Eliminating Climate Impact From Aviation

Potential pathways that are currently explored in DLR's EXACT project

Johannes Hartmann

ZAL Discourse

May, 18th 2021

Deutsche Gesellschaft für Luft- und Raumfahrt Lilienthal-Oberth e.V. Bezirksgruppe Hamburg

ROYAL AERONAUTICAL SOCIETY HAMBURG BRANCH e.V.

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HAW HAMBURG

Hamburg Aerospace Lecture Series
Hamburger Luft- und Raumfahrtvorträge

ZAL invites you to a lecture in cooperation with DGLR, RAeS, HAW Hamburg and VDI

ZAL Discourse: Flying Green Tomorrow

The Importance of Hydrogen for Future Aviation

Dr.-Ing. **Sebastian Altmann**, ZAL
Dr.-Ing. **Johannes Hartmann**, DLR
Dr.-Ing. **Holger Kuhn**, ZAL
Dilp.-Ing. **Tanja Neuland**, Airbus

Lecture followed by discussion
Registration required !
Online lecture

Date: Tuesday, 18 May 2021, 15:00 CEST

Register: https://bit.ly/3ueToAK

15:00 Welcome & Introduction

15:15 Aviation Powered by Hydrogen – Research Activities at ZAL

15:45 Hydrogen – A Universal Solution for Aviation? (Airbus)

16:15 Eliminating Climate Impact from Aviation – Potential Pathways (DLR's EXACT Project)

Kontakt: Meike Herbst, FoLuHH@zal.aero

Sustainability and hydrogen: two terms that can hardly be separated in aviation. Hydrogen is an essential element for achieving global and national climate protection targets. It is also the focus of Hamburg's newly established hydrogen cluster structure. Following the theme "away from fossil fuels and toward low-emission aircraft", Hamburg's aviation stakeholders are working on new flight concepts and technology roadmaps.

An important meeting place for this is the ZAL Center of Applied Aeronautical Research, because its infrastructure offers tenants and partners the perfect platform for research and exchange.

In this discourse, you will gain exclusive insights into the hydrogen activities at ZAL:
In three exciting lectures, experts will reveal more about the previous and future strategies on the way to low-emission flying. After each presentation, you will get the chance to directly address the speakers with your questions.

HAW/DGLR	Prof. Dr.-Ing. Dieter Scholz	Tel.: (040) 42875-8825	info@ProfScholz.de
RAeS	Richard Sanderson	Tel.: (04167) 92012	events@raes-hamburg.de
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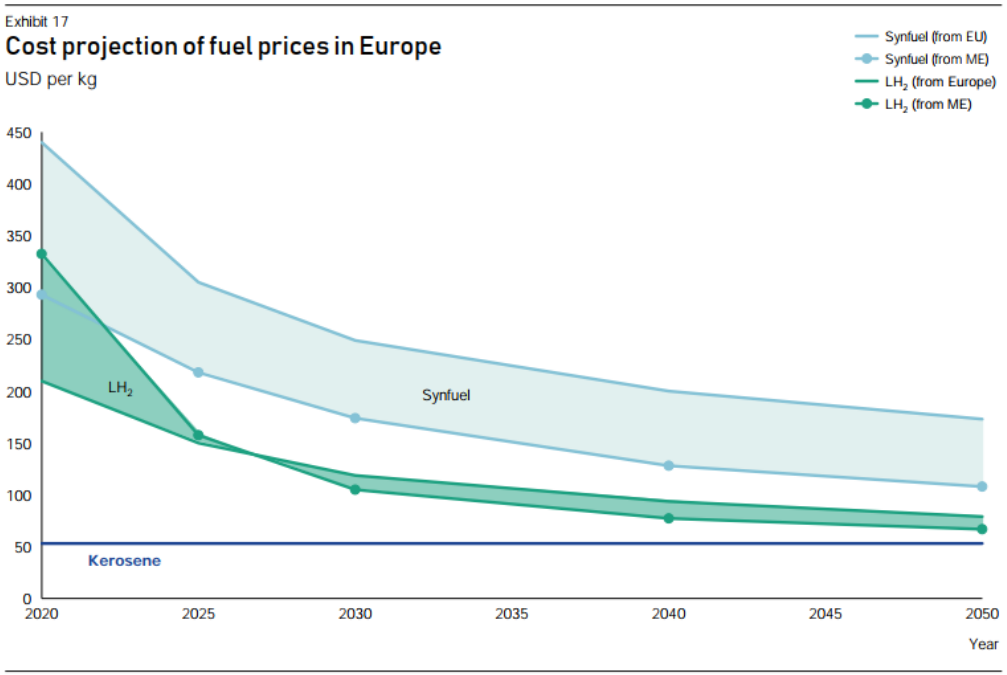
Hamburg Aerospace Lecture Series (DGLR, HAW Hamburg, RAeS, VDI, ZAL)

