

Scenario storylines - main Topics:

- ⇒ **The four CONSAVE Scenarios**
 - ⇒ Scenario structure & main characteristics
 - ⇒ Background Scenarios: Shaping factors & Drivers
 - ⇒ Aviation storylines (excerpt)

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

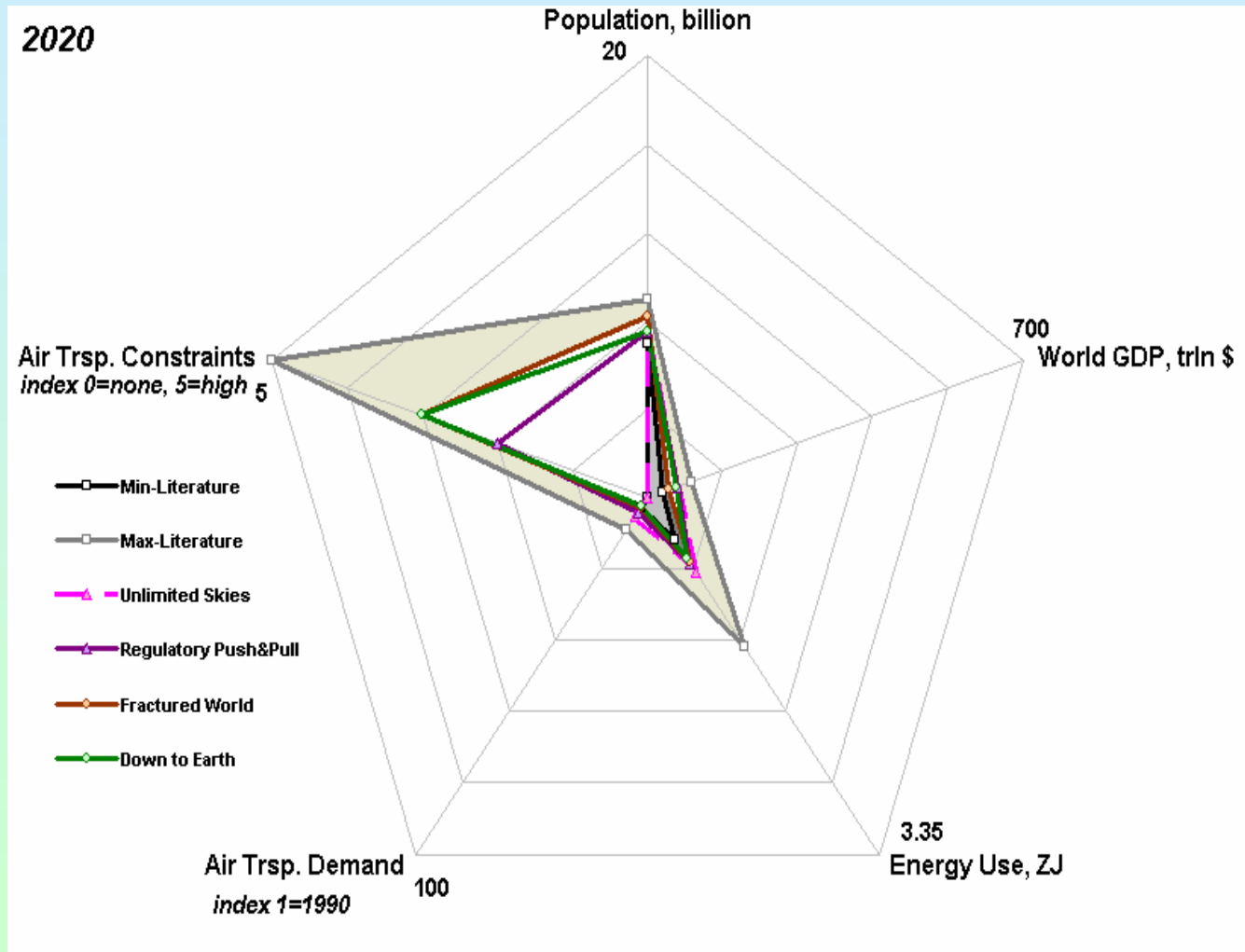
Higher costs for aviation:

- high energy prices, emission trading

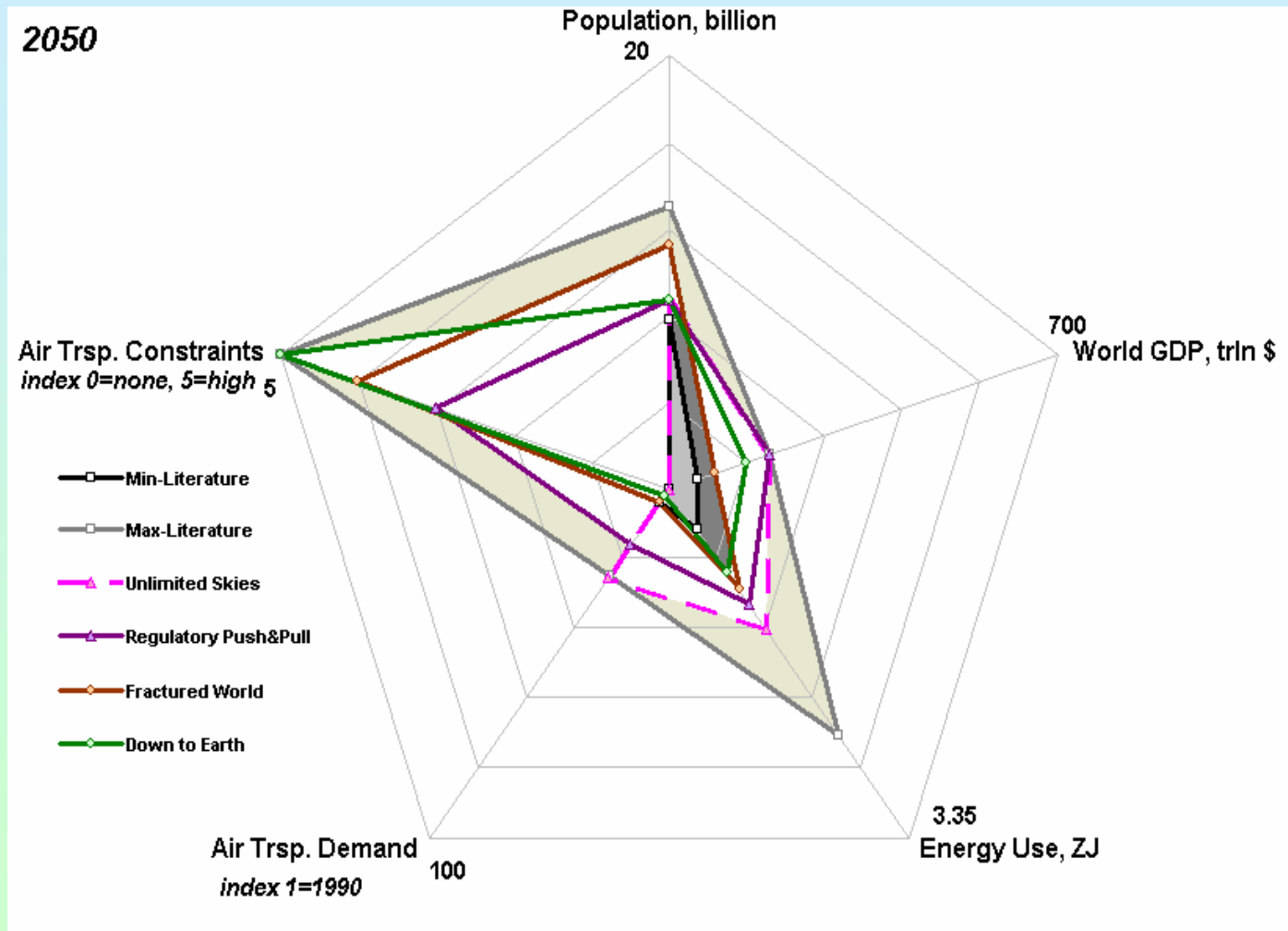
Strong Regulation:

- clean technologies (added)

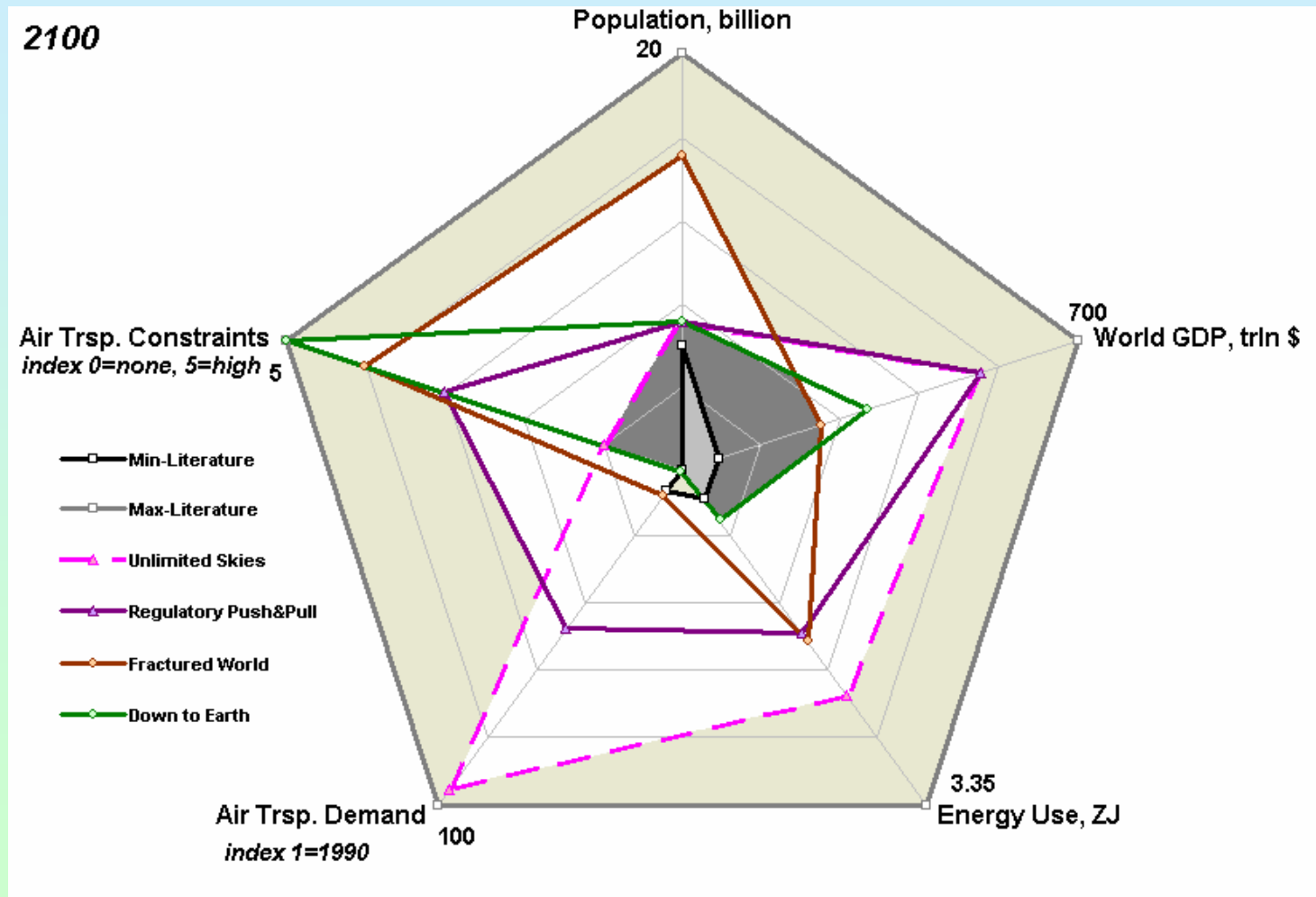
Assumed Scenario Constraints for 2020



Assumed Scenario Constraints for 2050



Assumed Scenario Constraints for 2100



Scenarios, Constraints and Stakeholder options

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

