



The future of aviation: New aircraft concepts and their impact on noise emissions

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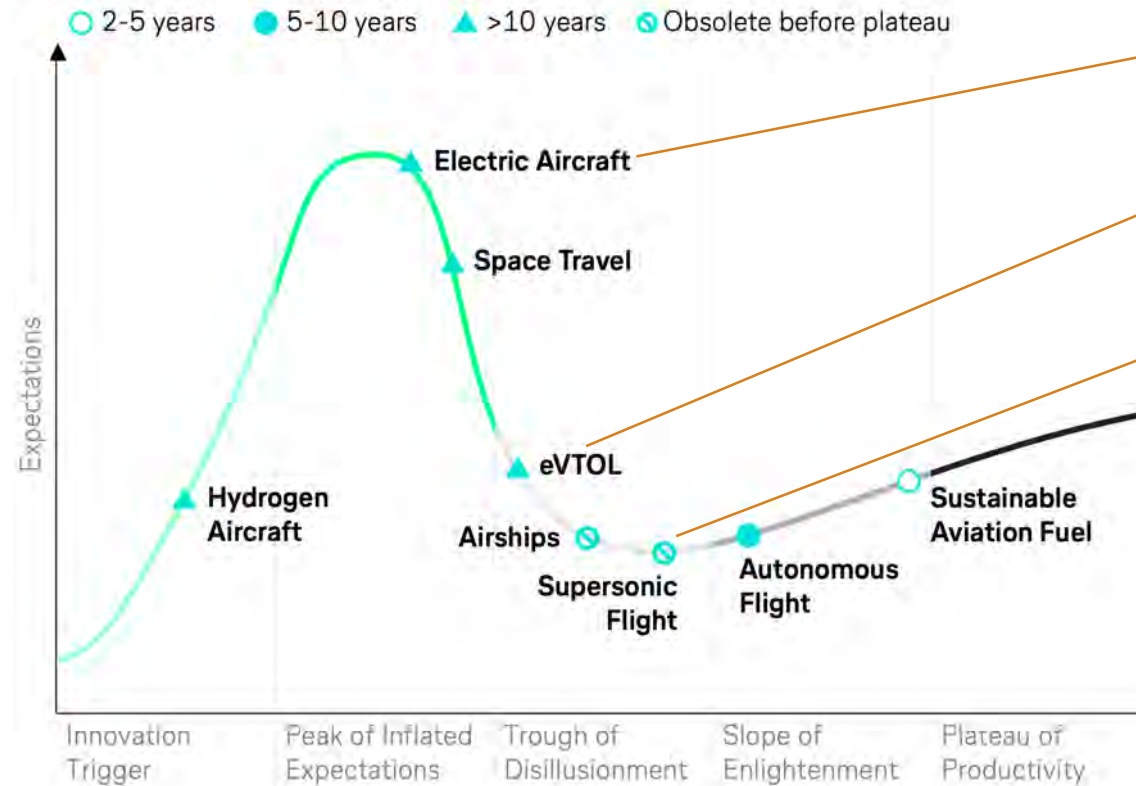
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Air Travel Hype Cycle

TNMT

Mapping the major technologies shaping the future of aviation

The New Air Travel Hype Cycle



Potential for emissions & noise reduction

Quiet, but a new source of noise in the sky

High energy consumption, unfavourable environmental impact and noisy

Source: Lufthansa Innovation Hub, TNMT.com, inspired by Gartner

Bauhaus Luftfahrt - The Aviation Think Tank

► Interdisciplinary research institution

- Located in Taufkirchen/Munich, Germany
- ~50 employees
- Founded in 2005 as independent research organization.

- Members:  Bayerisches Staatsministerium für Wirtschaft, Landesentwicklung und Energie

