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Institute for Aviation
and the Environment 

Future Scenarios for Aviation: Modelling the Effect of Emissions Trading

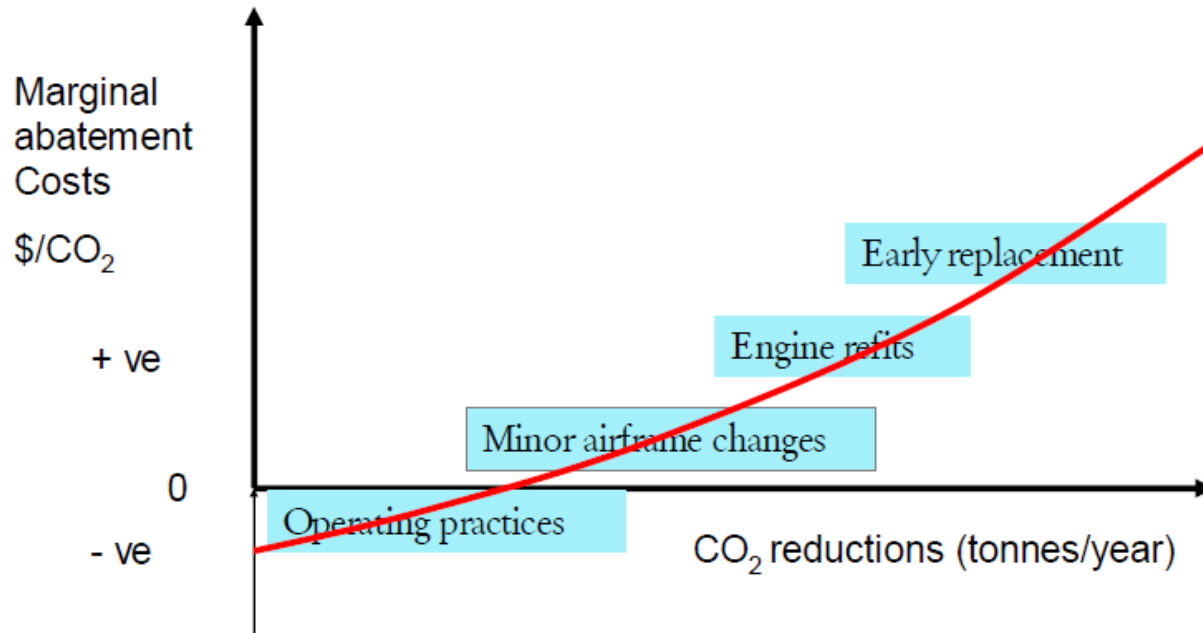
Lynnette Dray
University of Cambridge



TAROM Emissions Trading Workshop
Bucharest, 29th July 2009

- Emissions reductions from aviation ETS will have two sources:
 - Reductions in other sectors resulting from operators buying allowances
 - Direct abatement in aviation sector
- Proportions depend on marginal abatement curve for CO₂ reductions
- Various abatement measures available to aviation:
 - Now: retrofits, CDAs, increased maintenance etc.
 - Future: Radical new technologies, biofuels, SESAR...
- Which ones are economic to adopt depends on fuel + carbon prices

- E.g. Morris et al. (2009)
- Some measures potentially economic now (e.g. Winglet retrofits), some become economic with ETS – more tomorrow.