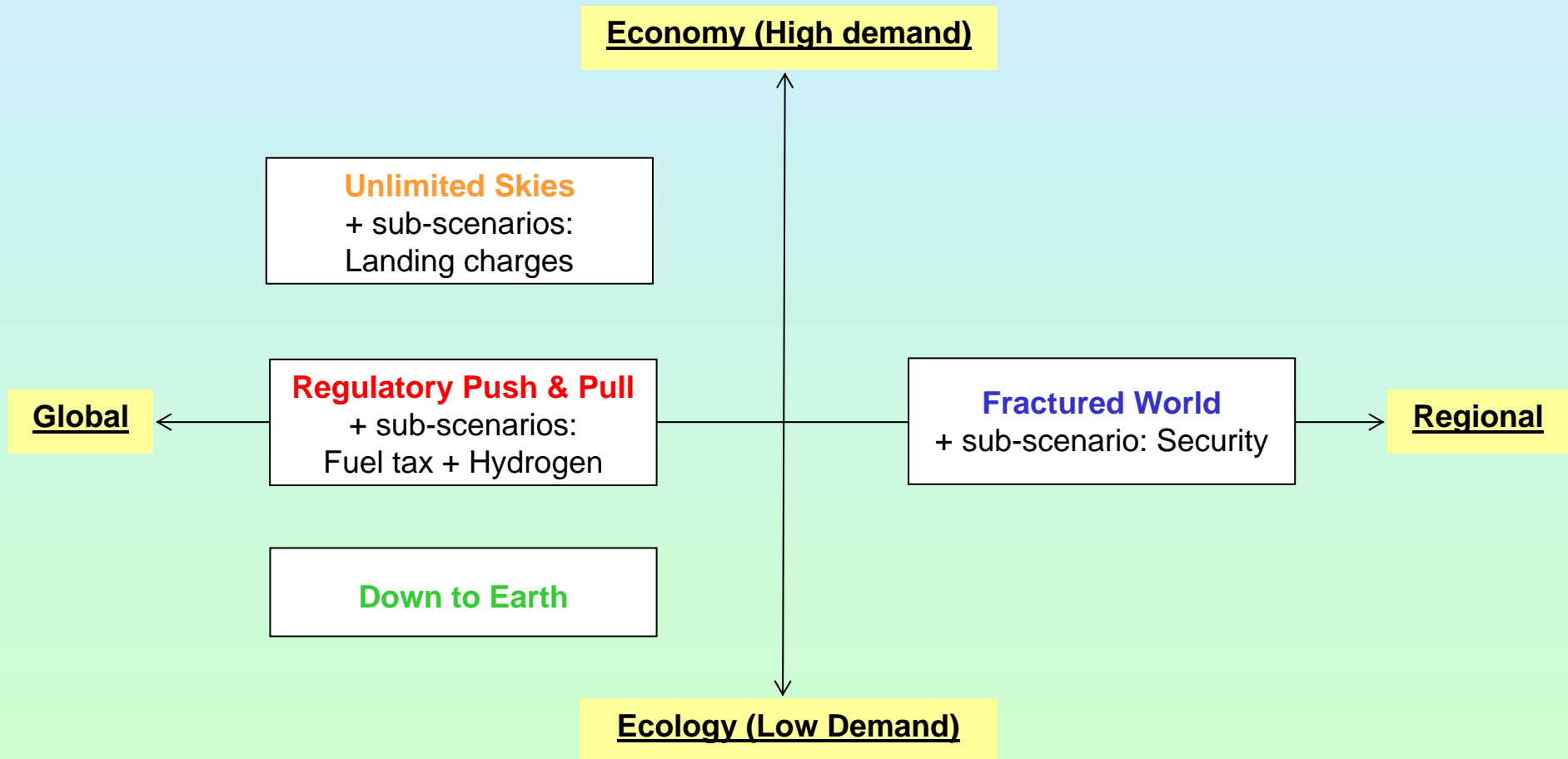
Focussing on Constraints

Trying to include developments in the world and the societies, which could turn out as limits to growth for aviation, the project foresees explicitly and as it's most important and innovative topic, the development of **constrained** scenarios.

