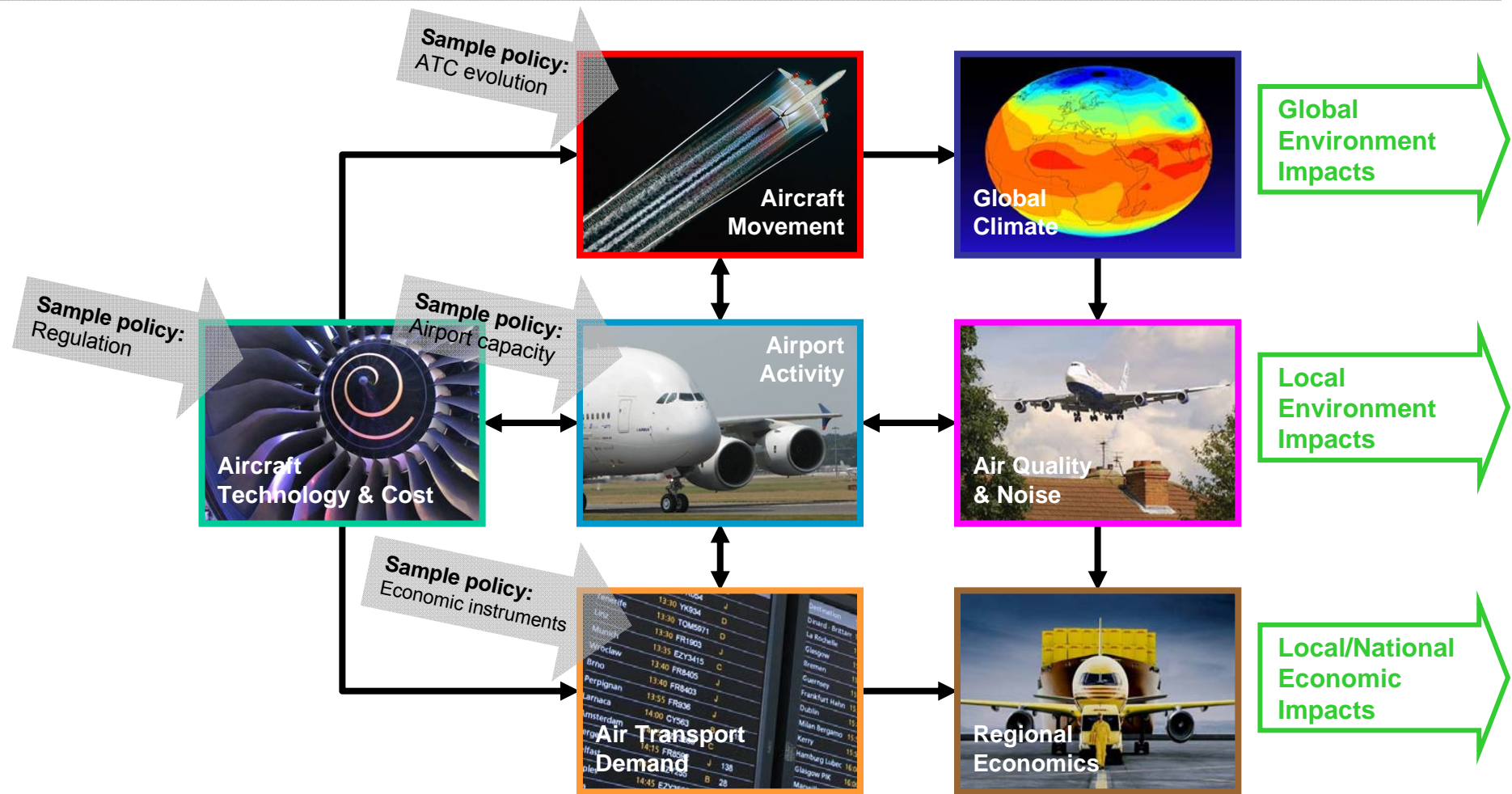
Uptake of abatement measures



- Now include abatement measures airlines can take to reduce emissions
- Largest effects on emissions from SESAR, biofuels
- Open rotors in high-cost scenarios only
- Airlines can reduce fuel/carbon costs so RPKM decrease is smaller than ETS-only case

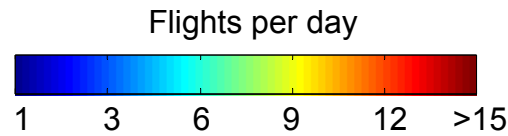


- Complex interactions - uptake of one mitigation measure can lower future uptake of other measures
- Depending on the scenario and assumptions, reductions in airborne CO₂ over reference case seem possible by 2050
 - 8-15% (ETS only)
 - 20-30% (ETS+non-biofuel abatement measures)
- Strongest reduction in **lifecycle** aviation emissions (under assumptions used here) is ETS+biofuels
 - Lifecycle CO₂ emissions below 2005 levels in 2050
 - However, noise, local and airborne emissions will be little-changed from reference case
 - Cellulosic biomass fuel → land area problems?