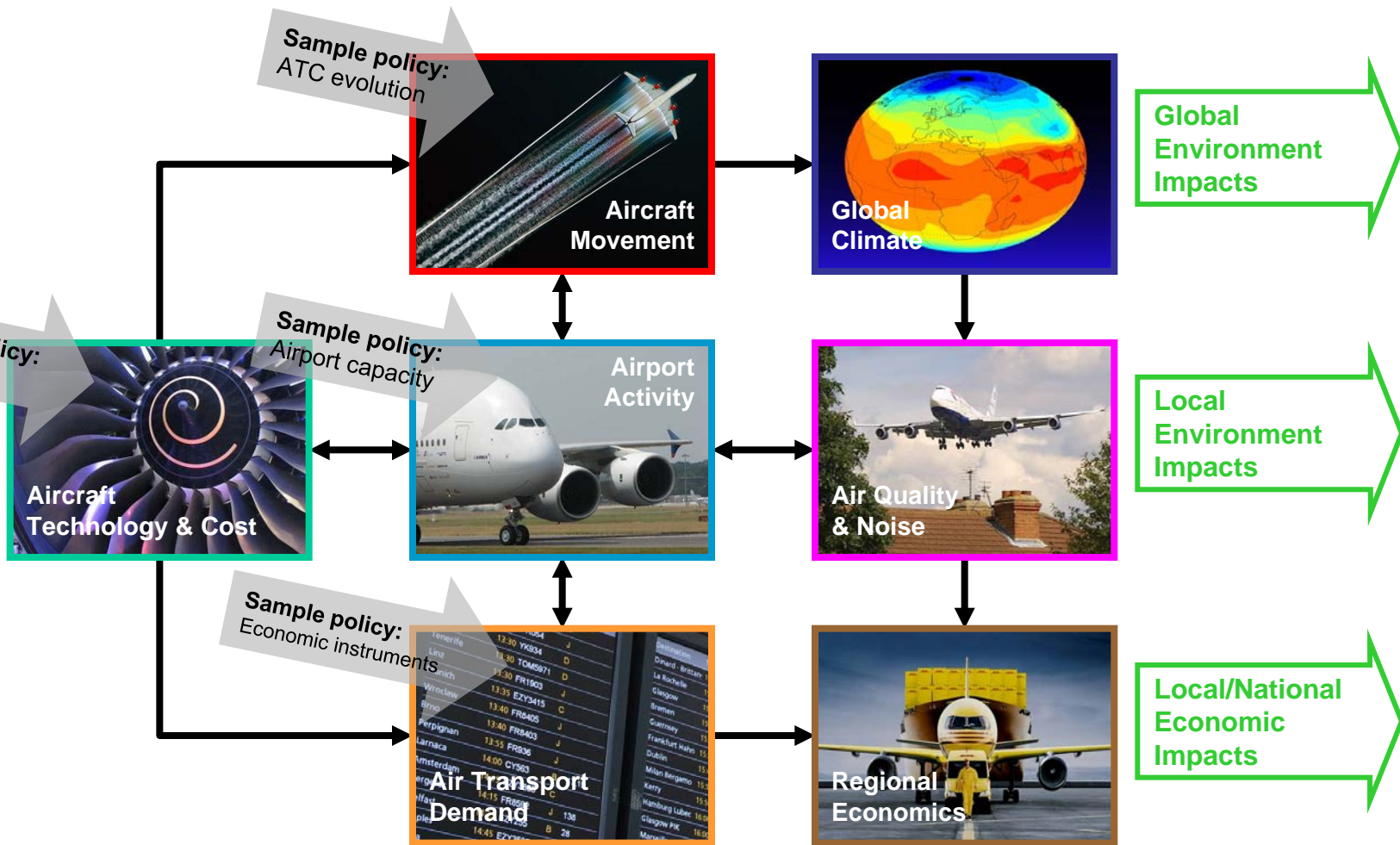


[Source: Morris et al. 2009]

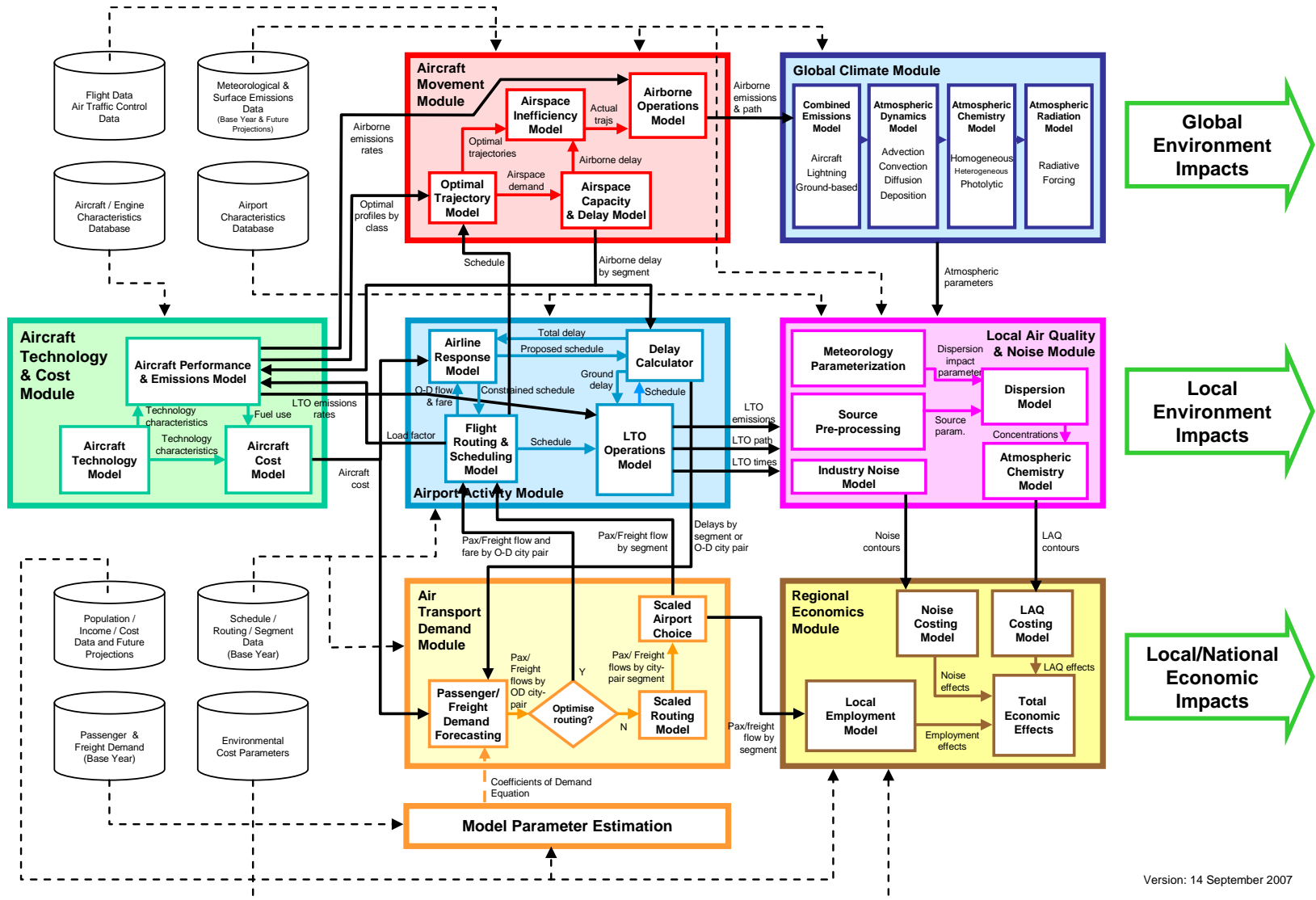
- Goal: Develop integrated assessment tool for aviation, environment & economic interactions at local & global levels, now and into the future
 - Assess policies to strike appropriate balances between economic benefits and environmental impact mitigation
 - Independent & transparent tool for mediating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