In our four different scenarios we focussed on different challenges:

High growth 1	Unlimited Skies (ULS)	Infrastructure constraints: Limits to airports and runways
High growth 2	Regulatory Push & Pull (RPP)	Climate problem: Environmental Regulation
Low growth 1	Fractured World (FW)	Fragmentation: Block building and Autarky
Low growth 2	Down-to-Earth (DtE)	Value Change: Regional lifestyle + slow mobility

Scenario Structure Overview



Short description of CONSAVE scenarios

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.

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)

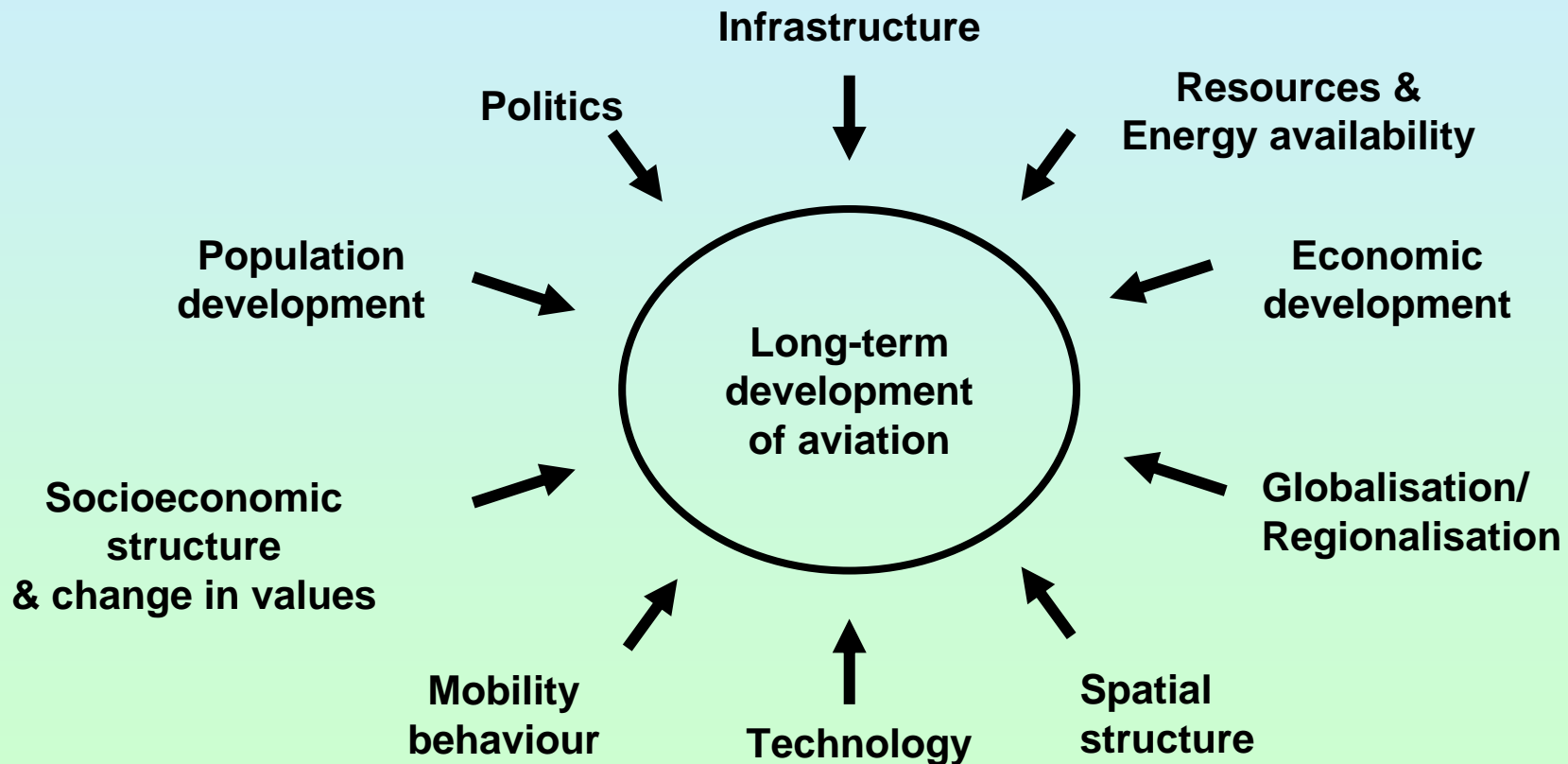
Shaping factors

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- energy availability, consumption, price
 - technologies
 - policy regulations
 - citizen preferences
 - customer values.

(input data investigated
by CONSAVE team)

Drivers

**Factors of influence for the long-term development of aviation,
taken into account for the quantification**



Drivers (Environment, Energy, Technology):

	Unlimited Skies	Regulatory Push & Pull	Fractured World	Down to Earth
Environment	no catastrophic change	significant change; main problems 2052-2058	little change	some alarming, but no catastrophic change
Energy availability	available	available	depending to regions; scarcity after 2050 expected	available, scarcity after 2050 expected
Peak of world oil production (incl. artificial oil)	2080	2050	2020	2020
Energy use / EJ	1350	1100	970	810
Energy price (1990 = 1)	2	4	8	4
Technology development	dynamism of technological innovation is broad-based; communication and transportation growth		heterogeneous, partly incompatible, interchange problems	rapid diffusion of post-fossil technologies - no solution for noise reduction

Drivers (Environment, Energy, Technology):

• Environment

While in the scenarios “Unlimited Skies” and “Fractured world” we are assuming no relevant changes, environment is a critical driver in the scenario “Regulatory Push & Pull”, leading to strong regulations in environmentally relevant activities.