AIRBUS

iABG

LIEBHERR

MTU
Aero Engines


DLR

► Our Mission

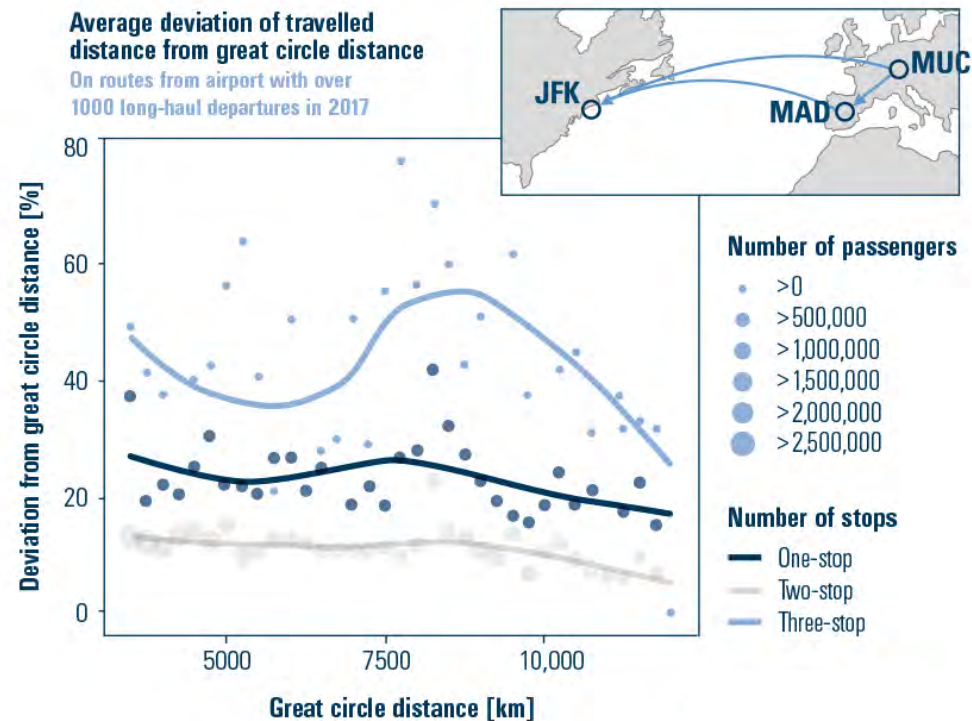
- Identification of **long-term options** for a sustainable and climate-neutral air transport
- **Bridge builder** between science, industry, politics, and the public
- Developing new approaches for the **future of aviation** with a high level of technical creativity and overall system understanding
- Optimizing through a holistic approach in **engineering, natural sciences, social sciences, and economics**

Actual Focus in Research on Future Air Transport: Climate Impact



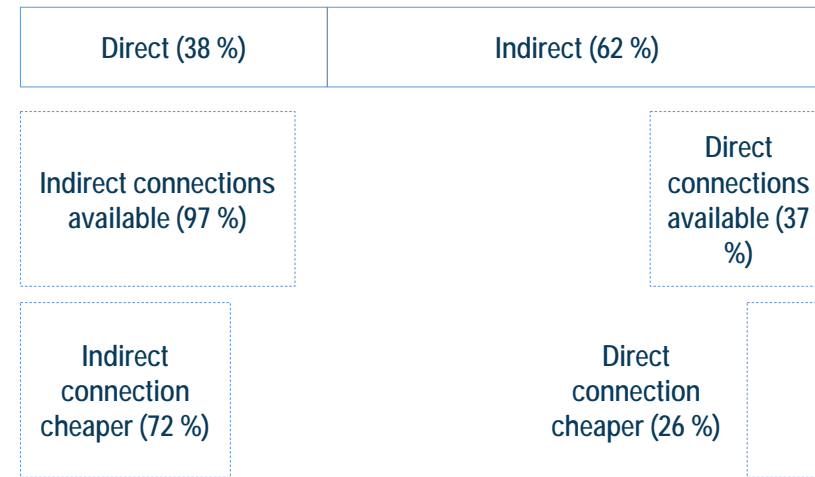
Operational Inefficiencies leading to avoidable Noise

➤ On average, ~4 % deviation from optimal route on long-haul flights



➤ Majority of long-haul passengers travels on indirect connections

Distribution of passengers across direct and indirect flights



➤ Less flights = reduced climate impact & noise

Sources: Own depictions, based on Sabre (2016), Sabre Data & Analytics Market Intelligence.

