



Modelling Environmental & Economic Impacts of Aviation

Introducing the Aviation Integrated Modelling Project

7th AIAA Aviation Technology, Integration
and Operations Conference, Belfast
18-20 September 2007

- Global air transportation system continues to grow
- System is large, complex and multi-disciplinary involving numerous stakeholders with different agendas
- Range of future trends
 - ❑ Developing regions
 - ❑ Developing sectors
 - ❑ 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



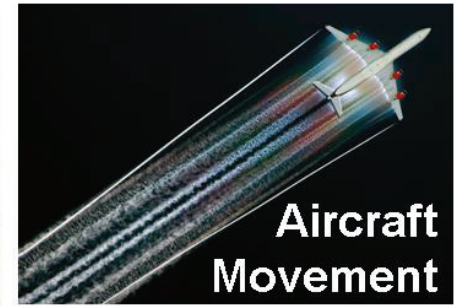
Aircraft Technology & Cost



Air Transport Demand



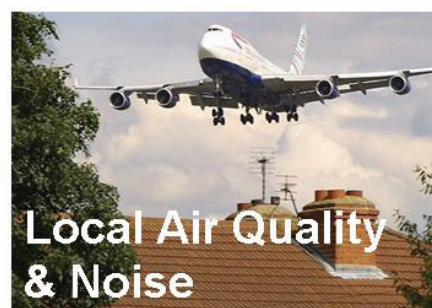