- Funding from:





AIM Detailed Architecture



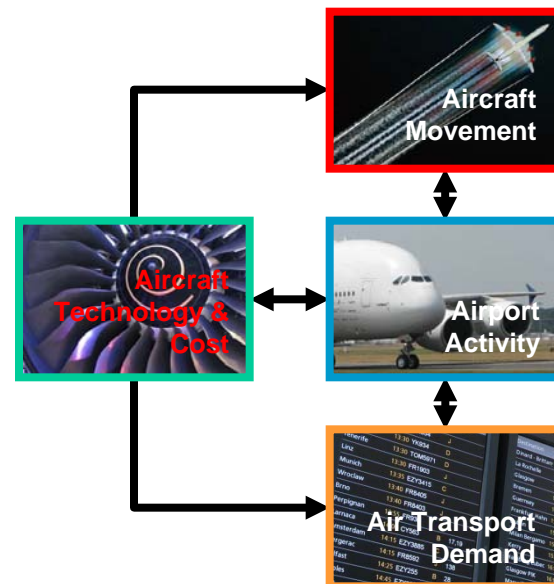
Version: 14 September 2007

Goals

- Simulate emission rates by aircraft type, and the associated direct operating costs

Methodology

- Below 3000 feet: ICAO Exhaust Emission Data, Reference LTO Cycle
- Above 3000 feet: Eurocontrol Base of Aircraft Data (BADA)
- Three size and two technology age categories
- Simple fleet turnover model for introduction of new technology

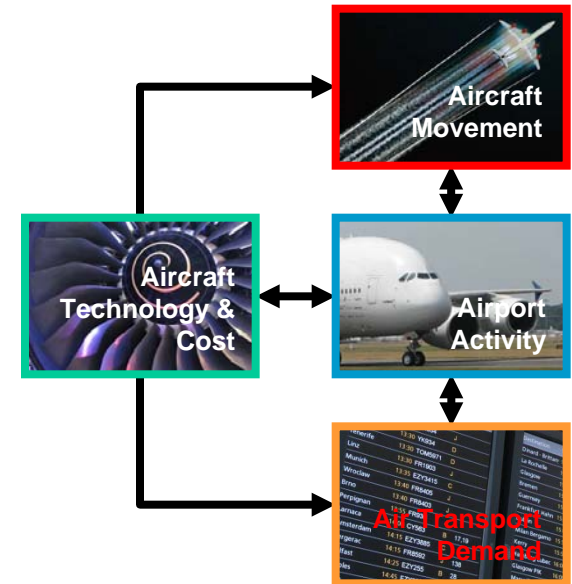


Goals

- Forecast true origin-ultimate destination passenger and freight demand for air travel
- Global set of 700 cities, 95% of scheduled RPKM

Methodology

- Simple gravity-type model
- Demand is a function of population, income, fare, travel time etc.
- Estimate separately for short-, medium-, long-haul and different world regions
- Does not include mode choice
- Modular – can plug in other projections if required

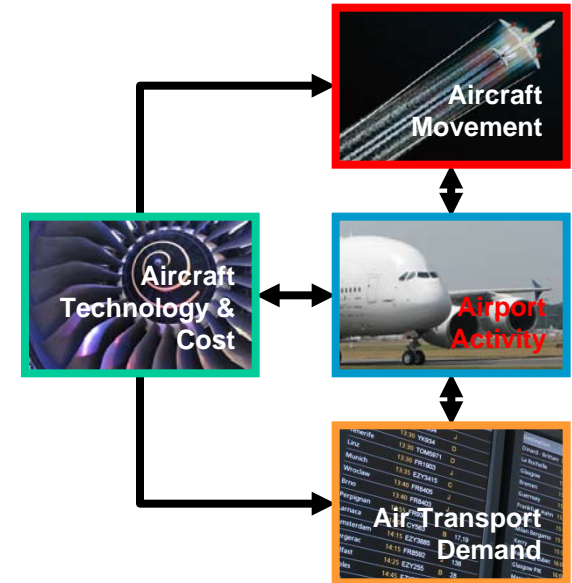


Goals

- Generate flight schedules
- Predict delay and LTO emissions

Methodology

- Flight routing and scheduling modelled according to forecast passenger demand
 - Routing network scaled from base year
 - Proportion of flights of each aircraft type estimated using a multinomial logit regression
 - Flight frequencies applying estimated base year load factors
- Flight delay modelled using queuing theory
- LTO emissions estimated according to schedule, delays, and engine emission rates