Relevance of Aircraft Classes resp. Markets



Ce-Liner
 Battery electric concept
 Requires battery energy density > 1000 kWh/kg



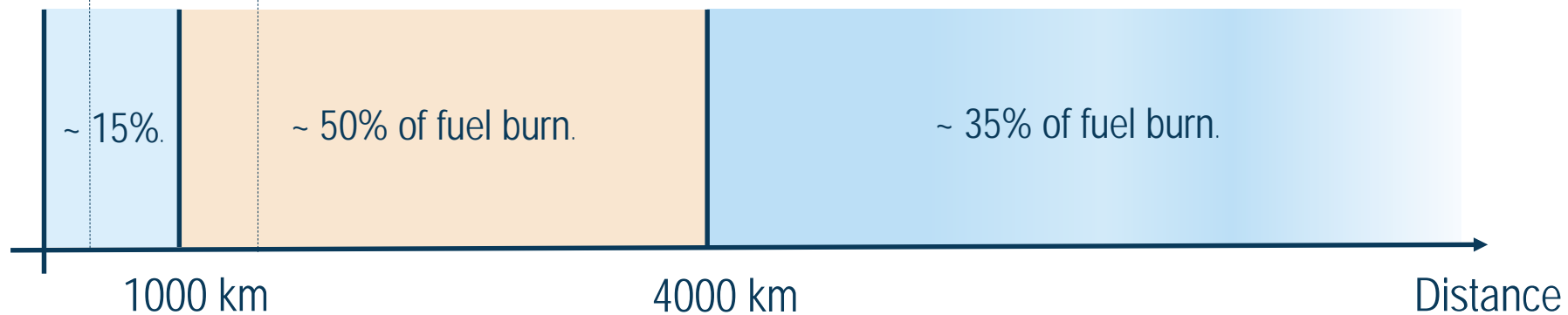
Centreline:
 Turbo-electric concept
 No change of energy carrier
 Efficiency measure



CoCoRe
 Hybrid-electric commuter
 High battery utilization

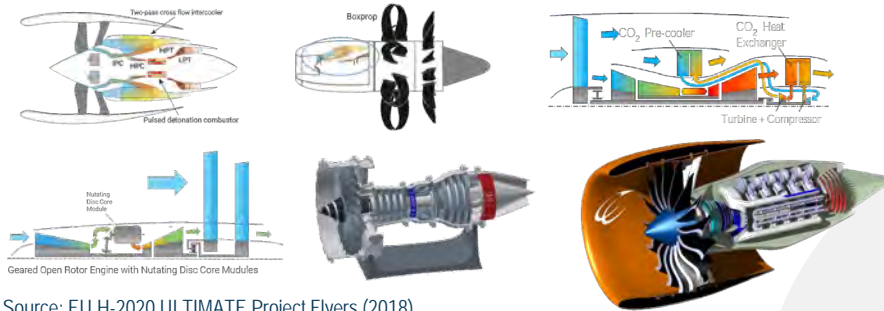


HyLiner
 Liquid hydrogen powered
 long-haul aircraft



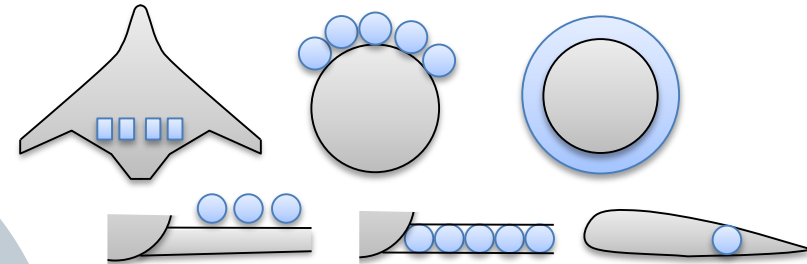
Sources: M. Hornung, *Ce-Liner – Case Study for eMobility in Air Transportation*, Aviation Technology, Integration and Operations Conference. Los Angeles. 12.8.2013
 EU Project Centreline: www.centreline.eu ; F. Troeltsch - Concept for a hydrogen-powered long-haul aircraft, Bauhaus Luftfahrt Symposium, 8.5.2019
www.dlr.de/content/de/artikel/news/2020/01/20200217_elektrisch-im-19-sitzer-von-mannheim-nach-berlin.html

Landscape of Revolutionary Propulsion Options



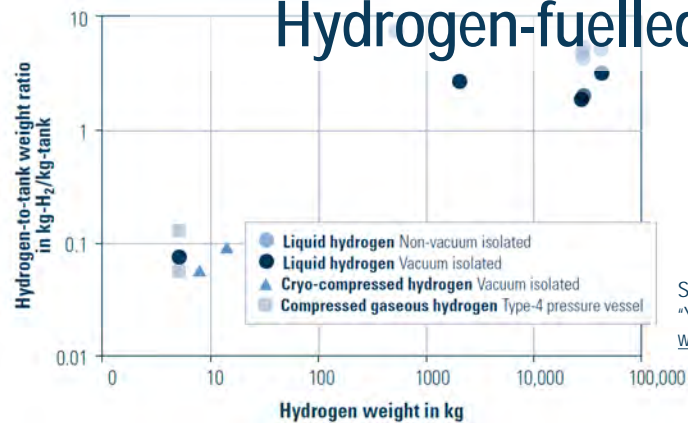
Source: EU H-2020 ULTIMATE Project Flyers (2018)
www.ultimate.aero

