

CONSAVE 2050 and the AERO model

Jan Middel

Air Transport & Environmental Policies

National Aerospace Laboratory NLR



AERO model

- **What is it designed for**
 - Policy analysis tool
 - Aviation Emissions and Evaluation of Reduction Options
- **What is it about**
 - World wide coverage, (IATA regional + EC countries)
 - Testing (regional) measures on impact, effectiveness, efficiency
 - Emissions, costs, economics, fleet built-up etc.
- **How does it do it**
 - Base case calibrated
 - Datum case with 'autonomous' scenarios
 - Forecast case with measures
 - Assessment and Comparison



AERO model scenario features

- **Demographic scenarios**
- **Macro economic scenarios**
- **Transport market**
- **Technological development scenarios**

- **Scenarios = developments as a function of:**
 - Time, Regions, Traffic types, AC size, (others)



AERO model

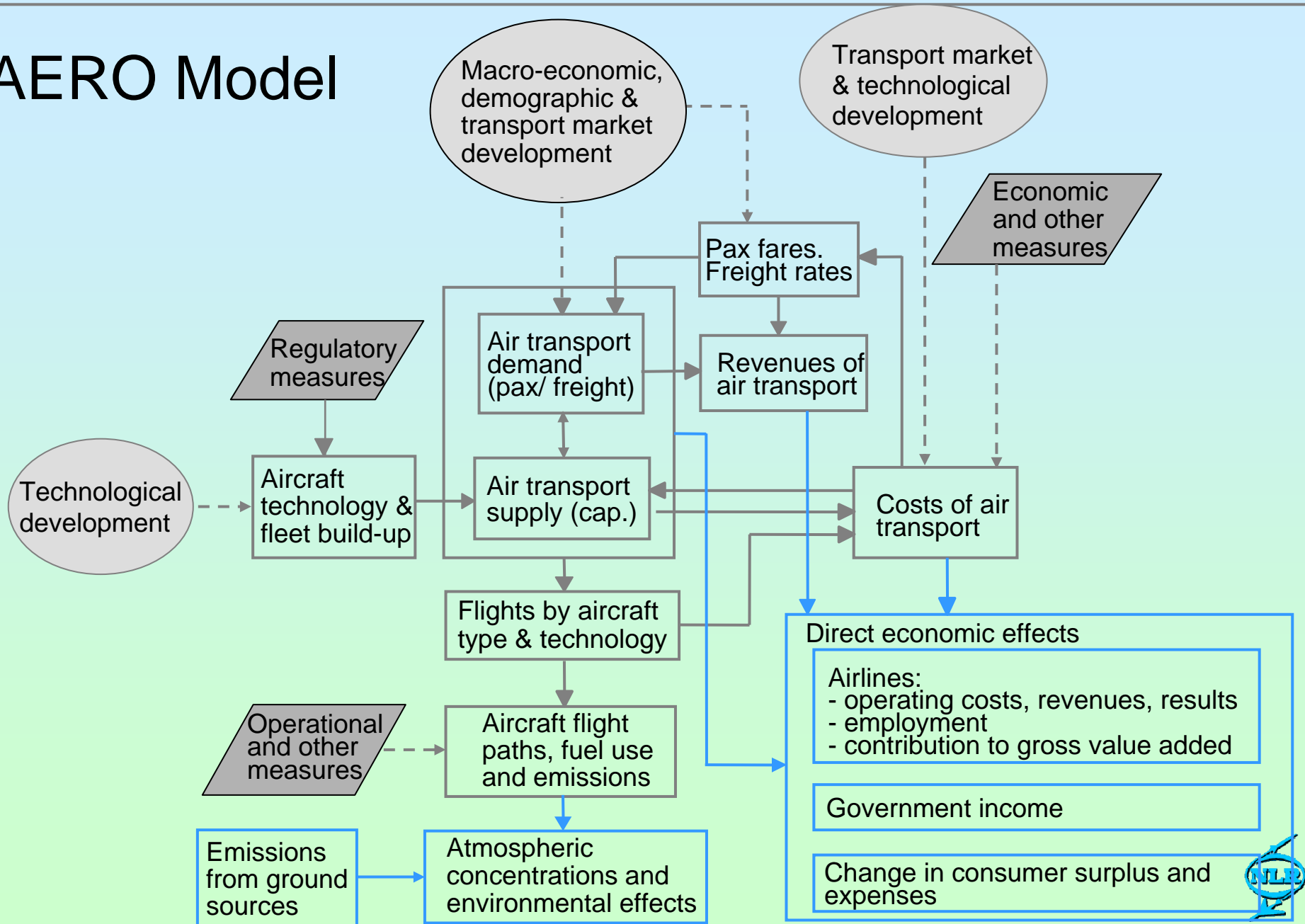
- **Base**
 - 1992 (fully), 1998 (partially) calibrated
 - Transport data (volume, leisure/business/economy)
 - Flights (350 major cities, others aggregated to IATA region)
 - Economic data (per region, costs components, GDP/capita, population)
 - Fleet data (per region, fleet size & age, aircraft size & range, aircraft technology level)

