Scenario work as part of the CONSAVE 2050 project:

⇒ Selection of Constraints
  ⇒ System Analysis 1: possible constraints
  ⇒ Questionnaire with aviation experts

⇒ Scenario Elaboration
  ⇒ System Analysis 2: possible influence factors
  ⇒ Inputs from external (scenario and other) activities
  ⇒ Workshop at IIASA: scenario construction
Choice of Constraints
possibly affecting the Long-term Development in Aviation (1/2)

⇒ Possible influences, which might cause constraints or absolute limits (I-IV: external, V-X = internal)

I. Demography (relevant for demand)
Population, Age, Household, Employment, Migration

II. Macroeconomics (relevant for demand)
Economy, World Trade, Travel cost budgets

III. Energy/Resources (relevant for ability to fit demand and policy regulations and restrictions)
New energy alternatives, Availability and prices of fuel and resources

IV. Social Trends, Mobility Pattern (relevant for all possible constraints)
Social Values (Mobility, Safety, Clean Environment, contacts, sustainability), Leisure time, Life-styles, Travel time budget

V. Transport (relevant for demand, ability to fit demand, costs and policy regulations and restrictions)
Infrastructure, Intermodal Connections, Growth of total Passenger/Freight traffic, Modal Split, Intermodal Co-operation/Competition

VI. Aviation Effects on Ecology (relevant for policy regulations and restrictions)
Sustainability of Aviation, Noise effects, climate change effects, air quality effects, Health risks from emissions of Aviation, Aircraft emissions, Eco-Efficiency of Aviation, Night Flight
Choice of Constraints  
possibly affecting the Long-term Development in Aviation (2/2)

⇒ Possible influences, which might cause constraints or absolute limits  (I-IV: external, V-X = internal)

VII. Technology (relevant for demand and policy regulations and restrictions)
Non-Transport Technologies with potential to substitute traffic/air traffic (Information Technology - main effects on Business trips; Computer Technology, virtual reality - main effects on personal trips);
New Transport Technologies (engines, airframes, CNS/ATM, Alternative fuels, Airport design, Technologies of alternative modes (especially high speed trains)

VIII. Policy / Standards, Regulations (relevant for demand, costs and ability to fit demand)
Planning and financing of infrastructure, Technological stringency’s, regulations, Market access and operating regulations, Liberalisation, privatisation, subsidies, Levies (taxes, charges – Noise, emissions), Emission trading, Voluntary options (agreements with Aviation industry), Restrictions / caps

IX. Air Transport – Supply side (relevant for costs and ability to fit demand)
Services characteristics, routes, frequencies, Safety, security, comfort, marketing,
Fleet characteristics, Infrastructure constraints, Market aspects, operating costs, Prices of airframes and engines, capital costs, indirect operating costs

X. Air Transport – Demand (relevant for ability to fit demand)
Elasticities, Long-term Development of demand, passenger transport by travel purpose (Business, private/tourism), freight transport, military movements
Concerning possible constraints experts expect a strong influence for the aviation system:

A) from external fields:
   - Energy availability
   - Economics / GDP worldwide
   - Globalisation versus Regionalisation
   - Legislation in general ("Laissez-faire" versus Regulation)
   - Social Values / Individual preferences

B) from Air Transport related fields:
   - Air Traffic Management / Air Traffic Control
   - Energy Demand
   - Aviation effects on climate
   - Airport operations
   - Policy Making
   - Tourism
The four CONSAVE Scenarios – Scenario Development

The CONSAVE long term scenarios explore how the global aviation system may change over the first half of this century. They consider alternative paths focusing different challenges like:

- infrastructure impacts,
- ecological pressure,
- fractured markets,
- low demand.

These paths are influenced by:

- economic growth
- population
- energy availability, consumption, price
- technologies
- policy regulations
- citizen preferences
- customers values.

