AKTUELLER STAND DER ENTWICKLUNG VON ANTRIEBSKONZEPTEN AUS DER SICHT DER STRÖMUNGSAKUSTIK

ICANA 2023, 10.03.2023

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Institut für Antriebstechnik, Institut für Elektrifizierte Luftfahrtantriebe

DLR

CURRENT STATE OF DEVELOPMENT OF PROPULSION SYSTEMS FROM THE POINT OF VIEW OF AEROACOUSTICS

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DLR

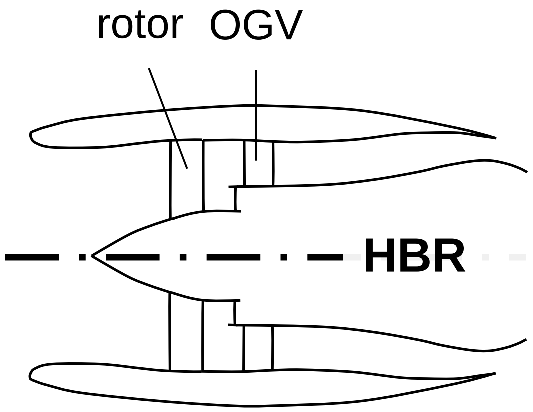
Motivation

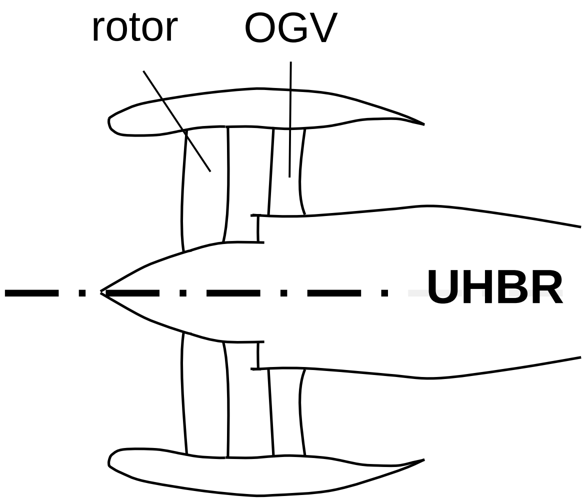
The next generation of ducted turbofan engines will likely exhibit

- Ultra High Bypass Ratio (UHBR, BPR~16)
- Low fan pressure ratio (FPR~1.3)

„old gen“ V2500 | „current gen“ GTF | „next gen“ UHBR

FPR~1.6 BPR~8 | FPR~1.4 BPR~12 | FPR~1.3 BPR~16





Due to weight penalty, the engines will become more compact and the L/D-ratio will decrease

Outline

Compact UHBR-Engines with short nacelle

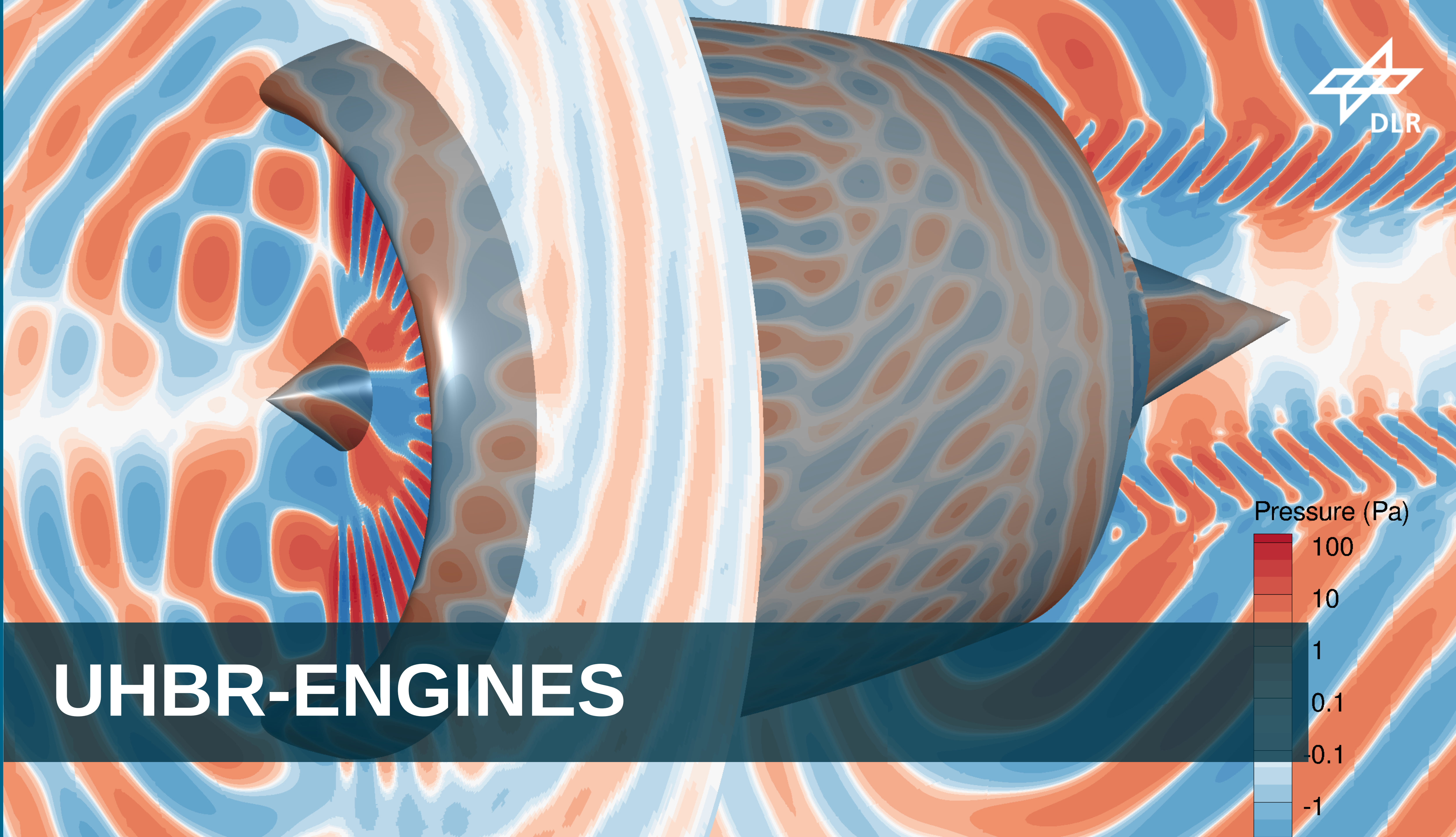
- Improved lining is needed due to less available internal surface
- Rotor inlet is prone to side wind effects (gusts)
- Engine positioning is to be investigated indepth
- Embedding engines becomes likely
- Noise shielding is an issue

Electrification of Propulsion

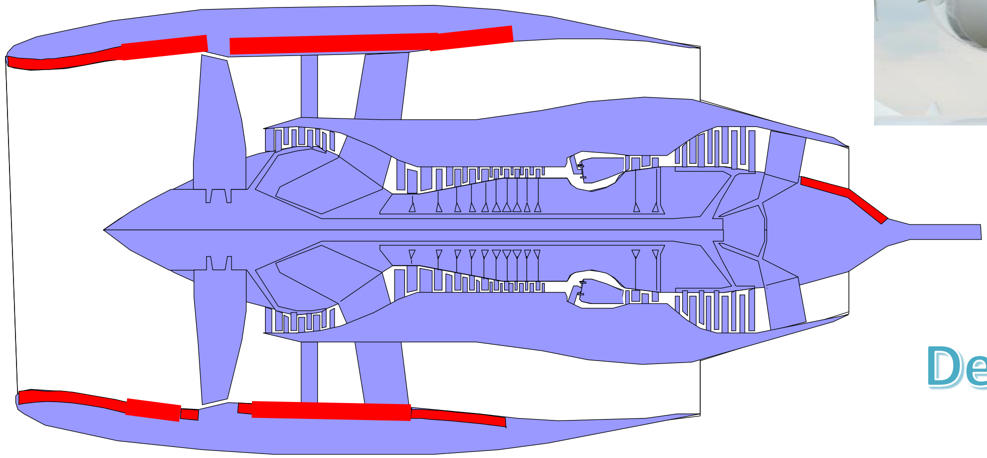
- Will a simple replacement reduce noise?
- Distribution of more and smaller engines becomes an option