Airport Activity



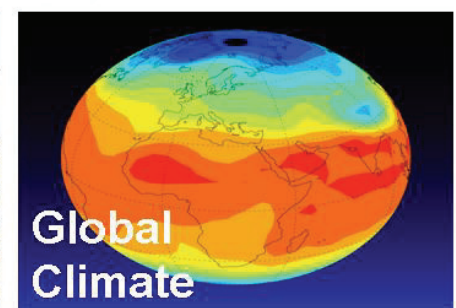
Aircraft Movement



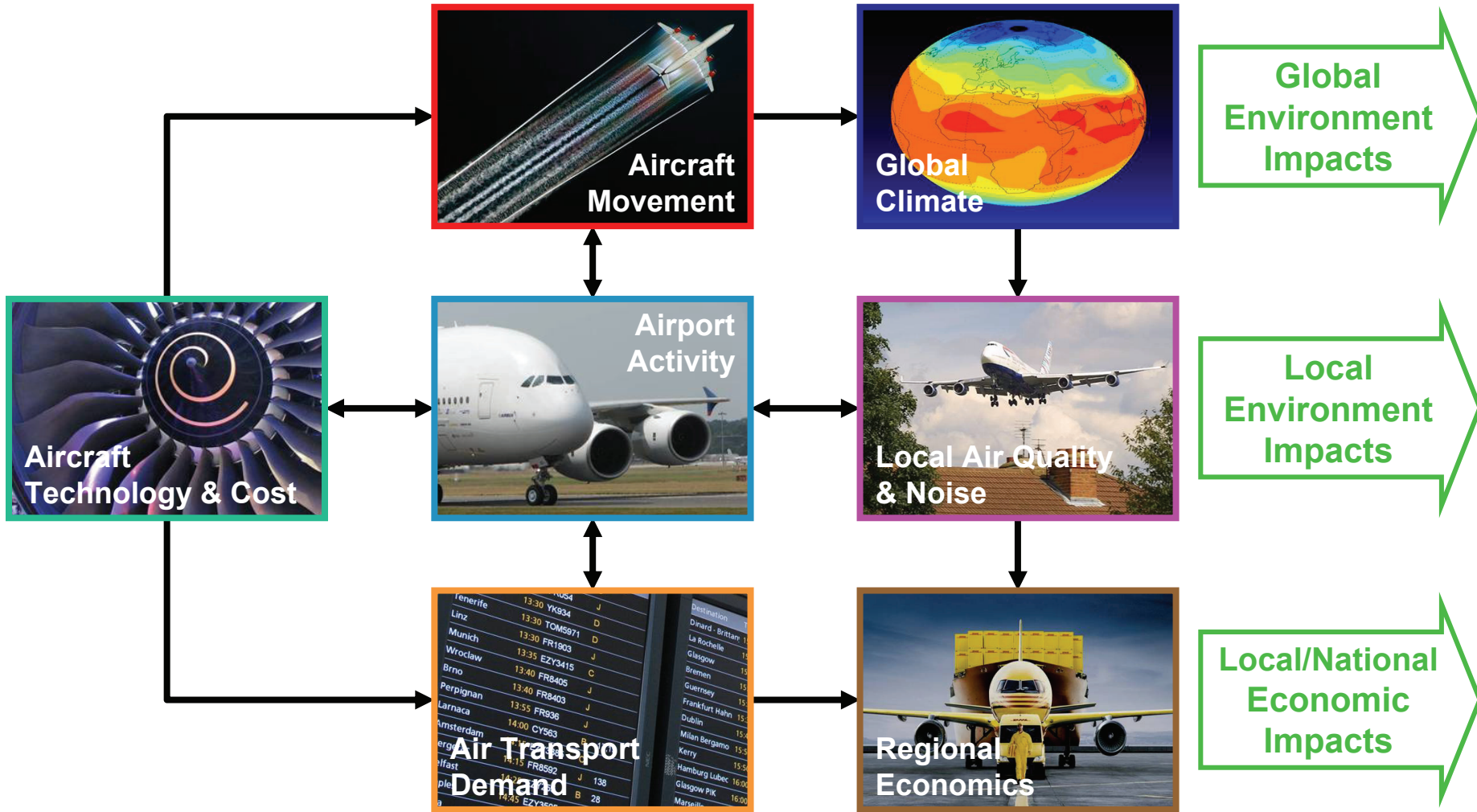
Regional Economics



Local Air Quality & Noise



Global Climate



- **Integration**

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

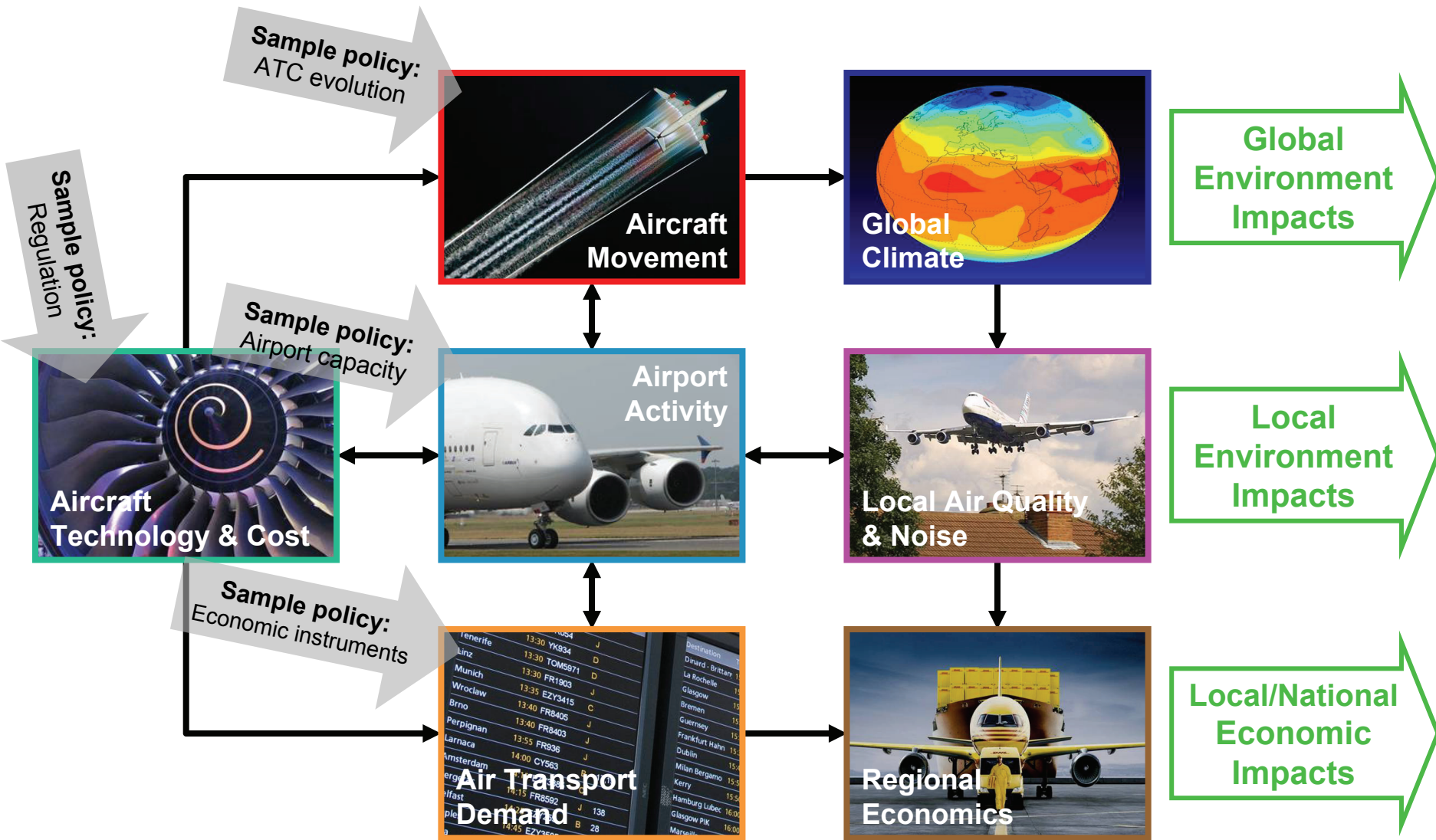
- **Modularity**

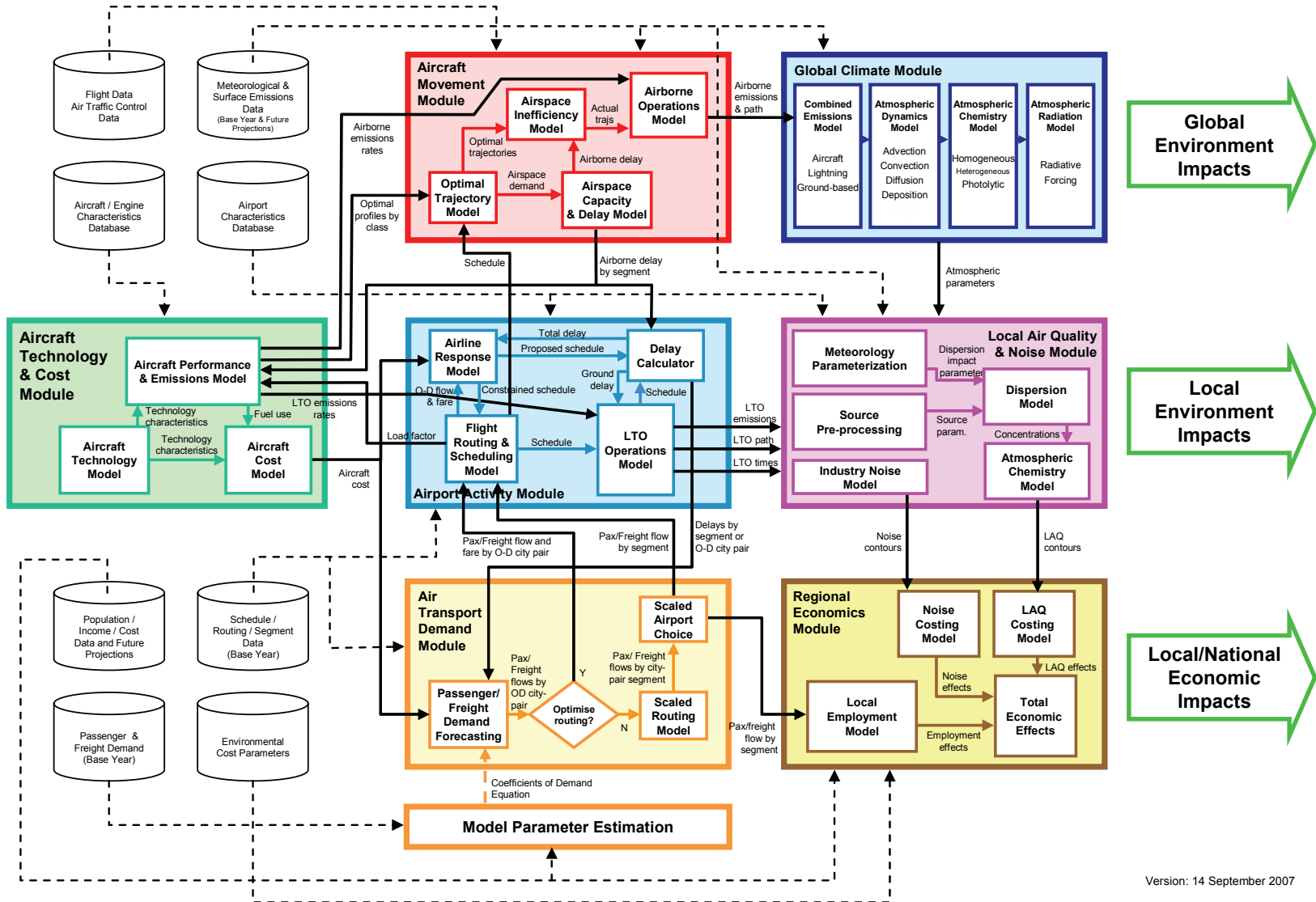
- Resolution of modules tailored to application
- Subset of modules run independently
- Substitution of models from other groups

- **Extendability**

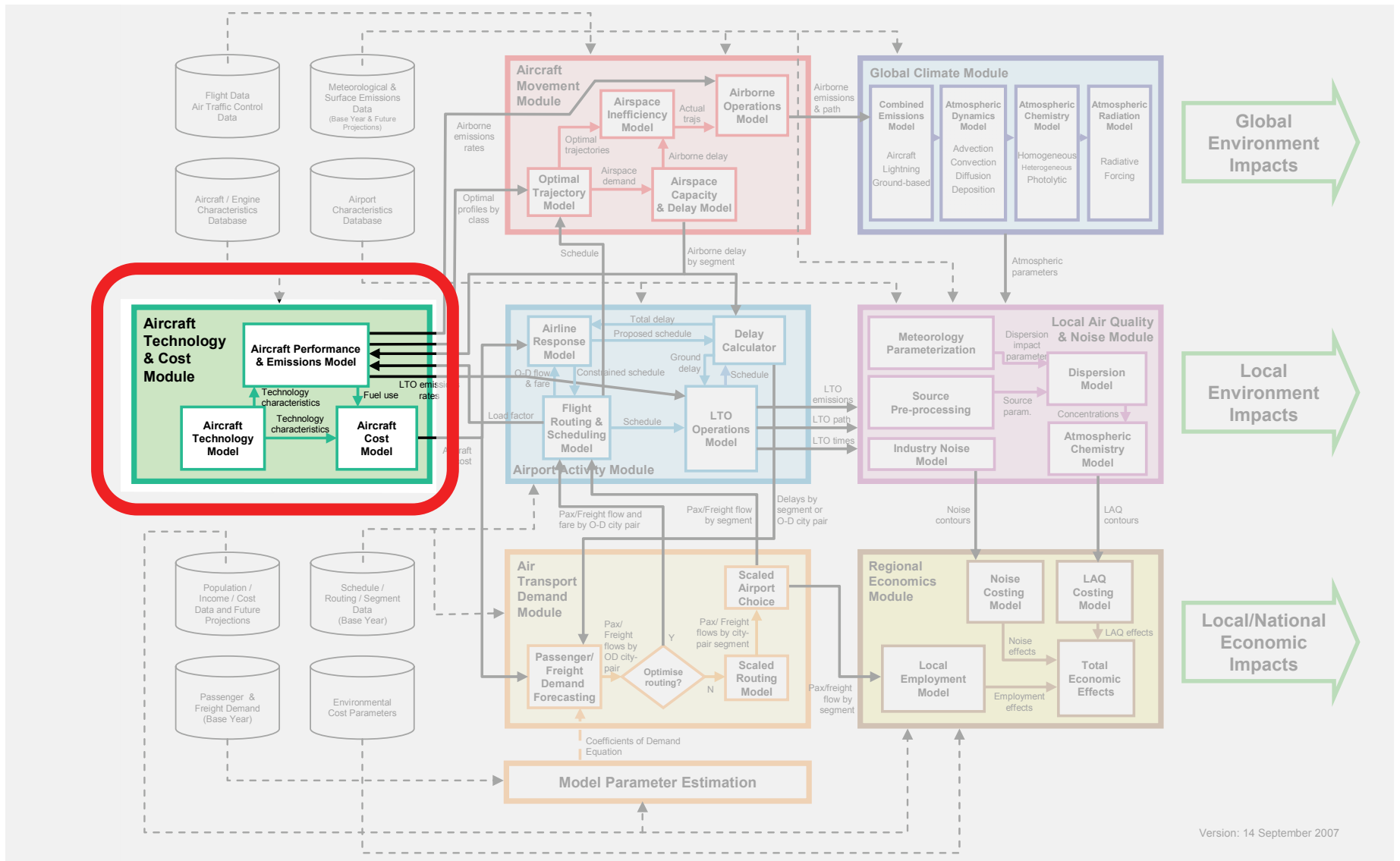
- Natural expansion in sophistication or number of modules