Shaping factors

(input data from IPCC)

Drivers

(input data investigated by CONSAVE team)
Factors of influence for the long-term development of aviation, taken into account for the quantification.
## Key fields, factors, features, and constraints addresses in CONSAVE 1/2

<table>
<thead>
<tr>
<th></th>
<th>Key fields</th>
<th>Addressed in Background-Scenario storylines</th>
<th>Addressed in Aviation Scenario description</th>
<th>Quantified as Input for the AERO-Model</th>
<th>Challenges, Constraints studied</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Demography</td>
<td>Population</td>
<td></td>
<td>Global + regional Population</td>
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<tr>
<td>II</td>
<td>Macro economics</td>
<td>Economic Development</td>
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<td>Global + regional GDP</td>
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<td>Regional Disparities</td>
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<tr>
<td>III</td>
<td>Energy /Resources</td>
<td>Resources</td>
<td>(Part of Aviation Costs)</td>
<td>Energy Use</td>
<td>Availability+ Price</td>
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<td>Energy Price</td>
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<td>IV</td>
<td>Social Trends / Mobility Patterns</td>
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<td>V</td>
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<td>Transport + IT Technology</td>
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<td>VI</td>
<td>Aviation Effects on Ecology</td>
<td>Environment</td>
<td>Environmental Impacts of Aviation</td>
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### Key fields, factors, features, and constraints addresses in CONSAVE 2/2

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<td>Technology</td>
<td>Aviation Technology</td>
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<td>Communication Technology</td>
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<td>Maintenance costs</td>
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<tr>
<td>VIII</td>
<td>Policy /Regulations</td>
<td>Governance</td>
<td>Var. Taxes + Charges</td>
<td>Regulations</td>
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<tr>
<td>IX</td>
<td>Air Transport - Supply</td>
<td>Air Transportation</td>
<td>Crew needed</td>
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<td>Air Transport - Gen. Supply</td>
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<td>Airport and ATM</td>
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<td>Security (as Tax)</td>
<td>Security</td>
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<td>Air Transport Market</td>
<td>Target Profits</td>
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<td>Aviation Costs</td>
<td>Volume costs</td>
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<td>Crew salaries</td>
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<td>X</td>
<td>Air Transport - Demand</td>
<td>Air Transportation</td>
<td>Air Transport - Demand</td>
<td>Saturation</td>
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<td>Autonomous Growth</td>
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<td>Elasticities</td>
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Overview of external inputs - main sources considered

Starting with scenario activities within AERONET and additional expert inputs:
- Questionnaire I (with AERONET and other experts)
- Scenario Workshop (at IIASA in Vienna)
- Review Workshop (at NTUA in Athens - plus Questionnaire II)
- Advisory Committee (led by DLH)

and based upon some of the IPCC SRES emission scenarios (with IIASA as leading author) with consideration of other relevant scenario activities like:

in general:
- IPCC/SRES: overall emissions and climate change
- Global Scenario group (GSG): development paths
- Millennium Project: development paths
- Shell: energy and mobility development

aviation specific:
- Boeing: market development
- Airbus: market development, Cryoplane
- FESG: market development
- ICAO/CAEP: aviation development

the project team identified main drivers and assumptions for the background development as well as for the aviation system, focussing on the questions that matter for informing decisions today under special consideration of possible constraints, relevant for the future aviation system.
Contact to Aviation Community – in general

- AC - Advisory Committee ( Covers representatives from all main aviation sectors): Permanent advise

- AERONET experts (+ selected others)
  Questionnaire and European review (Athens, April 2004)

- Related European external Projects
  (i.e. ASTERA/ACARE; TRADEOFF; AERO2K; European contribution to CAEP)
  Contacts to exchange information and results

- Total interested European aviation community
  European Review of preliminary results (Athens, April 2004)
Comparison of scenarios
(from ACARE/ASTERA, CONSAVE and EUROCONTROL)

- ACARE/ASTERA elaborated a base-case scenario for 2020 (de facto developed as a forecast of ACARE/ASTERA) and three alternative scenarios.

- Three of the CONSAVE scenarios (2020/2050) are similar to the three ASTERA scenarios.

- EUROCONTROL performed a long-term forecast (2020) with four scenarios. Their scenarios are similar to the CONSAVE and ASTERA/ACARE scenarios.

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>High Growth 1</th>
<th>High Growth 2</th>
<th>Fragmentation</th>
<th>Additional</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACARE/ASTERA</td>
<td>Business Model</td>
<td>Constraint Growth</td>
<td>Block building</td>
<td>Base Case</td>
</tr>
<tr>
<td>CONSAVE</td>
<td>Unlimited Sky</td>
<td>Regulatory Push and Pull</td>
<td>Fractured World</td>
<td>Down to Earth</td>
</tr>
<tr>
<td>EUROCONTROL</td>
<td>Global Growth</td>
<td>Regulated Growth</td>
<td>Regional Concerns</td>
<td>Business as usual</td>
</tr>
</tbody>
</table>

Resume: the scenarios are very similar and therefore acceptance in the aviation community is expectable.
**Scenarios are no forecasts**

The scenario approach brings together *different perspectives* on problems, which are *often dependent* within a system. Scenarios try to *reduce complexity*, to *improve our system knowledge* and to generate a *holistic view* for stakeholders, including ecological, economic and social perspectives. However, scenarios are no forecasts, but a structured look on possible future developments to generate knowledge on unclear futures.