Outlook

UHBR-ENGINES

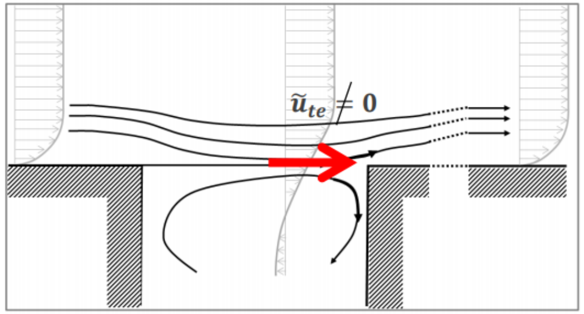


Passive Noise Reduction: Liner

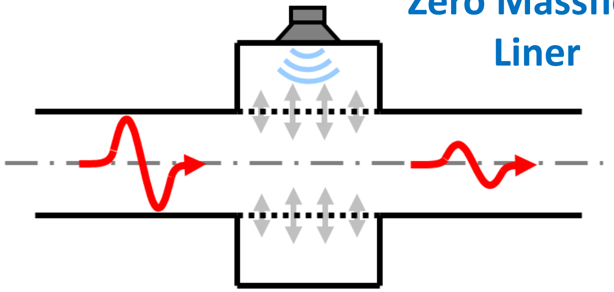


Lined Surface

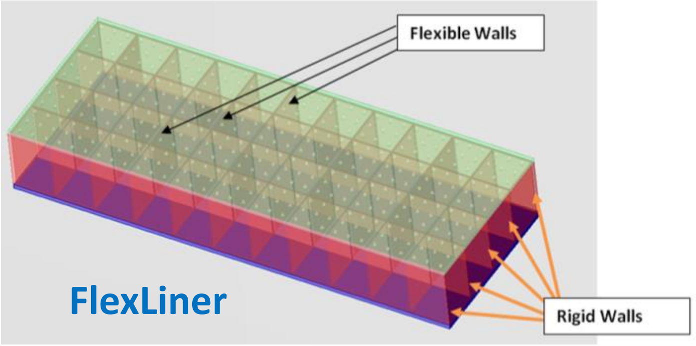
Physical Mechanisms



Development of Innovative Concepts

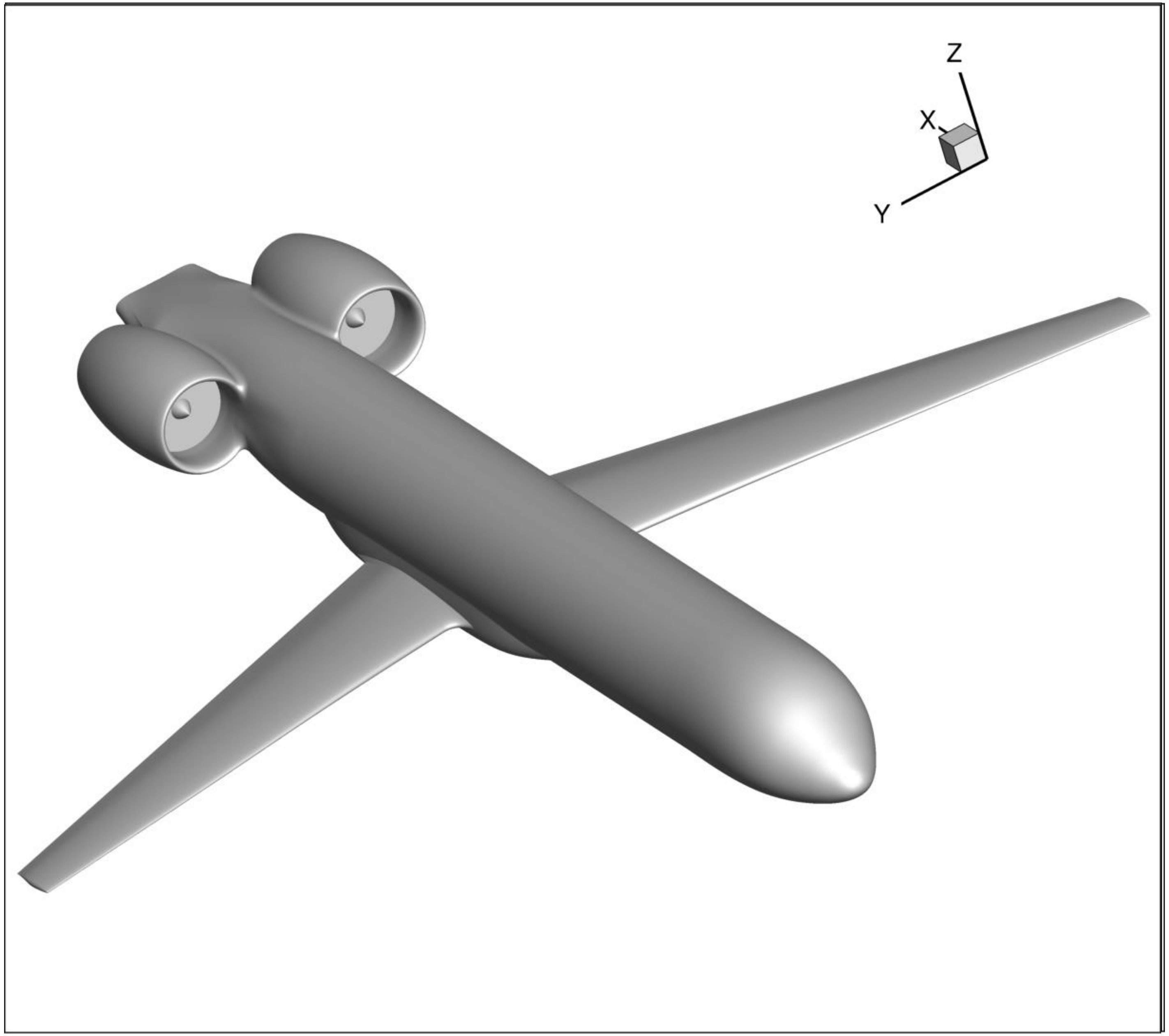


Zero Massflow Liner

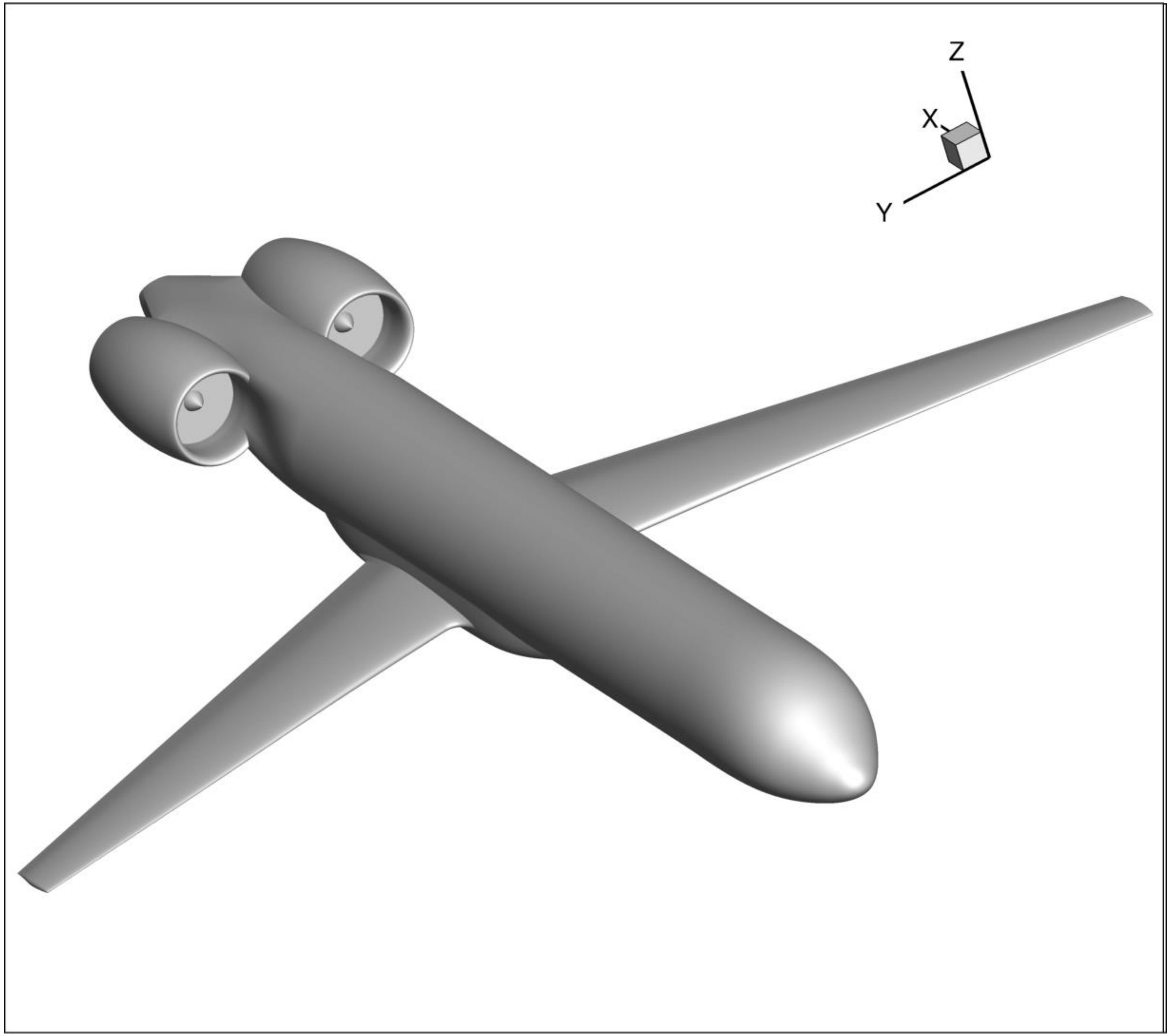


Positioning of Engines (1): Below/Above Wing