- **Datum**
 - Air Transport Demand: Economic, demographic (IATA regional) scenarios
 - Aircraft Technology scenarios
 - Operating Costs developments
 - Fares adjustments

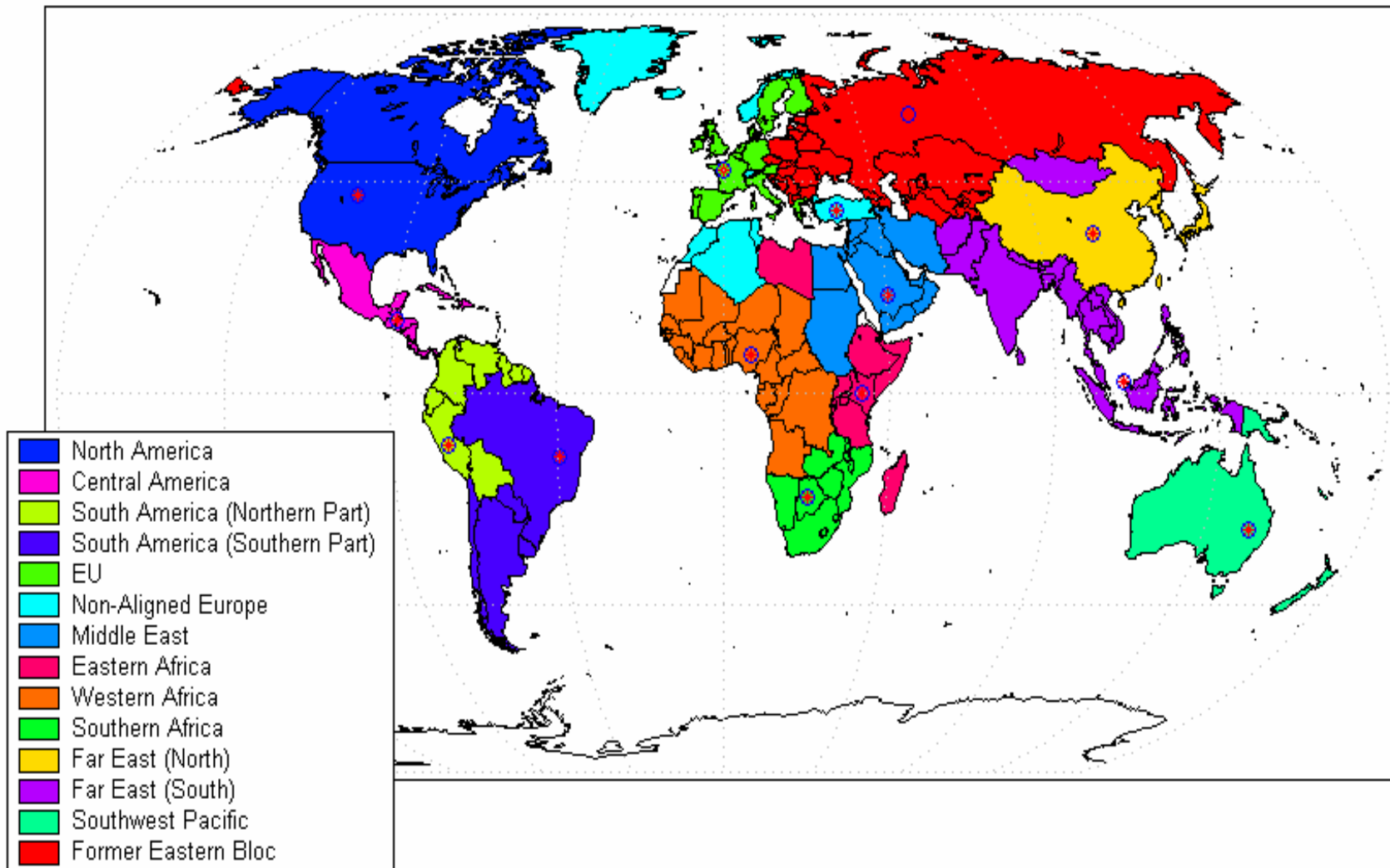
- **Forecast**
 - Measures, implying costs changes
 - Stakeholder response avoiding costs, minimising impact