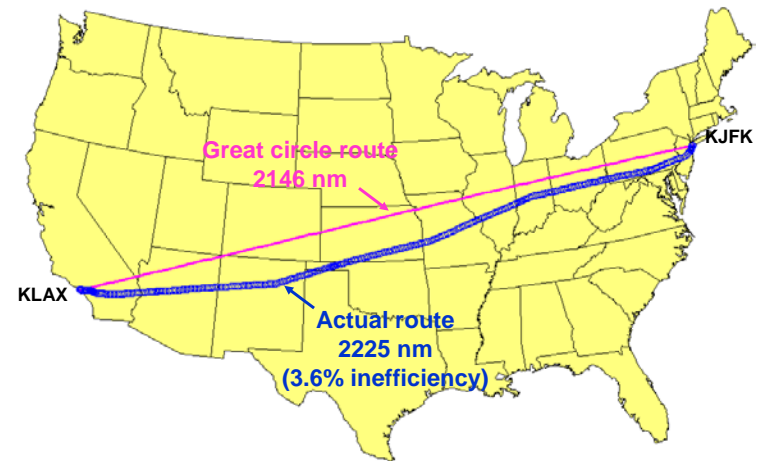
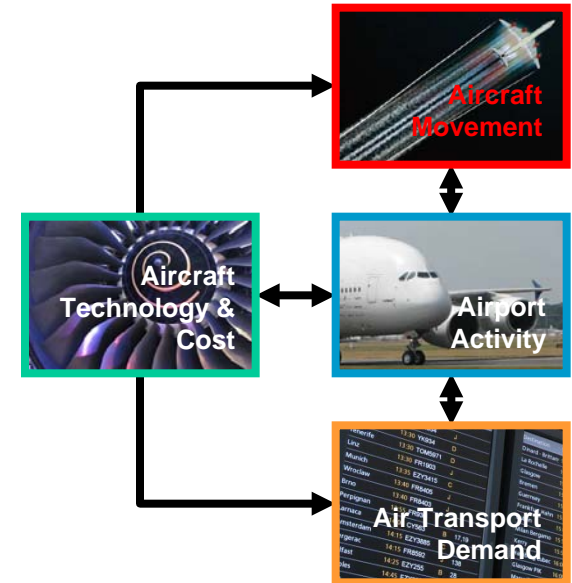


Goals

- Simulate the location of emissions release from aircraft in flight, accounting for ATM inefficiencies

Methodology

- Calculate optimal routes between given city pairs, e.g. great circle
- Add “inefficiency factors” to account for air traffic control



- **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**

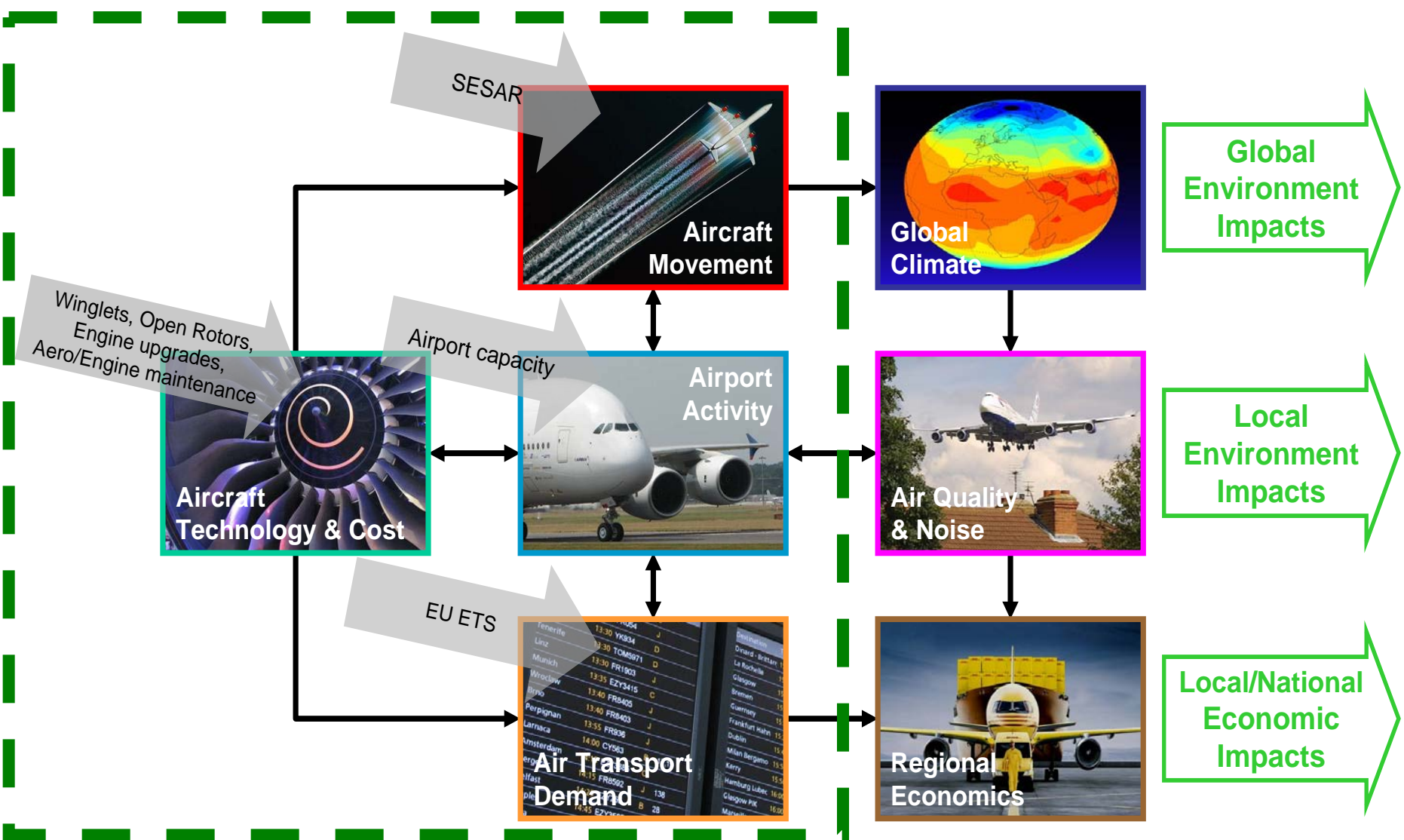
- Omega Project 41, “Opportunities for Reducing Aviation-Related GHG Emissions – a Systems Analysis for Europe”
- Use modular AIM structure to interface with the results of other Omega projects
- Goals:
 - Investigate interaction between different technological, operational and economic CO₂ emission 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:

- Marginal Abatement Costs
- Fleet Turnover
- Climate-related ATM
- Airspace Charging
- Sustainable Fuels
- EU ETS

Aviation Integrated Model (Cambridge)

Scenario inputs for future population, GDP, carbon/oil price (CCSP)

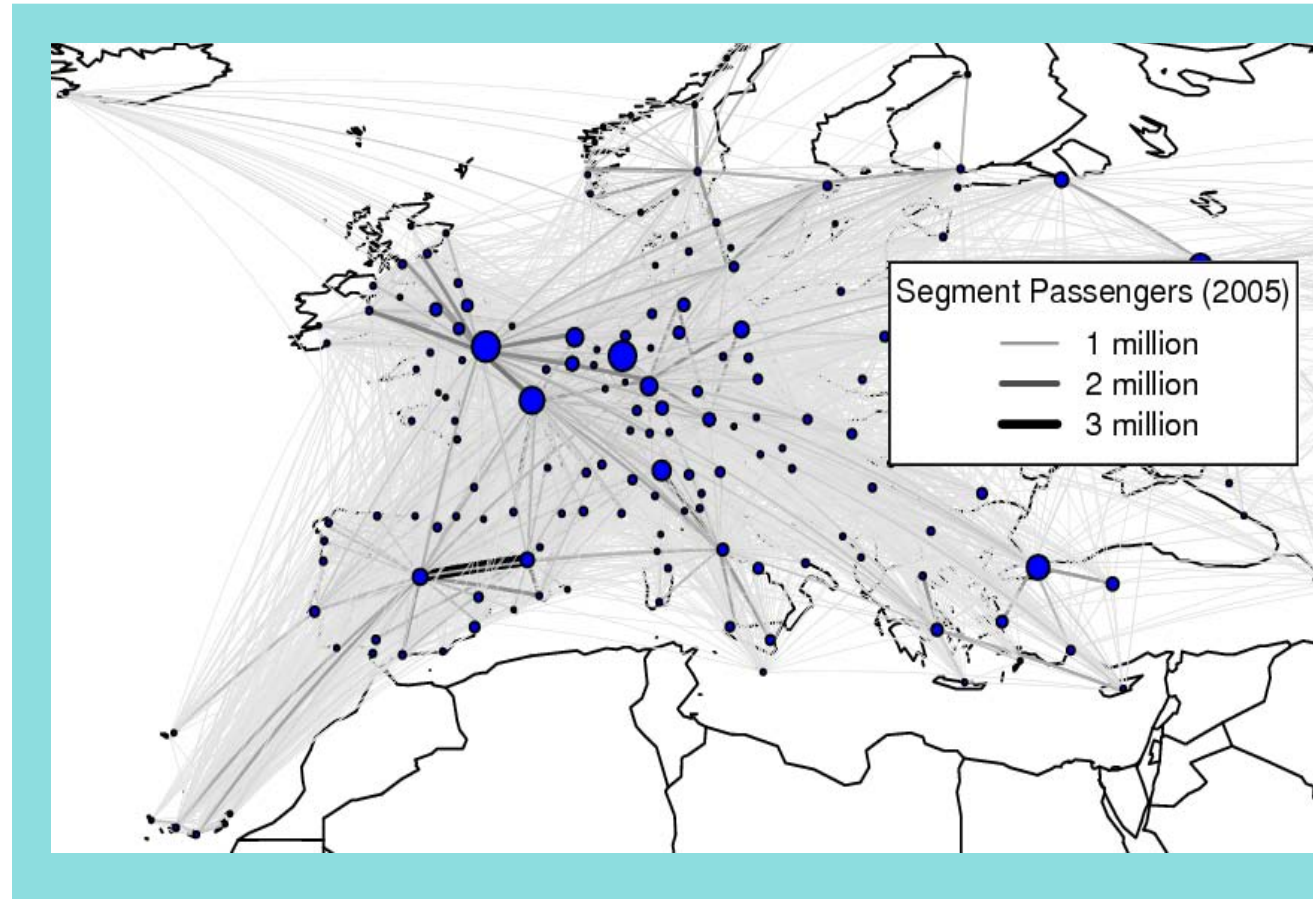


Future Scenarios
(CCSP 2007):