• Energy availability, price and consumption

Energy scarcities are not expected until 2050 on the global level. However, in a “Fractured world” resources are distributed unequally and every region has to take care for their own future energy supply, leading to different “regional” technologies (Asia: syn. Fuels from coal; NA+SA: unconv. Oil; Africa: biomass, MidEast oil+gas; Eurasia: electricity+hydrogen) and comparably to the other scenarios high energy costs. The energy consumption in 2050 is in line with the recent Shell scenarios - except the high value for the scenario “Unlimited Skies”, where also an optimistic assumption was chosen for the future availability of oil.

• Technology development

Technological innovations are expected in all scenarios, but while in the both “High Growth” scenarios “Unlimited Skies” and “Regulatory Push & Pull” the development is more traditional, the paths in the other scenarios are very different. In the “Fractured world” technologies are driven by regional resources. In “Down to Earth” we assume a rapid diffusion of post-fossil technologies, driven by a change of values and preferences in the light of a strongly required sustainable development.

Drivers (Policy, People):

	Unlimited Skies	Regulatory Push & Pull	Fractured World	Down to Earth
Political development	market philosophy	emission regulations	regional differences	pollution sources tightly controlled
Citizen preferences	global orientation, pragmatic solutions	regulatory approach in environmental issues	autarky, regional orientation	environmental and safety concerns
Customers values	convenient and flexible service and mobility	cheap and environmentally okay	security concerns	stigmatisation of "fast" and international patterns

Drivers (Policy, People):

• Political development

Policy as a consequence of circumstances is a different driver in all scenarios.

Representing a market philosophy in “Unlimited Skies”, policy is “soft” in this scenario: liberalisation if possible, compensation of negative impacts if necessary, combined with pragmatic choice of effective solutions.