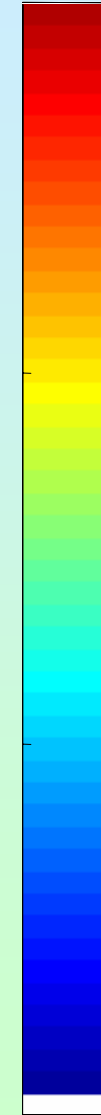
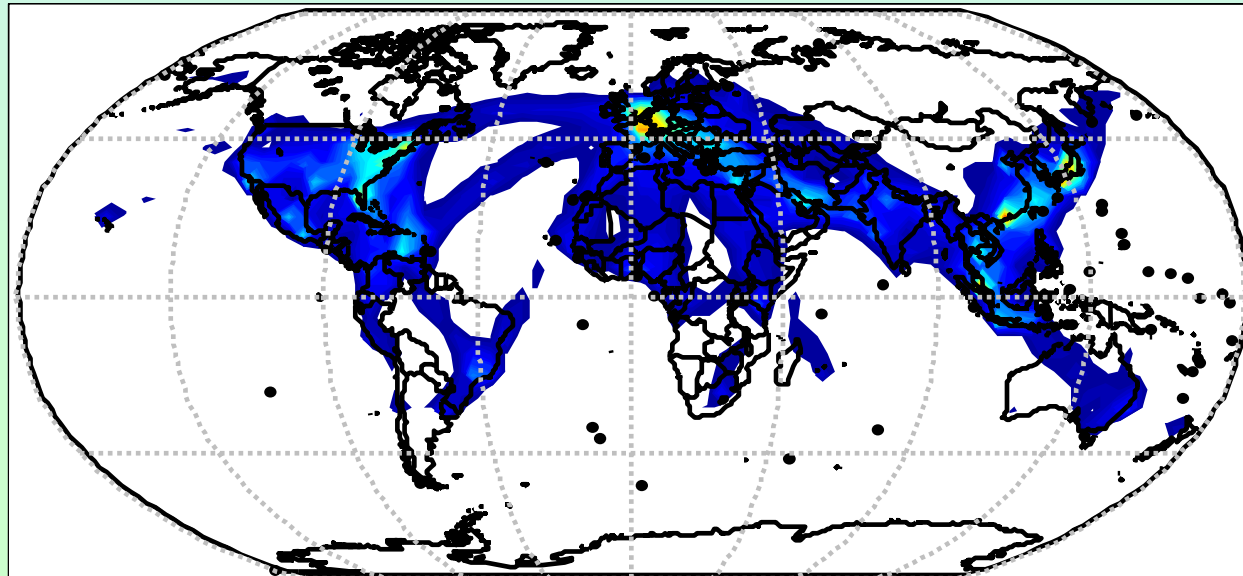
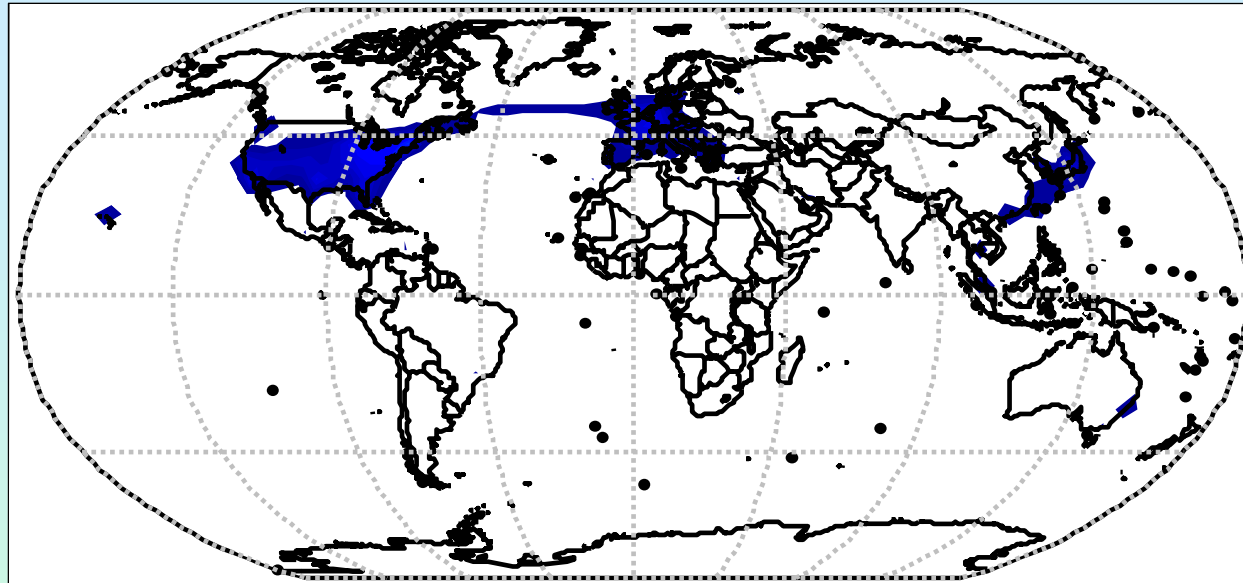
AERO Model