- **Policy assessment potential**



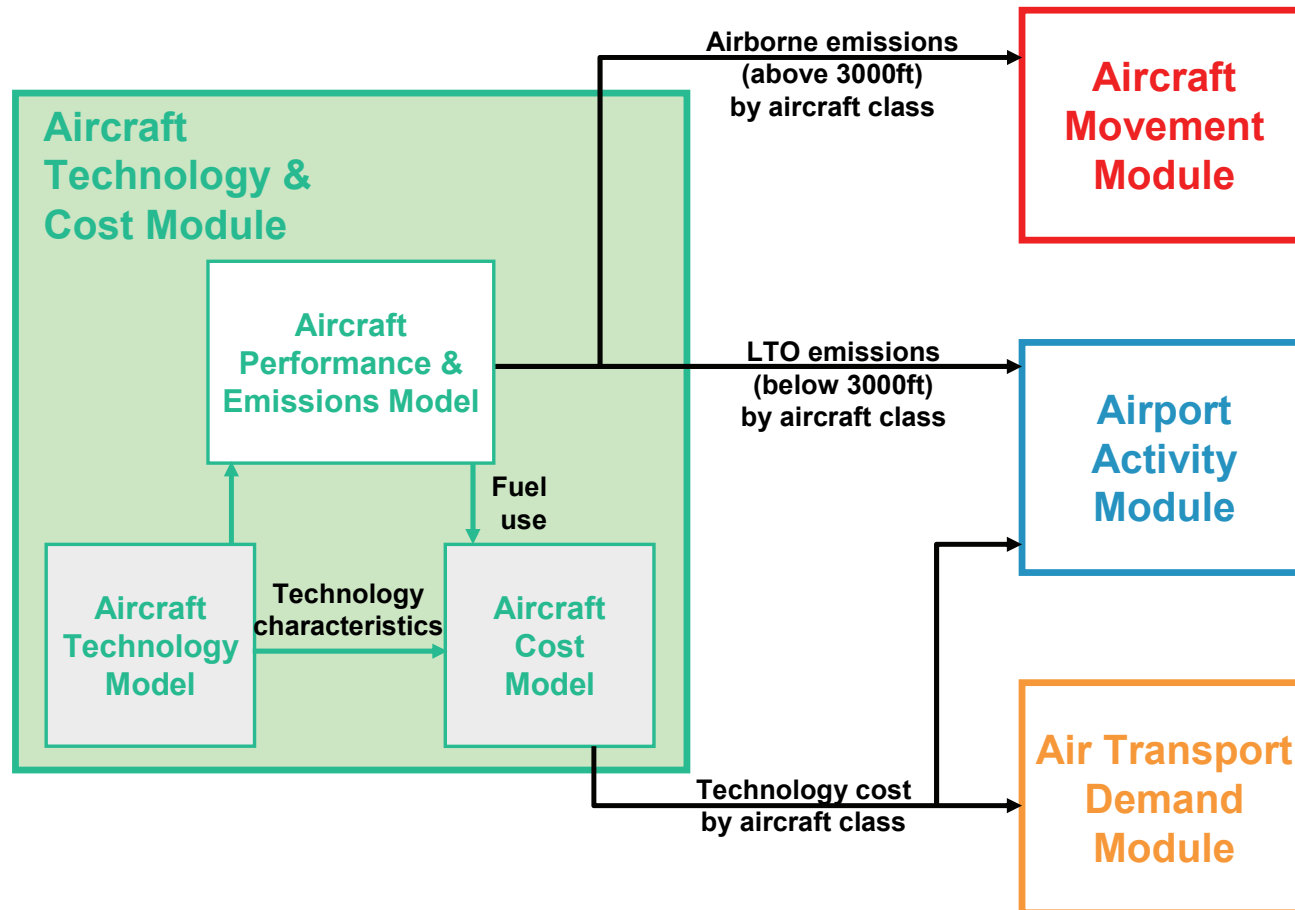


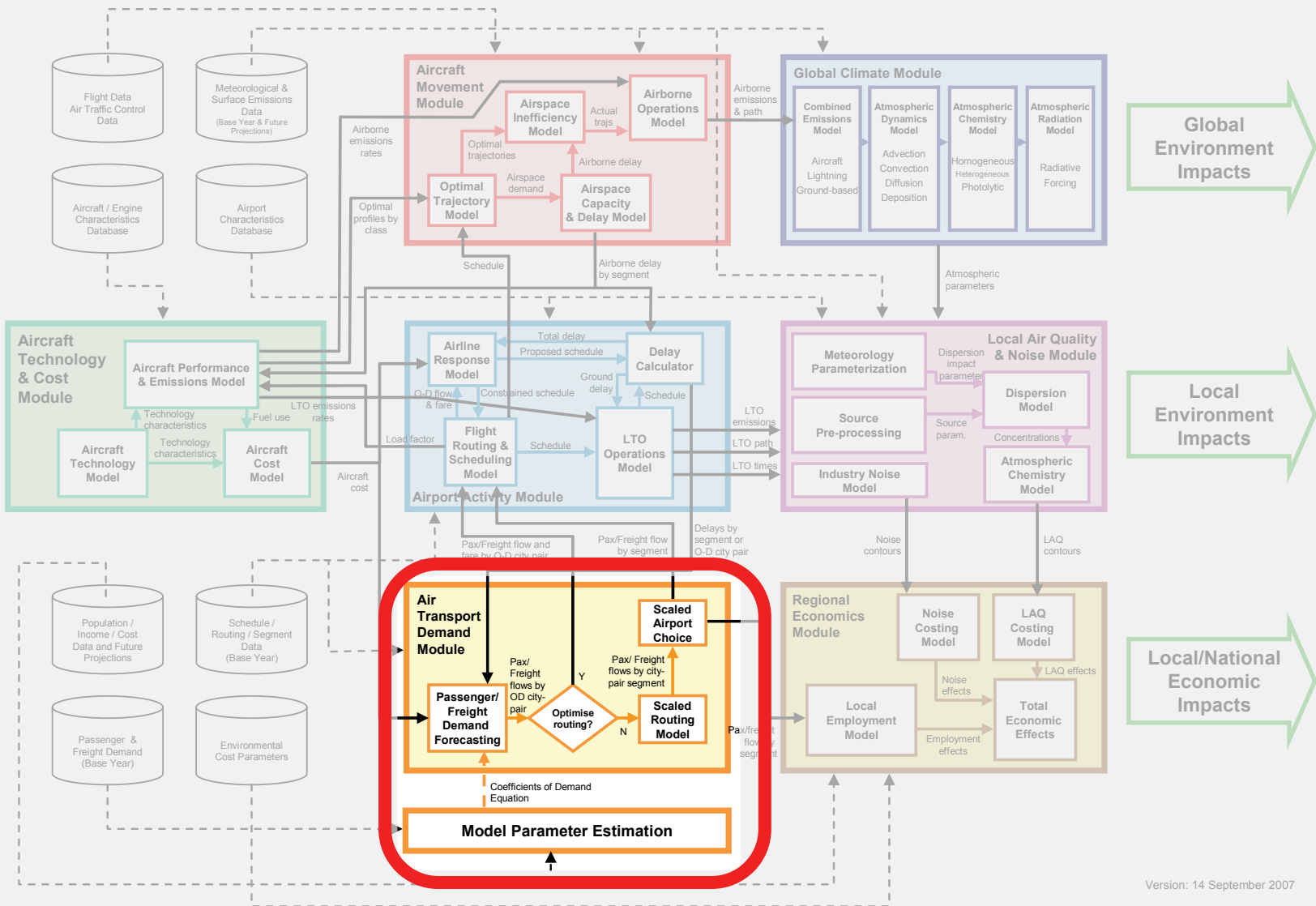
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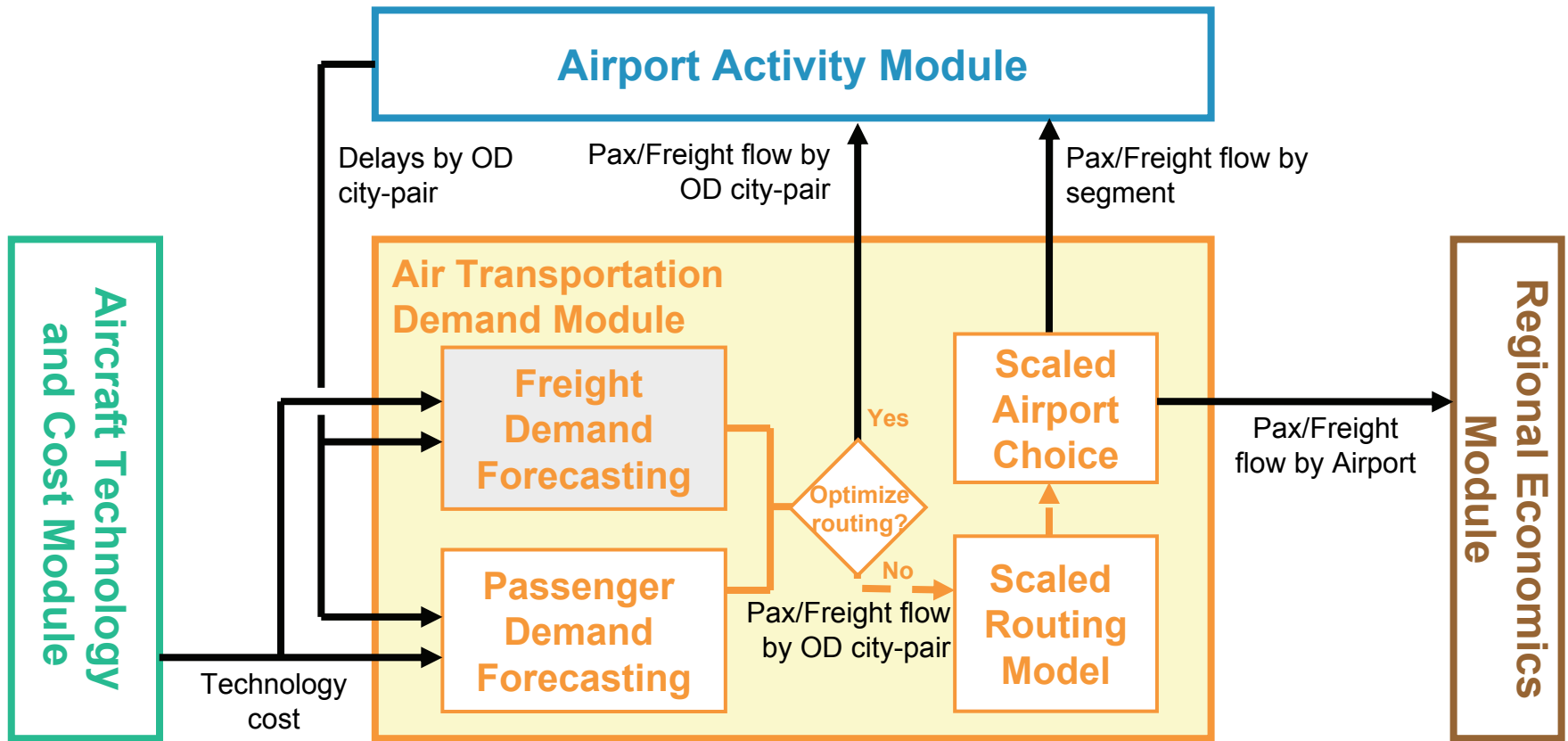
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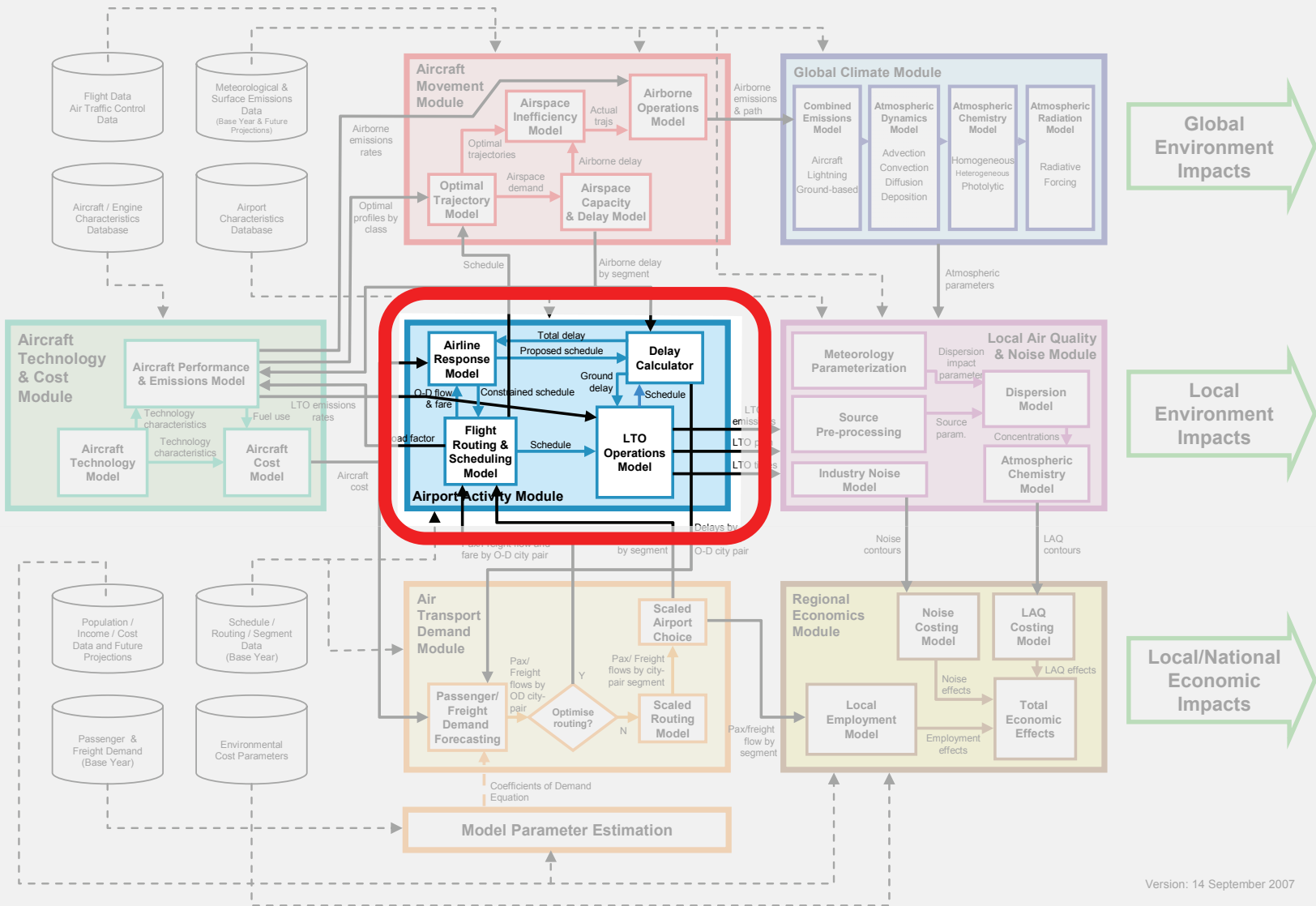
- **Goal:** Model aircraft performance, fuel use, emissions and operating costs for different technologies