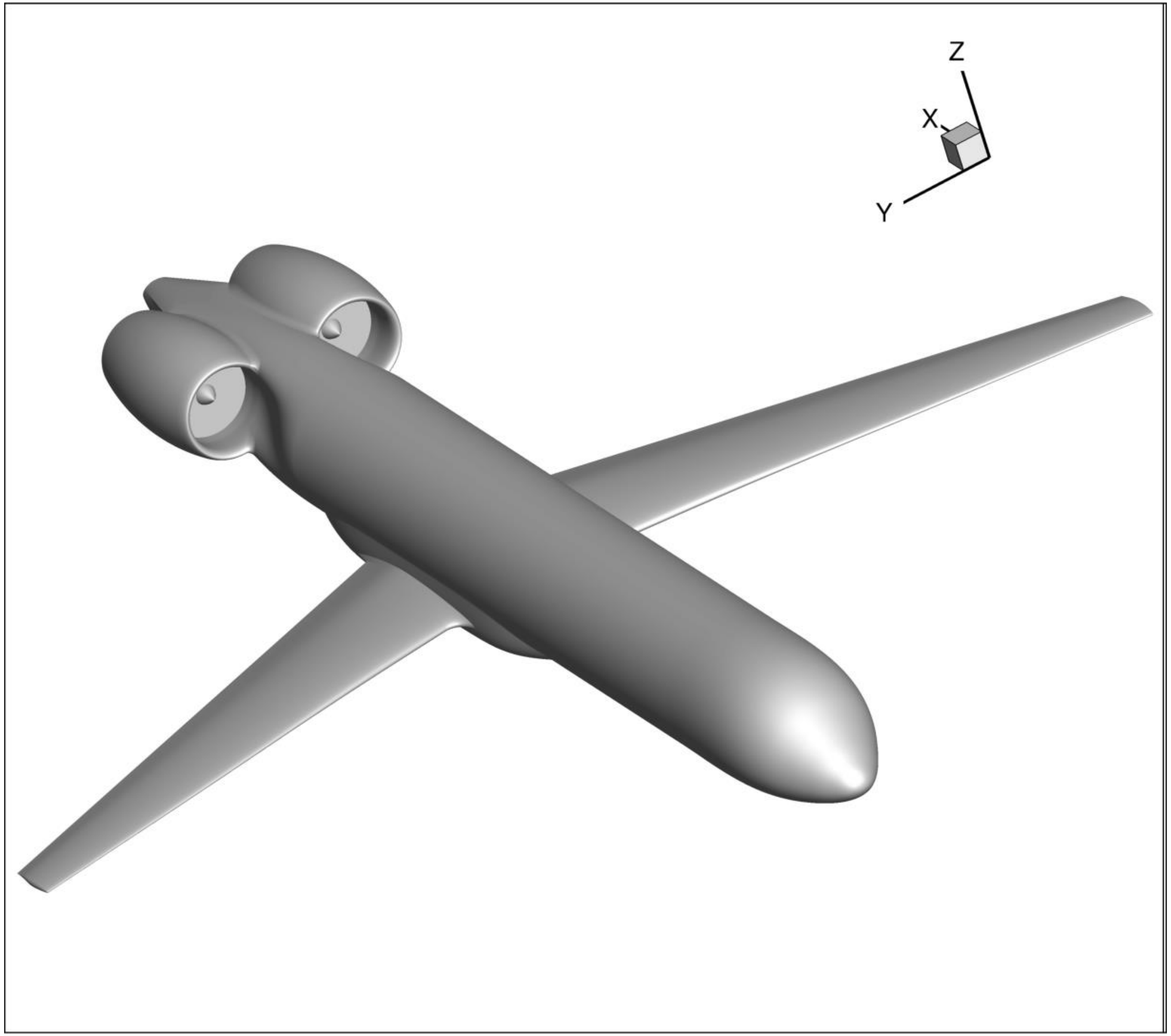
Positioning of Engines (2): Fuselage Side Configuration



Positioning of Engines (2): Fuselage Side Configuration



Positioning of Engines (2): Fuselage Side Configuration



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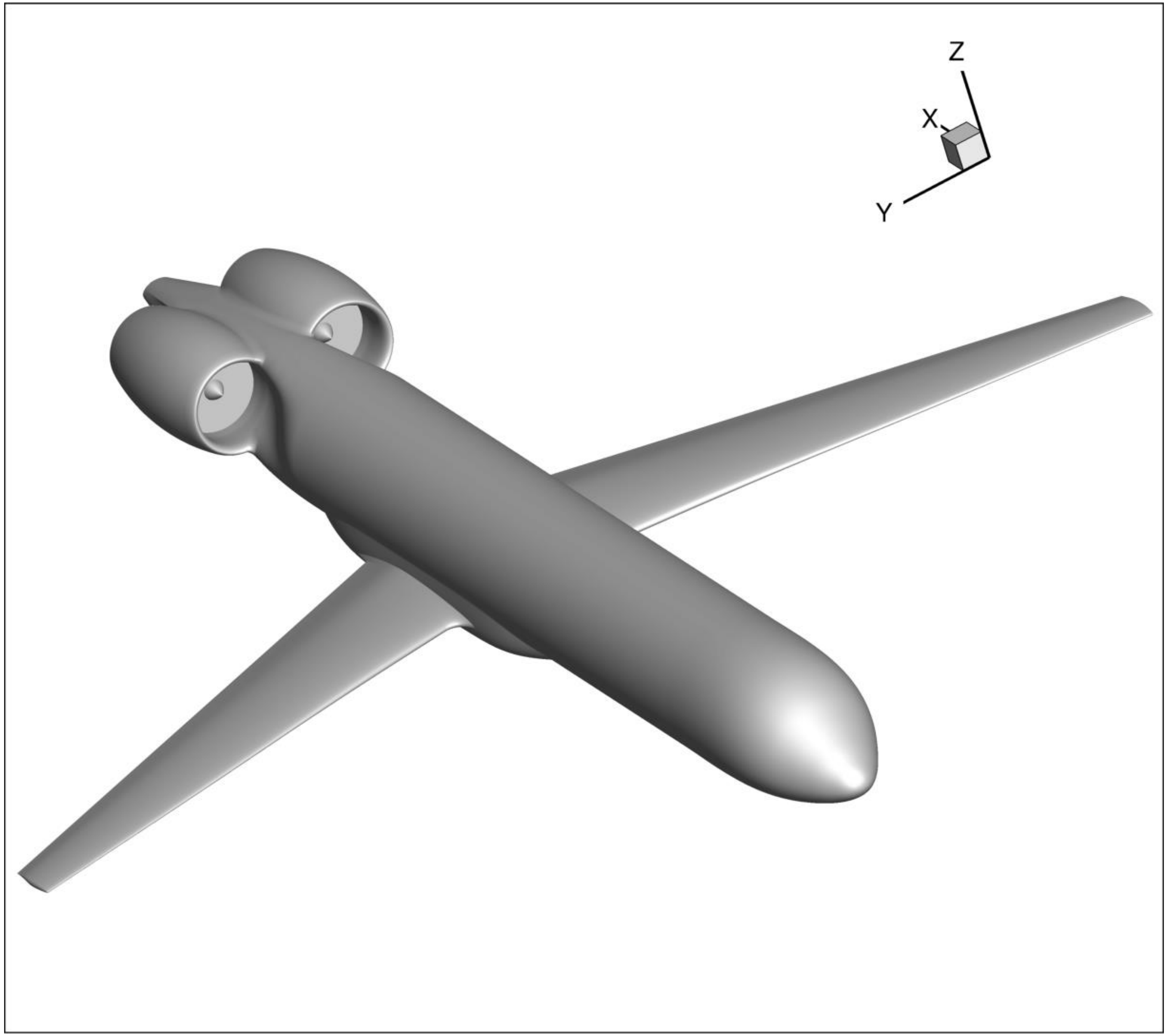
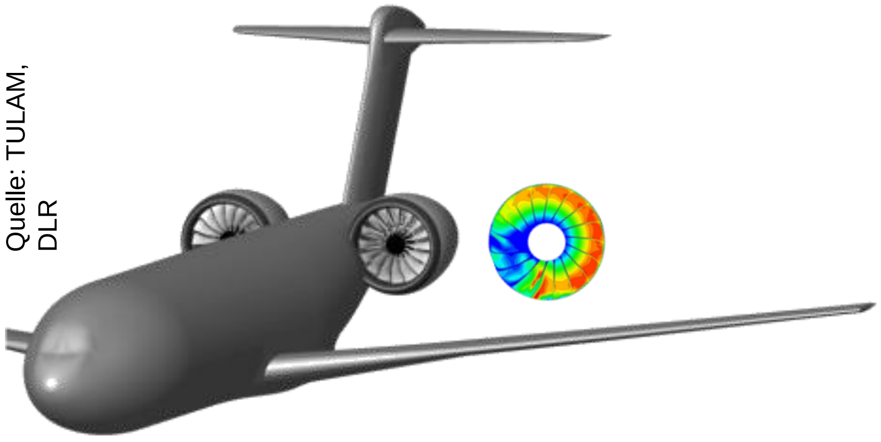
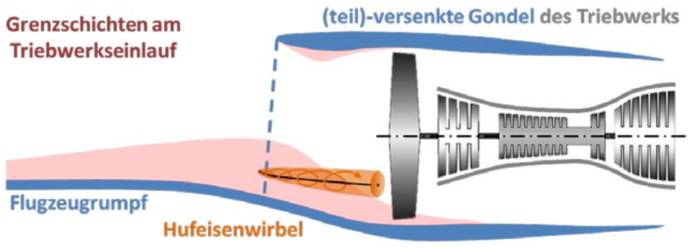