AERO (IATA) regions



Sample 1992/7 & 2050 results



Fuelconsumption / gridcell



List of typical outputs generated by the AERO-Model (1/2)

1. Fuel use and emission characteristics by Aircraft type and Technology level
2. Aircraft purchase prices because of price developments and possible measures
3. Air transport demand and traffic (passengers/ freight transported, flights by Aircraft type and Technology level, fares and freight rates) Forecast
4. Aircraft operating costs (by Aircraft type, Technology level and region pair)
5. Unit operating costs (per passengers and kg freight by Aircraft type, Technology level and Flight stage)
6. Unit composite costs
7. Aircraft flights (by Flight stage, Aircraft type and Technology level)
8. Extent and composition of Airline fleets (by Carrier Group/IATA region)



List of typical outputs generated by the AERO-Model (2/2)

9. Airline related employment
10. Airline contribution to gross value added
11. Government income from charges (if applicable)
12. Changes in Consumer surplus and expenses (by Carrier Group/IATA region)
13. Fuel use and emissions (CO₂, NO_x, SO₂, C_xH, CO, H₂O) in 3-dimensional space (5° by 5° horizontal grid cells and 15 equidistant Altitude bands of 1 km plus 1° by 1° by horizontal grid)
14. Concentrations of CO₂, NO_x and O₃ (36x24 horizontal grid cells and 19 layers)
15. Effective UV radiation
16. Change in global warming potential



Scenario development

General procedure AERO

- **Define Scenario Year(s)**
 - (1992 & 1998 calibration)
 - 2002 (FESG data matching)
 - 2020
 - 2050
- **Define time dependent (exogenous) Scenarios (timelines)**
 - Macro-Economics
 - Population
 - (Crude) Oil prices
 - Travelling behaviour
 - Autonomous environmental developments (ground sources)
- **Define Aviation developments**
 - Technology (fuel consumption, noise, emissions)
 - Costs
 - Constraints
 - (towards regional fleet averaged characteristics)
 - (Intermodality: High Speed Train)