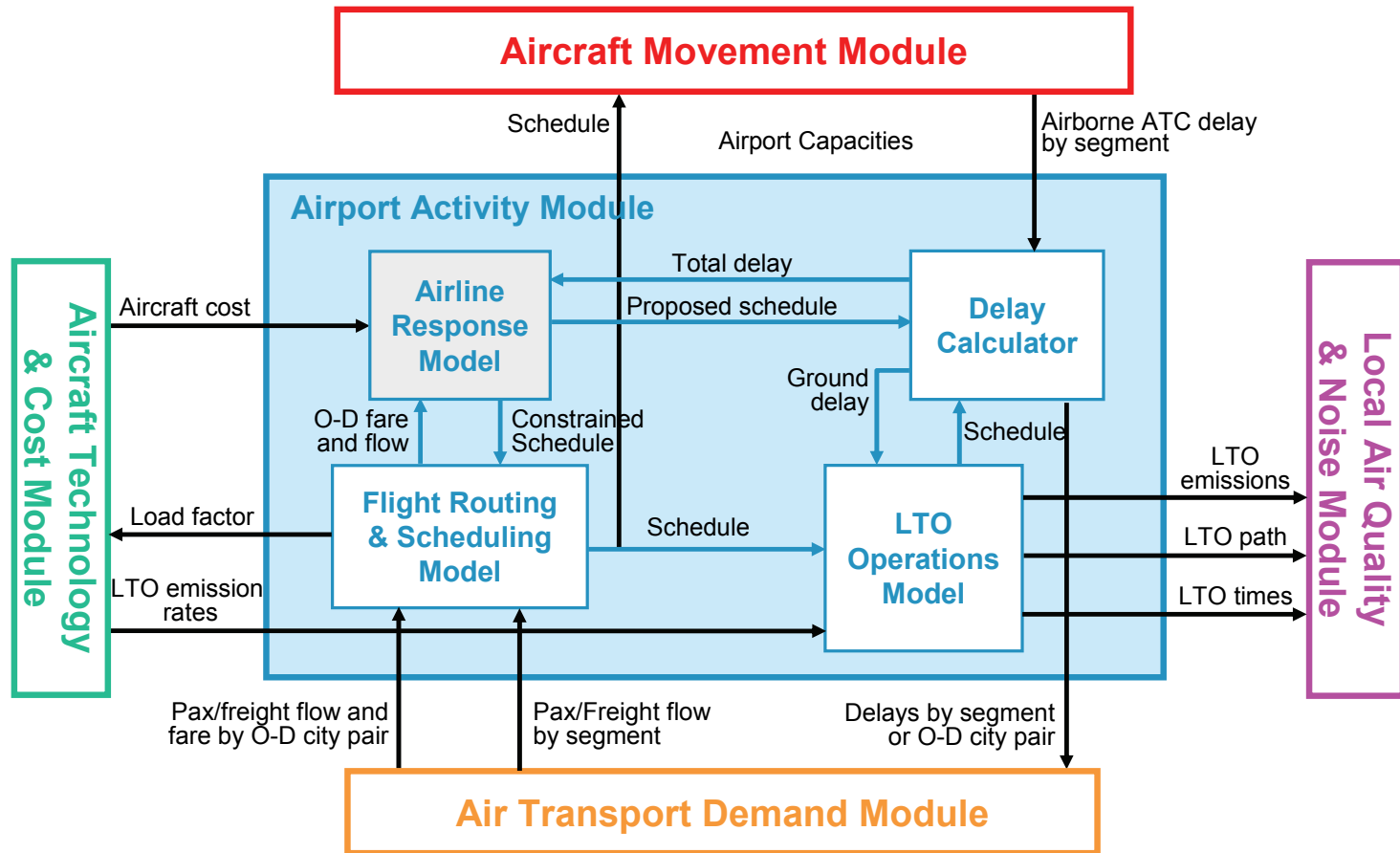


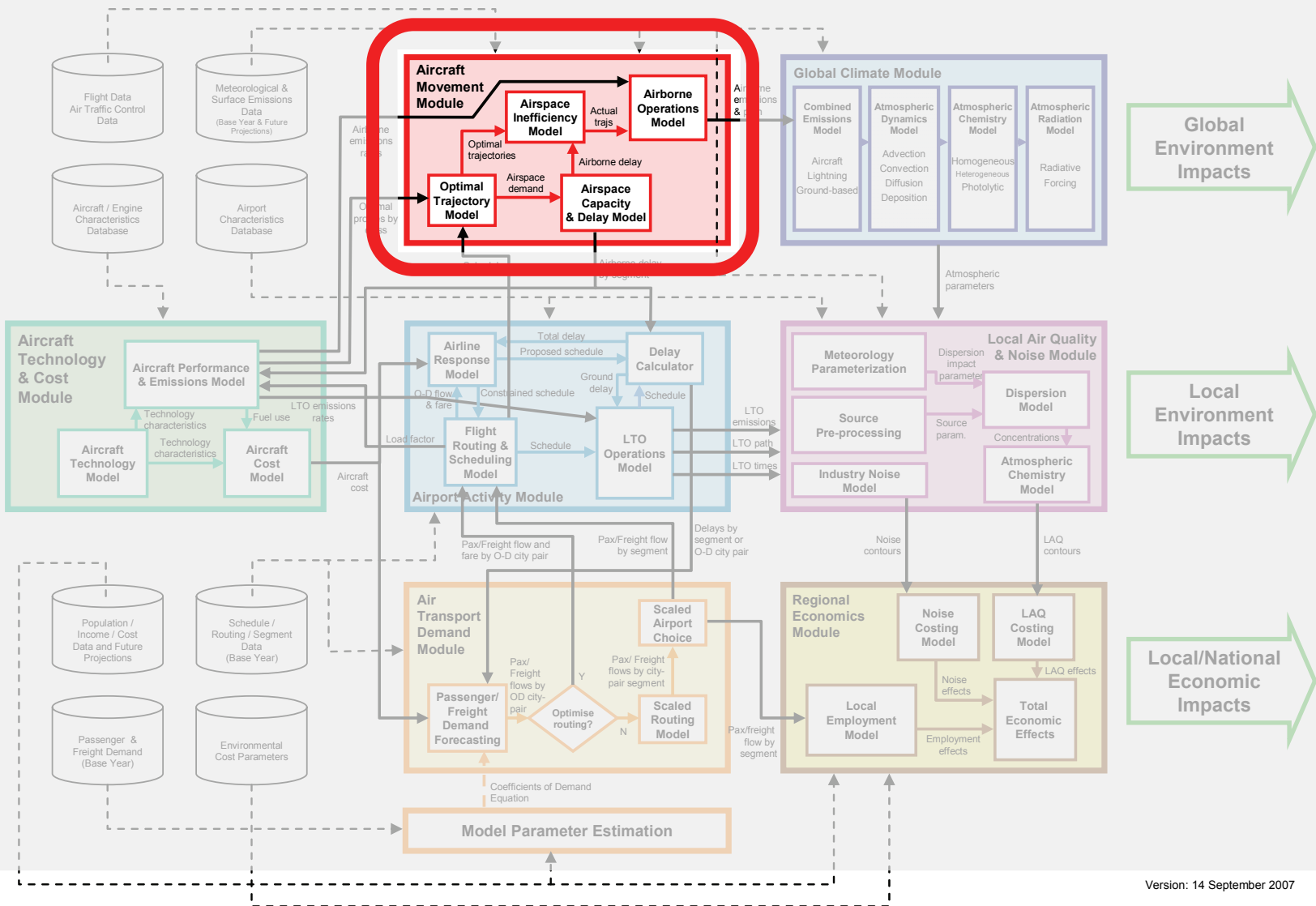
- Goal:** Forecast future passenger & freight demand for air travel between global origin-destination city-pairs