Radical heat engines



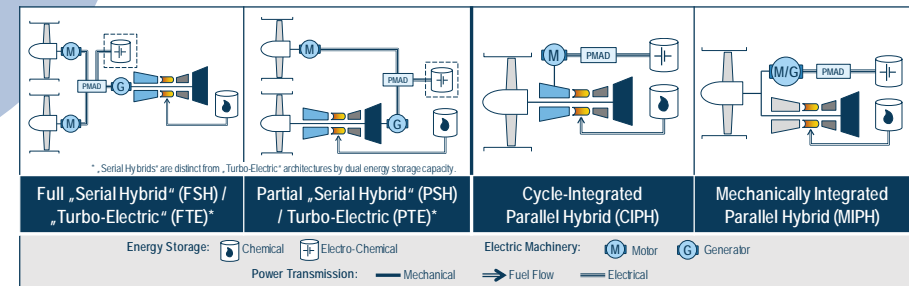
Synergistic propulsion-airframe integration

Hydrogen-fuelled propulsion

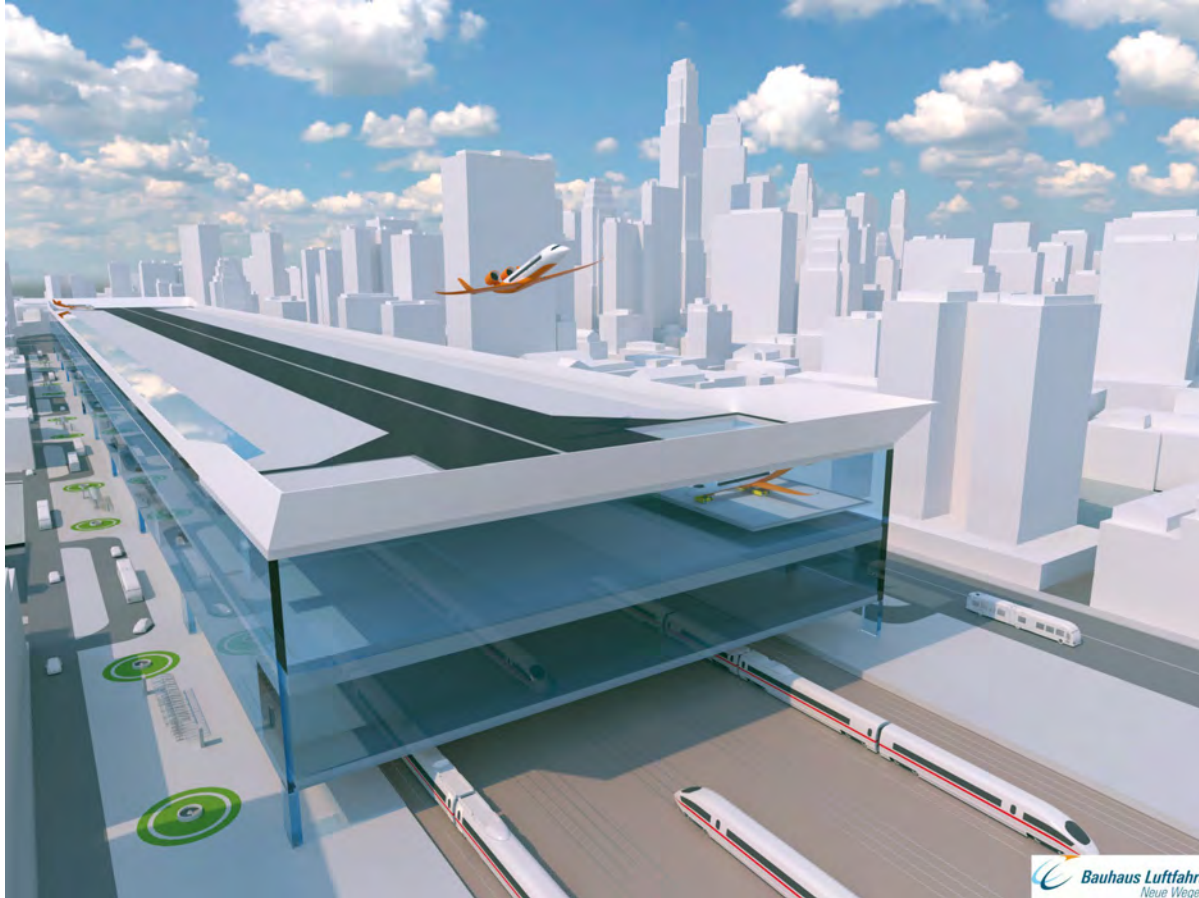


Source: Bauhaus Luftfahrt "Yearbook 2019" (2020),
www.Bauhaus-Luftfahrt.net