Scenario fitting

General AERO procedure

- **Define and Implement Scenarios**
 - Storyline fitting & expansion
 - Quantification
- **Match aviation Costs and Revenues**
 - Adjust fleet (sizes, numbers, ages)
 - Adjust (sub-) scenarios affecting cost development trends
 - Adjust pax and cargo fares
 - Adjust (constraint driven) government impacts
 - Criterion: profitability
- **Check scenario consistency**
 - Internal AERO (numbers reasonable?)
 - Assessment: Do Storyline, Quantification and Results match?
 - Methods: Scorecards, Reports, Graphs
- **Iteration process**



Air Transport Specific Scenarios (1)

- **Kerosene fuel prices**
 - World Market Crude Oil (Unlimited Skies)
 - Region oriented Market Crude Oil (Fractured World)
 - Based on GDP, Population, Scarcity

- **Fleet technology characteristics**
 - Fuel Use & Emissions Technology developments incl. alternative fuels (QinetiQ supplied data)
 - (Regional) Fleet Characteristics
 - Technology, Lifespan, Numbers, average Age
 - Operating Costs:
 - Maintenance, Crew and Cabin staff,



Air Transport Specific Scenarios (2)

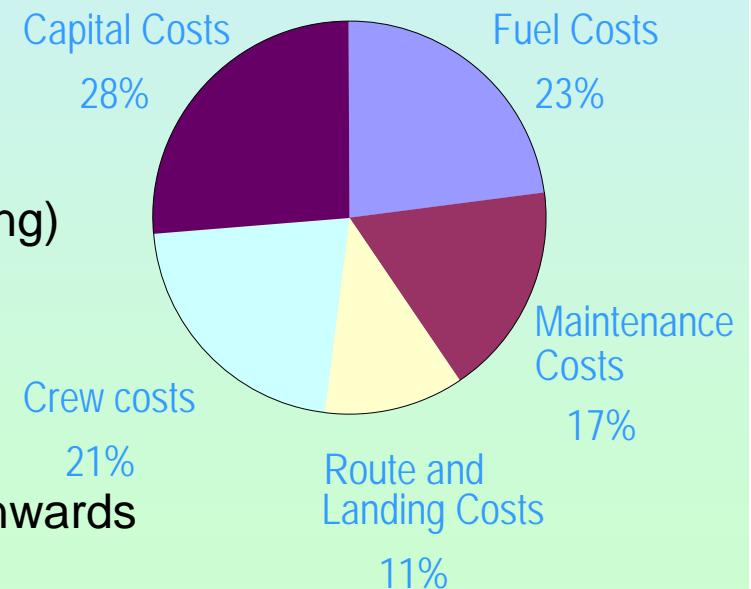
- **Define Air Transport developments**

- Operating costs:
 - Maintenance
 - Capital & Finance costs
 - Crew (flight & cabin)
 - Fuel consumption
 - Route & Landing costs
- ATM efficiency (detouring)
- Volume related costs (e.g. airport pax handling)
- Intermodal transport (High Speed Train)
- Fleet composition & growth

- **Events, Actions & Responses**

- Measures, Regulation from Measure Year onwards
 - Taxes, Charges, **Security & Safety**
- Simulation of:
 - Kerosene to Hydrogen fleet rollover
 - Infrastructure constraints