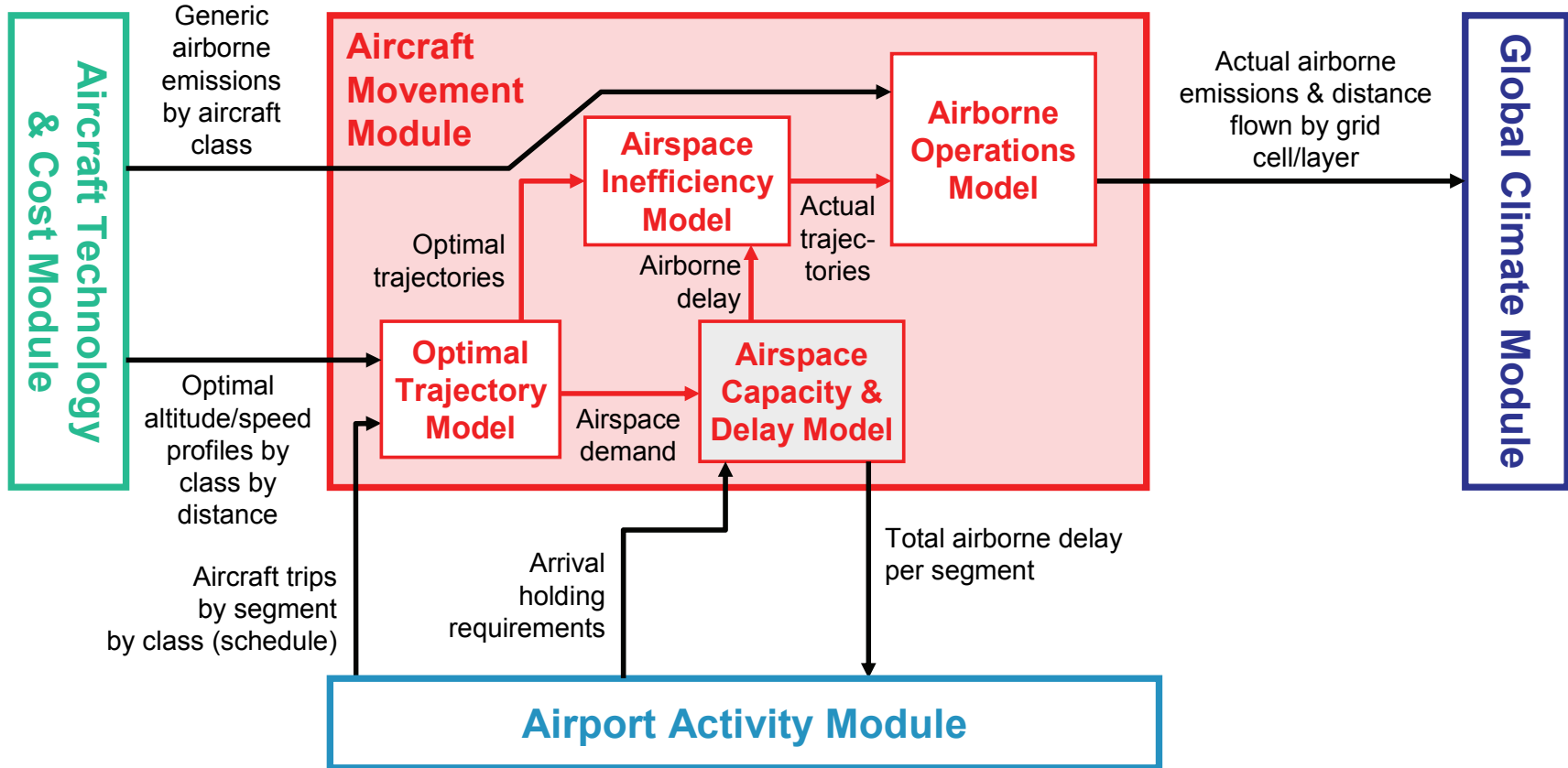


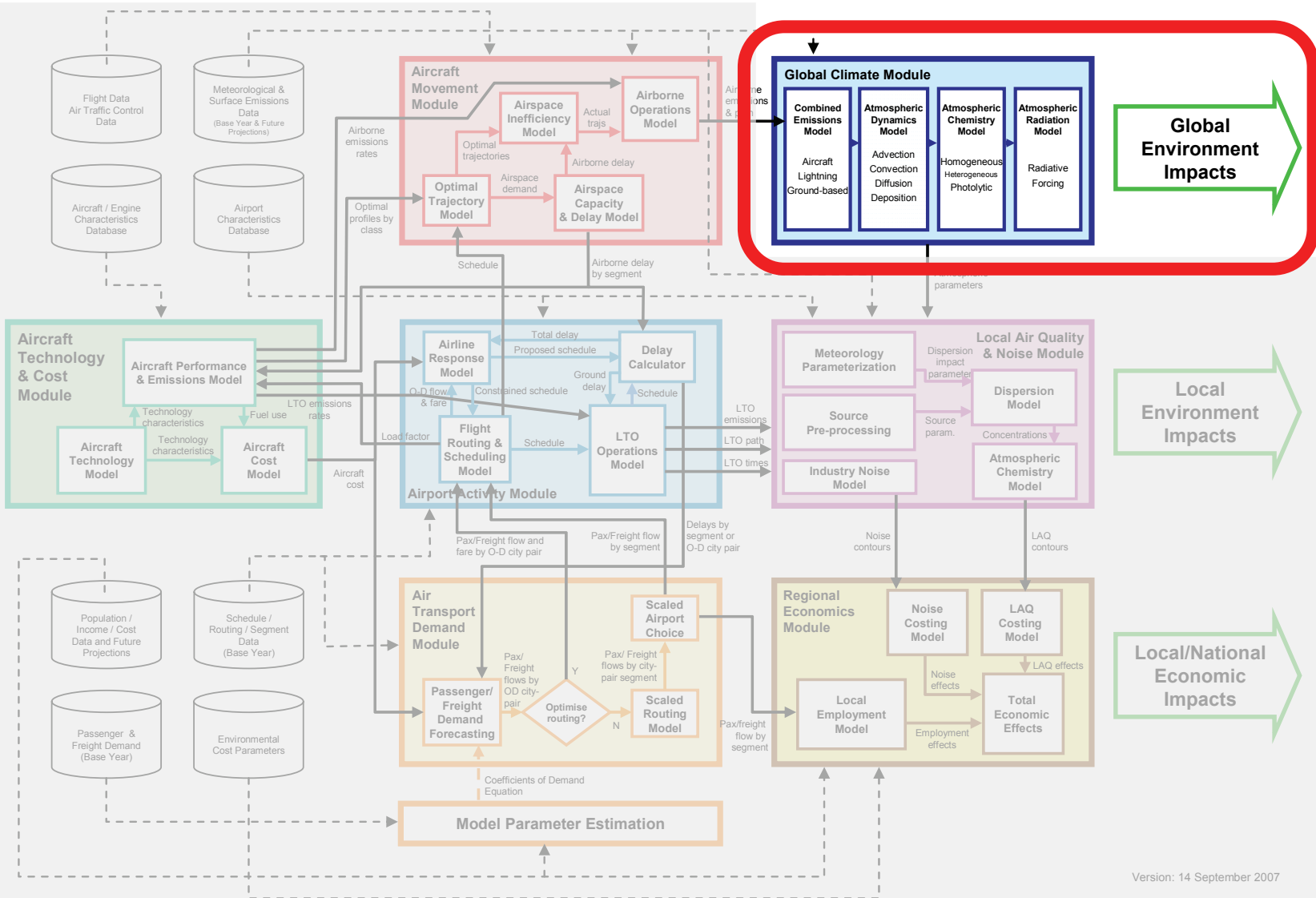
- Goals:** Forecast air traffic growth as function of demand; and airport operations/congestion as function of air traffic