(Partially) electrified energy & power



Airport in the City – CentAirStation & CityBird



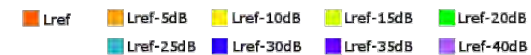
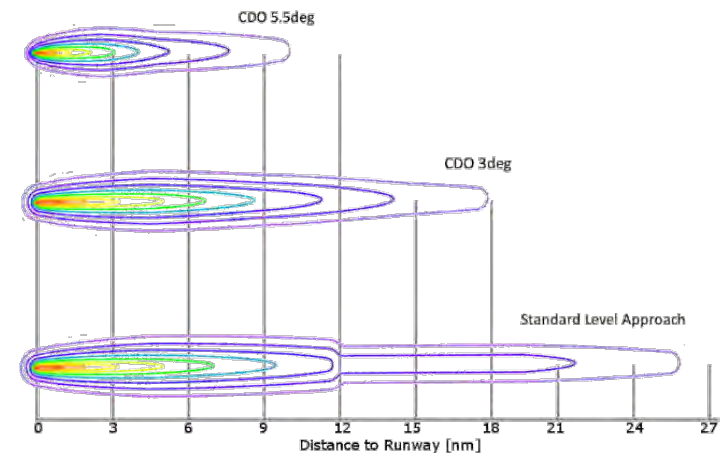
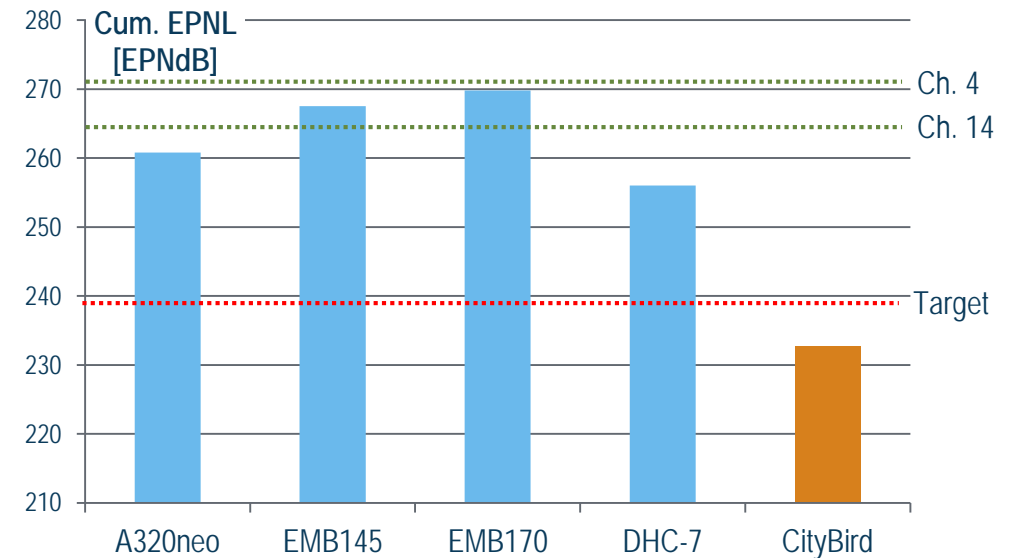
CityBird - Noise

