Technologies for the Future

Focusing on
Aircraft Configuration Design Perspectives

Lecture at DLRK 2018, Friedrichshafen

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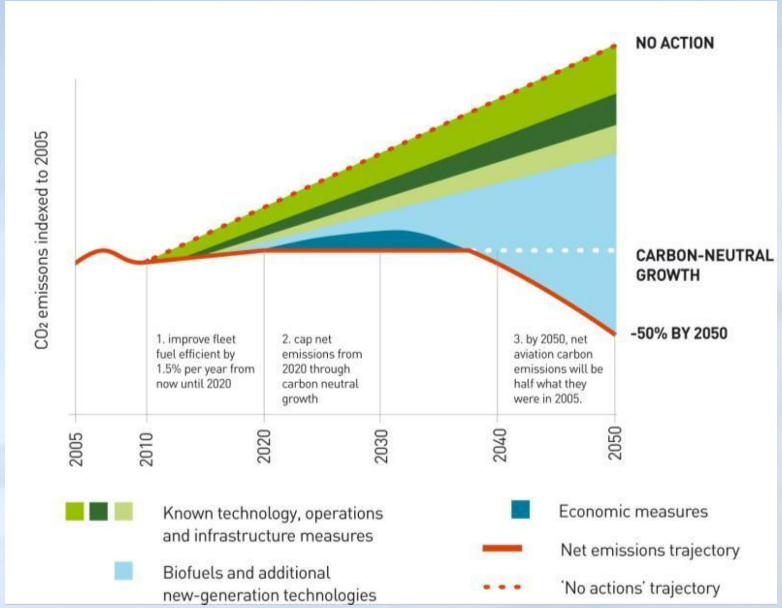
Advanced technology … serving customer expectations

Expectations

- Flying Safely
- Flying Economically & Efficiently
  - Airline operating costs (fuel, maintenance, …)
  - Productivity (size, operational reliability, load factor, TAT)
  - Translate extra comfort & passenger experience into revenues
- Flying "Simple"
  - Simple to fly, handle on ground
  - Simple to maintain
  - Simple & intuitive to passengers
- Flying Green
  - Keep aviation footprint small, while responding to growing traffic demand
  - Reduce landing & take-off noise
  - Doing more with less, think life cycle

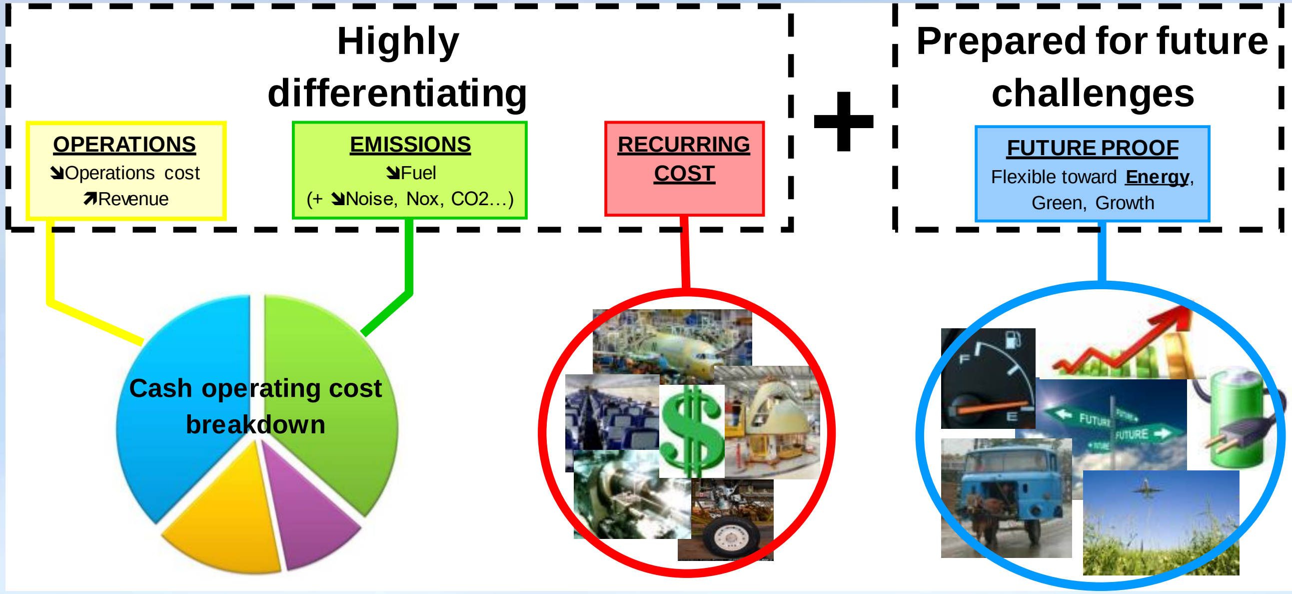
Challenges

- Traffic growth
- Fuel price rising
- Increased competition and deregulation
- New environmental regulations
- Economic challenges

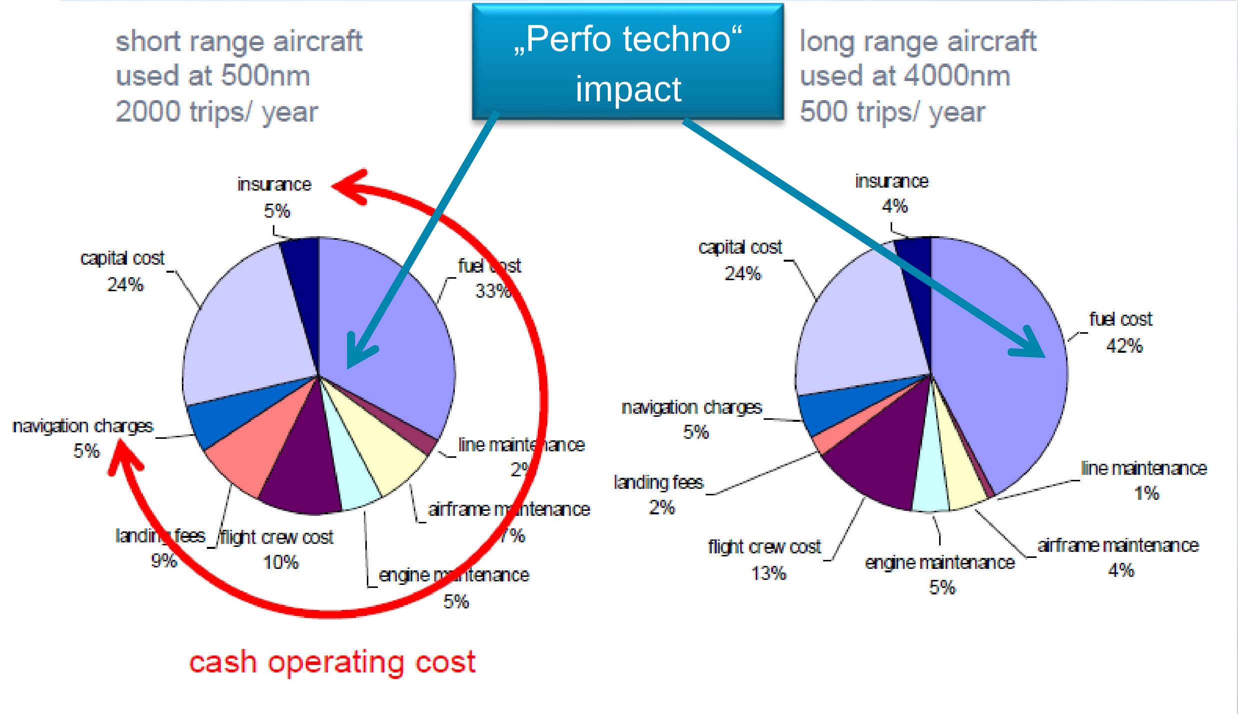


Advanced Technology is seen as key means to master these challenges

Advanced technology … serving business needs



Illustrative figures only !



Technology can provide significant direct value (e.g. fuelburn, weight), but there are strong indirect drawbacks (aircraft price, maintenance, operability …)