IGSM: High GDP growth, high oil price

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

MiniCAM: low GDP growth, low oil price



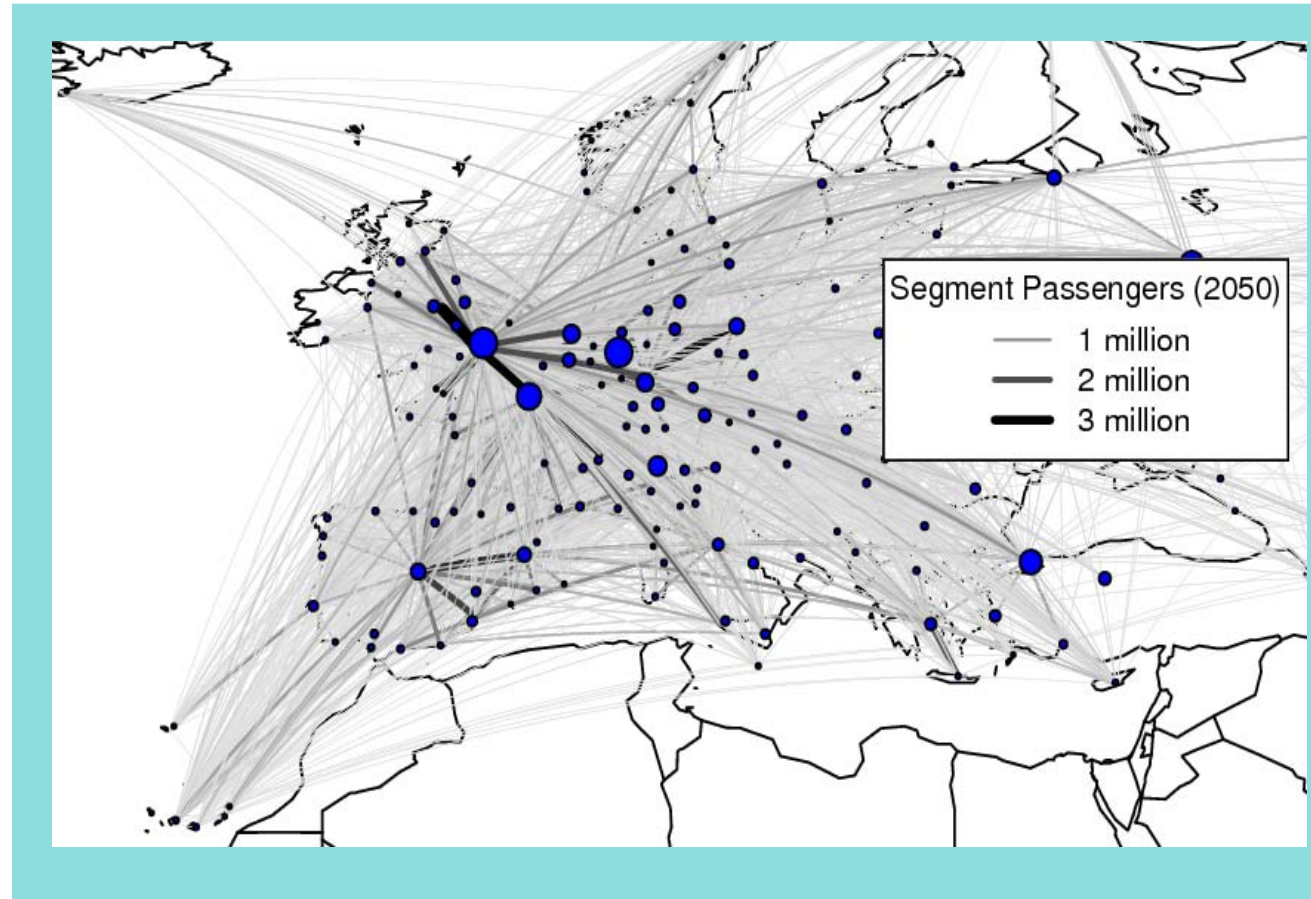
MERGE 2005

Future Scenarios
(CCSP 2007):