► Low noise signature

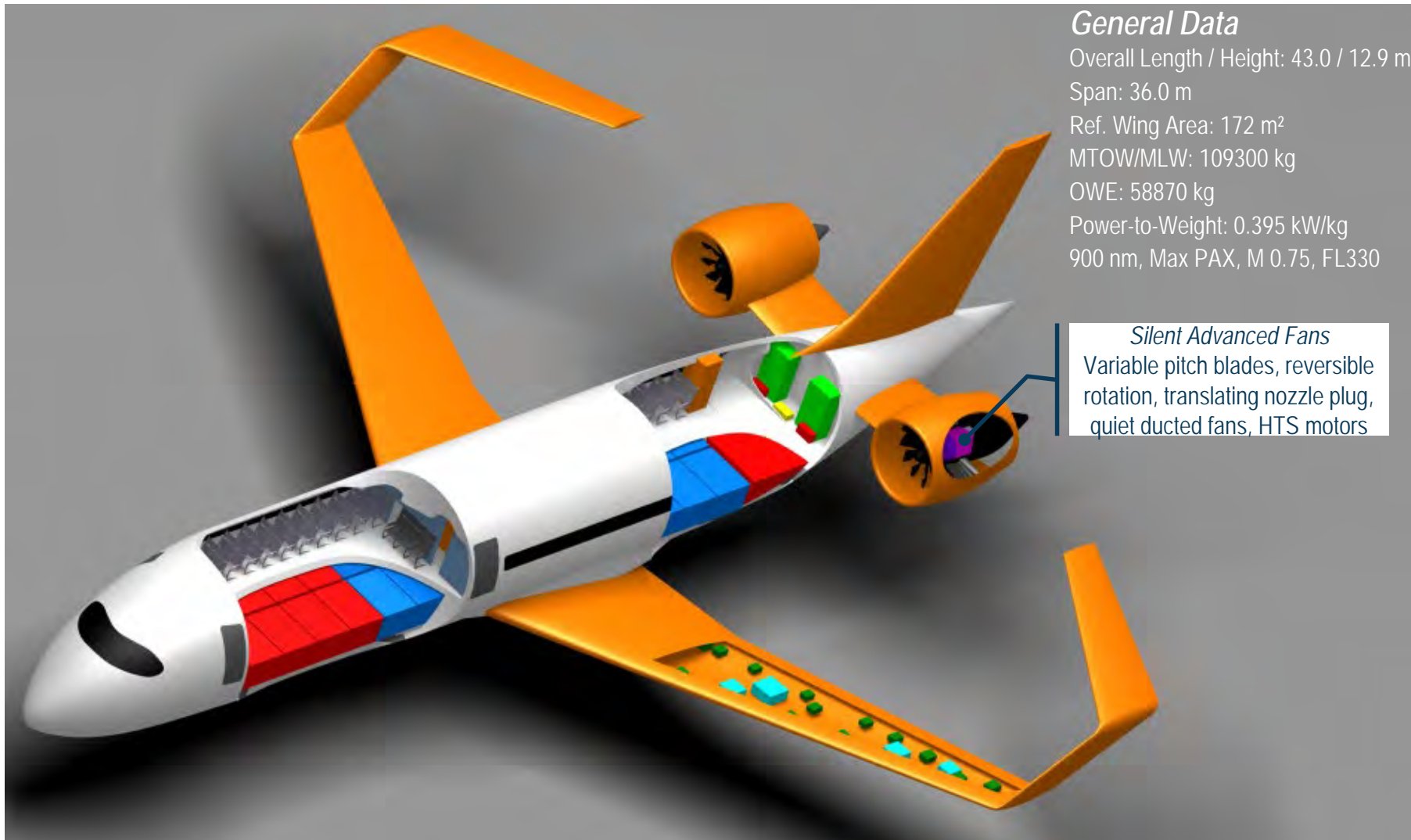
- Engine shielding
- Short landing gear with fairings
- Flap edge devices
- Sealed Krueger flap
- Engine technologies (Acoustic Liners Engine, Chevrons, Shielding)

► Steep Approaches

- Less noise through trajectory and less power



Electric Aircraft - CeLiner



General Data

Overall Length / Height: 43.0 / 12.9 m

Span: 36.0 m

Ref. Wing Area: 172 m²

MTOW/MLW: 109300 kg

OWE: 58870 kg

Power-to-Weight: 0.395 kW/kg

900 nm, Max PAX, M 0.75, FL330

Silent Advanced Fans

Variable pitch blades, reversible rotation, translating nozzle plug, quiet ducted fans, HTS motors

Max. efficient aircraft propulsion design (-50% - aircraft)