Impact of Boundary Layer Ingestion on Noise

Quelle: TULAM, DLR



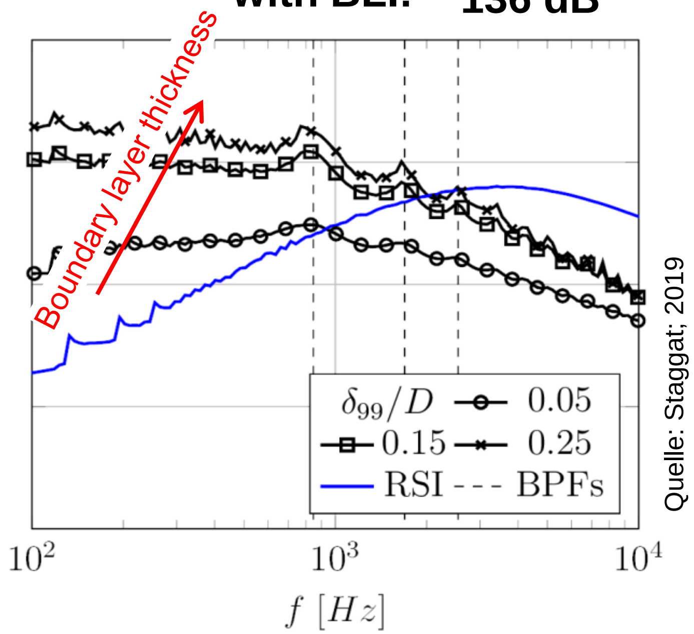
Embedded Engine



Quelle: DLR

Boundary Layer Ingestion (BLI)

	OAPWL
without BLI:	134 dB
with BLI:	**136 dB**

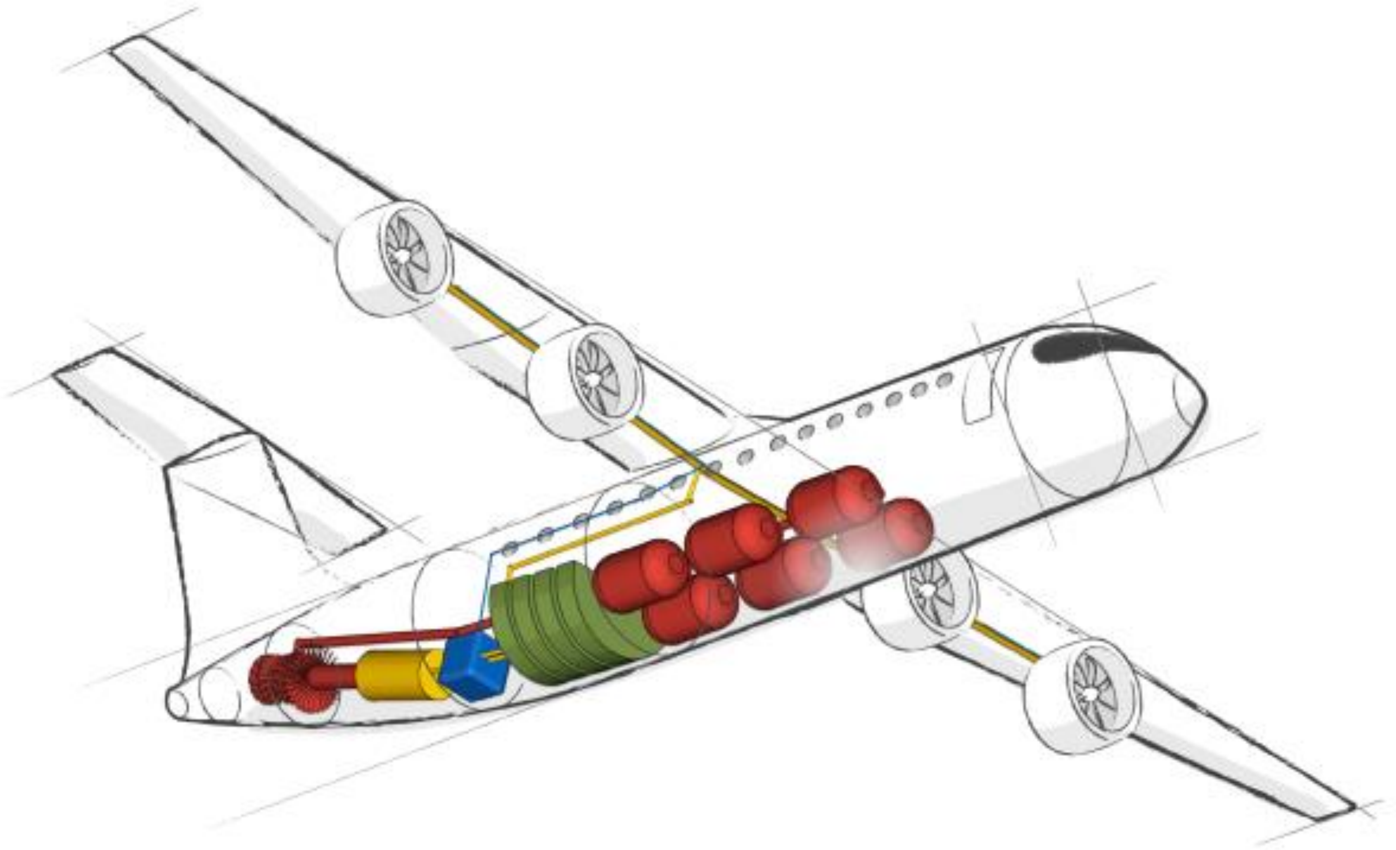


Quelle: Staggat; 2019

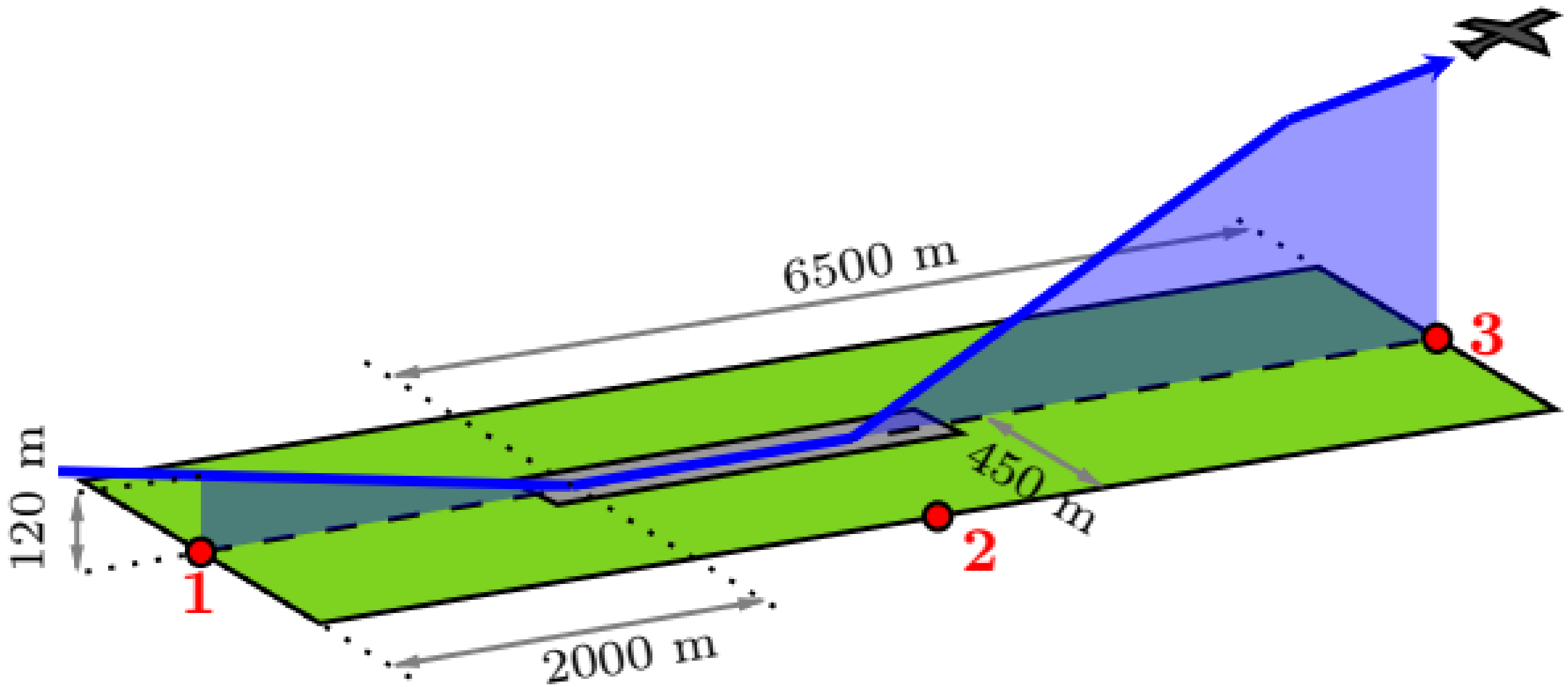
Impact of BLI on Noise

ELECTRIFICATION (1)