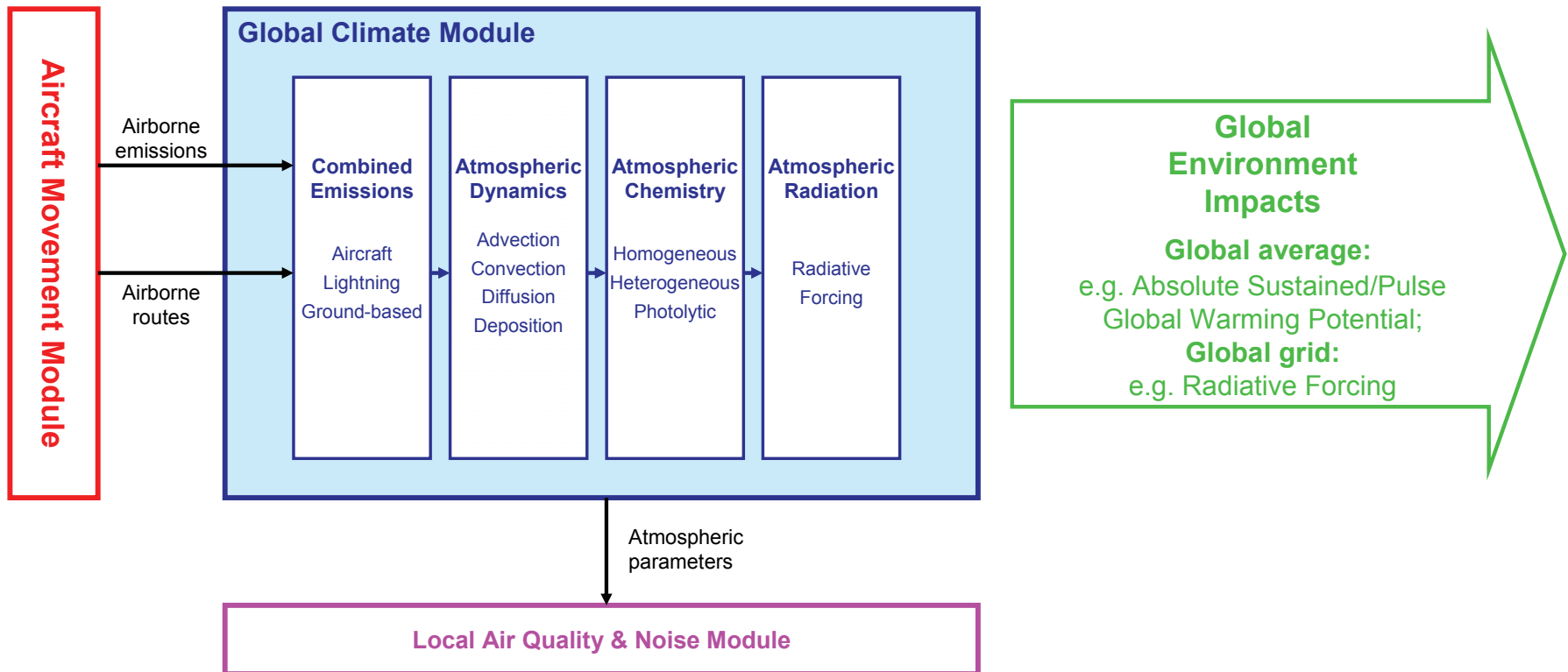


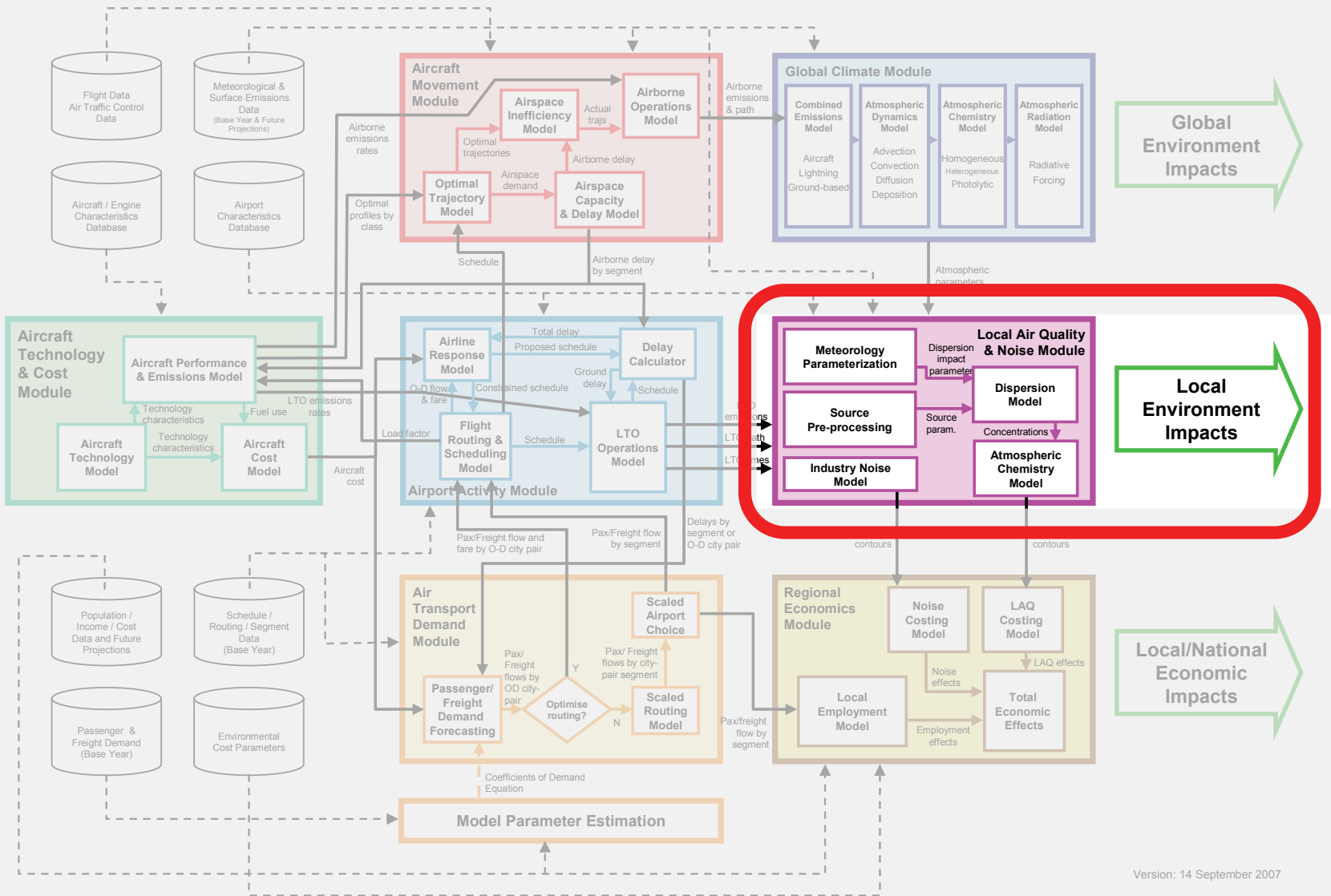
- Goals:** Identify location of emissions released from aircraft in flight; Predict airborne delay characteristics



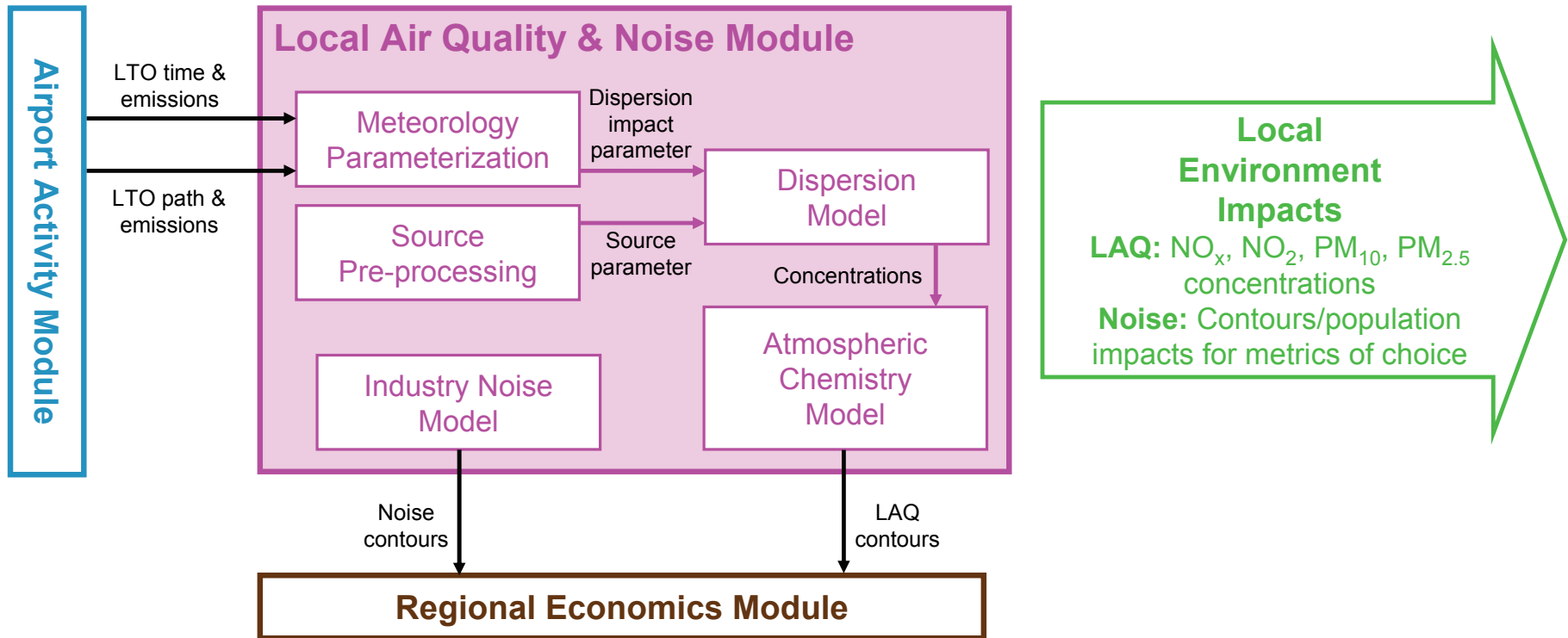


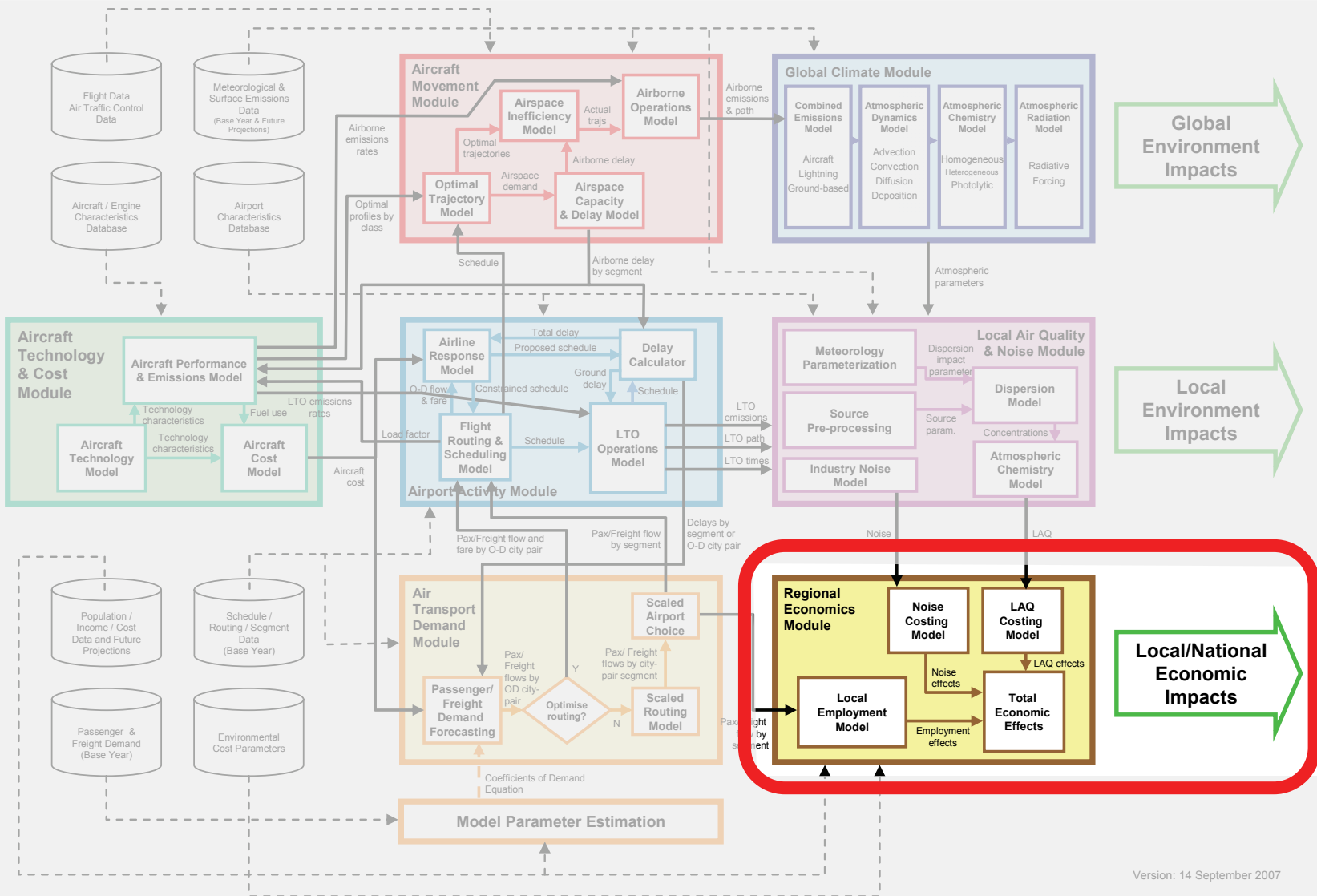
- Goals:** Determine impact of aircraft emissions on the global climate system (CO_2 , NO_x , SO_x , H_2O)