DGLR Bezirksgruppe Hamburg	https://hamburg.dglr.de
RAeS Hamburg Branch	https://www.raes-hamburg.de
ZAL TechCenter	https://www.zal.aero
VDI Hamburg, Arbeitskreis L&R	https://www.vdi.de

Hamburg Aerospace Lecture Series (AeroLectures): Jointly organized by DGLR, RAeS, ZAL, VDI and HAW Hamburg (aviation seminar). Information about current events is provided by means of an e-mail distribution list. Current lecture program, archived lecture documents from past events, entry in e-mail distribution list. All services via http://AeroLectures.de.

Aircraft as complex system of energy systems

Energy Sector

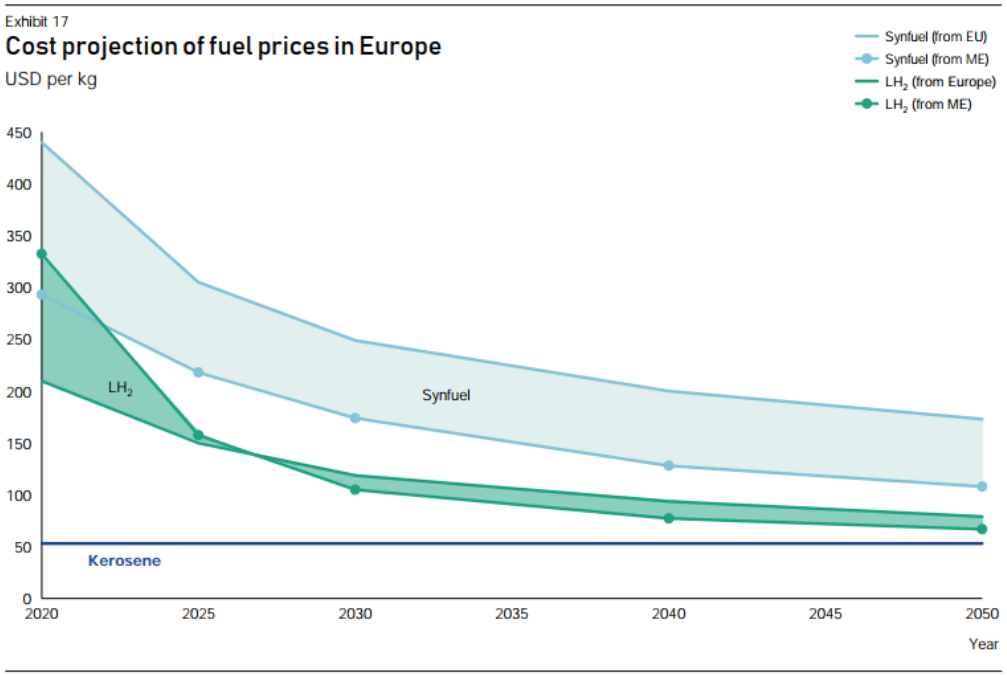


Aviation Sector

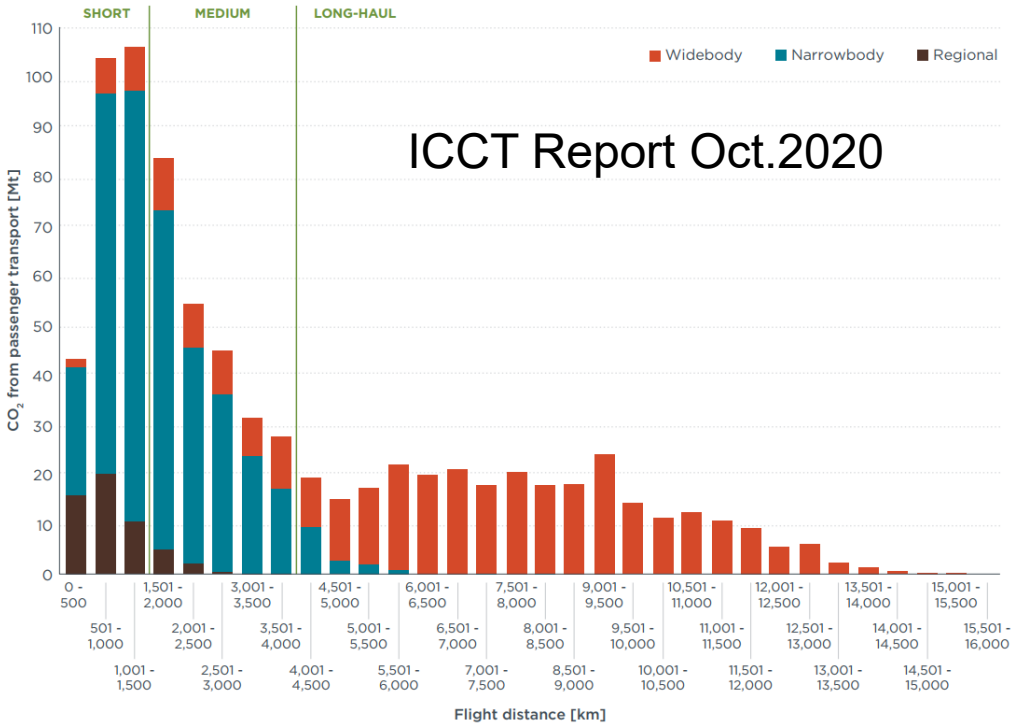
Green energy is the key for climate neutral air mobility. In order to identify sustainable solutions for a green air transportation system, the aviation sector has to go hand in hand with the energy sector. In EXACT, capabilities from 4 DLR divisions (energy, aviation, space, transport) are contributing to EXACT project.

Aircraft as complex system of energy systems

Energy Sector



Aviation Sector



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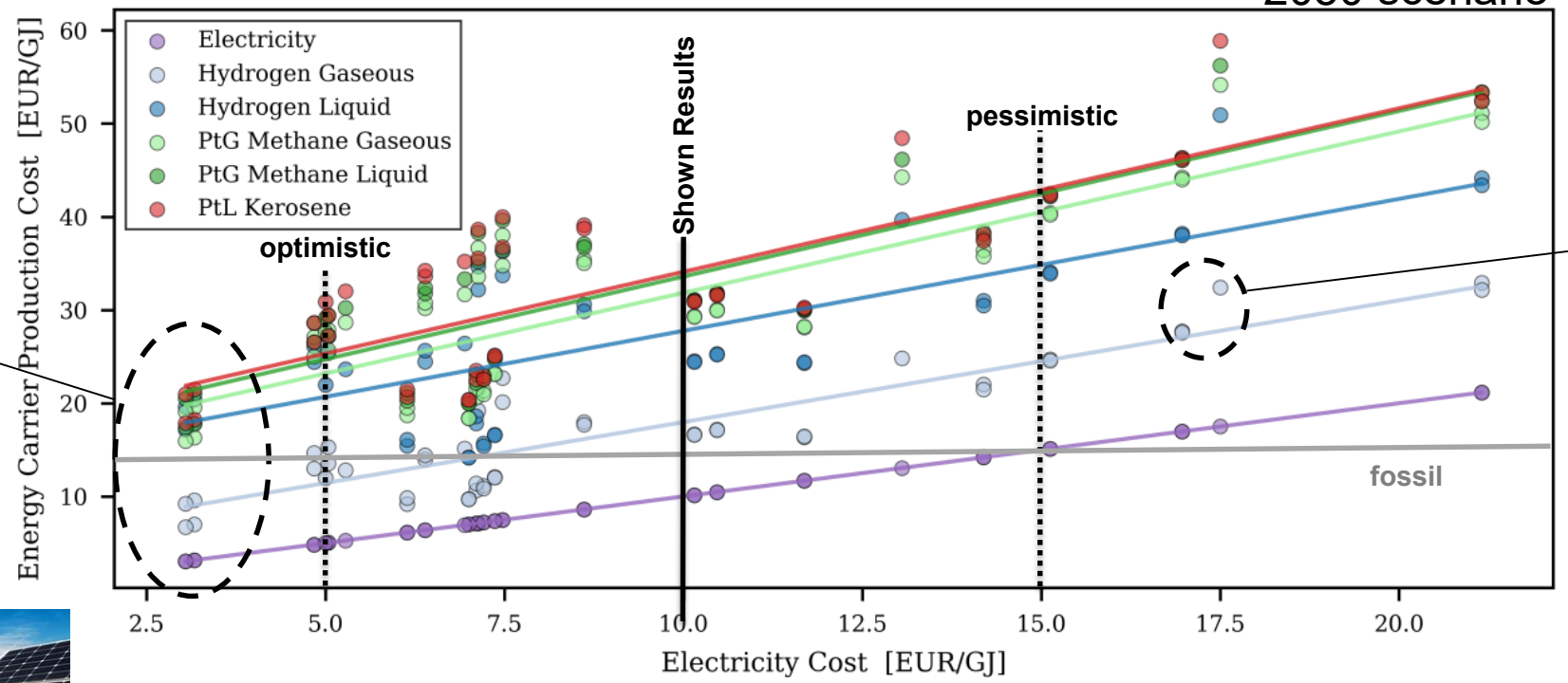
The energy infrastructure

