Responding to the ACARE Challenges

Technologies and Concepts

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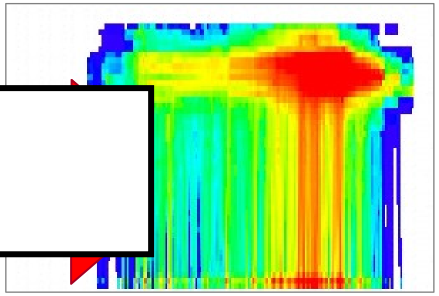
- **Vision 2020, Strategic Research Agenda SRA 1 & 2**
  - Environment
  - Quality and Affordability
  - Air Transport System Efficiency
  - Security
  - Safety

- **Goals for the Environment** (based on the technological level of 2000)
  - Reduction of fuel consumption and CO_2 emissions by 50%
  - Reduction of NO_x emissions by 80 %
  - Reduction of perceived external noise by 50%
  - Reduction of impact of production, maintenance, and disposal of A/C

Aviation

Noise | Emissions

local | local | global



Metrics?

to enable tradeoffs

Community health | Local air quality | Climate change

Regulations, Charges, external costs

Contributors to Fuel Burn Reduction

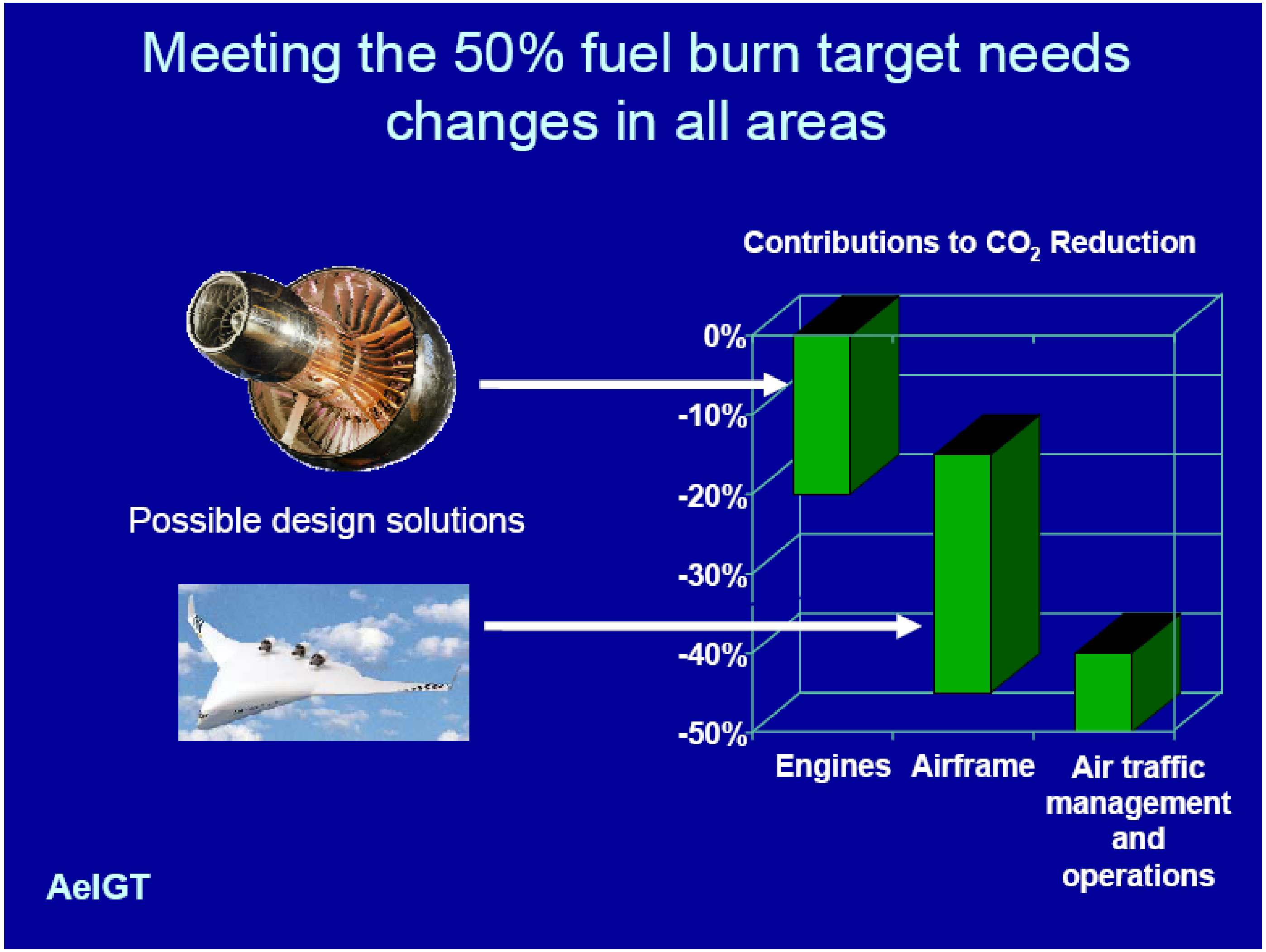
Potential for fuel burn reduction:

Engines: ~20%

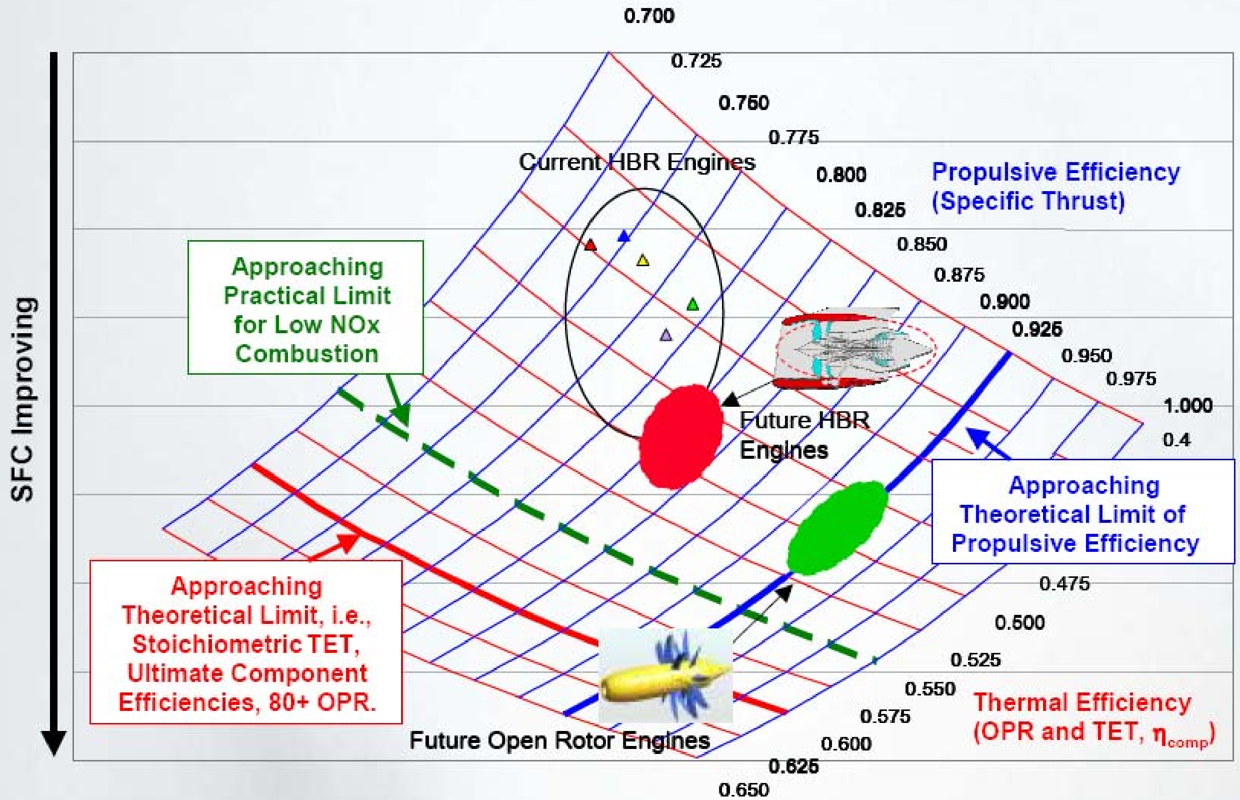
Airframe: ~25%

ATM: ~10%

Source:
Jeff Jupp,
Mitigating the Environmental Impact of Aviation



Cycles to meet ACARE targets



Rolls-Royce

Roadmap for Engine Technology

Rolls-Royce technology 'Vision'

- **Vision5 – Near term**
  - Latest 'on-the-shelf' technologies applied to existing architectures
  - Near term upgrade and improvement programmes


TP 400


Trent 1000

- **Vision10 – Next generation**
  - Leading edge, technology validation.
  - Technologies currently at demonstrati stage


Engine 3 E Demonstrator

- **Vision20 – Future generation**
  - Includes technologies that are currently emerging or as yet unproven

    Advanced environmental and efficiency targets for aircraft, engines and systems.