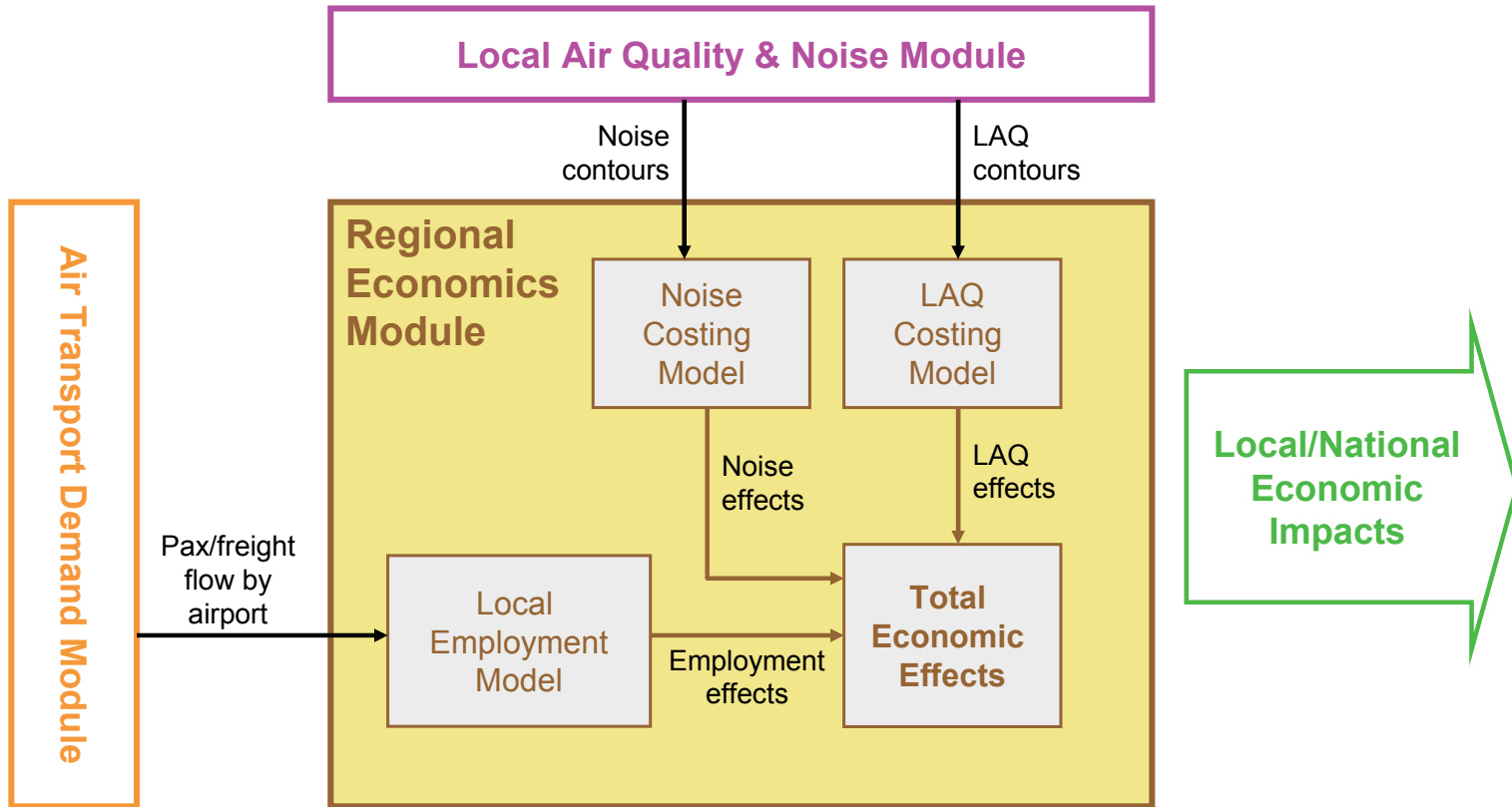


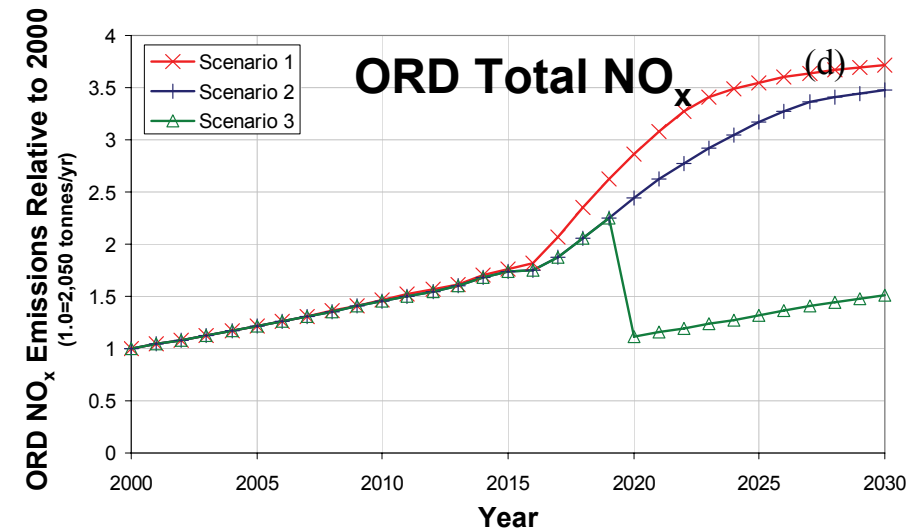
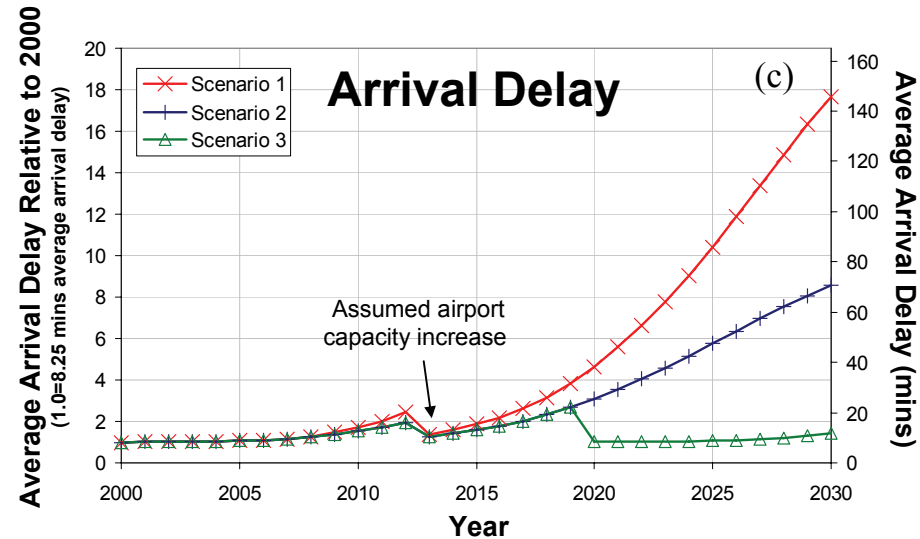
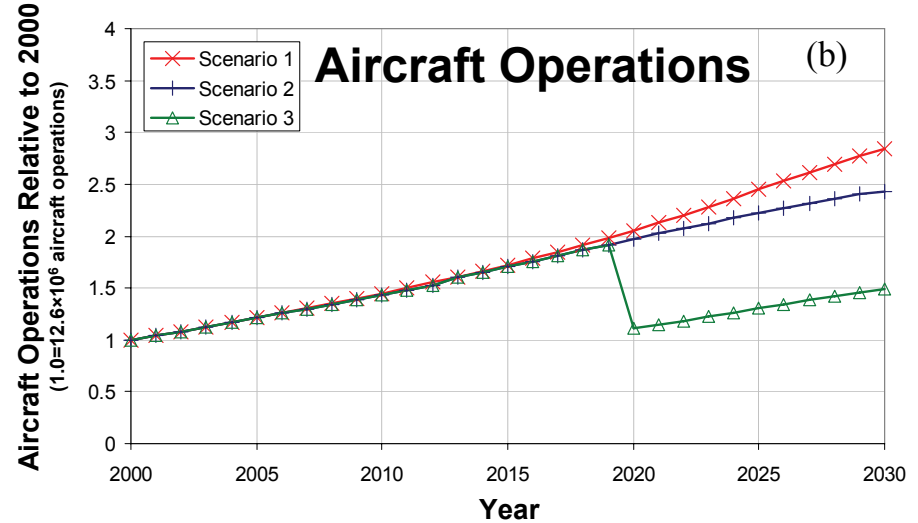
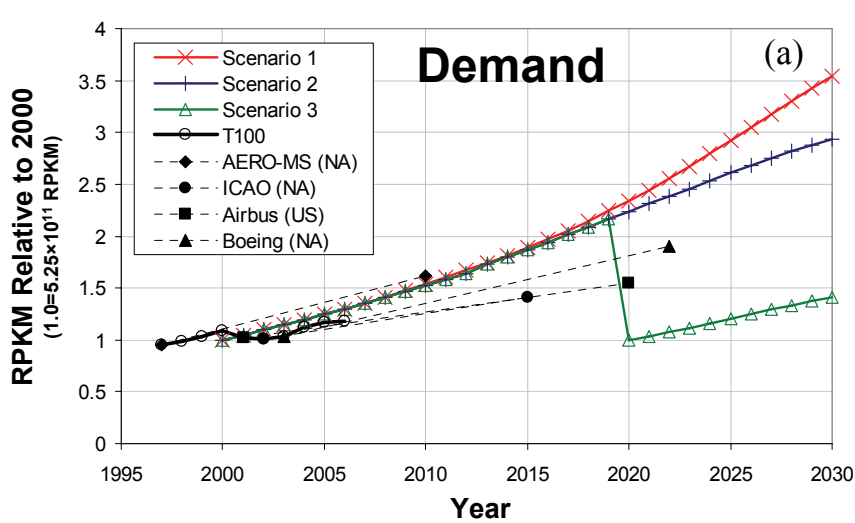
- Goals:** Investigate dispersion of critical pollutants (NO_x , PM, O_3) and noise impacts in airport vicinity