2050 scenario

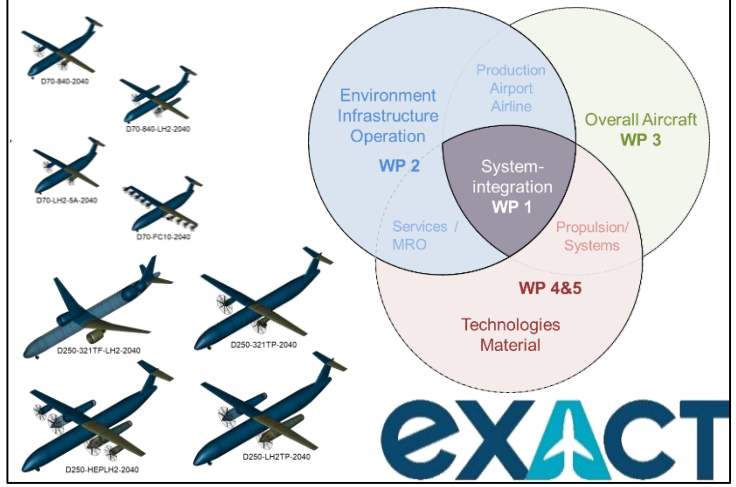


Fixed cost based on production infrastructure effort

Efficiency of production processes

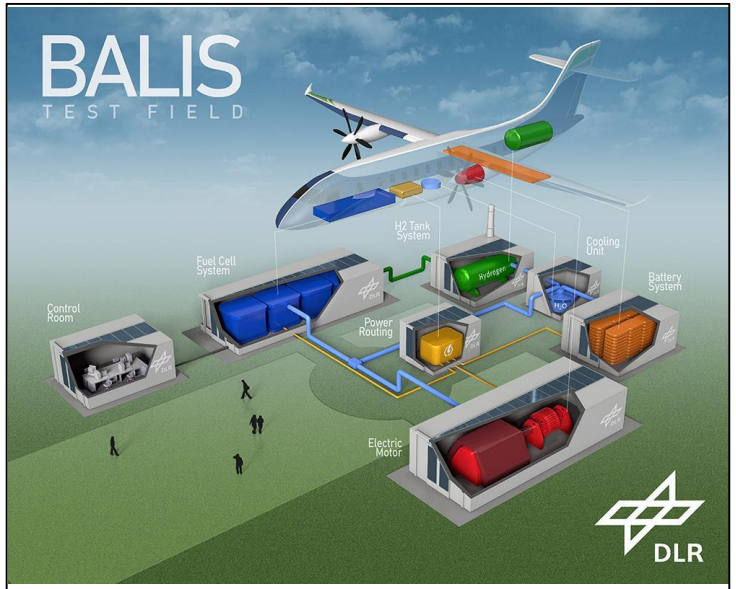
Different point of views

Market Pull



(In-Flight) Demonstration

Technology Push



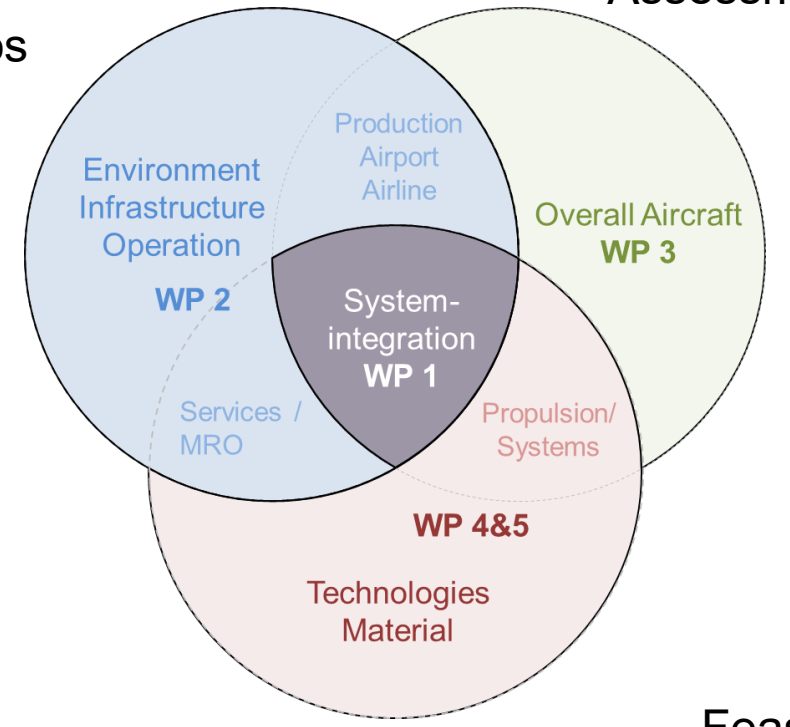
EXACT project approach

Future Demand Scenarios

Top Level System Requirements
- Climate Neutral
- Economically Viable
- Operational Feasible

CONOPS

Energy Carrier



Enabling Technologies

Assessment (Operation, LCC, LCA)
- Aircraft Level
- Fleet Level
- Global Air Transportation System Level
- Global Energy System Level