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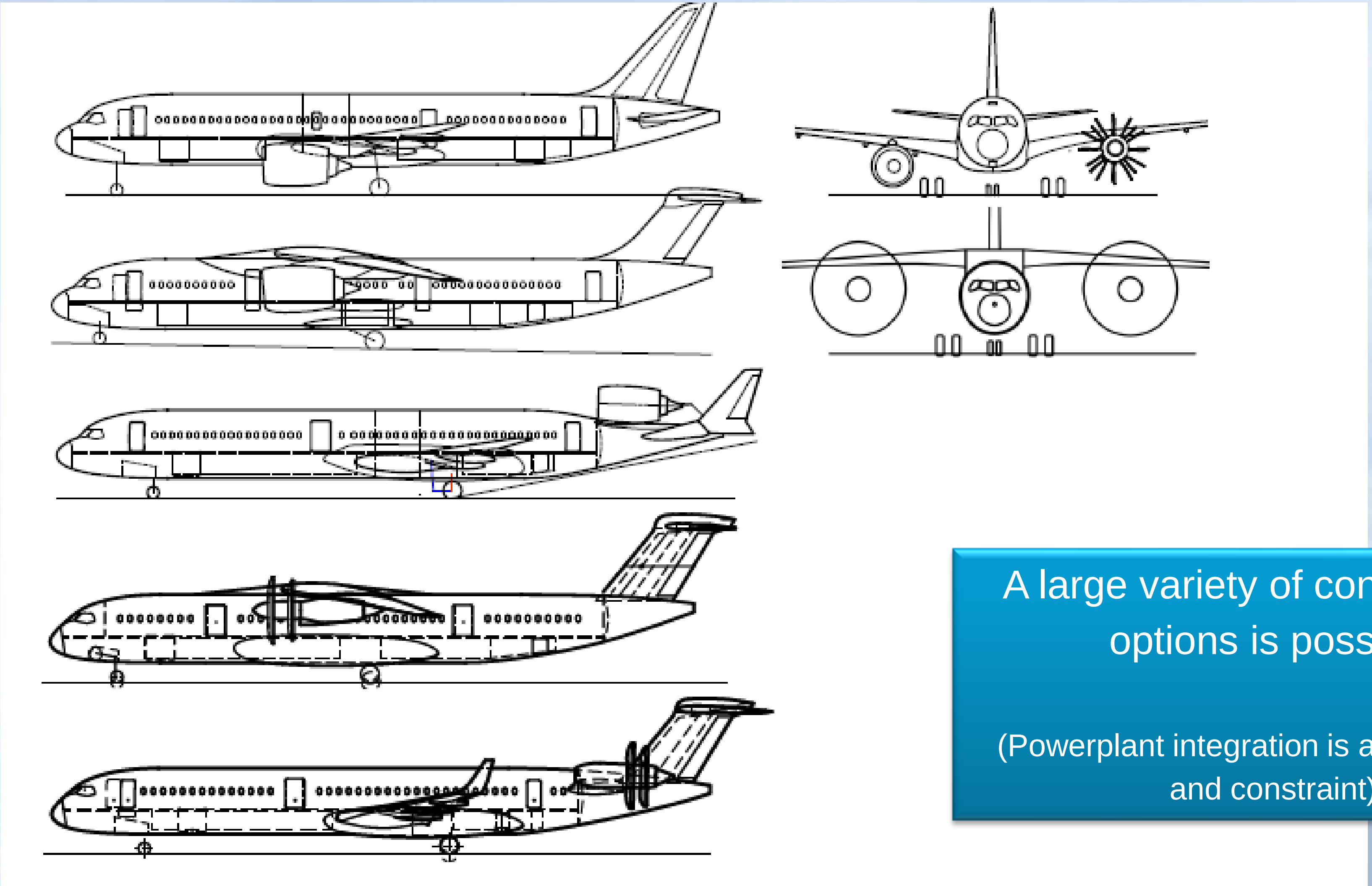
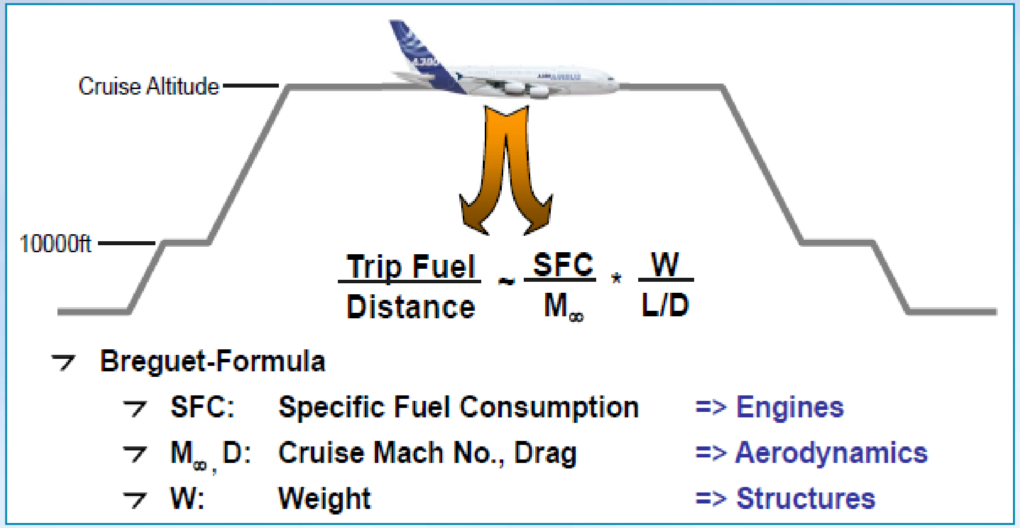
Configuration design – a value lever on its own

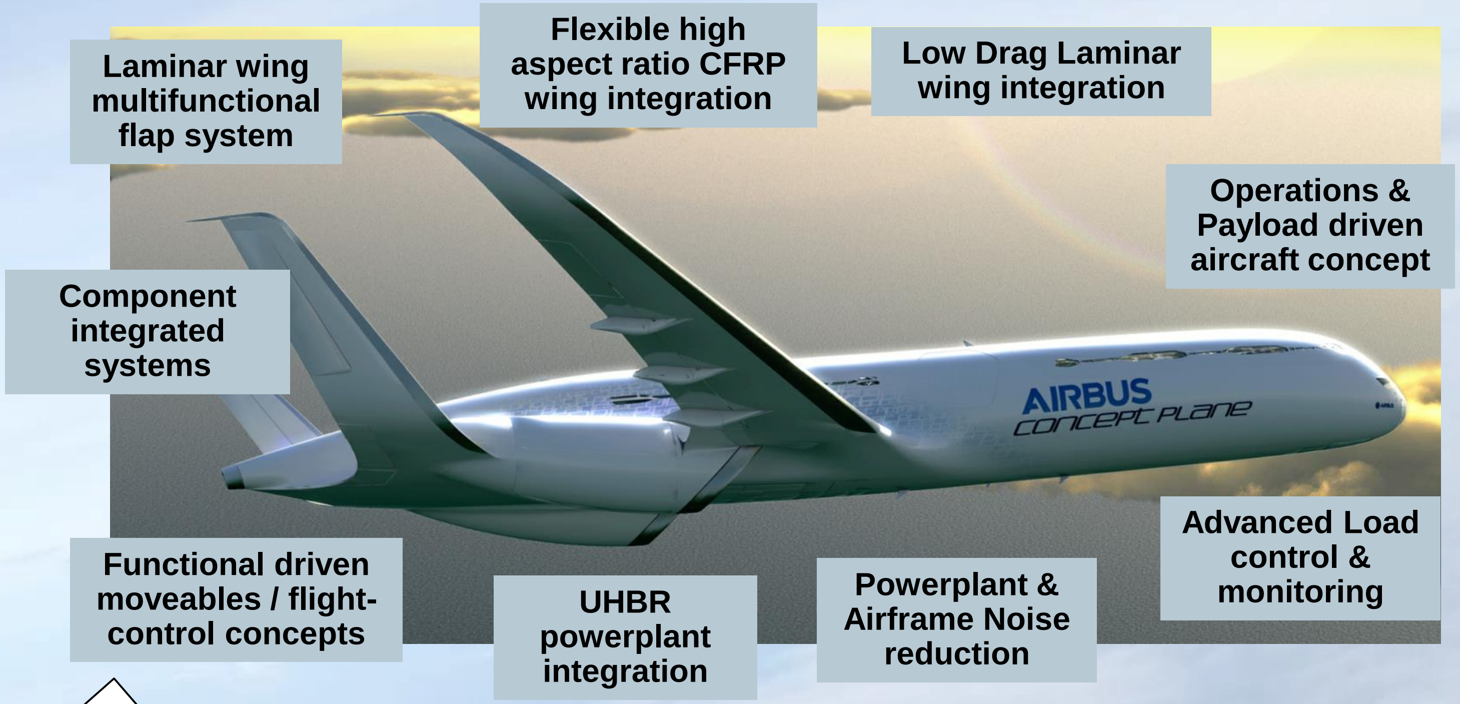


A large variety of configuration options is possible

(Powerplant integration is a major driver and constraint)