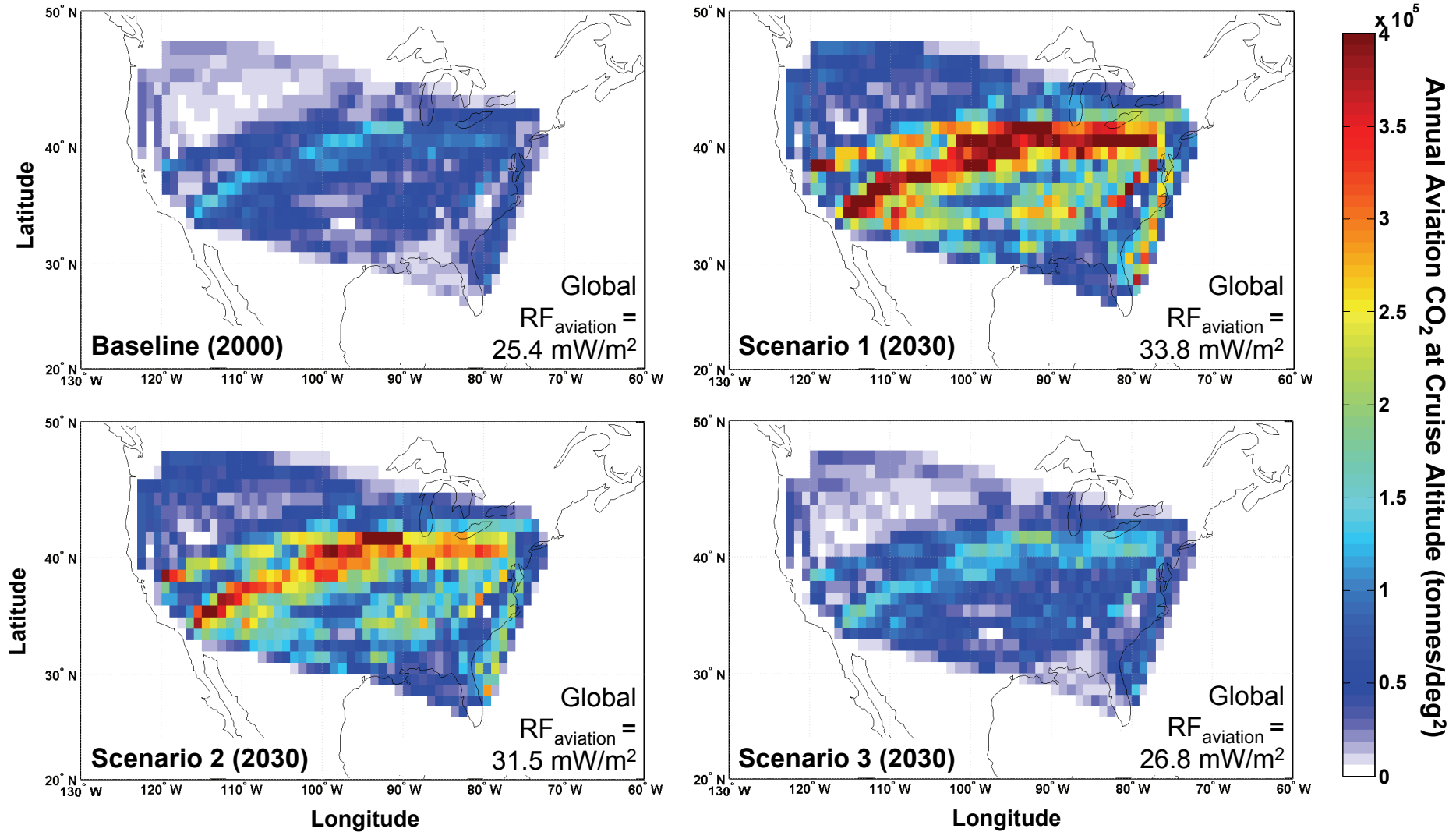


- Goals:** Quantify positive and negative economic effects of air transport activity on surrounding regions

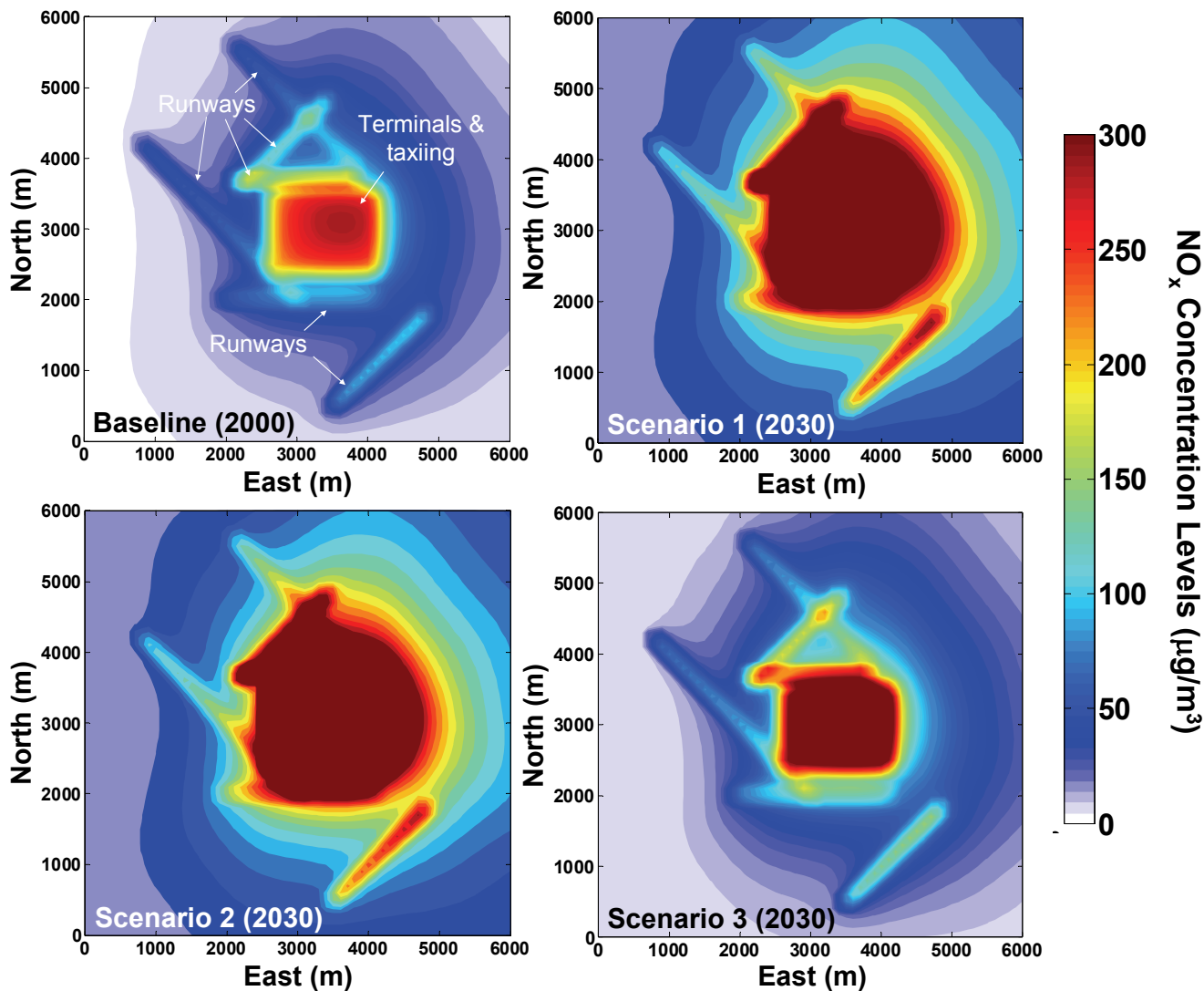




- Importance of feedback of delay effects
 - 20% reduction in demand in 2030 with Scenario 2
 - 15% reduction in operations in 2030 with Sc. 2
 - Less than demand reduction: higher proportion of smaller aircraft
 - 50% reduction in average arrival delay in 2030 with Sc. 2
 - Highly non-linear behaviour of delay with operations, especially when close to capacity
- Policy 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 policy introduction



- 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
 - Evidence of emissions increase in Scenario 3
 - Demand creeps back 10 years after introduction of policy
- Global radiative forcing perturbation analysis shows similar trends
 - Scenario 1 up 8.4 mW/m² by 2030, Scenario 2 up 6.1 mW/m², Scenario 3 up 1.4 mW/m² relative to baseline 25.4 mW/m² in 2000



- Rapidity of LAQ algorithm allows a large number of airports to be modelled – case study focus on ORD
 - NO_x 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 NO₂ regulations in Scenario 1 and 2
 - Policy measures may be required to avoid this
 - Emissions increase due to increased operations and delays, so capacity increases produce temporary improvement

- Modelling world passenger and freight demand
 - ❑ Focus on developing regions, e.g. S and E Asia
 - ❑ Business vs. leisure consideration
 - ❑ Passenger mode choice
- Airline response model
 - ❑ Capture effects of airline schedule/routing/fleet modification behaviors with changing operating environments
- Modelling of future aircraft/engine technologies and their likely introduction to system
 - ❑ Incremental designs: higher efficiency
 - ❑ Novel configurations: open rotor engines, blended wings
 - ❑ Alternative fuels

- AIM developing policy assessment tool for aviation, environment and economic effects
- Breadth and depth of model presented
- Case study results demonstrate utility of approach
- Future enhancements planned

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*)
- Zia Wadud (*Regional Economics*)

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- Prof. Bill Dawes (*Engineering*)
- Dr. Chez Hall (*Engineering*)
- Prof. Peter Haynes (*Applied Mathematics & Theoretical Physics*)
- Prof. Roderic Jones (*Chemistry*)
- Dr. Jonathan Köhler (*Economy*)
- Prof. John Pyle (*Chemistry*)
- Dr. Helen Rogers (*Applied Mathematics & Theoretical Physics*)

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