The ACARE Goals*

- Half current perceived average noise levels
- Reduce CO_2 by 50% per passenger km
- 80% cut in NOx

Rolls-Royce

Engine Technologies

Increase of Bypass Ratio

Geared Fan (BPR = 12)
Tests at DLR starting in 2007

DLR-Study on BPR-influence

BPR 25: weight and size penalty

BPR 17: lowest fuel consumption (mission + SFC)

BPR 12: significant mission fuel reduction

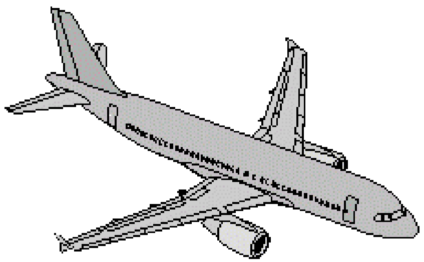
Lean Combustion for NO_x-Reduction

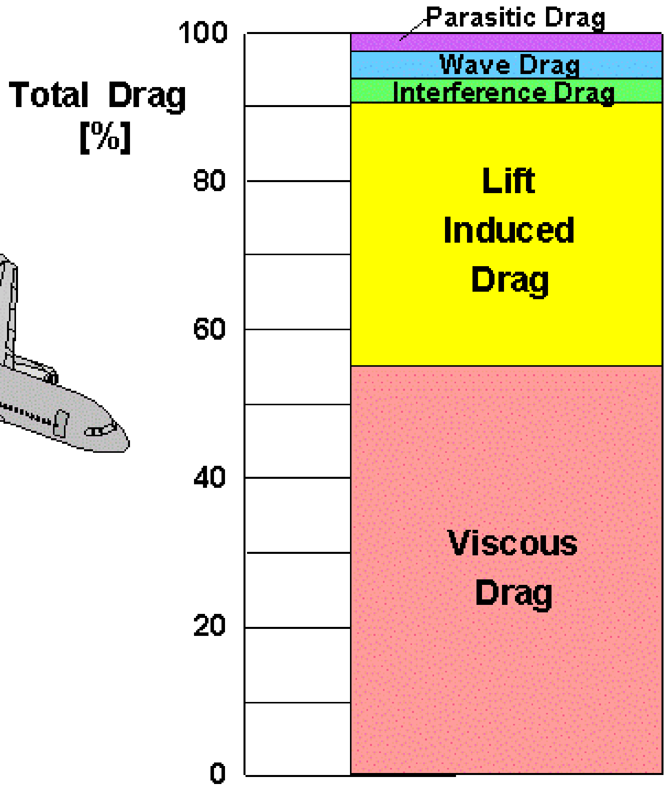
Lean piloted burner

DLR Investigation of RR-D lean burner module with internal staging

Drag Reduction

Drag Break-down	Technology Opportunities	Drag Reduction Potential
	• Shock Control • Novel Configurations	- 3%
	• Shape Optimisation • Adaptive Wing Devices • Wing Tip Devices • Load Control	- 7%
	• Laminar Flow Technology • Turbulence & Separation Control Technologies	- 15%
	Total	- 25%



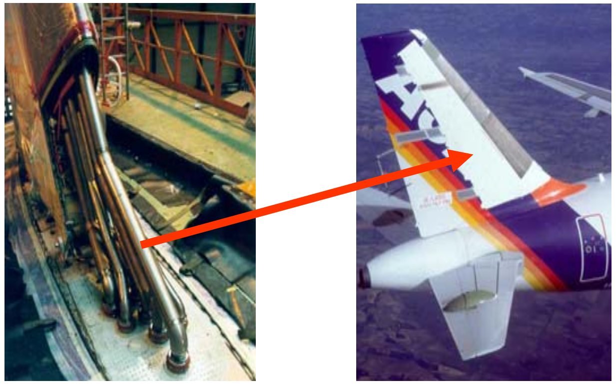


Source:
Geza Schrauf,
KATnet
Key Aerodynamic Technologies
For Aircraft Performance Improvement