Scenario development requires at least:
- a clear question for the development of the scenario structure,
- a reviewed set of assumptions, which should be monitored and updated for further use,
- an adequate quantification model.

Any outcomes/results are strictly scenario related, relative to the assumptions made for the different development paths!
CONSAVE/IIASA Workshop results:

1.1 Unlimited Skies: This scenario assumes a very high air transport demand highlighting the challenges ahead for the global aviation industry.

1.2 Regulatory Push & Pull: The (hypothetical) “unconstrained” demand of this scenario is the same as in Unlimited Skies above. However, a number of constraints as well as regulatory actions addressing those are likely to dampen the effect on global transport volume.

2 Fractured World: This fractured world scenario assumes an absolute decline in international flights and the second lowest GDP-air transport elasticity of all scenarios considered. The available scenario literature provides no equivalent example, making this scenario quantification highly interesting but also challenging.

3 Down to Earth: This scenario of significant lifestyle changes (high environmental consciousness) postulates an entire decoupling of air transport from GDP growth.

4.1 Dynamics as Usual: For this "middle ground, unconstrained demand" scenario different developments are assumed for the different regions with incremental changes. Ecological concerns are high, but don’t lead to strong regulations.

4.2 Zero Risk Tolerance: Because of several safety and security problems people don’t accept any risks. Additional price increase impacts due to the constraints explored in this scenario should further dampen air transport demand.
### Scenario work – starting with 6 scenarios

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>High Growth</th>
<th>Patchwork World</th>
<th>Down to Earth</th>
<th>Dynamics as Usual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unlimited Skies</td>
<td>Regulatory Pull (after 2020)</td>
<td></td>
<td>DaU</td>
</tr>
</tbody>
</table>

**Main character of constraints**
- Ability to fit demand
- Higher costs & lower demand
- Lower demand
- Unconstrained
- Regulation

**Main challenge**
- Ability to fit fast-growing demand with regard to regulation
- Regional oriented demand and high energy prices
- Aviation ecologically sustainable in regard to low demand
- Sufficient flexibility for heterogeneous markets
- Safe and secure air transport

**Typical strategy**
- Expansion
- Concentration and efficiency
- Concentration and efficiency
- Incrementalism
- Concentration and adaptation
## Scenario work – Reducing number of scenarios 1

### Scenarios, Constraints and Stakeholder options – Titel change

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>High Growth</th>
<th>Dynamics as Usual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unlimited Skies</td>
<td>DaU</td>
</tr>
<tr>
<td></td>
<td>Regulatory Push &amp; Pull (after 2020)</td>
<td>Zero Risk Tolerance</td>
</tr>
<tr>
<td>Main character</td>
<td>Ability to fit demand</td>
<td>Unconstrained</td>
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<tr>
<td>of constraints</td>
<td>Regulation</td>
<td>Regulation</td>
</tr>
<tr>
<td>Main challenge</td>
<td>Ability to fit fast-growing demand with</td>
<td>Sufficient flexibility for</td>
</tr>
<tr>
<td></td>
<td>regard to regulation</td>
<td>heterogeneous markets</td>
</tr>
<tr>
<td>Typical strategy</td>
<td>Expansion and adaptation</td>
<td>Safe and secure air</td>
</tr>
<tr>
<td></td>
<td>Expansion</td>
<td>transport</td>
</tr>
</tbody>
</table>

- **Fractured World**
  - High costs & lower demand
  - Lower demand
- **Down to Earth**
  - Aviation ecologically sustainable in regard to low demand
  - Safe and secure air transport

- **Regional oriented demand and high energy prices**
- **Aviation ecologically sustainable in regard to low demand**
- **Sufficient flexibility for heterogeneous markets**
- **Concentration and efficiency**
- **Incrementalism**
- **Concentration and adaptation**

- **Typical strategy**: Expansion
- **Main character of constraints**: Ability to fit demand
- **Main challenge**: Ability to fit fast-growing demand with regard to regulation
## Scenario work – Reducing number of scenarios 2