Identification of beneficial technology on overall system level



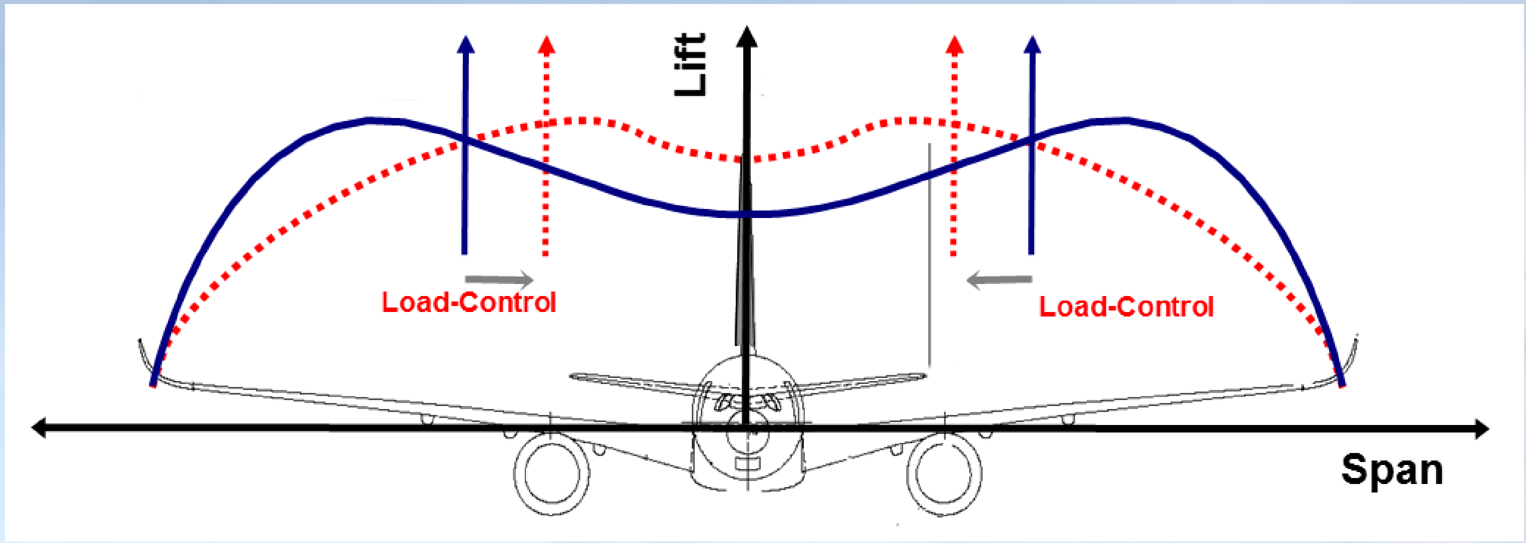


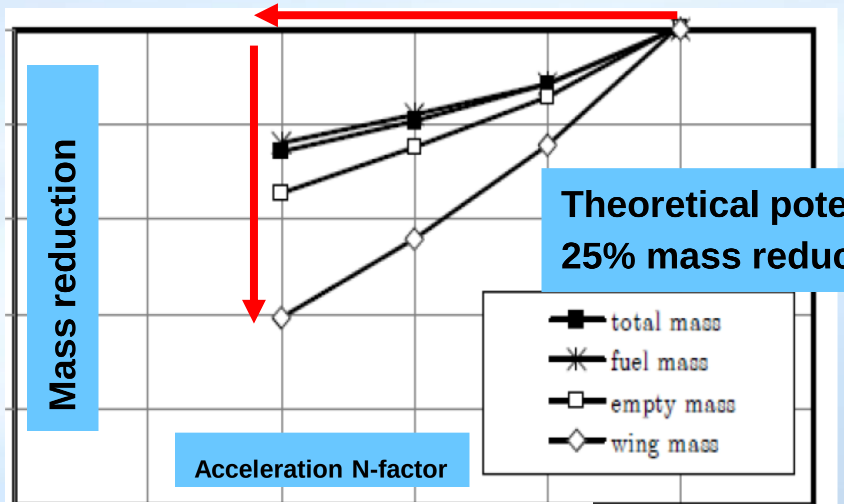
Derive technology bricks from overall value levers

A key challenge is to ensure integration of novel component **”technology bricks”** to ensure overall level benefits maturing on aircraft level.

The Active Adaptive Wing

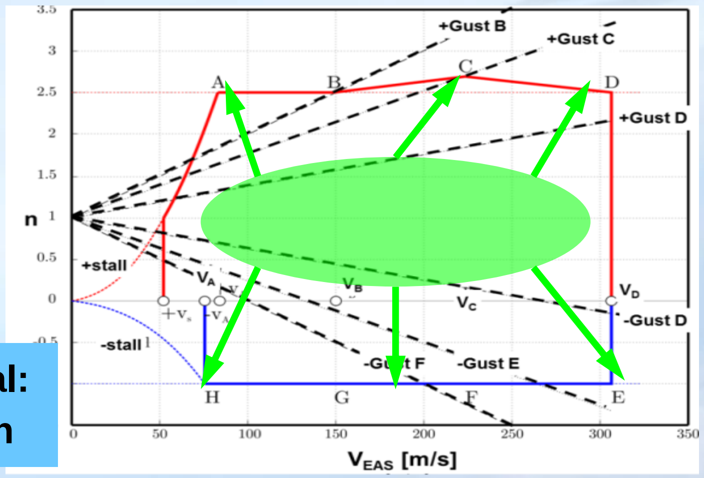
- Wing is sized by a huge number of load cases, e.g. maneuver & gust loads
- Simultaneous design of aircraft aerodynamics, structural dynamics & control laws necessary
- **Vision: limit as close as possible to ideal 1-g load case**
  → significant mass reductions possible

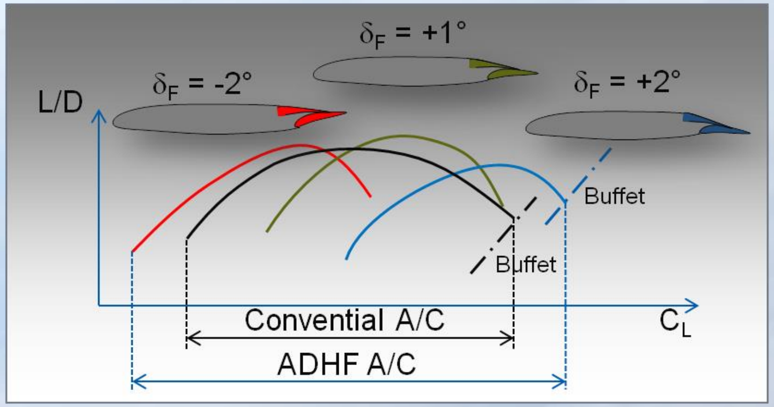




Theoretical potential:
25% mass reduction

Ref: C.C. Rossow / M.Hepperle, DLR





Advanced Load Control with a novel integrated approach up to certification can significantly reduce aircraft weight beyond current limitations

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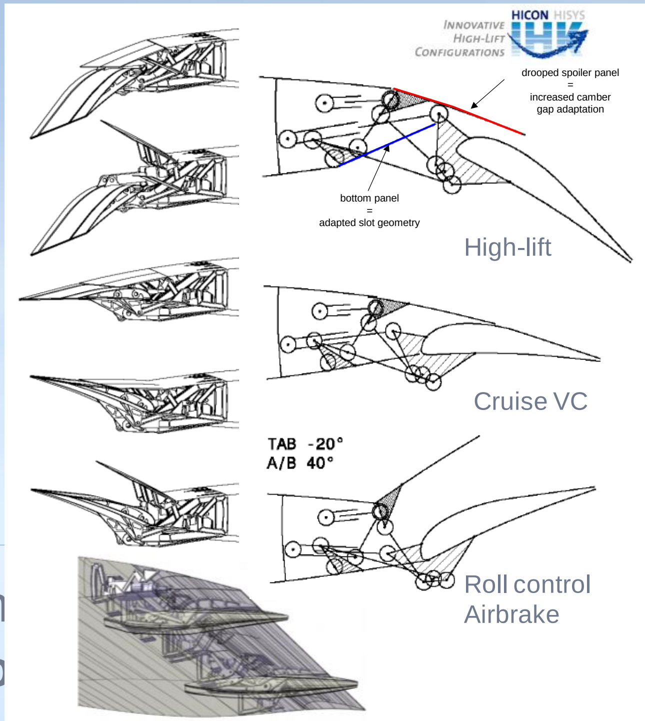
Functional Driven Moveables

- Fully functional driven approach → targeting step changes in weight & complexity and performance and to enable novel overall wing concepts.
- Not separating devices by functions (wing primary flight controls, high-lift devices, tails controls…) but integrated contribution to all needs

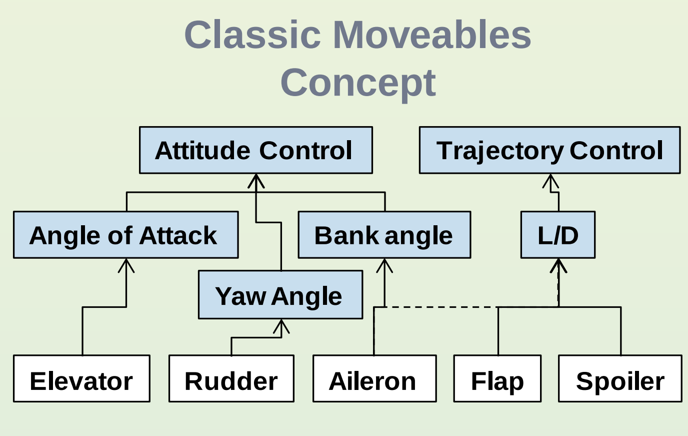


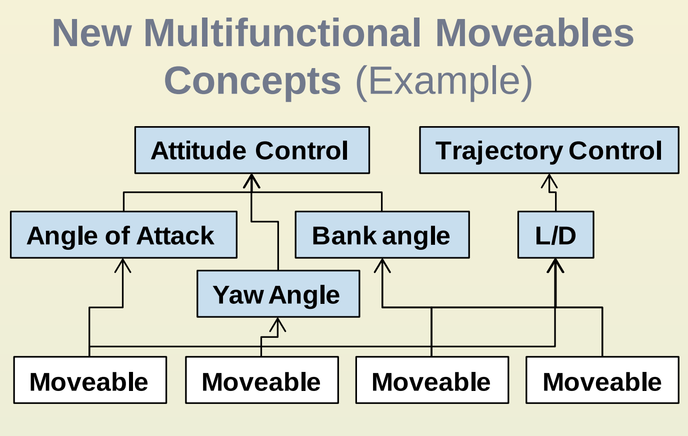
Integrated multifunctional flap concept

First step application on A350

Novel moveables layouts can enable full integration of performance, flight mechanics and loads management functions