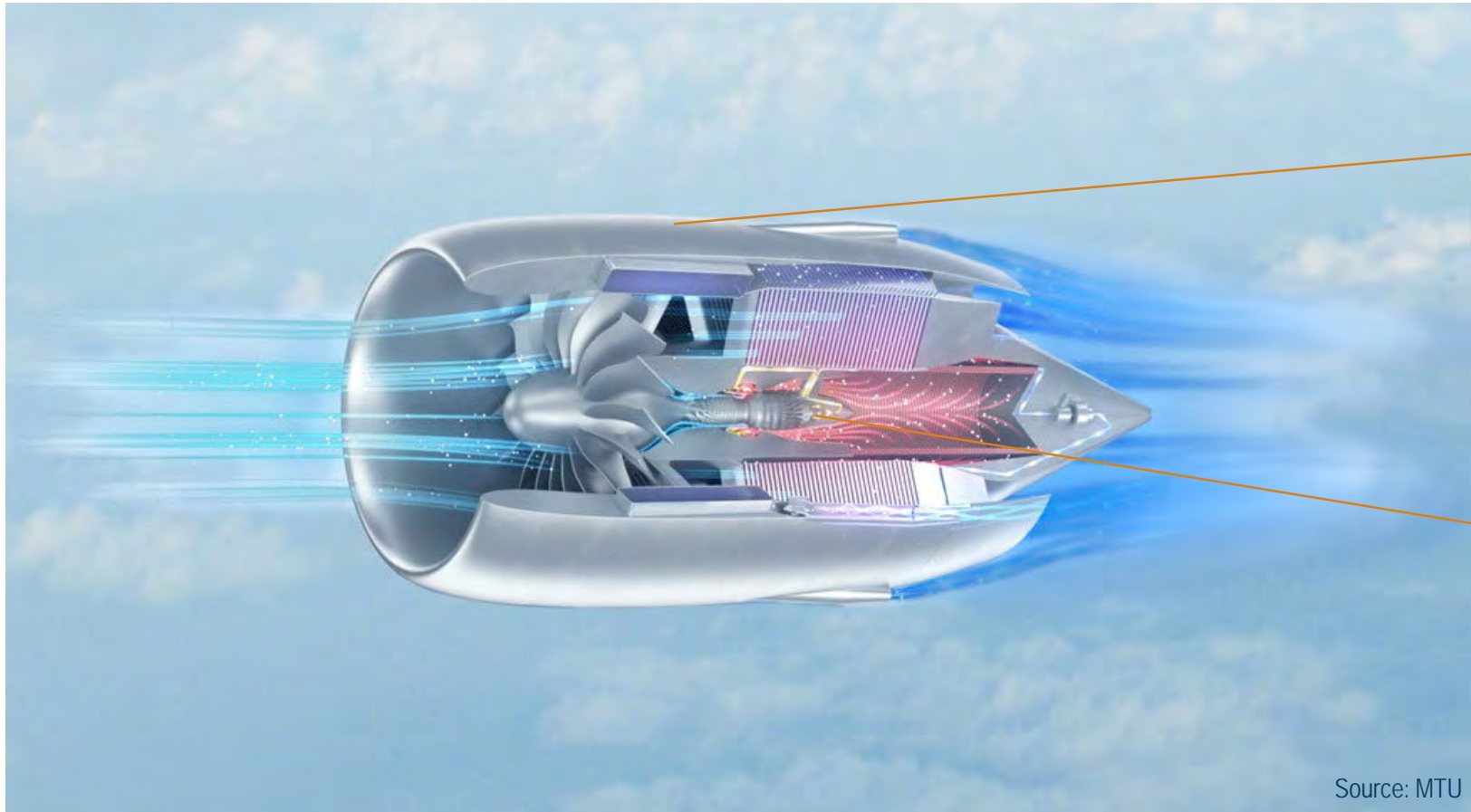


Image Sources: ¹ Kierbel, D. "Closing of Clean Sky 1 SFWA-ITD BLADE project", Presented in Brussels, 21-22 March 2017.

² Troeltsch, F., et al. "Re-Thinking the Long-Haul Air Transport Segment" Aerospace Europe Conference, Bordeaux, France, 25-28 February 2020.