Laminar Flow Control Research at DLR

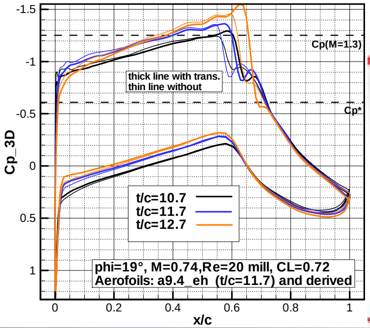
Hybrid Laminar Flow (HLF, B.L.-Suction)

- High System Complexity (Proof of Concept)
- Alternative System Designs
- Wing and Configuration Design



Natural Laminar Flow (NLF)

- Wing and Configuration Design
- Robustness to Disturbances (Receptivity)
- Mission Assessment (Speed vs. Fuel)



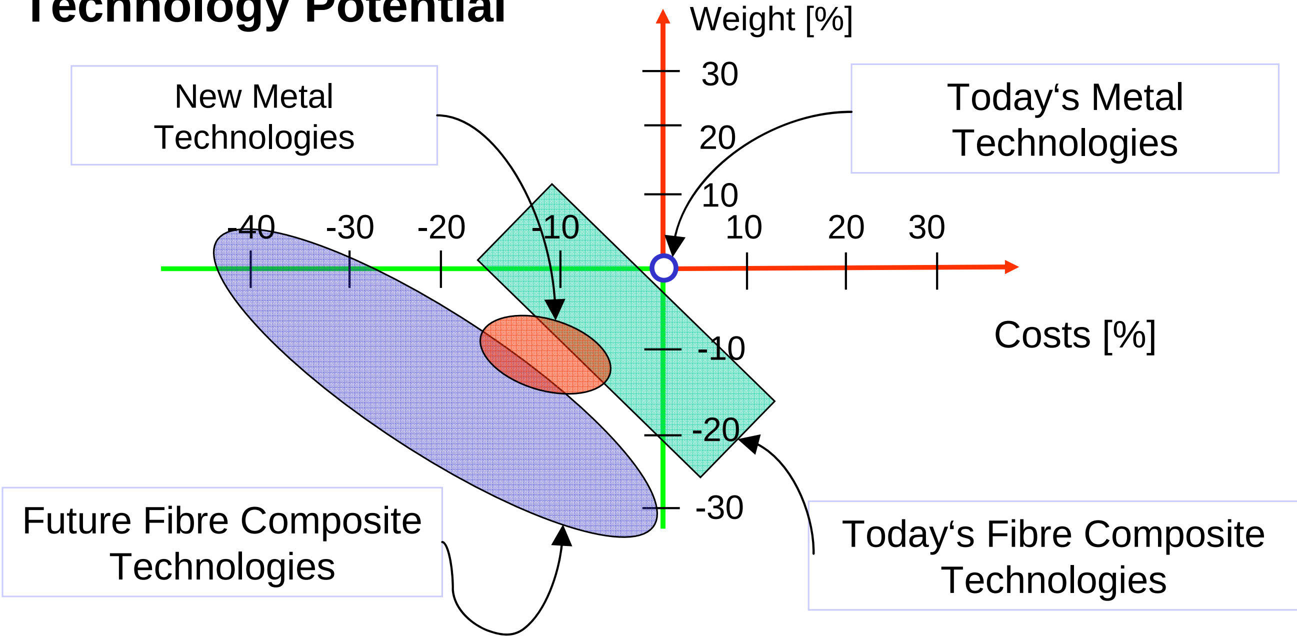
Operational Parameters

- Anti-Contamination / De-Icing
- Surface Quality and Integrity

Weight Reduction by Composites

Weight Reduction
⇓
Fuel Reduction
⇓
CO_2 Reduction

Technology Potential



30% Reduction in Structural Weight:

15% Reduction in Fuel Consumption

(Estimate for 250 PAX, 6500 km configuration with pre-design tool PrADO)

Operational Improvement

Reduction of unnecessary fuel consumption during all flight phases from Gate-to-Gate

