An Integrated Modelling Approach for Climate Impact Assessments in the Future Air Transportation System – Findings from the WeCare Project


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Knowledge for Tomorrow
Part 1 quantity structures and timing & Part 2 potentials of mitigation strategies

Future scenarios
Simulating quantity structures & timing:

- Modelling growth on city pair level
- Evolution of the global ATS over time
- System’s inertia with respect to decision making or policy planning

Potentials
Assessment and quantification of mitigation potentials of measures:

- Operational
- Technological
- Policy
Why are we designing the AIRCAST environment?

AIRCAST quantifies decision scenarios for aviation

Global passenger & air traffic forecasts on city pair level

Network and fleet forecasting combined

Assessing global aviation climate impacts

Strategy development: goals, growth & technology
4-Layer Philosophy

- exogenous socio-economic scenarios
- exogenous parameter:
  - GDP
  - POP
- time series:
  - world region level
  - country level
  - city level

Diagram:
- Network initialization
- Network generation for future time steps
- Passenger networks
- Passenger behavior
- Routes
- Network
- Aircraft networks
- Aircraft behavior
- Trajectories
- Network

Layers:
- Airlines
- Aircraft
- Infrastructure
- Stakeholder-network interaction
Overview of possible Input quantitative Scenarios

- **Randers**
- **GCAM**
- **IFs**
- **Base**
- **Markets First**
- **Policy First**
- **Security First**
- **Sustainability First**

- **FOCUS** as reference only

**Randers**
- variable Randers
- extension of history

**GCAM**
- maximum economic growth
- strong top-down policies
- rich, national, regional
- equity, environment, transparency

**IFs**
- strong top-down policies
Randers Scenario – CITYCAST model
Network initialization: ATS *city pair* dimensions

**Exogenous socio-economic scenarios**

- **Time series**
  - BIP
  - POP

**Network initialization**

- Network generation for future time steps

**Derived spatial evolutions of ATS dimensions**

Think scenarios in ATS networks: transition & evolution
Air passenger demand forecasting – 2 Steps

**Exogenous socio-economic scenarios**

**Origin-destination demand network**

**TOPOLOGY-Forecast**
Evolution of the demand network topology over time every five years

**First predicted time slice**

**Time slice 2050**

**PASSENGER-Forecast**
Evolution of the number of passengers on city pairs over time every five years

**First predicted time slice**

**Time slice 2050**

**Cost**
- New technologies
- Direct and indirect operating cost

**Routes network**

**Aircraft movements network**

**Trajectories network**

**Quality of travel**
- Frequency
- Travel time
- Number of transfers
Air passenger demand under Randers scenario
Simulation results: Demand Network Layer
Modelling of passenger routes

- Which routes are possible/reasonable?
  - list of possible transfer airports (ca. 500 worldwide)
  - minimum segment distance
  - maximum number of transfers
  - maximum detour factor

- What are the probabilities for the choice of a certain route?
Modelling of passenger routes

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- For all demand city pairs worldwide
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Passengers on segments

Goal:
Deduce passenger volumes on segments worldwide
Deducing an aircraft movements network

..., because the portion of deployed aircraft sizes are a function of:
- segment distance
- passenger volume on segment

- aircraft sizes are abstracted in seat categories
Aircraft movements on segments by seat categories

How many flights are performed by which seat categories on which segments?
Market-size-range relation

Distance frequency distributions

- SEATCAT 601-650
- SEATCAT 151-210
- SEATCAT 101-150
- SEATCAT 51-100

# flights per year

- 2050
- 2020
- 2015

Flown distances [km]

Market

Range

Aircraft size (seat category)

Seat categories

- 9 601-650
- 8 501-600
- 7 401-500
- 6 301-400
- 5 211-300
- 4 151-210
- 3 101-150
- 2 51-100
- 1 20-50
- 0 <20
Distance-frequency-distributions (Randers scenario)
Simulation results: Aircraft Movements Network Layer
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2035
Distance-frequency-distributions (Randers scenario)

Simulation results: Aircraft Movements Network Layer
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Distance-frequency-distributions (Randers scenario)

Simulation results: Aircraft Movements Network Layer

2050
WeCare Part 1: emission inventories (Randers scenario)

Simulation results: Trajectories Network Layer (DLR Module GRIDLAB)

Linke 2016
WeCare Part 2: assessment of eco-efficient flight trajectories
Simulation results: Quantification of mitigation potentials (DLR Module TOM)
Outlook

Create aircraft movements network with **aircraft type and aircraft generation** information (assumed BAU-scenario of new aircraft)

Trajectory network calculation for Randers-Scenario (interface has been already defined)

- to prepare a prototype input for further models
- to provide an ATS **city pair „energy forecast“** including the capability of modelling the introduction of hybrid and alternative energy concepts

Run whole chain on IF-scenarios: **Create „scenario libraries“**

& Develop methods for collaborative working and workshops
Outlook: Aircraft movements network with aircraft generations

1. Status quo
   - Current fleet
     - Civil fleet
     - Sub-fleets
   - AIRCAST fleet data

2. Aircraft categories
   - Shares by seat category
   - FESG retirement curves

3. Growth scenario
   - RPK growth: global and by seat categories
   - Shift of market shares by seat categories
   - Seat load factor scenario by seat categories

4. Fleet Forecast
   - Fleet in service
   - Retirements
   - Deliveries

5. New aircraft
   - Technology timeline
   - Introduction pattern over all seat categories
   - Generic aircraft

Aircraft movements network

Number of flights by seat category on segments

Aircraft movements network with aircraft generation information

Number of flights by seat category and by generation of aircraft
Outlook: World Fleet renewal & networks

**Specific und generic aircraft**
- „fixed“ aircraft
- Current fleet & orders
- Specific aircraft
- Aircraft types (ICAO-Codes)
- Grouped by seat categories
- Generation N and N+1

**New aircraft concepts: unfixed aircraft**
- „unfixed“ aircraft
- Generic aircraft
- No aircraft types
- N+1, N+2, ... according to EIS

Specific aircraft types (ICAO-Codes) grouped by seat categories for Generation N and N+1.

- Gen650
- Gen600
- Gen500
- Gen400
- Gen300
- Gen210
- Gen150
- Gen100
- YS11
- YK42
- T204
- T154
- T134
- SU95
- RJ85
- RJ70
- RJ1H
- MS21

**New aircraft concepts** are applicable only to generic subfleets according to their EIS and seat category.
city pair demand network 2012
connections > 100k PAX

Thank you for your attention.