³ ASUMED Project, Grilli, F., et al, Journal of Physics: Conference Series 1590 (2020), doi:10.1088/1742-6596/1590/1/012051

MTU WET - Water-Enhanced Turbofan



Long and more massive engine nacelle enables good shielding

Core engine does not produce a typical primary stream

Open Fan/Rotor



Open Fan/Rotor propulsion technology is again under consideration due to its potential for additional efficiency gains

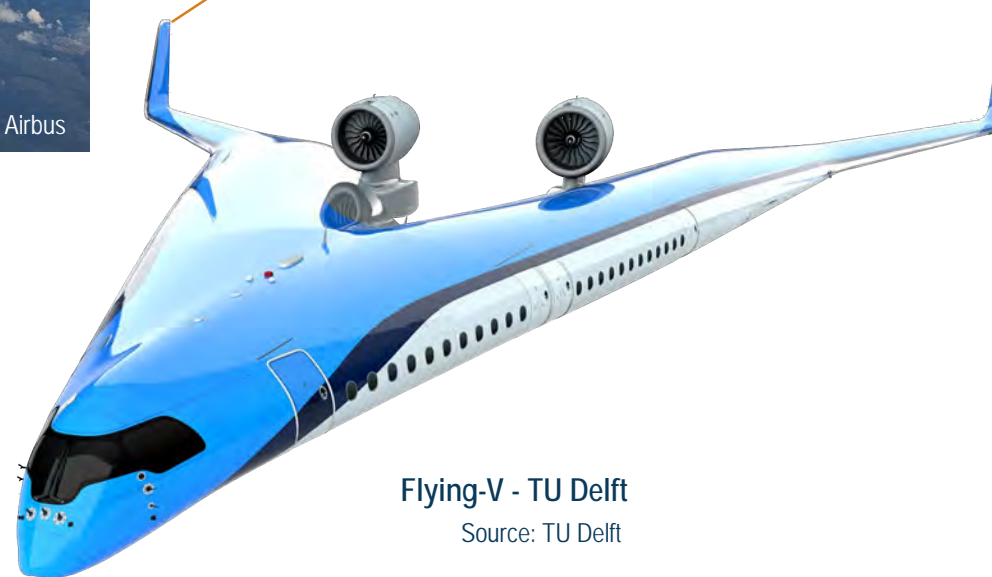
Noise-optimised design and integration necessary

Blended Wing Body



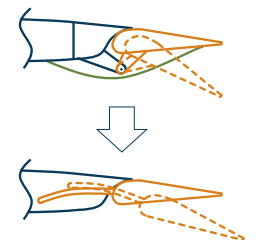
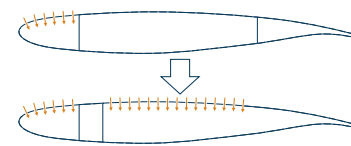
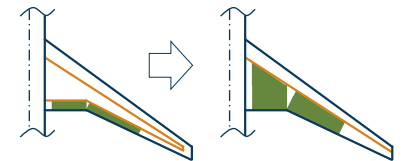
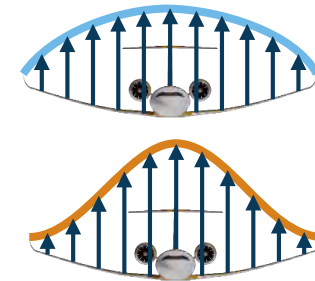
Shielding from noise by placing the engines above the aircraft structure

Long timeframe (20+ years) for the development and certification of such aircraft



LH₂ Aircraft – Technologies with an Impact on Noise

- ▶ APU gas turbine replaced by a fuel cell based auxiliary propulsion and power unit
- ▶ Dry wing design (LH₂-tanks within fuselage)
- ▶ Advanced airframe technologies like **alternative wing primary structure and/or bell shaped lift**
- ▶ Dry wing design offers space for new and **noise-avoiding technologies**



Summary of Future Opportunities and Challenges

Regional (70Pax @ 1000nmi)



- ▶ Electric propulsion with fuel cell
- ▶ Noise signature of propeller to be optimised

Short range (200Pax @ 2000nmi)



- ▶ Single gas turbine – fuel cell hybrid powered electric twin-fans
- ▶ Integration and shielding of the gas turbine

Long range (400Pax @ 6400nmi)



- ▶ Maximum efficient aircraft design & propulsion integration (-50% - aircraft)

- ▶ Improved organisation of air traffic can reduce the total number of aircraft flights
- ▶ Create motivation for environmentally responsible aviation