Example Airline Operating Costs



Scenario development

Air Transport Actors and Aviation Internal Constraints

Stakeholder factors

Response time

actor  constraint

- **Airlines**

- Fleet: sizes and numbers



- **Airports & ATM Infrastructure**

- Capacity
- Noise
- Detouring



- **Government**

- Regulations
- Taxes/charges



- **Passengers & Cargo**

- Travel demand
- Fares



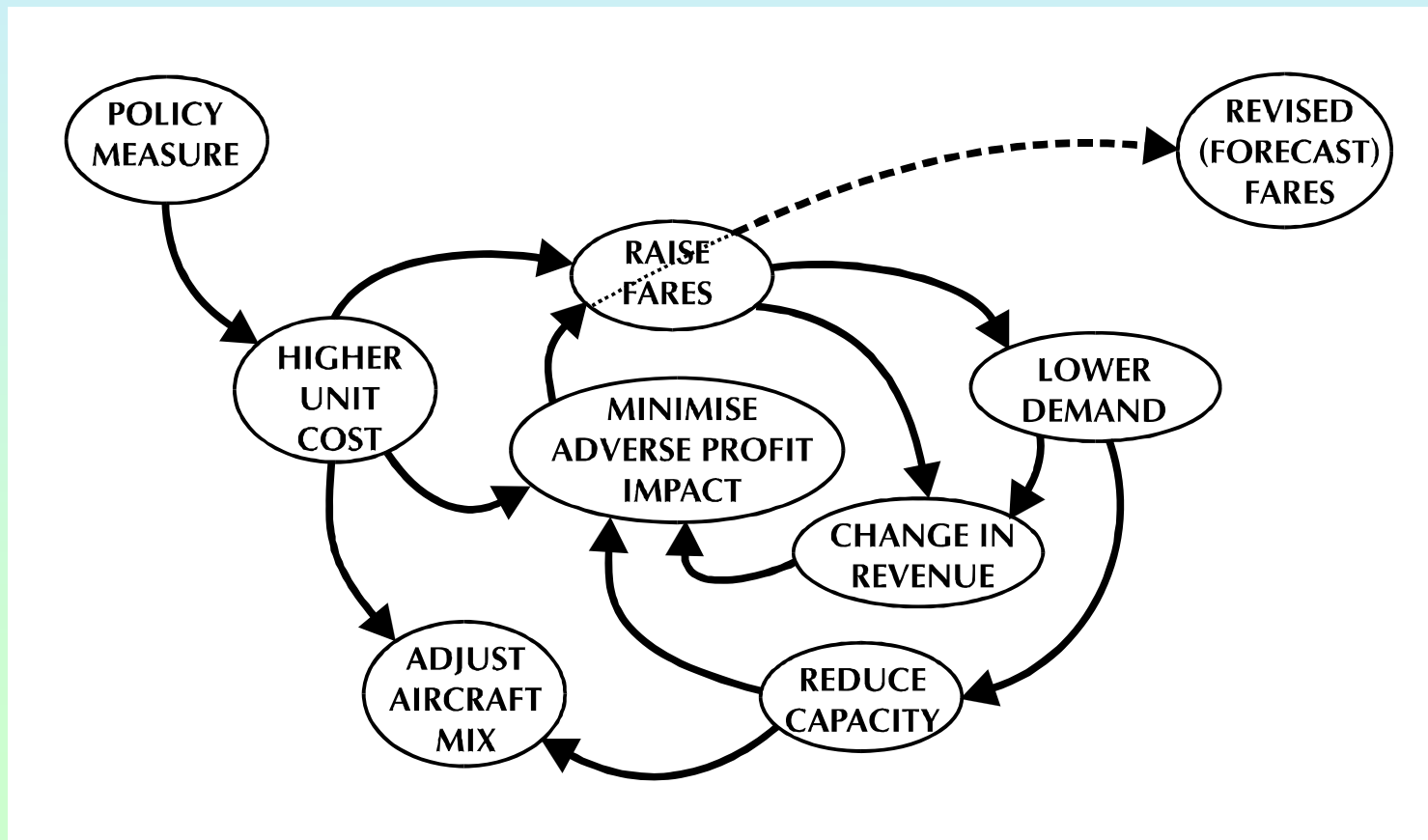
CONSAVE scenario development

- **Moderate costs**
 - Function of GDP/capita & autonomous development
 - High fuel prices, **NO shadow prices for environmental impacts**
 - Relative high growth in traffic volumes
 - Early and high level of constraints
- **Exception: high costs:**
 - Constraints (supply < demand) handled through additional costs
- **Differences between scenarios (costs components) based on**
 - Efficiency, Competition, Economies of scale
 - Impact of Technology development
 - Governmental / Society impact
 - Start from common (calibrated) base data



Infrastructure constraints

Avoiding costs: Aviation system response to higher costs



AERO model enhancements during CONSAVE

- **Extend time horizon to 2050**
- **Handling Non-Uniform Worlds**
 - Aircraft technology (fractured world)
 - Interregional vs. intra regional traffic volumes
- **Timelines supplementing Snapshots**
 - Travelling behaviour
 - Fleet roll-over
- **New post-processing facilities**
 - Noise



List of additional outputs generated within CONSAVE by subsequent modelling:

1. Noise reduction
2. Local Air Quality
3. Level of Landing Charges for financing additional runways