### Scenarios, Constraints and Stakeholder options – Safety/Security move

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>High Growth</th>
<th>Fractured World</th>
<th>Down to Earth</th>
<th>Dynamics as Usual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unlimited Skies</td>
<td>Regulatory Push &amp; Pull (after 2020)</td>
<td>Down to Earth</td>
<td>DaU Zero Risk Tolerance</td>
</tr>
<tr>
<td>Main character of constraints</td>
<td>Ability to fit demand</td>
<td>Regulation</td>
<td>High costs &amp; lower demand</td>
<td>Lower demand</td>
</tr>
<tr>
<td>Main challenge</td>
<td>Ability to fit fast-growing demand</td>
<td>Ability to fit fast-growing demand with regard to regulation</td>
<td>Regional oriented demand and high energy prices</td>
<td>Aviation ecologically sustainable in regard to low demand</td>
</tr>
<tr>
<td>Typical strategy</td>
<td>Expansion</td>
<td>Expansion and adaptation</td>
<td>Concentration and efficiency</td>
<td>Concentration and efficiency</td>
</tr>
</tbody>
</table>

**Typical strategy**

- **Expansion**
- **Expansion and adaptation**
- **Concentration and efficiency**
- **Concentration and efficiency**
- **Incrementalism**
- **Concentration and adaptation**

**Main character of constraints**

- **Ability to fit demand**
- **Regulation**
- **High costs & lower demand**
- **Lower demand**
- **Unconstrained**
- **Regulation**

**Main challenge**

- **Ability to fit fast-growing demand**
- **Ability to fit fast-growing demand with regard to regulation**
- **Regional oriented demand and high energy prices**
- **Aviation ecologically sustainable in regard to low demand**
- **Sufficient flexibility for heterogeneous markets**
- **Safe and secure air transport**

**Typical strategy**

- **Expansion**
- **Expansion and adaptation**
- **Concentration and efficiency**
- **Concentration and efficiency**
- **Incrementalism**
- **Concentration and adaptation**
## Scenario work – Reducing number of scenarios 3

### Scenarios, Constraints and Stakeholder options – from 6 to 4 scenarios

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>High Growth</th>
<th>Fractured World</th>
<th>Down to Earth</th>
<th>Dynamics as Usual</th>
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<tbody>
<tr>
<td></td>
<td>Unlimited Skies</td>
<td>Regulatory Push &amp; Pull (after 2020)</td>
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<tr>
<td>Main character of constraints</td>
<td>Ability to fit demand</td>
<td>Regulation</td>
<td>High costs &amp; lower demand</td>
<td>Unconstrained</td>
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<tr>
<td>Main challenge</td>
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<td>Aviation ecologically sustainable in regard to low demand</td>
<td>Safe and secure air transport</td>
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<tr>
<td>Typical strategy</td>
<td>Expansion</td>
<td>Expansion and adaptation</td>
<td>Concentration and efficiency</td>
<td>Incrementalism</td>
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</tbody>
</table>

“Dynamics as Usual” are no extreme or constrained scenarios, Safety & Security are possible to quantify in the Fractured world => Reduction to four scenarios!
# Scenario work – Reducing number of scenarios 4

## Scenarios, Constraints and Stakeholder options – Final set of scenarios

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>High Growth</th>
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<tbody>
<tr>
<td></td>
<td><strong>Unlimited Skies</strong></td>
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<tr>
<td>Main character of constraints</td>
<td>Ability to fit demand</td>
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<td>Main challenge</td>
<td>Ability to fit fast-growing demand</td>
</tr>
<tr>
<td>Typical strategy</td>
<td>Expansion</td>
</tr>
</tbody>
</table>
Main Scenario Constraints

**Unlimited Skies**
Higher costs for aviation:
• additional infrastructure
High challenge to fit demand:
• insufficient airspace & aircraft capacity because of high demand or limit values
• insufficient airport capacity mainly in Europe & Asia

**Regulatory Push & Pull**
Higher costs for aviation:
• high energy prices, eco-taxes & emission trading
Strong Regulation:
• noise & emission limit values
• market regulation

**Fractured World**
Lower Air Transport Demand:
• health awareness, lower travel budget, and lower long distance travel
• worldwide regionalisation
• shifting of demand to other transport modes, only in developed countries
Higher costs for aviation:
• very high energy prices, costs for security
Strong Regulation:
• strong regulations for safety & security

**Down to Earth**
Air Transport Demand:
• bad perception of aviation
• environmental consciousness: substitution of air transport, lower long distance travel, other (physical) mobility needs
Higher costs for aviation:
• high energy prices, emission trading
Strong Regulation:
• clean technologies (added)