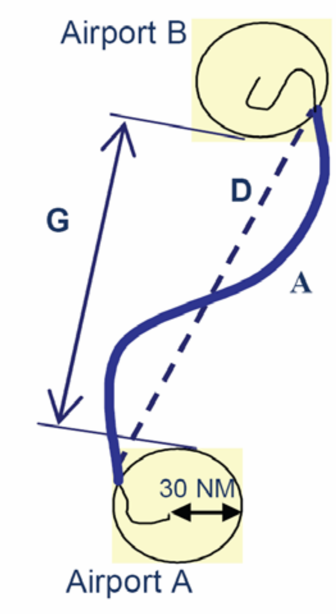
Optimization of Air Space Structure to avoid route extensions

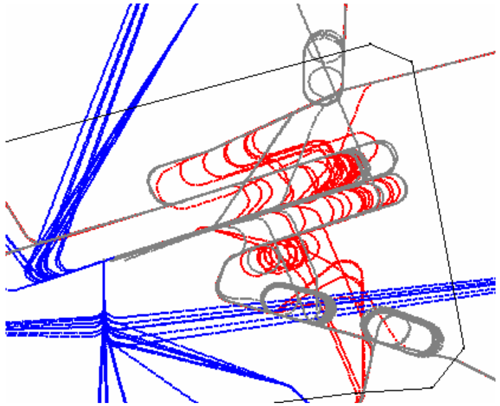
Reduction of Holdings

Use of efficient Approach and Departure Procedures

Avoid traffic jams at runway heads before take-off

Operational Towing



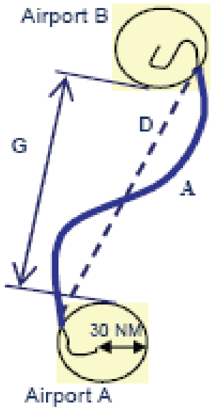


Reduction of Route Extensions

Average route extension in Europe per flight: 48.6 km

Additional distance flown in 2006 in Europe:
441 million km

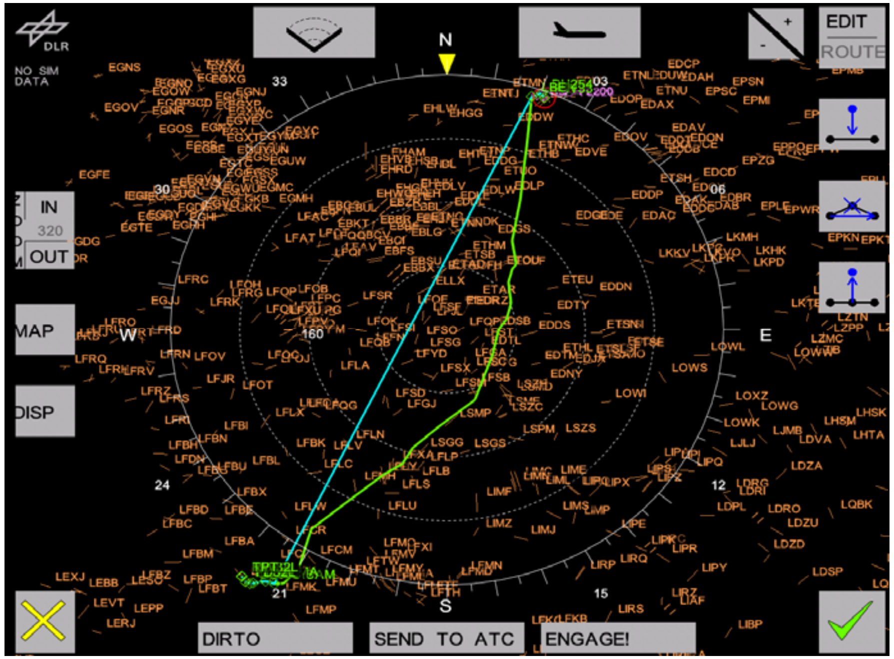
Additional CO2 Emission of ~4%



	Direct Extensions	TMA Interface	Total 2006
Extension (%)	4,0%	1,9%	5,9%
Extension per Flight	32,9 km	15,7 km	48,6 km
Additional Distance	298 M km	143 M km	441 M km
Additional CO2 Emissions	3,2 M t	1,5 M t	4,7 M t