IGSM: High GDP growth, high oil price

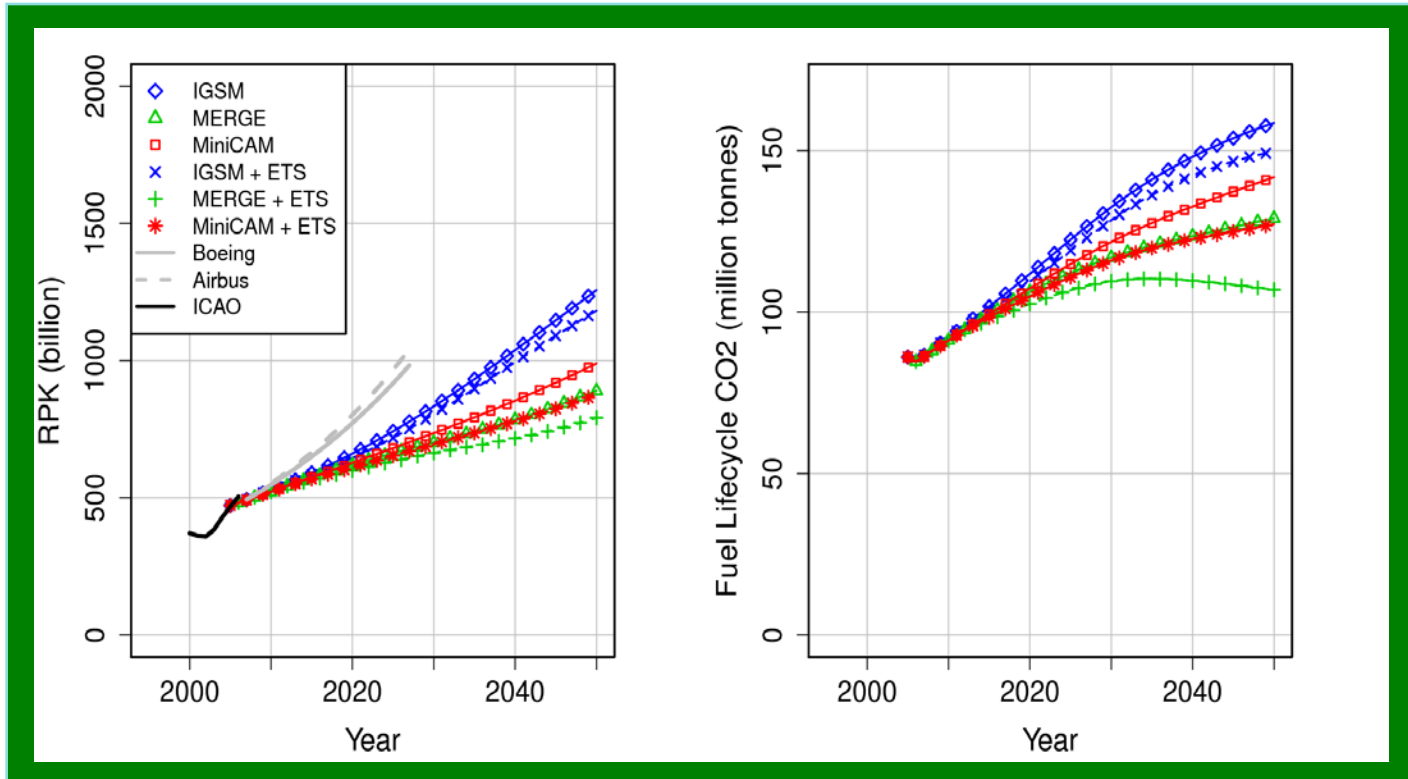
MERGE: medium GDP growth and oil price, higher carbon price