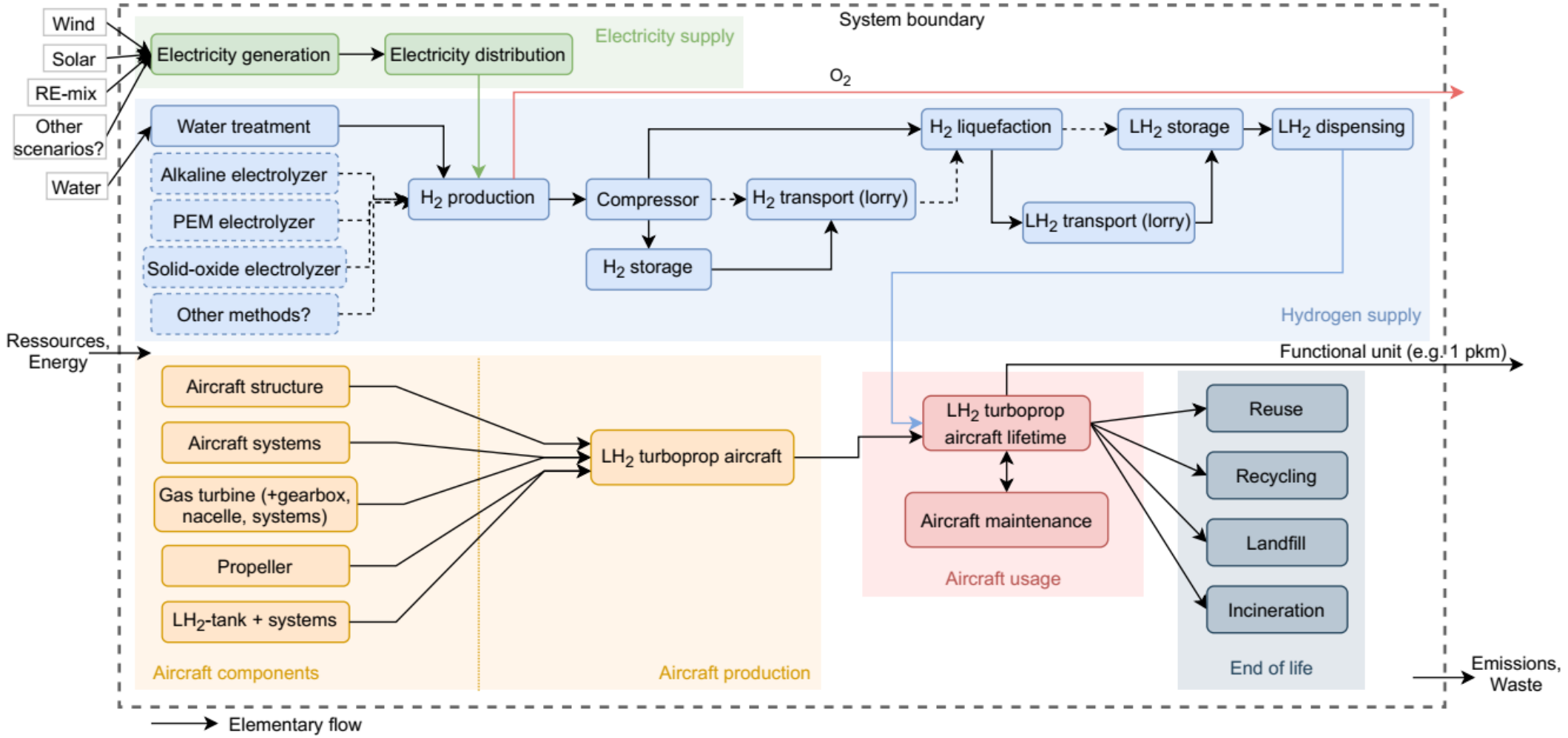
Overall Aircraft Design

Integrated Technology Bricks

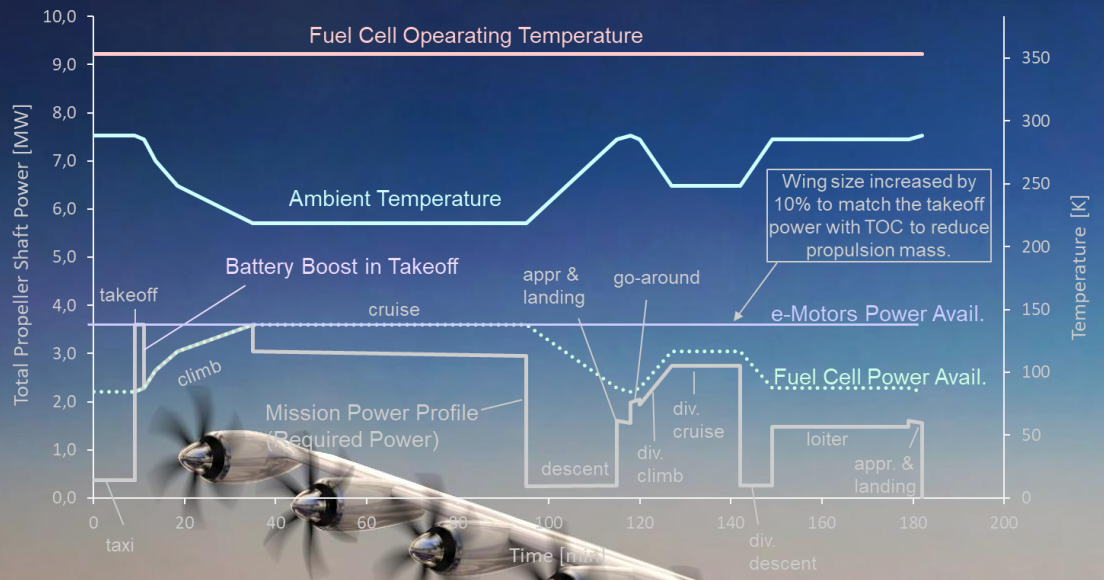
Feasible Solution

Fully digital model based backbone

EXACT project approach



(Fuel Cell) Electric Regional Aircraft



Comparison against ATR72-like aircraft

Energy demand	-20%
CO2 reduction	100%
Climate impact reduction	80-90%
Seat Mile Cost	-11%
Entry into service	2040
MTOW	+16%
Fleet size change for same departure count	-3%

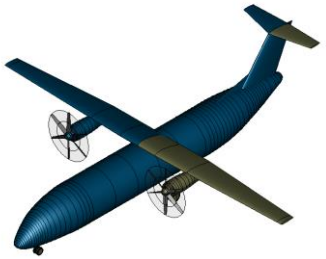
Design Mission

- 70PAX, in single class layout
- Mach 0.55; 1000nm range

Features

- Distributed propulsion with 10 self-sufficient nacelle modules (FC, Inv, eMot, HX)
- Central tank architecture with 2 LH2 tank @ rear end in 5-abreast fuselage

Comparison of Aircraft Concepts



Design Mission Block Energy

-10%

D70-LH2-5A-2040

Cruise Efficiency

-12%

Design Mission Block Energy

-16%

+6% Energy
Due to increased fuselage & vtp mass.