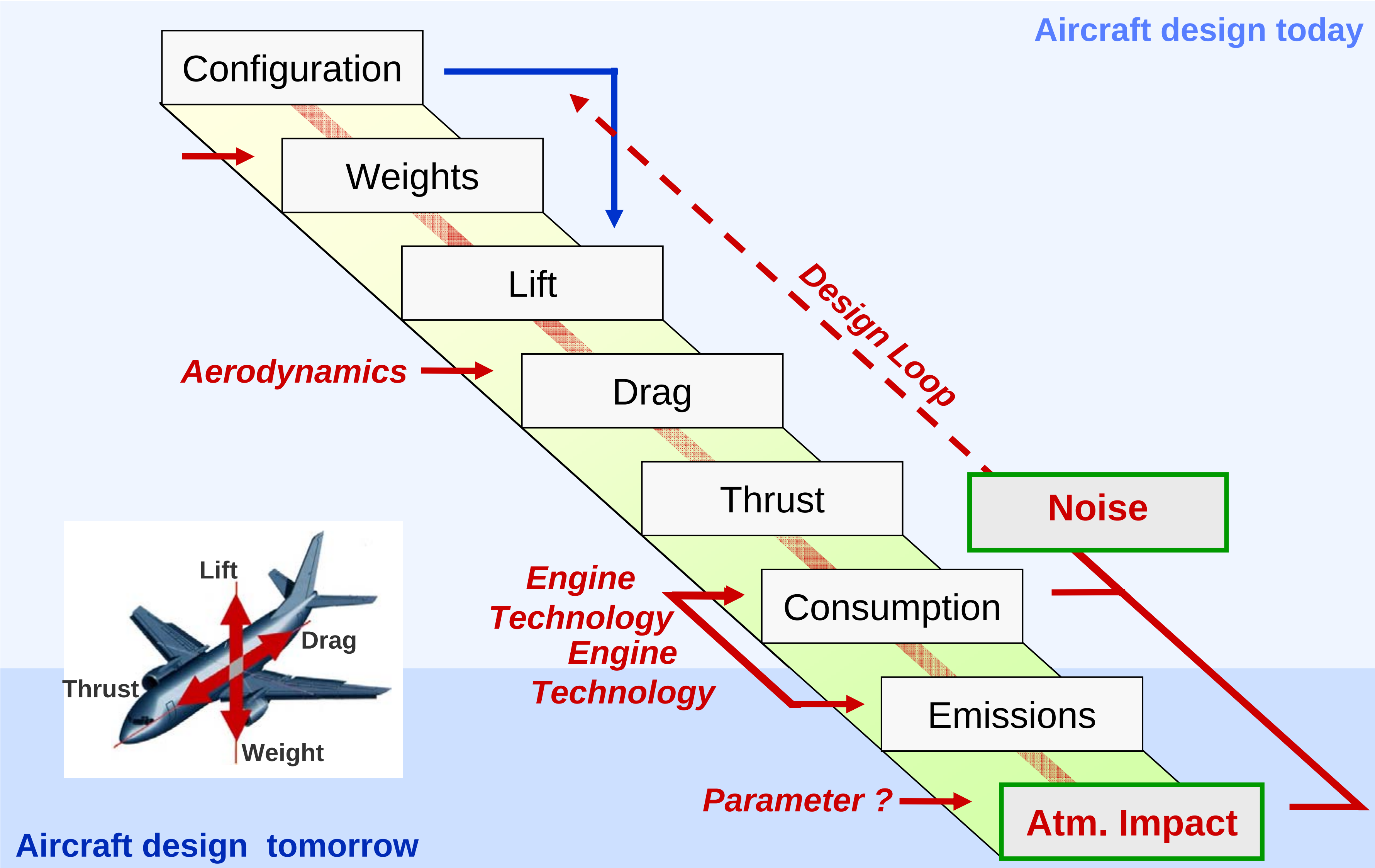
Source: Eurocontrol, Performance Review Report 2006