1. In… es concepts & layouts based on o… ements driven approach

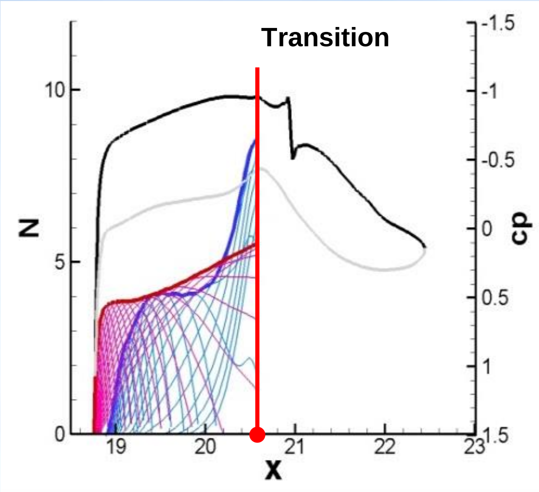


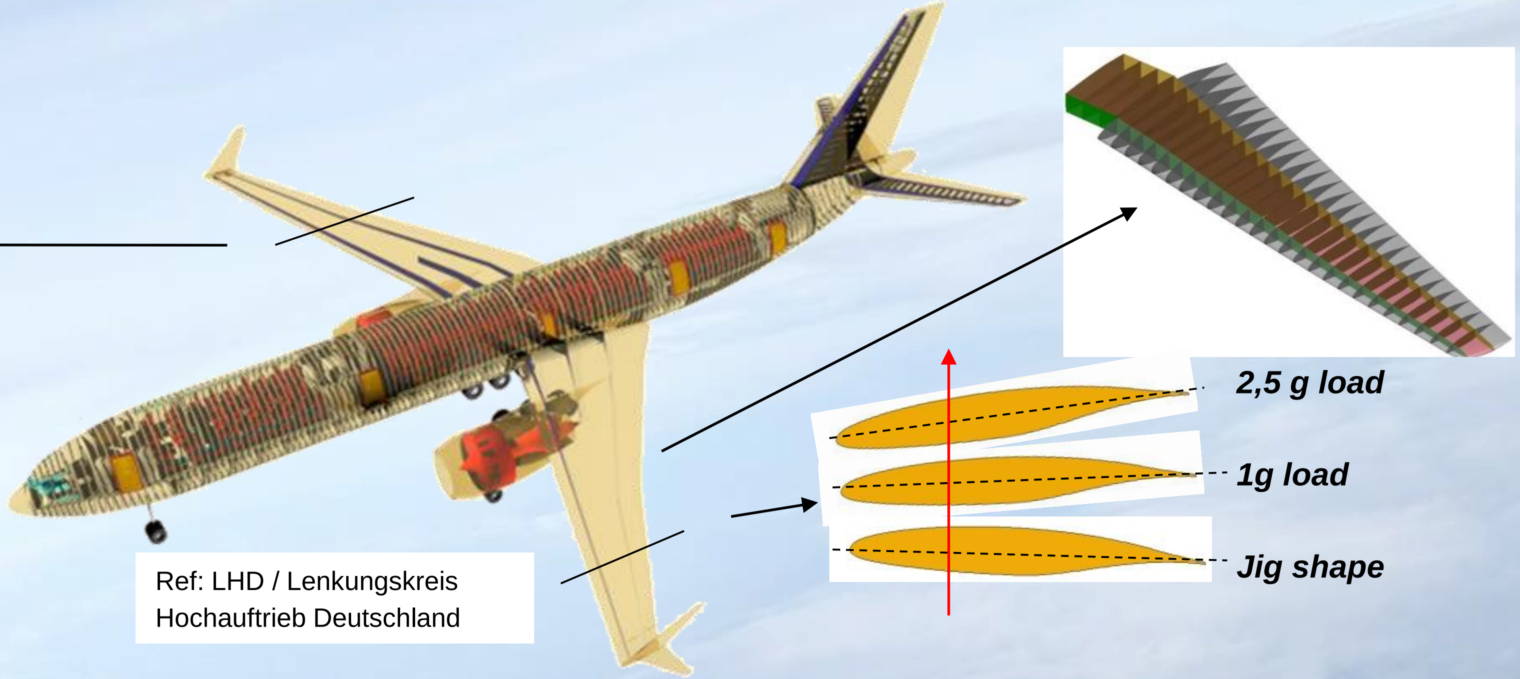


Laminar Wing Integration

- Natural or hybrid laminar flow could yield significant improvements in friction drag
- Forward swept wing could be an enabler for maintraining high cruise Mach Number
  - Advanced CFRP design & aeroelastic tailoring is mandatory

Laminar Forward swept wing





Ref: LHD / Lenkungskreis Hochauftrieb Deutschland

Optimized Laminar wing integration via change in wing planform design paradigms, enabled by advanced structural technology

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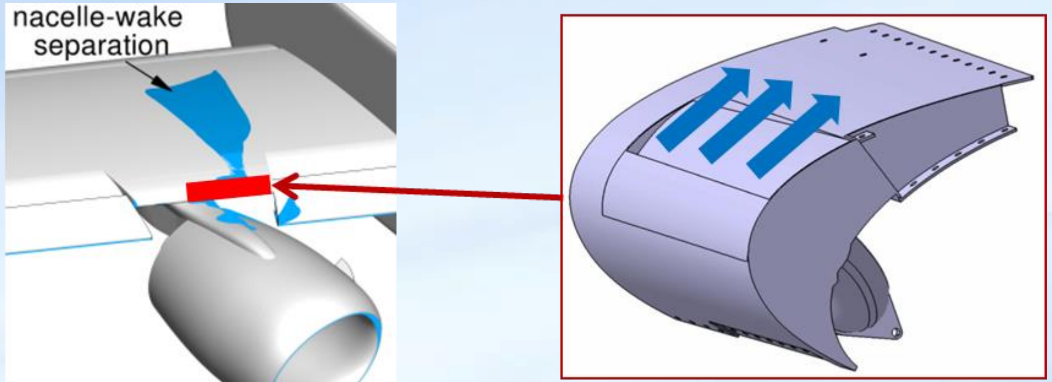
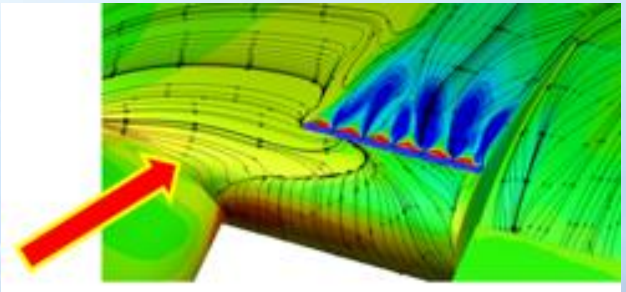
Active Flow Control

Active flow control for low speed applications

- To enhance the performance of passive moveables
- To „repair“ critical areas on the wing
- To fully replace classical moveables (in long term)
- ... with the aim of flow control solutions being more effective or lighter than passive mechanical moveables solutions

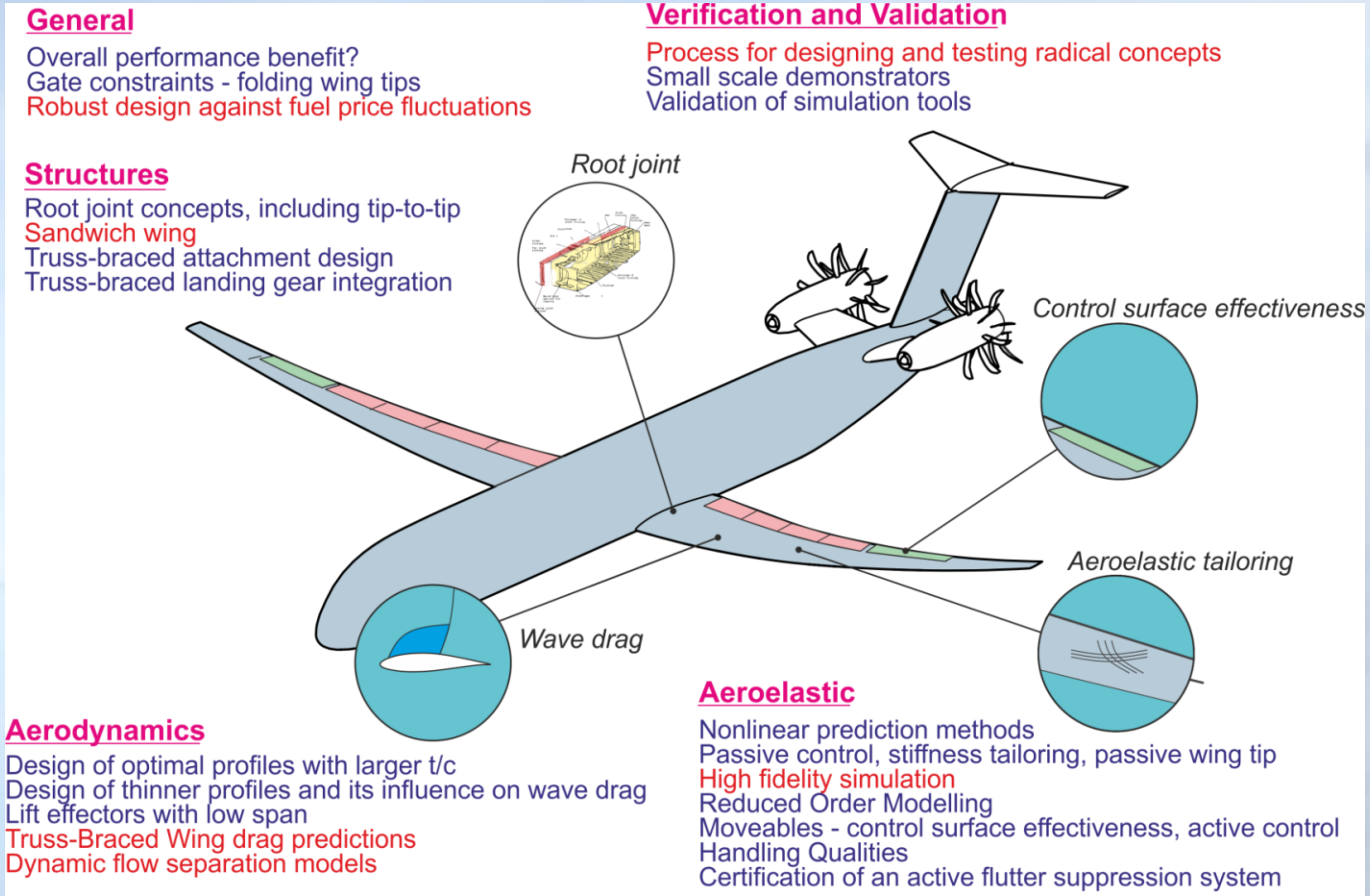




Local active separation control – potential areas of application on future configurations