In “Regulatory Push & Pull” environmental pressure leads to limits of fossil fuel consumption and noise plus support of non-fossil technologies.

In the “Fractured world” regions, blocks and nations are looking for themselves, decreasing chances for global policy approaches.

In “Down to Earth” citizens and customers with post-industrial lifestyle and values are playing a major role for policy, so that any pollution sources are tightly controlled.

• Changing citizen preferences and customers values

Depending to the potentials, goals and threats people have different preferences and values in the four scenarios, leading to different challenges, travel patterns and demand for the aviation system.

While in “Unlimited Skies” their focus lies on fast and convenient intercontinental travel, in “Regulatory Push & Pull” mobility is more limited because of higher costs and environmental restrictions. In a “Fractured world” with confrontations between regions, terrorist activities increase as well as security concerns. In “Down to Earth” people prefer a slow and regional lifestyle, including a stigmatisation of “fast” and international patterns.

Key air transport assumptions

2050 Scenario Assumptions	Unlimited Skies	Regulatory Push & Pull	Fractured World	Down to Earth
Aircraft technology	new very large aircraft available	ULS (slower) + introduction of hydrogen powered ac	different standards	NOx optimized ac
Safety & Security	high standards	high standards (regulation)	high effort for security	high standards
Market Development	deregulation, strong competition	controlled liberalisation, medium competition	dominance of national carriers	decrease in the number of airlines

Key air transport assumptions 2

2050 Scenario Assumptions	Unlimited Skies	Regulatory Push & Pull	Fractured World	Down to Earth
Air transport supply & demand	Very high increase	High increase	Low growth in interregional flights	Decrease
Airport & ATM Capacity	Constraints	Capacity regulated	Depending to regions	No constraints, but low profitability
Aviation Costs	Lower specific costs	Lower specific costs	Higher (security & standards)	Higher specific costs

Specific assumptions for Fractured World (1/2)

Region	Resource Availability	Aircraft fuels	Aircraft size
North + Central America	low quality fossil fuels	manufactured kerosene from low quality fossil fuels, e.g. tarsands etc	large
Eurasia	renewables and Russian gas	kerosene alternatives such as LH2, Russian gas	large
Middle East	abundant oil reserves	Kerosene	medium (no change)
Sub-Himalayas	Coal	manufactured kerosene from coal	medium (no change)
Far East North	Nuclear	manufactured kerosene and kerosene alternatives such as LH2	large
Other (Southern Africa, Oceania, Latin America)	coal and biomass	manufactured kerosene from coal and biomass	medium (no change)

Specific assumptions for Fractured World (2/2)

Region	Fleet roll-over	Other characteristics	Technology / manufacturing capability
North + Central America	High	high efficiency new aircraft types, designed for continental travel (<3k miles)	very high technology for conventional aircraft designs
Eurasia	High	high efficiency new aircraft types running on alternative fuels, designed for continental travel (<2k miles)	very high technology, new aircraft designs and concepts (LH2, gas)
Middle East	very low	current aircraft stock (post 2010 aircraft) used for intercontinental travel	none, use existing stock
Sub-Himalayas	very low	continued use of old aircraft stock (post 2000 aircraft), continental travel	none, use existing stock
Far East North	High	replacement with new high efficiency/ high technology, continental travel	very high technology, new aircraft designs and concepts (LH2, nuclear?)
Other (Southern Africa, Oceania, Latin America)	very low	continued use of old aircraft stock (post 2000 aircraft), continental and intercontinental travel	none, use existing stock

<u>Scenario Drivers</u>	Unlimited Skies	Regulatory Push & Pull	Fractured World	Down to Earth
Regional disparities				
Social values				
Role/Level of Governance			global regional	
Environmental consciousness (public)			global regional	
Environmental policies			global regional	
Resources availability			global regional	
Technology development (i.e. Computer + Bioscience)				
Communication options			global regional	
Transport demand in general			global regional	
Air Transport Demand			global regional	

Overview of external inputs - main sources considered

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.