Example: Route Hamburg – Toulouse

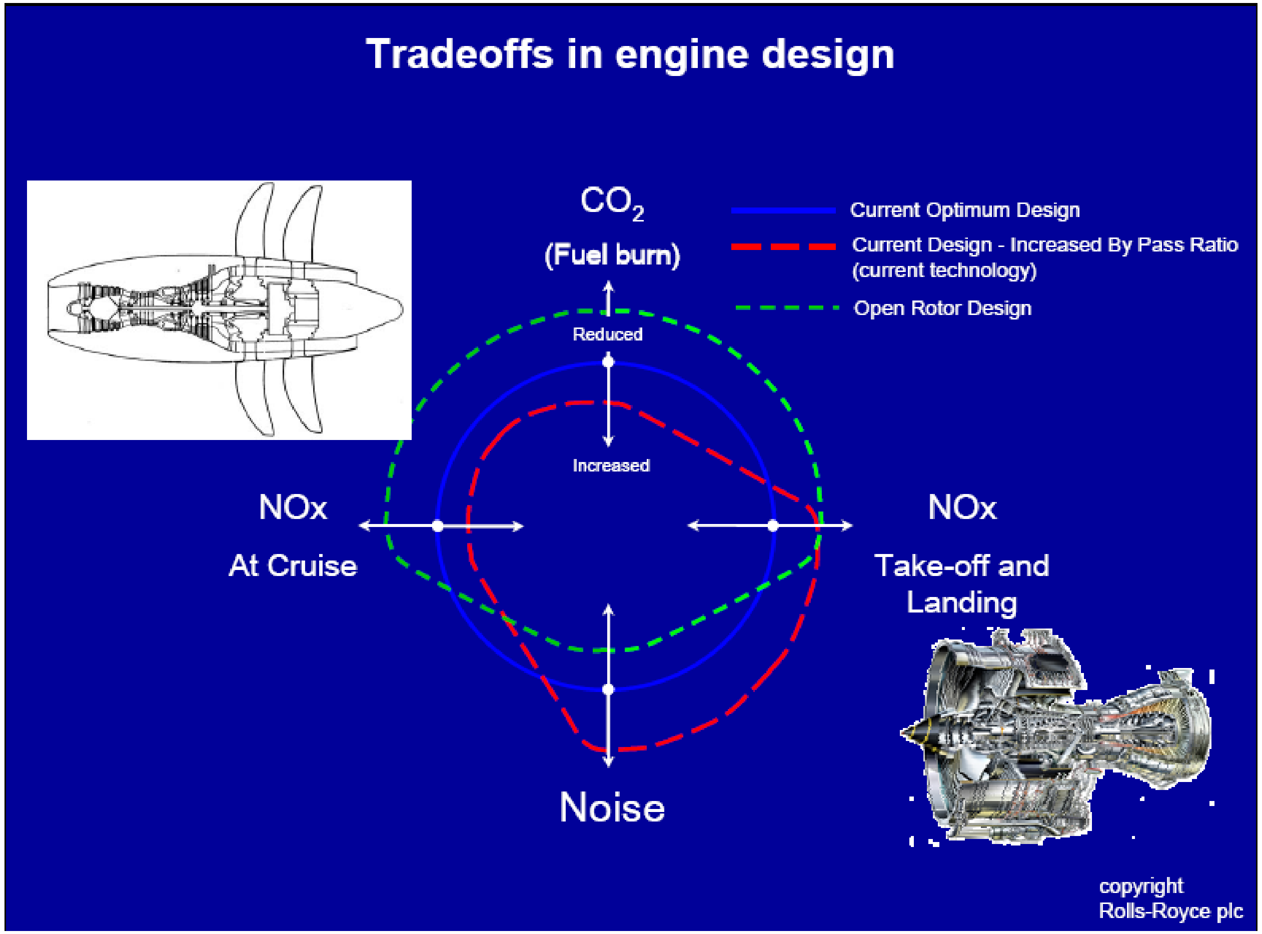


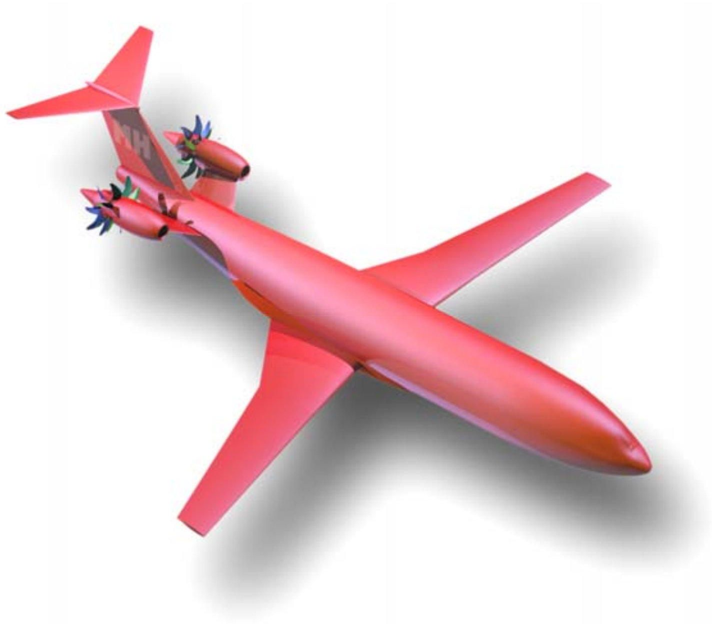
- Flight on airways vs. “Direct Routing”: 52,8 NM
- 2470 Kg CO_2 Reduction (6,2%) on a A330-300