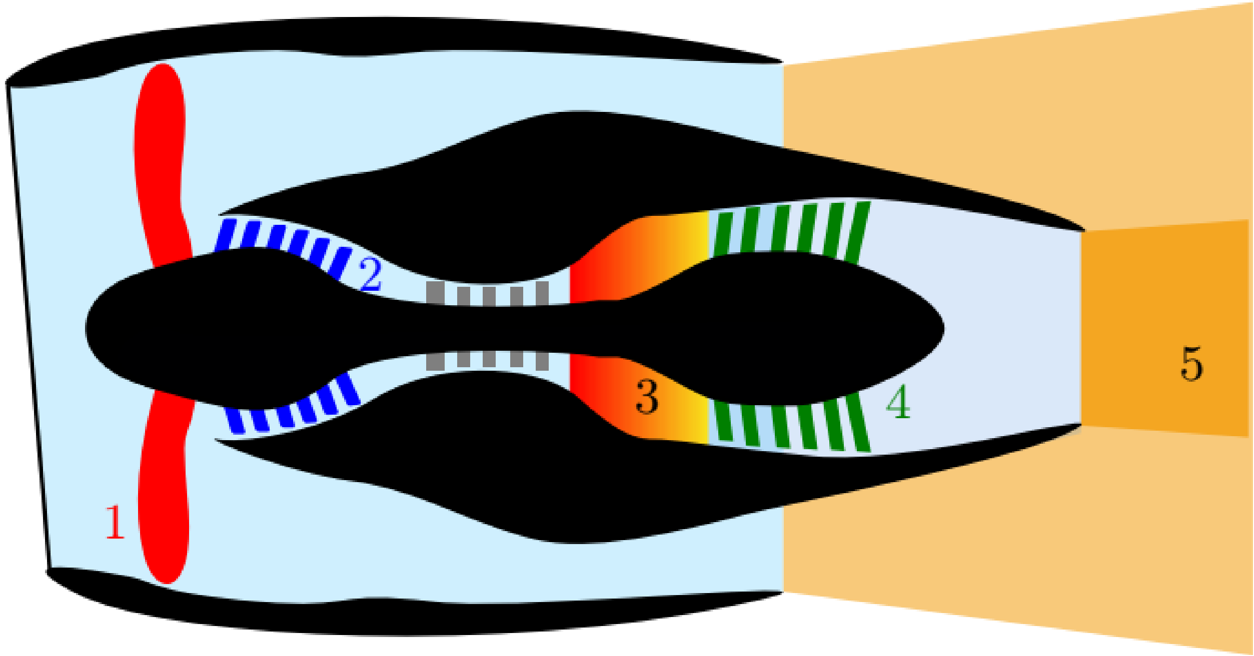
Schematic of a Future Electrified Regional Aircraft



ICAO Noise Certification Points

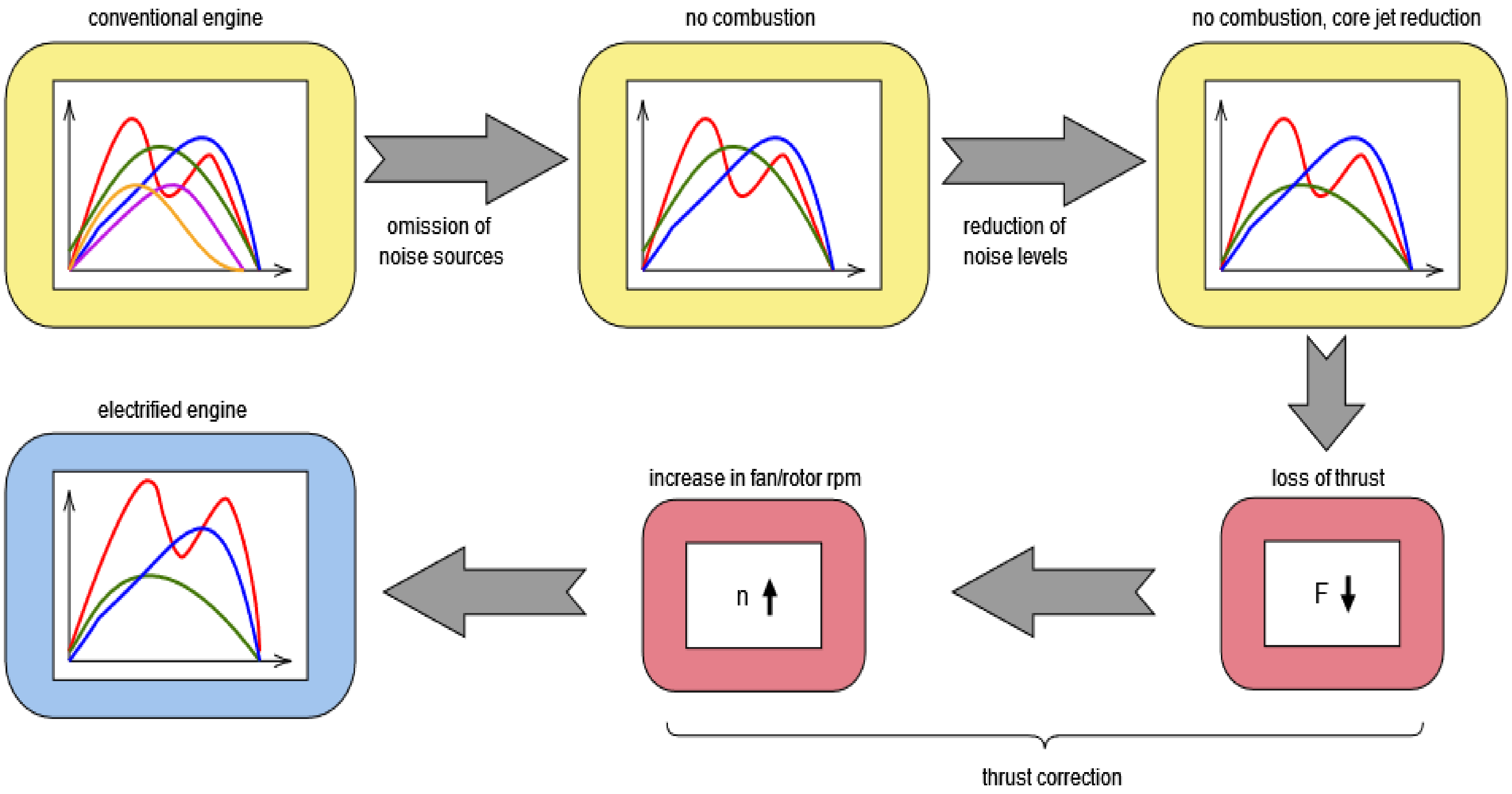


Noise Sources of Aero Engines



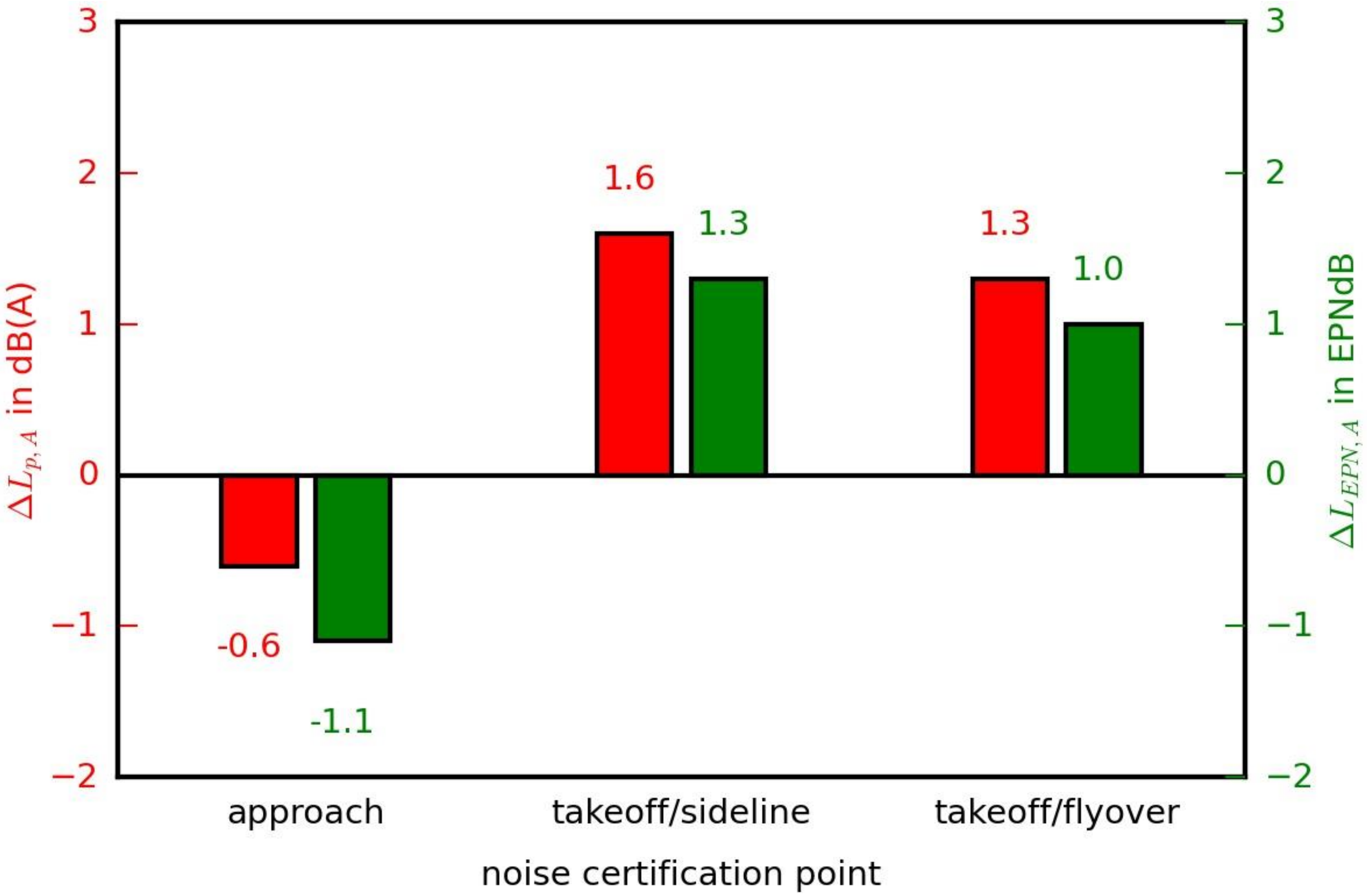
1. Fan
2. Compressor (LP)
3. Combustor
4. Turbine (LP)
5. Jet