+6% Energy
Due aero penalties

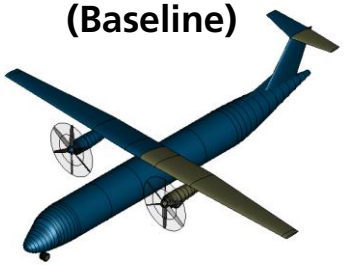
-2% Energy
Better sfc (bigger engines)

-21% Energy
Increased efficiency of power generation.

-4% Energy
Improved descent and allowances efficiency.

+9% Energy
Due to increased mass.

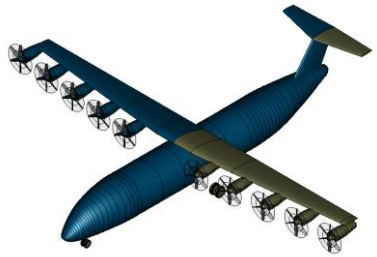
D70-840-2040 (Baseline)



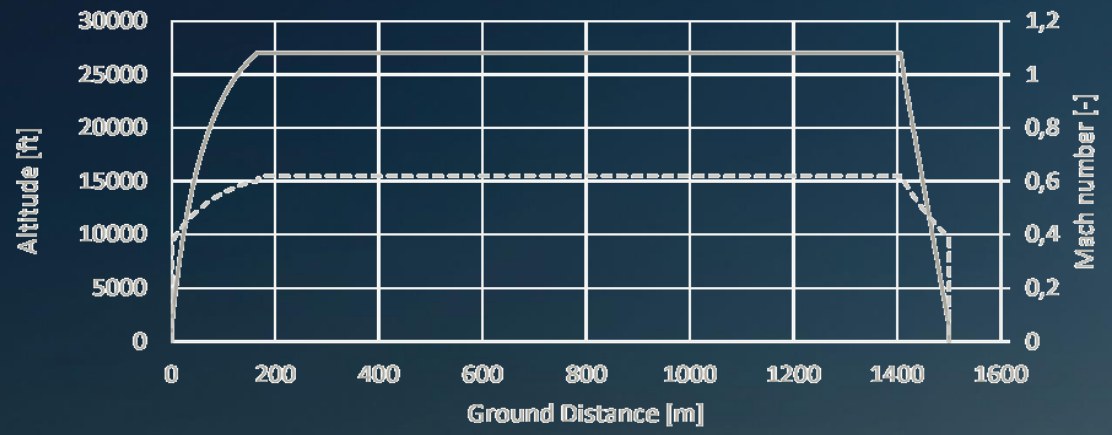
-5% Energy
Improved aero-propulsive eff. due to distributed propellers & VTP redesign.

+5% Energy
Due to fuel cell cooling losses.

D70-FC10-2040



LH2 Short Range Aircraft



Comparison against A320NEO-like aircraft

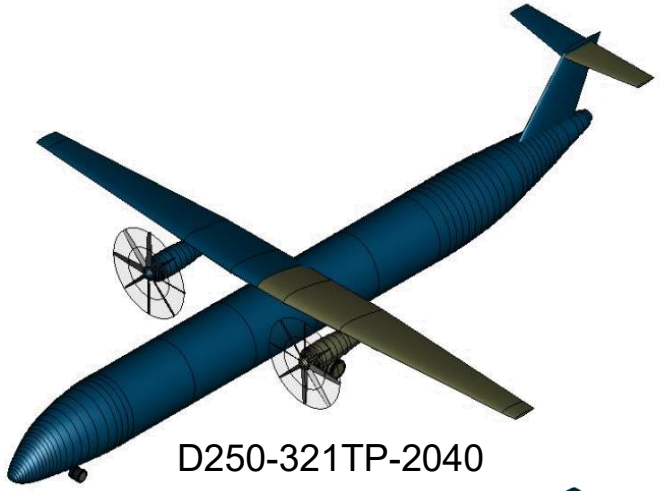
Energy demand	-40%
CO2 reduction	100%
Climate impact reduction	70-85%
Seat Mile Cost	+4%
Entry into service	2040
MTOW	-11%
Fleet size change for same departure count	+5%

