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

External inputs – Questionnaire (2002) results

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 focussing different challenges like:

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

These paths are influenced by:

- economic growth
- population

(input data from IPCC)

Shaping factors

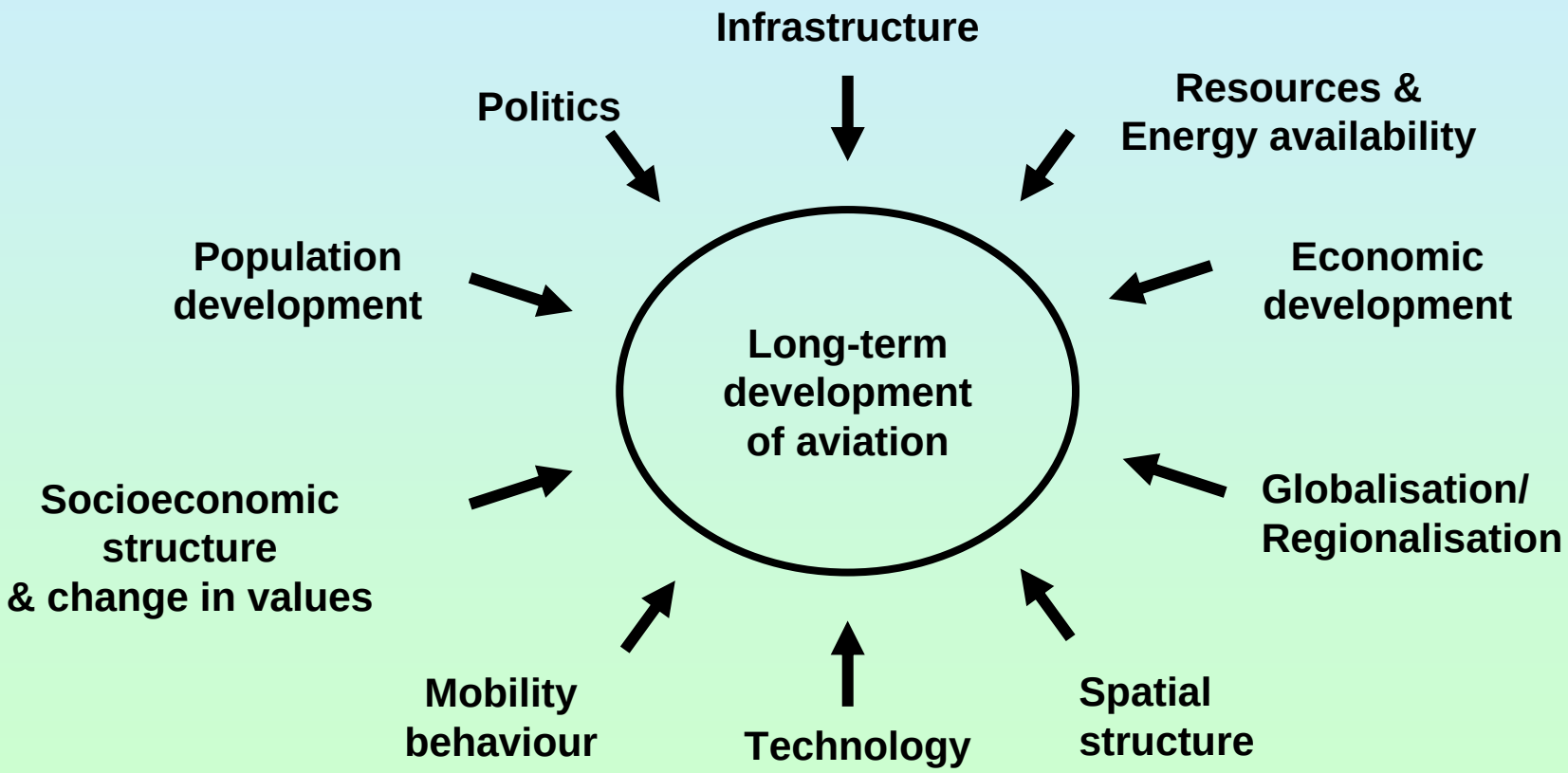
- energy availability, consumption, price

- technologies
- policy regulations
- citizen preferences
- customers values.

(input data investigated by CONSAVE team)

Drivers

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

	Key fields	Addressed in Background-Scenario storylines	Addressed in Aviation Scenario description	Quantified as Input for the AERO-Model	Challenges, Constraints studied
I	Demography	Population		Global + regional Population	
II	Macro economics	Economic Development		Global + regional GDP	
		Regional Disparities			
III	Energy /Resources	Resources	(Part of Aviation Costs)	Energy Use	Availability+ Price
				Oil Prod. Peak	Price to Cryoplane Technology
				Energy Price	
IV	Social Trends / Mobility Patterns	Social Trends	Mobility Patterns		Mobility Pattern
					Global Conflicts
V	Transport	Transport	Gen. Transport Development		
			Transport + IT Technology		
VI	Aviation Effects on Ecology	Environment	Environmental Impacts of Aviation		Environmental Impacts
			Environmental Regulation		

Key fields, factors, features, and constraints addresses in CONSAVE 2/2

	Key fields	Addressed in Background-Scenario storylines	Addressed in Aviation Scenario description	Quantified as Input for the AERO-Model	Challenges, Constraints studied
VII	Technology	Technology	Aviation Technology	Various Technical	Lag of Standardisation
		Communication Technology		Assumptions	Maintenance costs
				Cryoplane Intro. Year	
				New Aircraft Price	
				Surface competition	
VIII	Policy /Regulations	Governance	(Part of Environ. Impacts)	Var. Taxes + Charges	Regulations
IX	Air Transport - Supply	Air Transportation	Air Transport - Gen. Supply	Crew needed	
			Airport and ATM	Detour Factor	Infrastructure Capacity
			Safety and Security	Security (as Tax)	Security
			Air Transport Market	Target Profits	
				Load factor	
				Aircraft crap value	
				Interest Rate	
			Aviation Costs	Volume costs	
				Crew salaries	
X	Air Transport - Demand	Air Transportation	Air Transport - Demand	Autonomous Growth	Saturation
				Elasticities	

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 (leaded 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.**

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

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

Scenarios, Constraints and Stakeholder options - Start

Scenarios	High Growth		Patchwork World	Down to Earth	Dynamics as Usual	
	Unlimited Skies	**Regulatory Pull** (after 2020)			**DaU**	**Zero Risk Tolerance**
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 1

Scenarios, Constraints and Stakeholder options – Titel change

Scenarios	High Growth		Fractured World	Down to Earth	Dynamics as Usual	
	Unlimited Skies	Regulatory Push&Pull (after 2020)			DaU	Zero Risk Tolerance
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 2

Scenarios, Constraints and Stakeholder options – Safety/Security move

Scenarios	High Growth		Fractured World	Down to Earth	Dynamics as Usual	
	Unlimited Skies	Regulatory Push&Pull (after 2020)			DaU	Zero Risk Tolerance
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

Scenarios	High Growth		Fractured World	Down to Earth	Dynamics as Usual	
	Unlimited Skies	Regulatory Push&Pull (after 2020)			DaU	Zero Risk Tolerance
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

"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

Scenarios	High Growth		Fractured World	Down to Earth
	Unlimited Skies	Regulatory Push&Pull (after 2020)		
Main character of constraints	Ability to fit demand	Regulation	High costs & lower demand	Lower demand
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
Typical strategy	Expansion	Expansion and adaptation	Concentration and efficiency	Concentration and efficiency

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)