Calculation Method



Estimated Noise Reduction caused by Engine Replacement

Turbofan with Bypass-Ratio 10

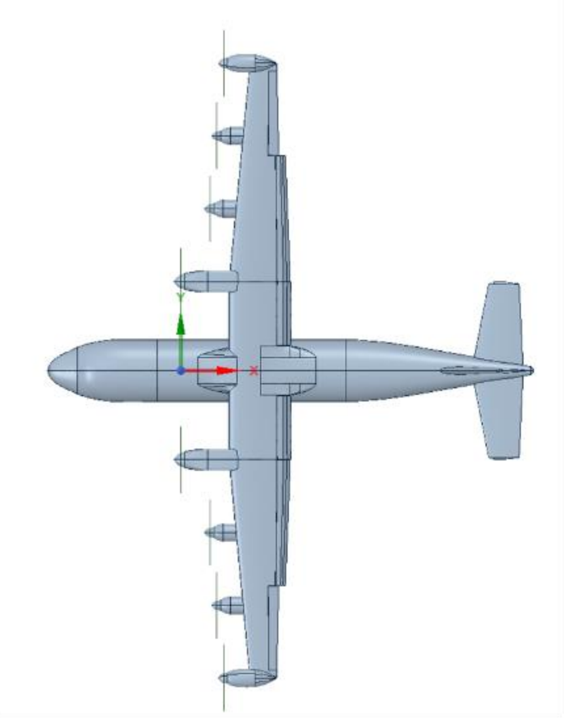


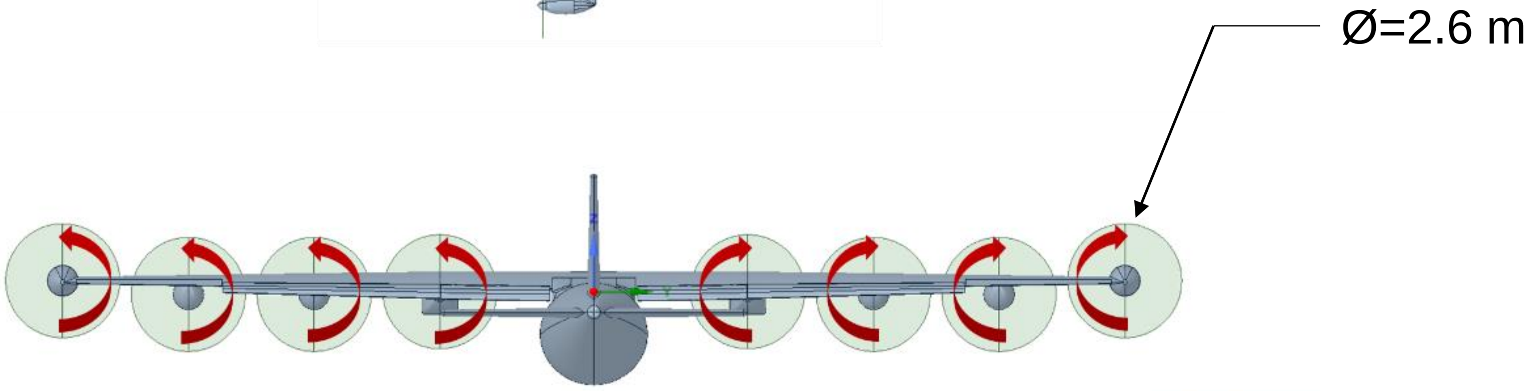
To be published in Acta Acustica as:
Th. Geyer, L. Enghardt: Conceptual estimation of the noise potential of electrified aero engines

ELECTRIFICATION (2)

Distributed Propulsion: Investigated configuration

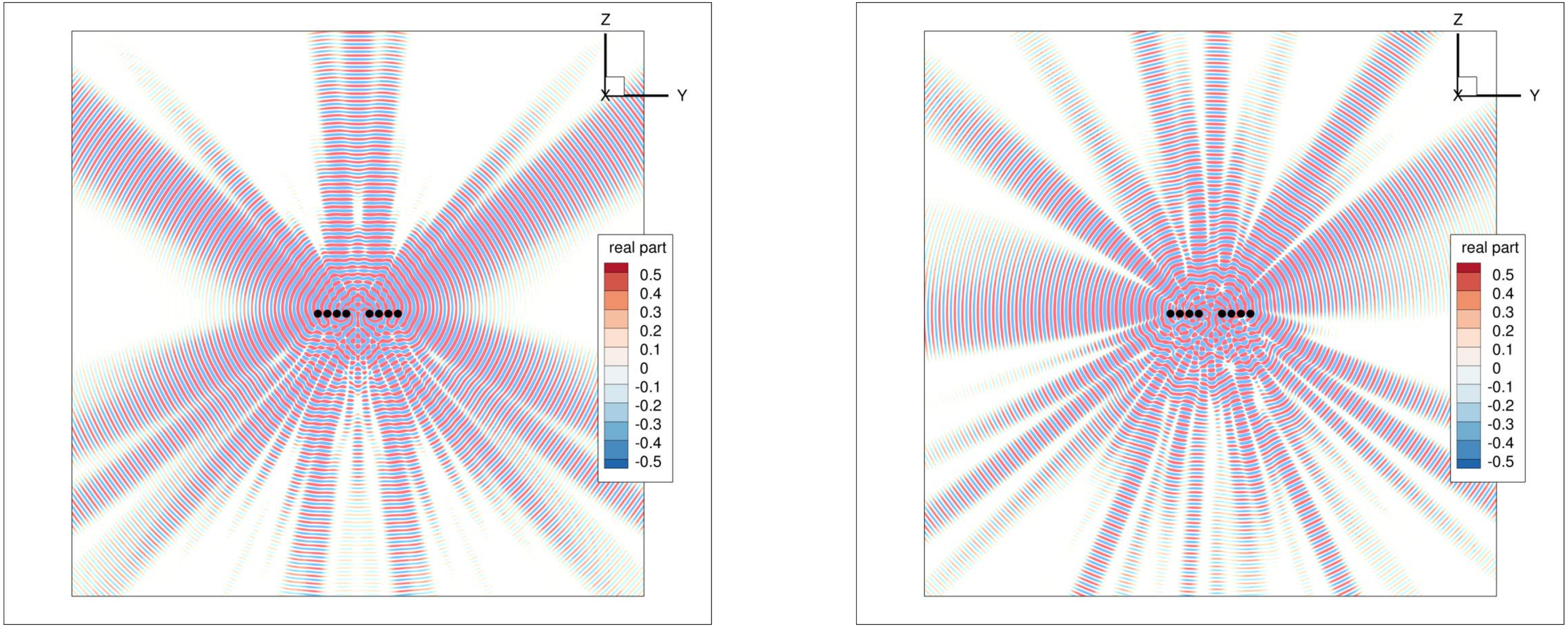
- ~ATR-42-600
- Design PAX = 40
- Design cuise: M = 0.48
- Design range: 600 nmi
- Power Degree of Hybridisation: 20%