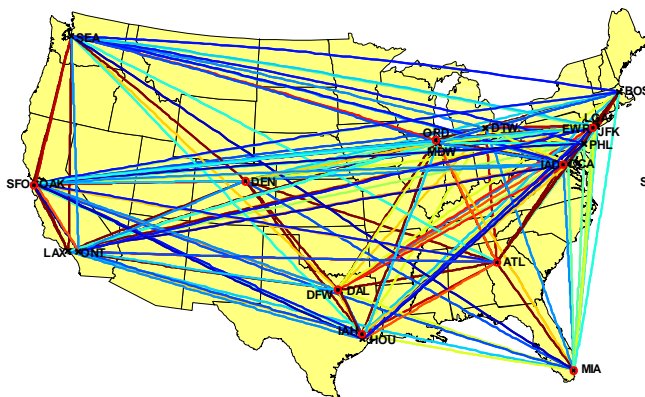


- How would likely **airline responses** to policy measures and constraints affect the environmental impact of aviation?

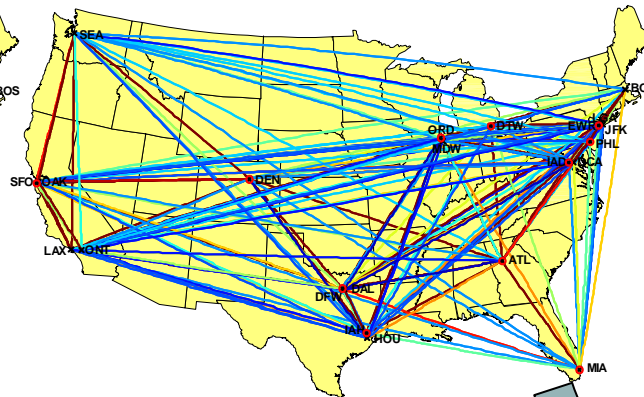
- Objective: Develop model of airline responses to changes in cost and demand caused by policy measures and constraints
 - Routing network changes (e.g. avoid congested hubs)
 - Changes in aircraft size
 - Changes in flight frequency
- Methodology: Select each airline's routing network, flight frequencies, and aircraft to maximize individual profit
 - Simulate game between airlines to capture effects of competition endogenously
 - Model effects of policies and constraints on airline costs and demand endogenously



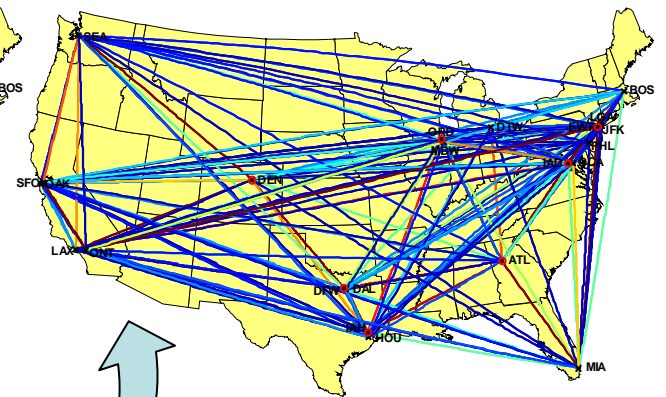
Model 5 airlines in 14 cities /
22 airports / 9 hubs in the
domestic US in 2005



Actual Network Operated, 2005



Airline Game Theoretical
Equilibrium Network



System Optimal Network

Tripling of 2005 fuel cost

Airline Optimal Network
System Optimal Network

O-D Seats		O-D Flt Freq.		Segment Flt Freq.	
% diff. System	R ²	% diff. System	R ²	% diff. System	R ²
25% high	0.858	15% high	0.927	12% high	0.670
9% low	0.703	26% low	0.618	29% low	-

- Greater consideration of supply side effects
 - Aircraft fleet planning model
 - Global location of aircraft
 - More advanced marginal abatement modelling
- Integrate airline response modelling
- Further sophistication of aircraft performance modelling
- Contrails and regional non-CO₂ climate impacts
- Cruise related air pollutant emissions
- Further development of economic impacts modelling