Application of local Active Flow Control to overcome local performance limiting effects, e.g. adverse UHBR integration drawbacks

Extreme High Aspect Ratio Wing



A very high aspect ratio wing can enable ultimate aerodynamic efficiency, but active control technologies and disruptive structural solutions are required

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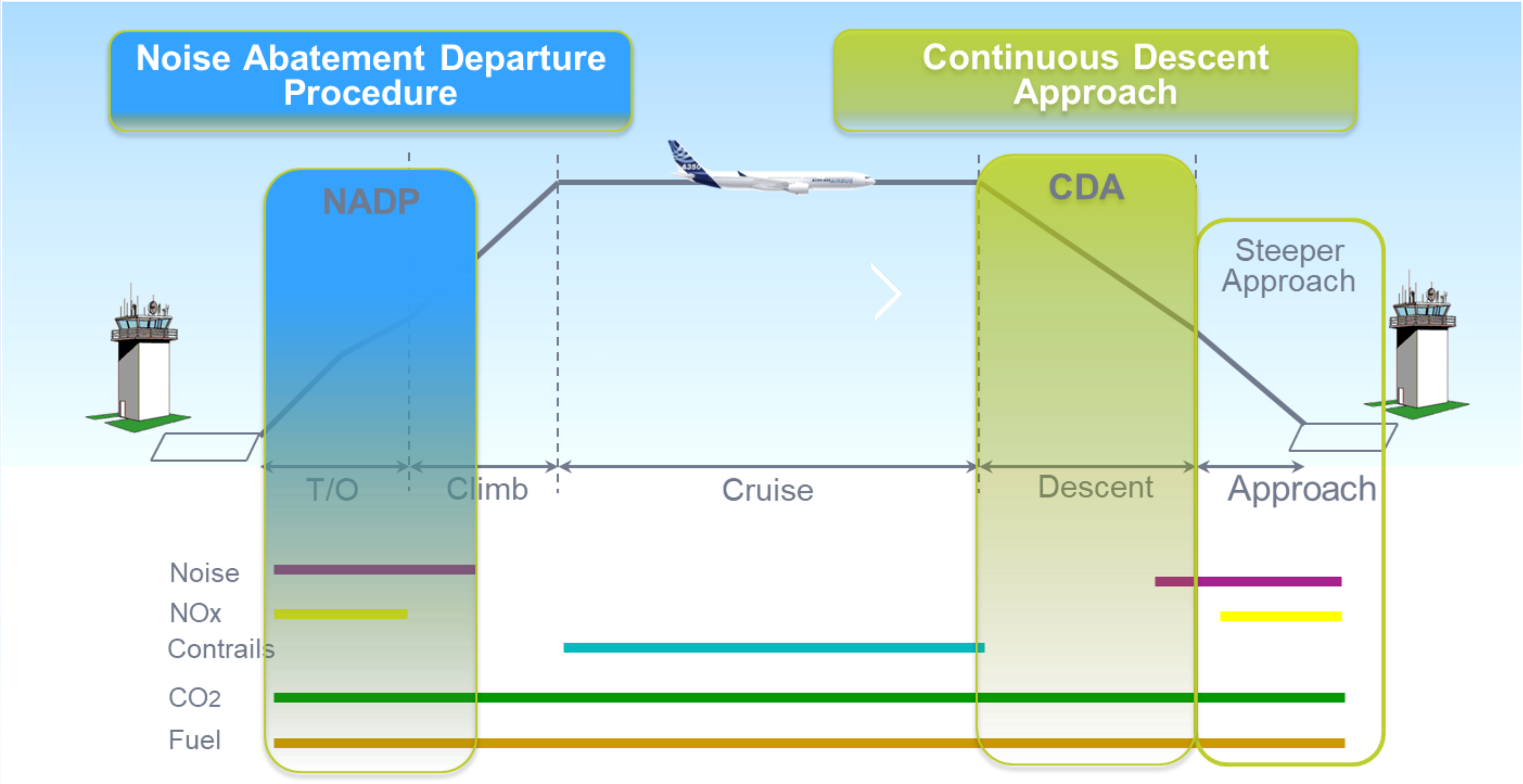
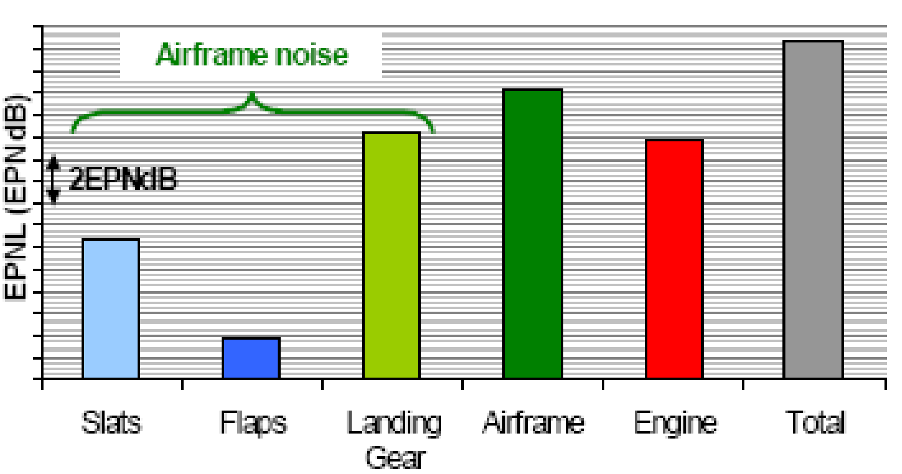
Eco-Efficient & Low Noise Operations – Flight Trajectories

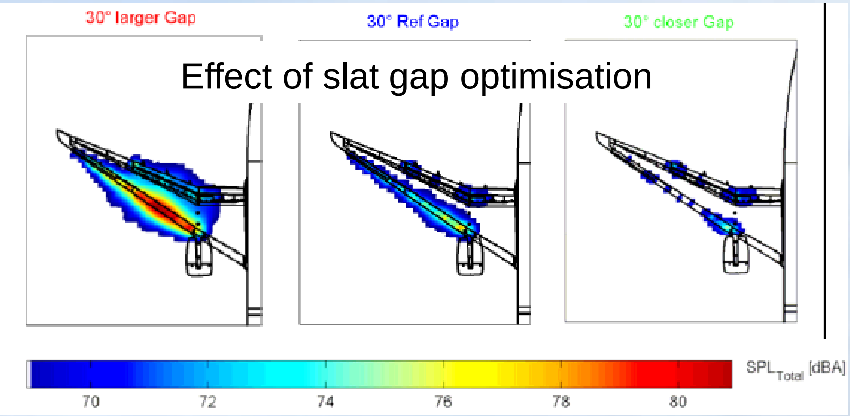


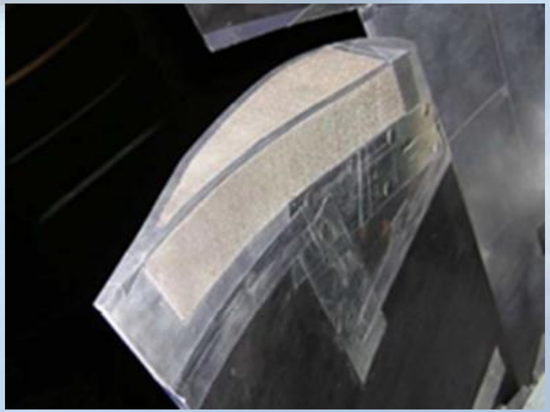
- Trajectory management can improve noise footprints at departure and in descent/approach
- Optimised “4D” trajectories in cruise can reduce fuelburn and emissions
- Cruise routing also could be optimized for contrail avoidance (greenhouse effect)

Low Noise Design – Airframe and Configuration



Airframe Design





New Configurations

As engine noise becomes minor contributor in approach, noise reduction is to be tackled by both source noise optimisation and considerations on configuration level

Propulsion Systems Perspectives

Disruptive propulsion systems will require significant changes on the aircraft architecture (airframe and systems).