Distributed propulsion: Sensitivity to initial angular positions

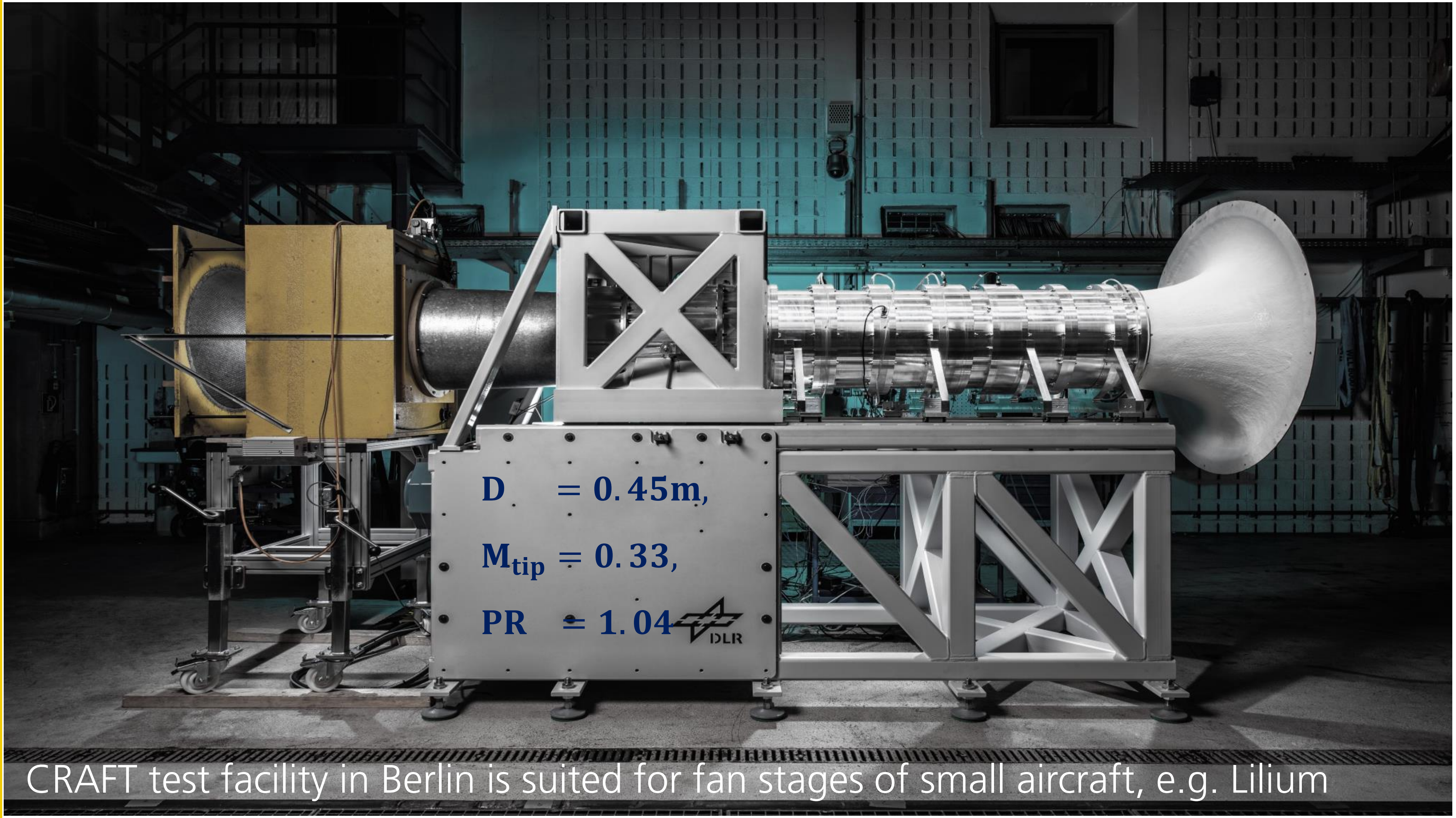
$\Delta\theta_\mu = \frac{\pi}{2}, \forall\mu \in [1,8]$ | random $\Delta\theta_\mu$



Results taken from:
Sebastien Guerin, Damiano Tormen: Noise radiation by eight wingspan-distributed propellers, DLRK 2022, Dresden

OUTLOOK

CRAFT – Co/Counter Rotating Acoustic Fan Test rig



VoloConnect

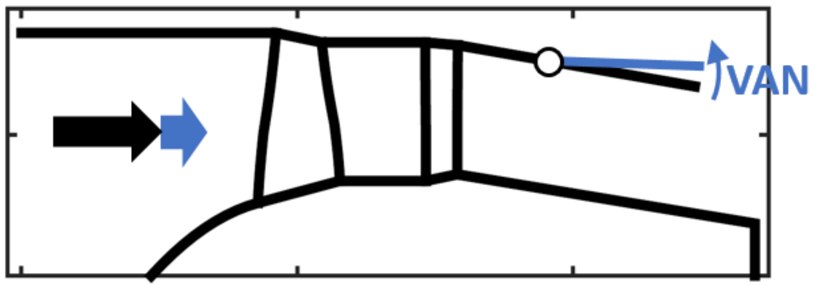
Lilium

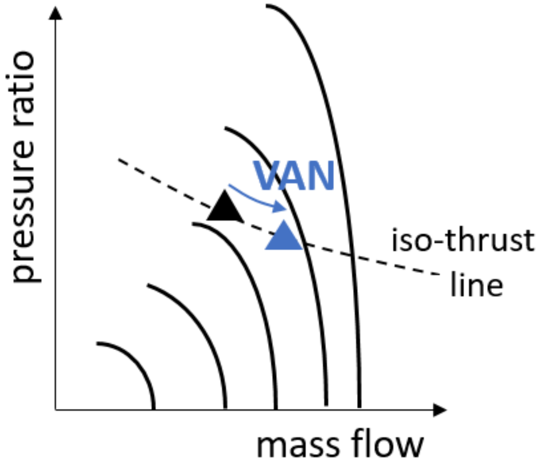
eSAT

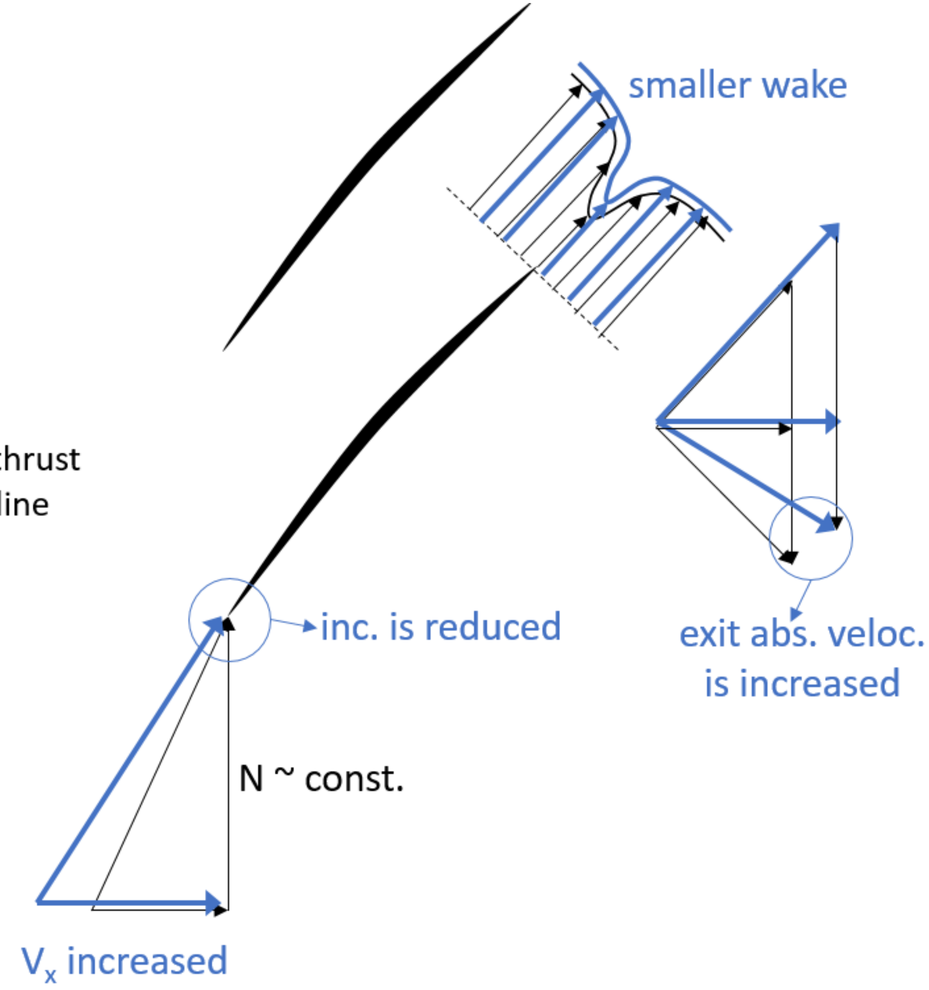
VAN: variable-area nozzle to reduce engine noise

Main mechanism:

Increase of axial velocity ➔ reduction of incidence ➔ aerodynamic **unloading**





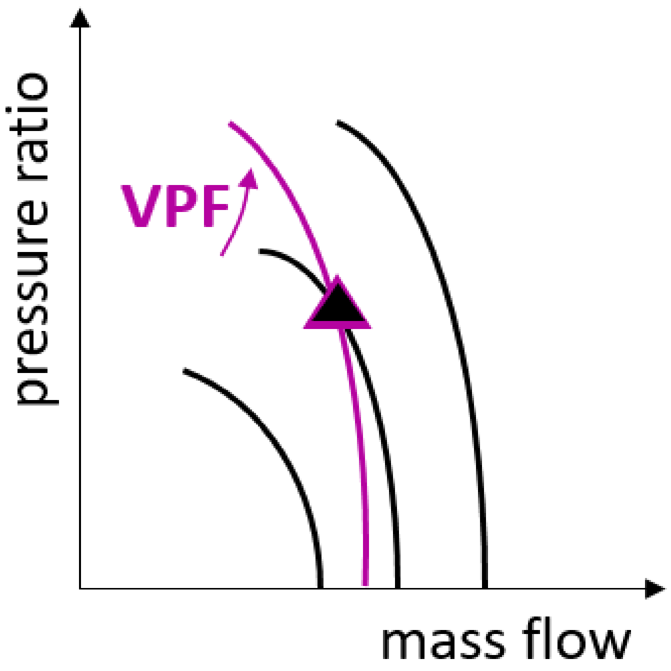


Pictures taken from:
A. Moreau, R. Schnell, M. Mennicken: Acoustic preliminary design of a low-noise fan stage considering a variable-area nozzle and variable-pitch rotor blades., DLRK 2022, Dresden

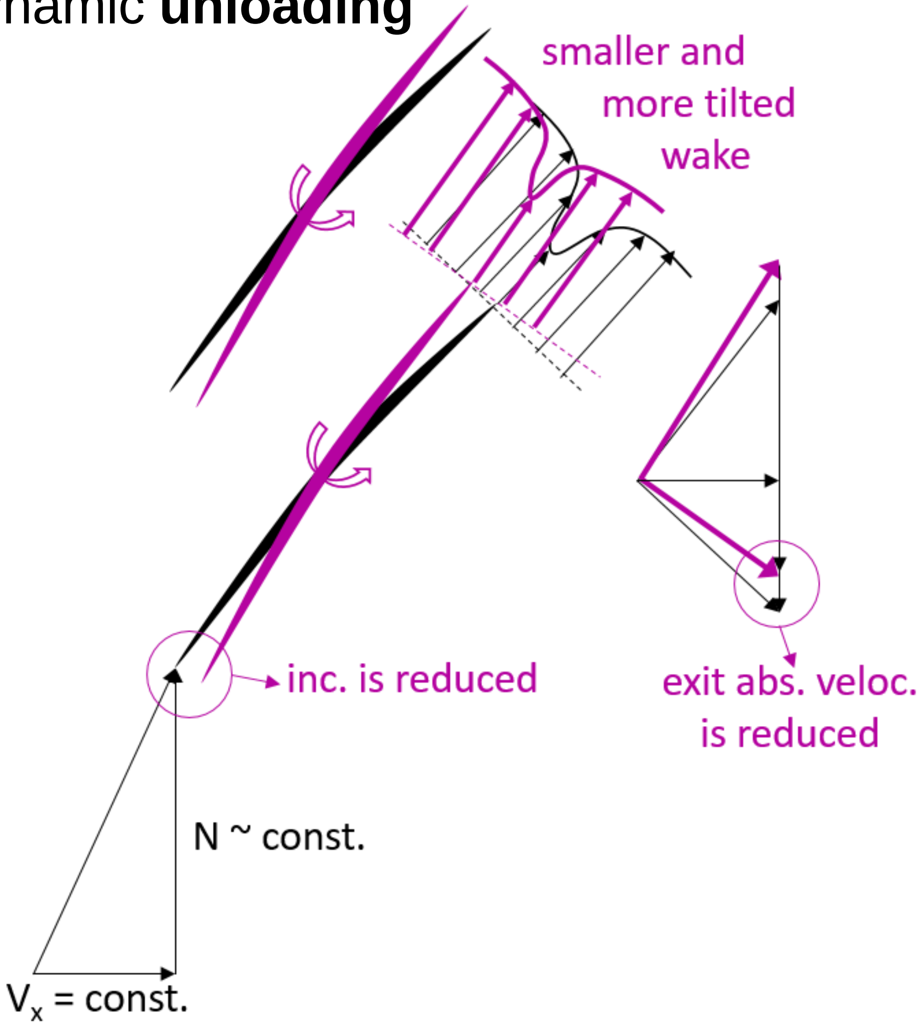
Variable-Pitch Fan (VPF) to reduce engine noise

Main mechanism:

Closing the blades ➔ reduction of incidence ➔ aerodynamic **unloading**



Shape of fan map is modified by VPF



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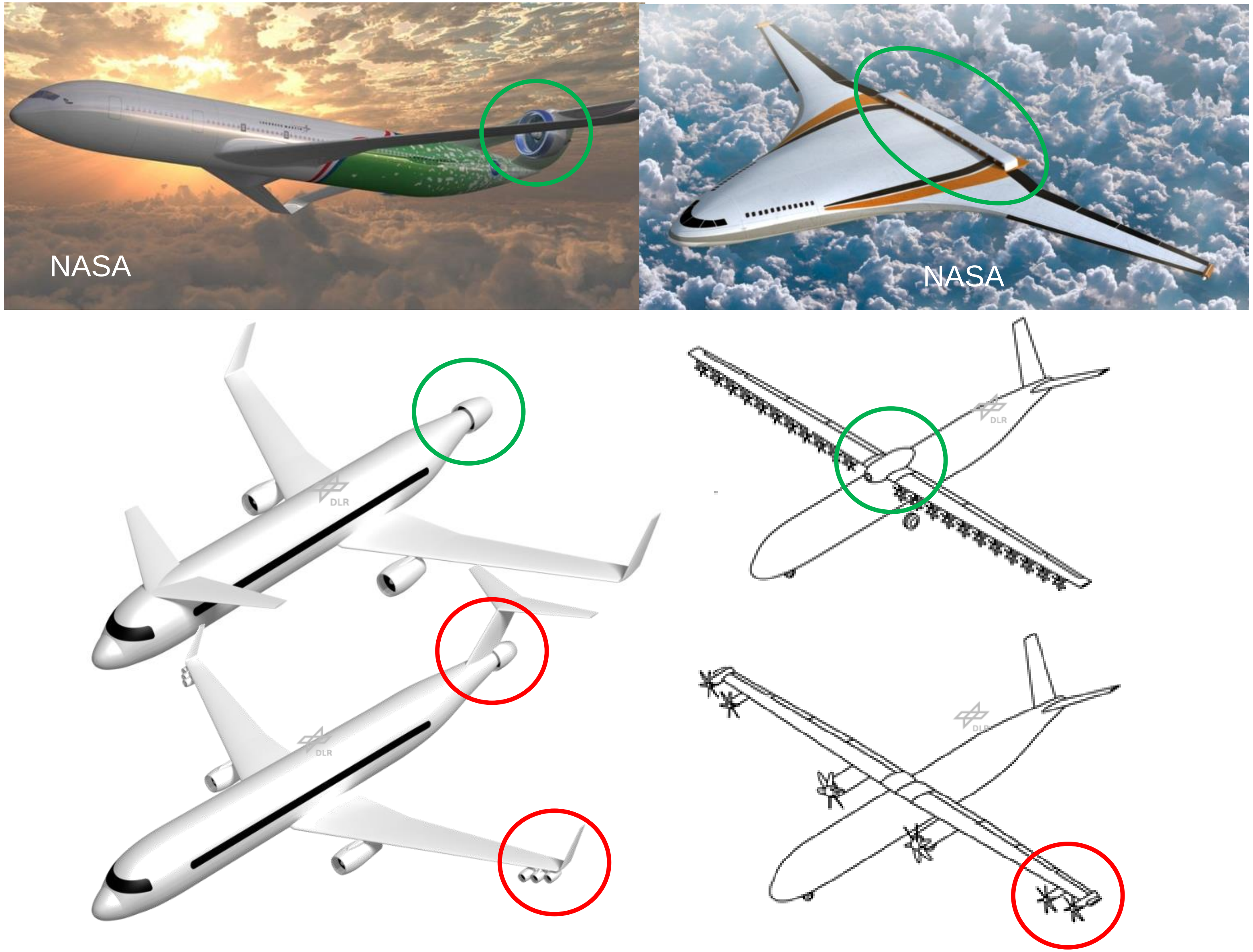

Source: M. Iwanizki, M. Strack, M. Plohr, M. Arzberger, T. Hecken

Summary/Asessment

Future UHBR Engines

- More compact engines with increased diameter will reduce the L/D ratio
- Liner impact will be decreased due to reduced available internal space
- Engine positioning will become an important issue for noise abatement
- Embedded engines are likely to increase fan noise
- VAN and VPC can help to reduce fan noise

Electrification

- The principal sound sources of civil aircraft are caused by the propulsion system (Fan/Propeller at aircraft start, Fan/Propeller + airframe at aircraft landing)
- Sound sources related to combustion are less important, so that their reduction **in classical airplane configurations** does not reduce aircraft noise substantially
- Distributed propulsion has the potential to reduce noise
- Control of the far-field directivity needs further research effort

Thank you!