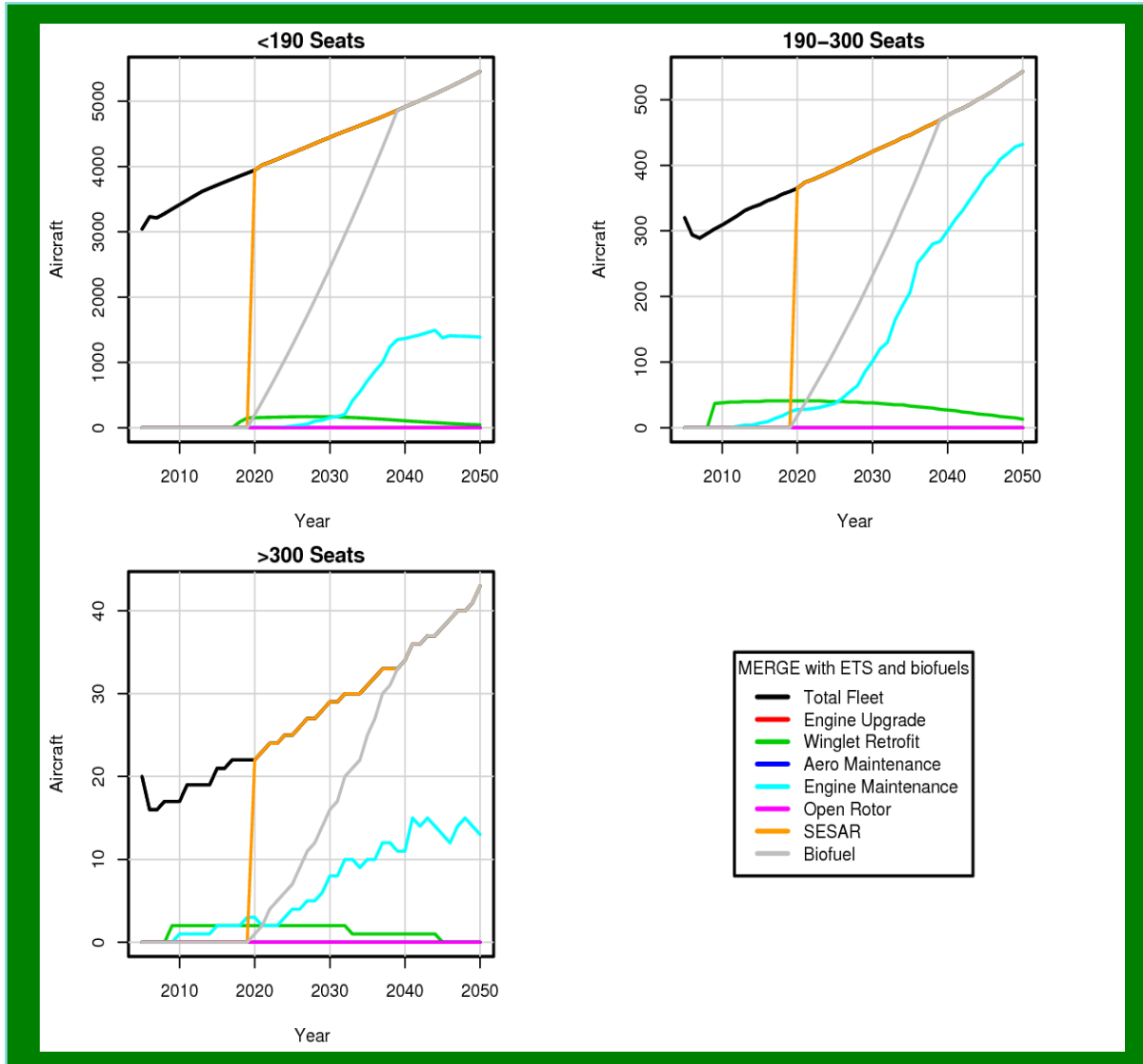
MiniCAM: low GDP growth, low oil price



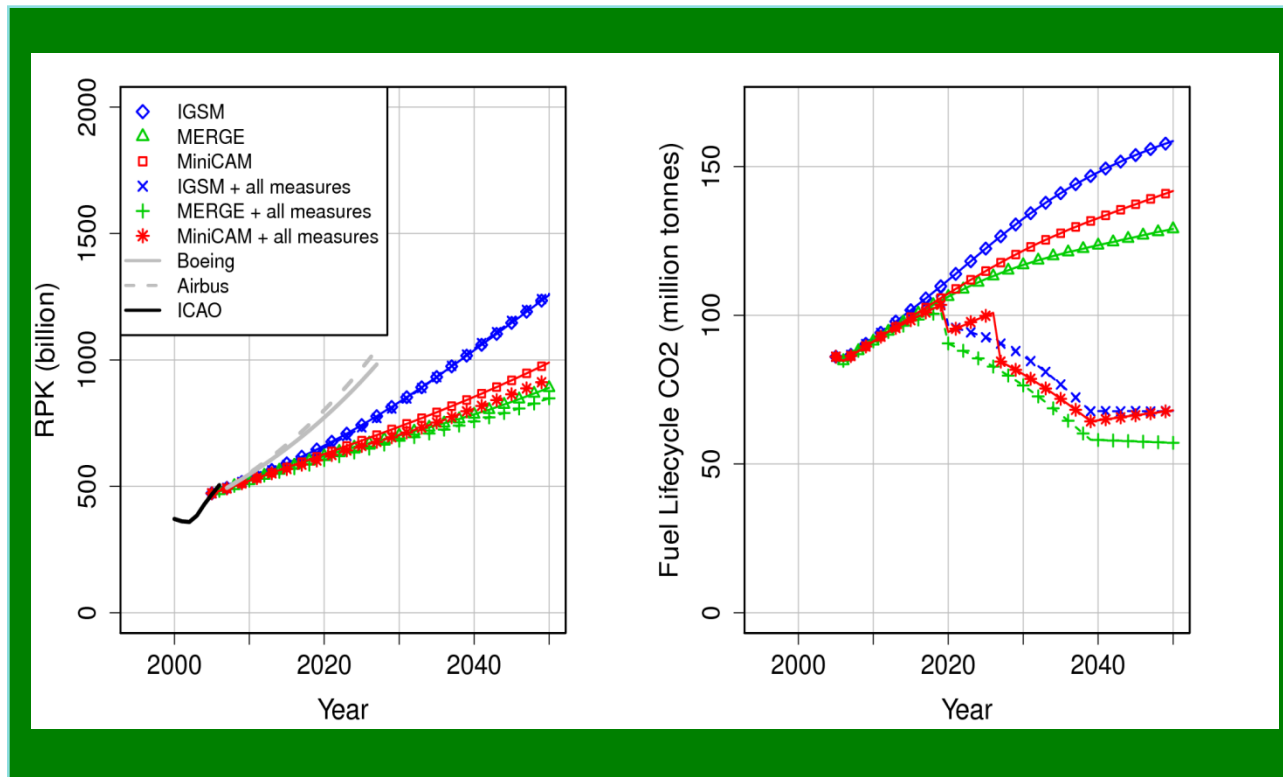
MERGE 2050

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





- 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?

Core team:

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- Dr. Lynnette Dray (*Air Transport Demand*)
- Antony Evans (*Airport Activity*)
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- Dr. Maria Vera Morales (*Aircraft Technology and Cost*)

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

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- 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*)