‘Ecologically’ Driven Design



Propfan

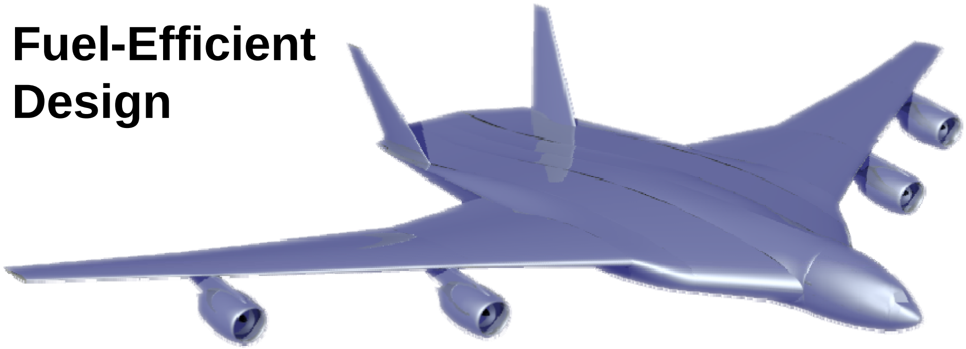

Tradeoffs in engine design
CO_2
(Fuel burn)
Current Optimum Design
Current Design - Increased By Pass Ratio (current technology)
Open Rotor Design
Reduced
Increased
NOx
At Cruise
NOx
Take-off and Landing
Noise
copyright
Rolls-Royce plc



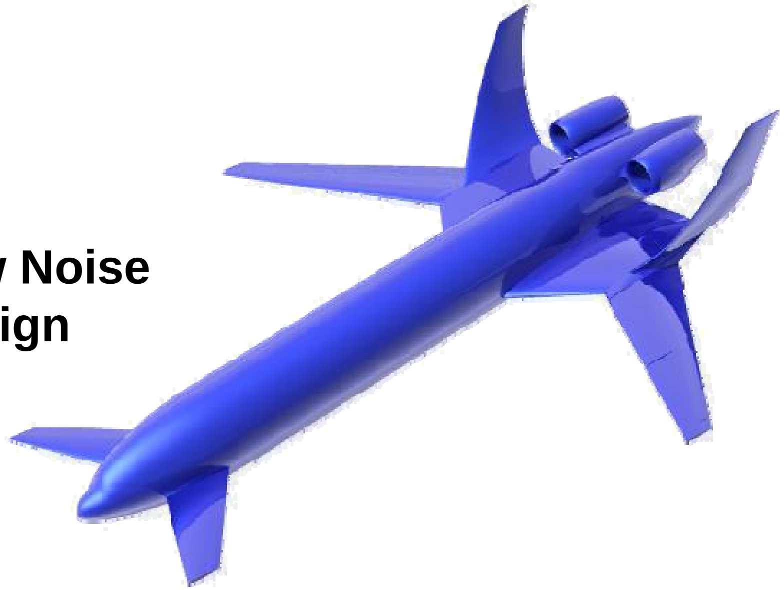
Future Airframe Concepts

Possible New Configurations

Fuel-Efficient Design



Low Noise Design



Strong drivers required for drastic change:

Air Transport is an economically based system

Conclusions

- Today's air transport system is highly matured and efficient
- Drastic system changes require high incentives
- Reliable Metrics necessary to include emissions into design loop
- Global legislation and ecological targets necessary
- Physics does not make ACARE goals unachievable (John Green)
- Research and Industry committed to address ACARE challenges