2016

A320neo Powerplant System generation

2020+

Continuous Improvements on current generation Powerplant Systems

2025-2030

Next Generation Powerplant Systems

- Integrated Ultra-High Bypass Ratio Engines
- Low power hybridization of Turbofans
- Electric flight on small commercial vehicles (<20 seats)

2035

Disruptive Powerplant Systems

- Medium power hybridization of Turbofans
- BLI
- Open Rotors
- Distributed Propulsion
- Electric flight (<100 seats)

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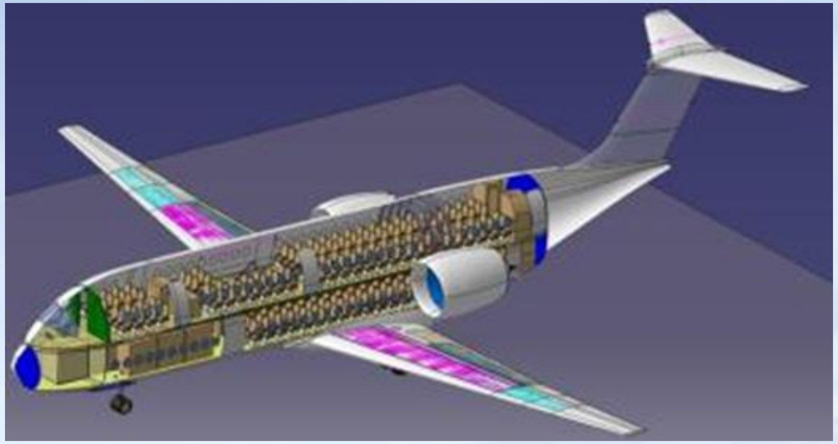
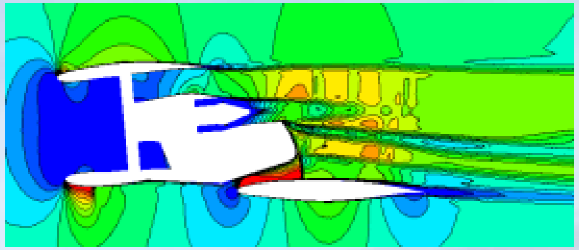
Disruptive Turbofan and Open Rotor Integration

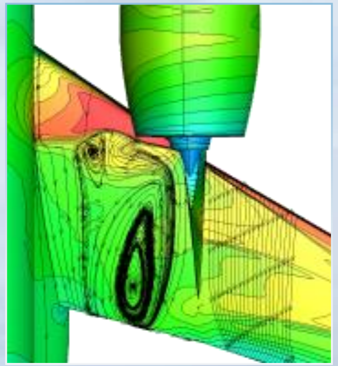
- For Ultra High Bypass Ratio (>>15) or Open Rotors radical installation concepts become necessary

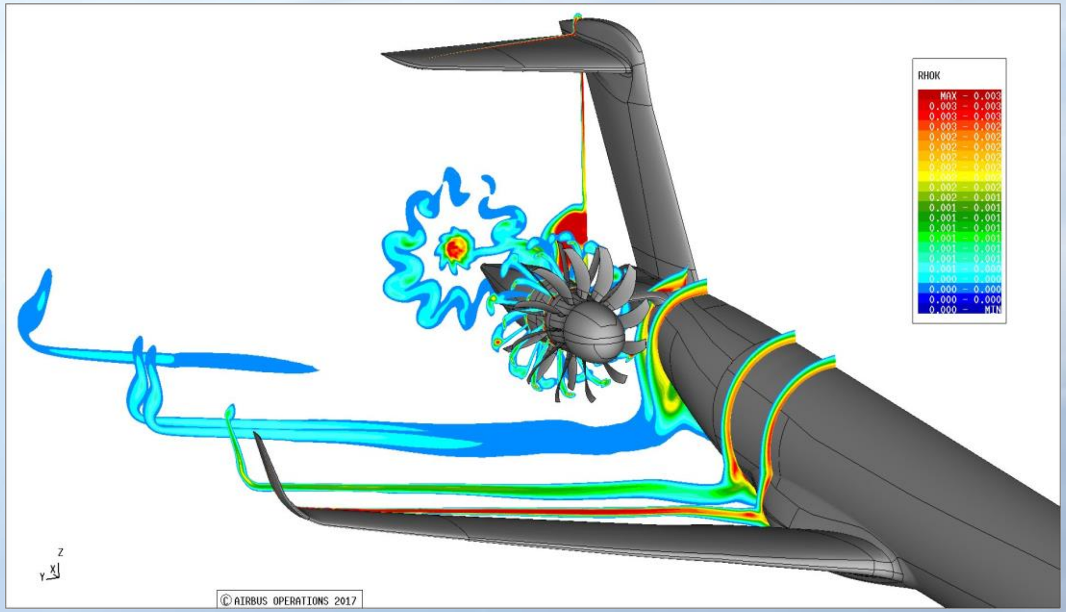
- Novel pylon structures solutions
- Aerodynamic shaping of wing planform, wing & pylon profile
- Management of engine noise drawbacks on cabin

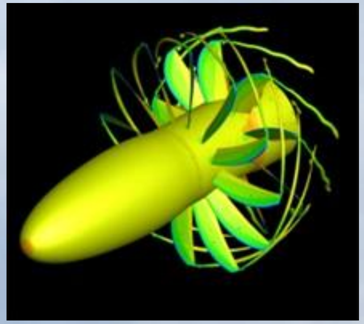
For installation of large UHBR and Open Rotor it seems to be unavoidable to relax constraints → will benefits on overall aircraft level remain ?





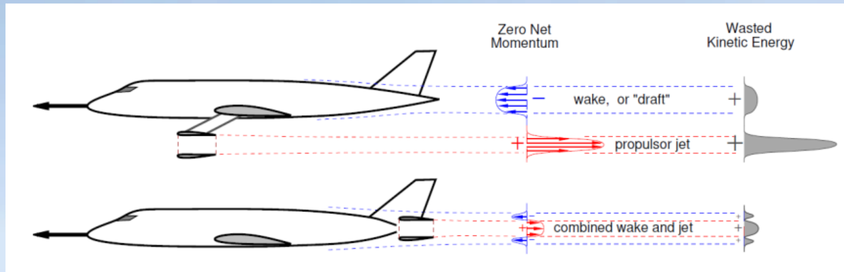






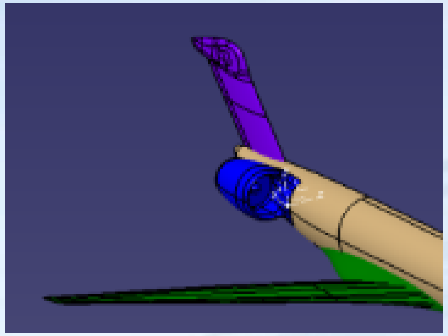
Boundary Layer Ingestion

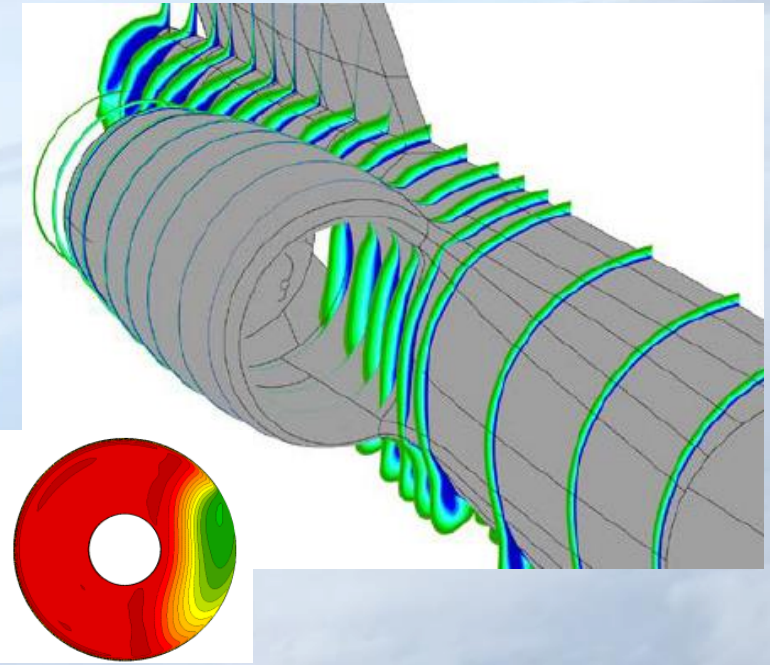
BLI-concepts can provide a significant fuel burn reduction through a closer coupling and integration between the airframe and engine.



Challenges

- Reduce A/C weight & drag
- Design of a distortion-tolerant fan
- Design of air inlet minimizing the fan penalties

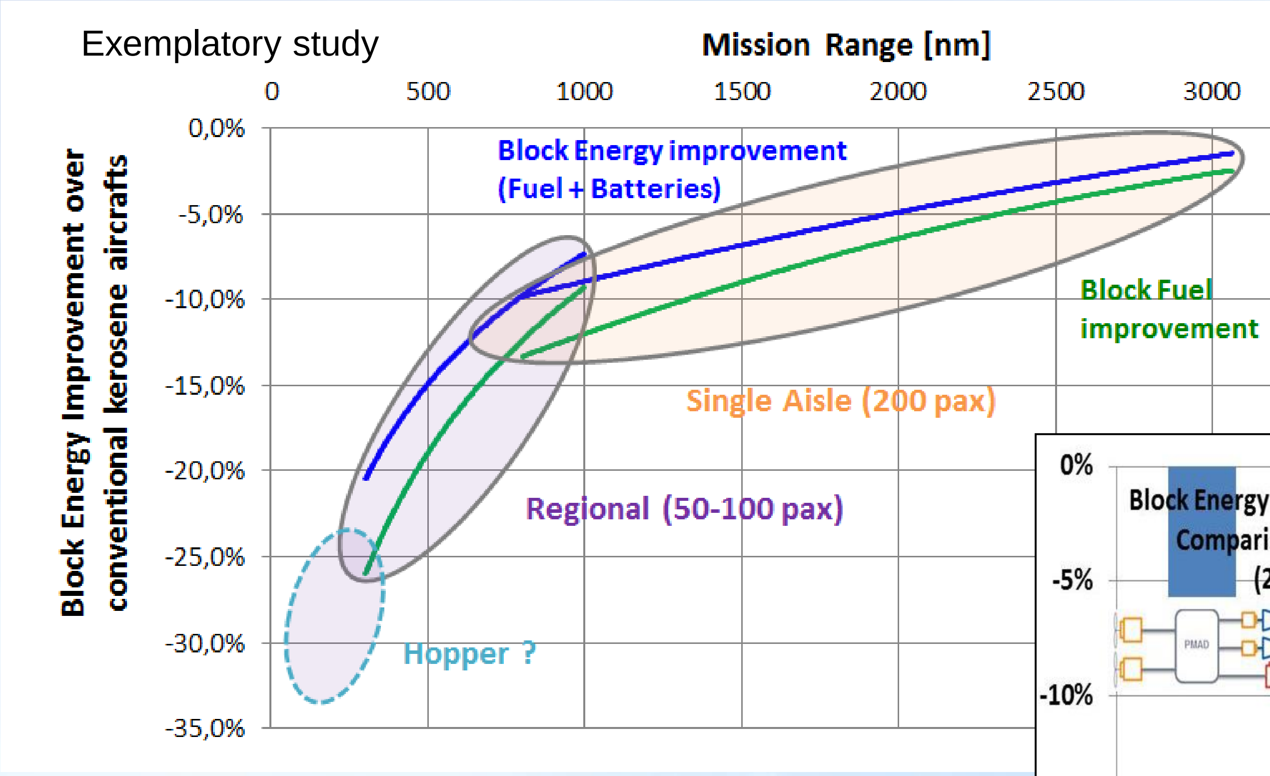


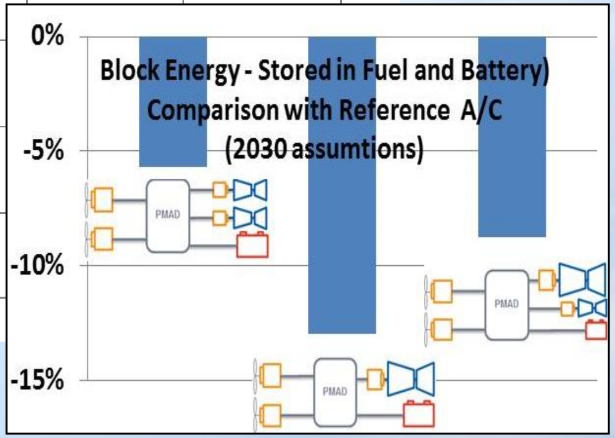


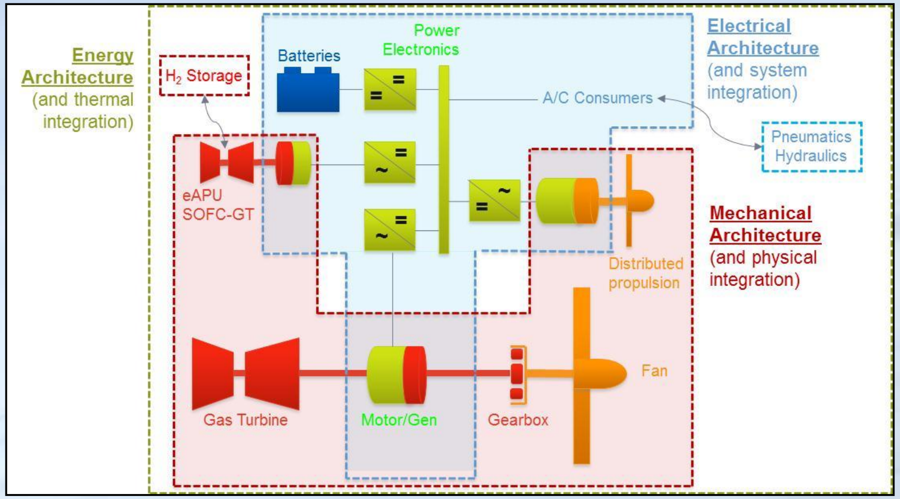
- Integration requires unconventional A/C configurations

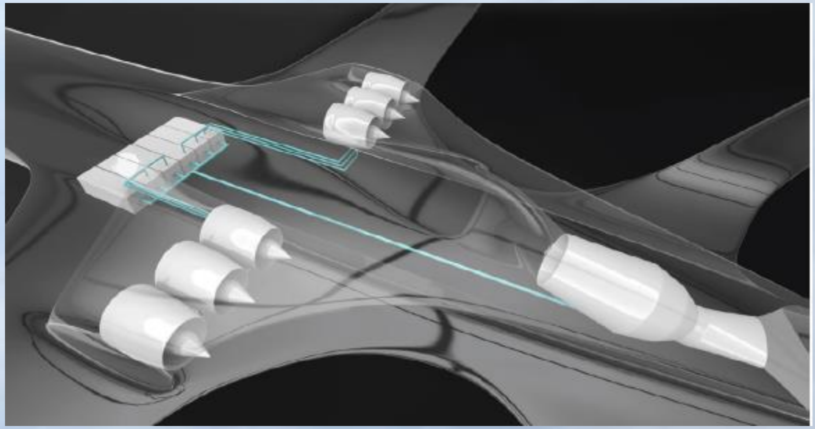
Shared challenges between Aircraft and Engine manufacturers to capture BLI benefit while not over-compromising the aircraft configuration

Hybrid Electric Propulsion









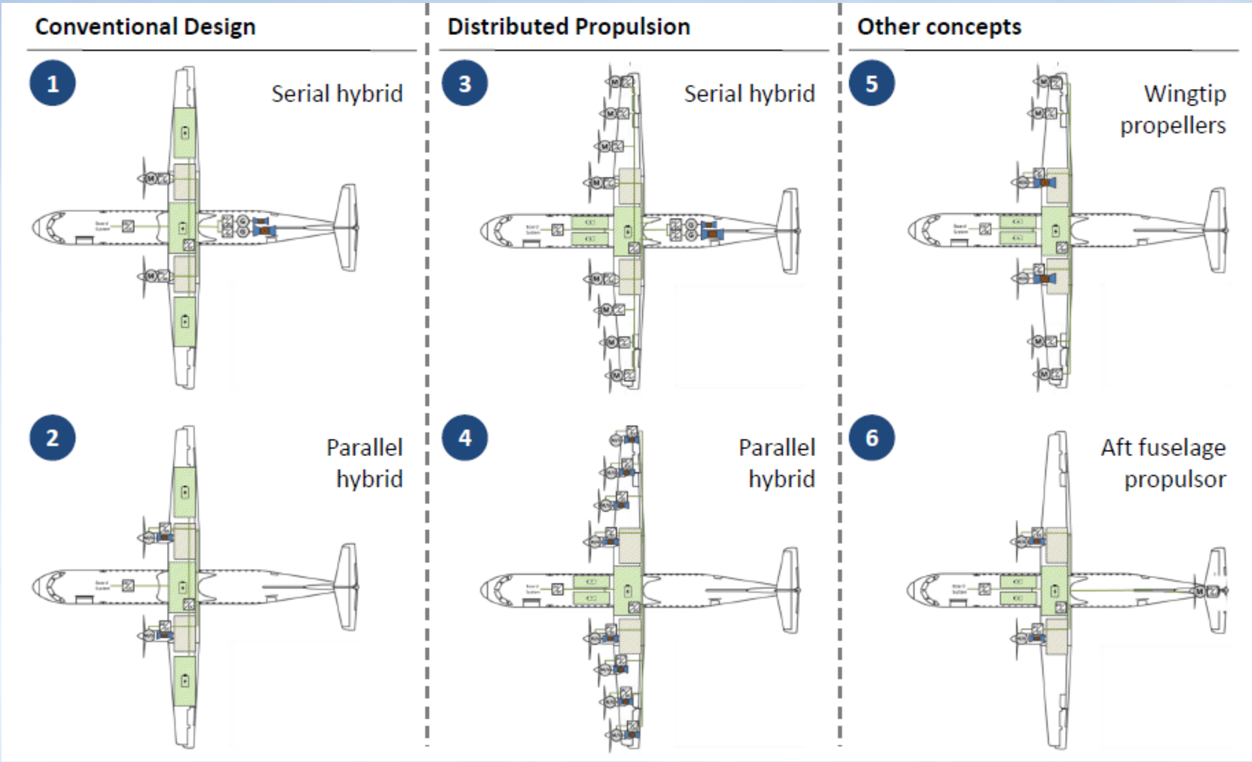
Hybrid / Electric propulsion can visibly reduce block energy need → but is this enough for a paradigm shift ?

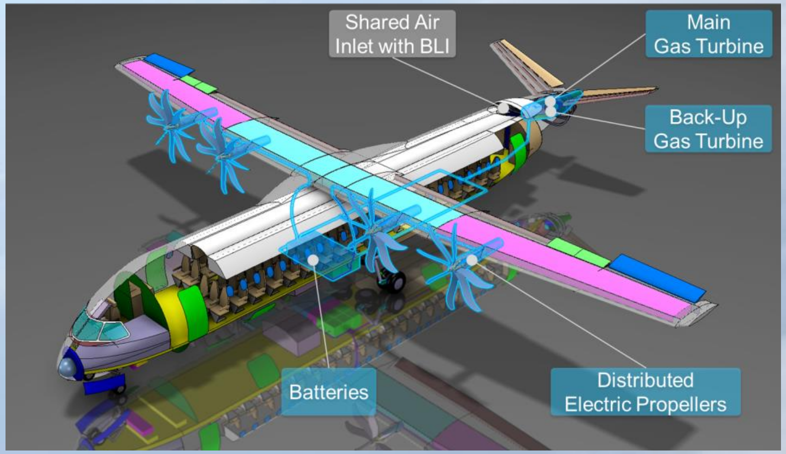
Hybrid Electric Distributed Propulsion

- Synergies from integrated design
  - Powered lift
  - Differential thrust for A/C control
  - Significant reduction of excess power, due to limited impact of failure cases
  - Low noise designs

- A wide range of aircraft concepts is suddenly possible !
  - Top level aircraft requirements may become part of the design variables …

Hybrid electric powered aircraft can directly benefit from improved efficiency in a limited extend, however breaking up the aircraft architecture suggest massive synergies





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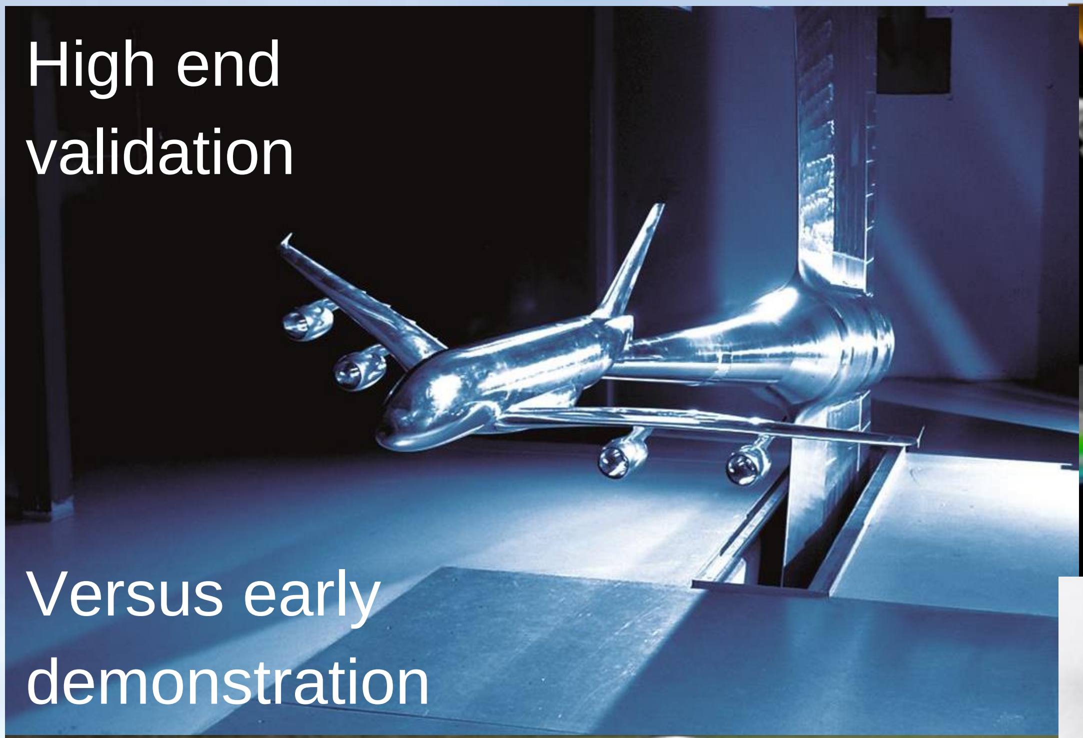
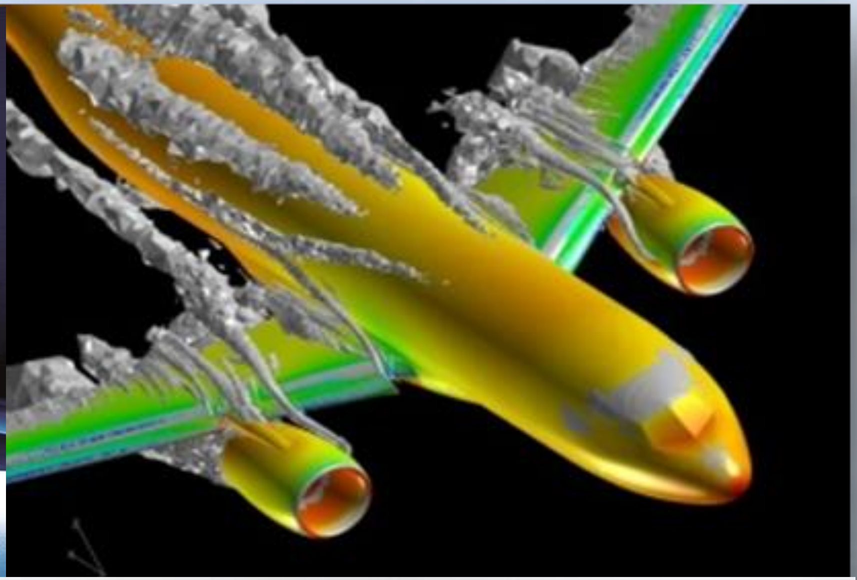
Tools for technology demonstration – on a turning point ?

High end validation





Versus early demonstration

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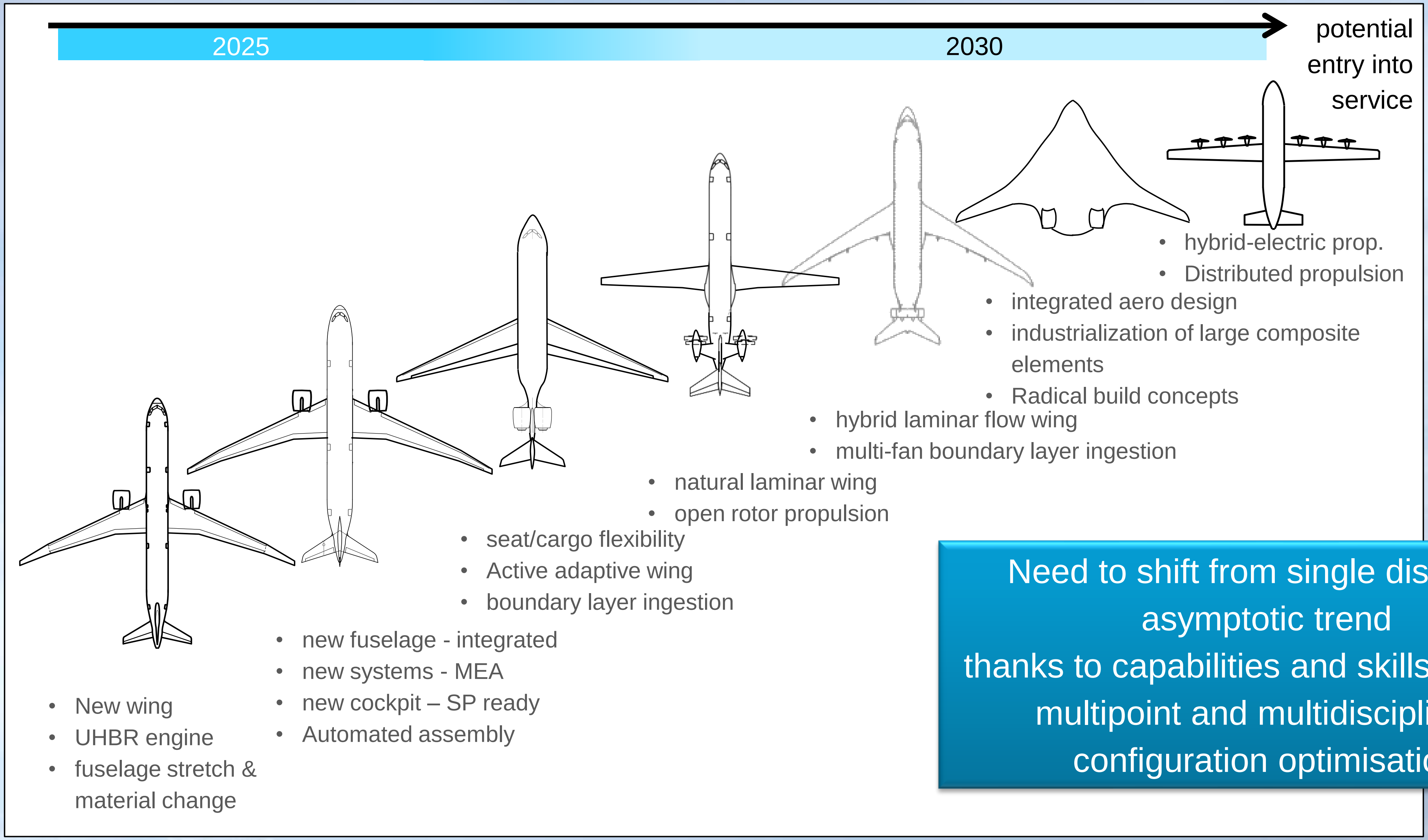
Configuration design – integrating technology bricks in aircraft level



Need to shift from single discipline asymptotic trend thanks to capabilities and skills enabling multipoint and multidisciplinary configuration optimisation

The Role of Research & Technology

- Research & Technology development provides key enabling bricks for Airbus to master the challenges for the future of flight
- Significant improvements can be realized in
  - Economic aspects: operating and manufacturing costs
  - Ecologic aspects: fuelburn, emissions and noise
  - Socioeconomic aspects: travel growth, sustainability, …

- The „value driven“ integration of technologies into a product needs to ensure the maturation of these benefits on system level

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