Design Mission
- 250PAX, in HD single class, flat 6-abreast
- 1500nm range
- Mach 0.62

Features
- Advanced Low NOx H2 Gas Turbine in combination with FC-APU+ (mild hybrid)
- LH2 Storage System in Pods **OR** in fuselage (with aviation specific characteristics)

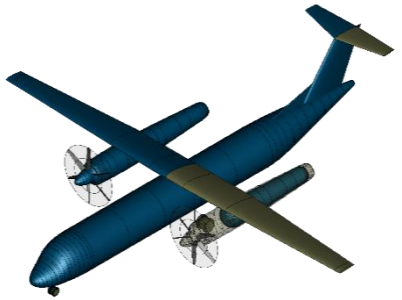
Various Aircraft Architectures for Reduced Climate Impact

D250-321TF-LH2-2040

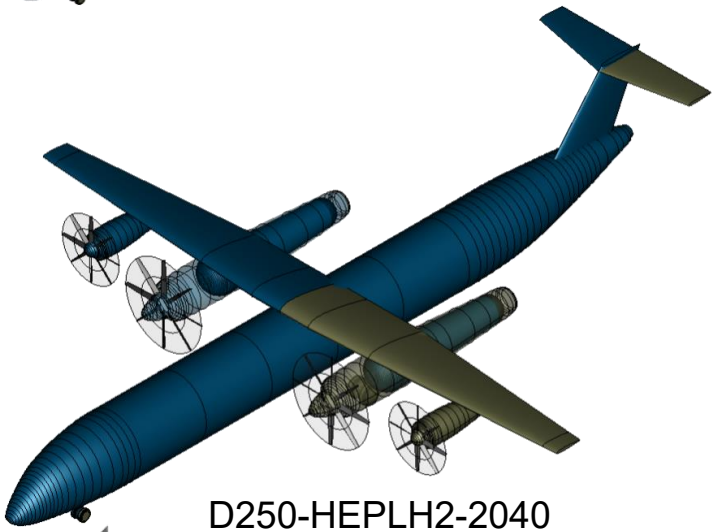


D250-321TP-2040

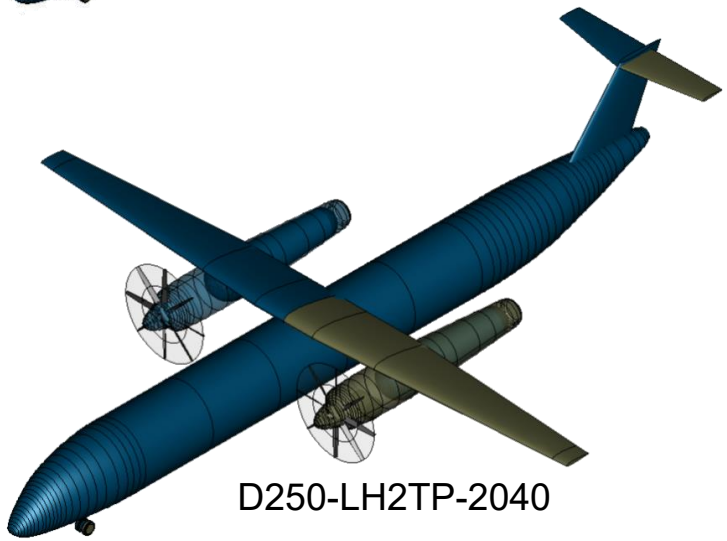
D70-840-2040



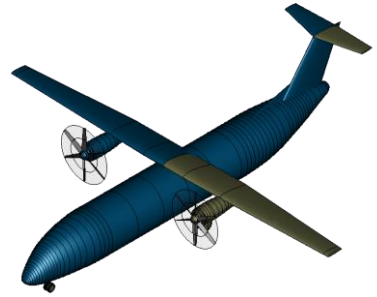
D70-840-LH2-2040



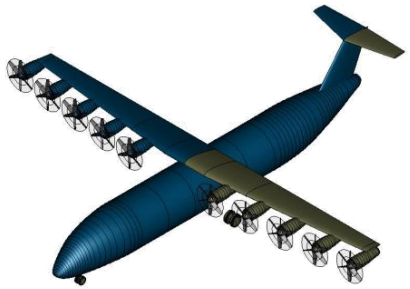
D250-HEPLH2-2040



D250-LH2TP-2040

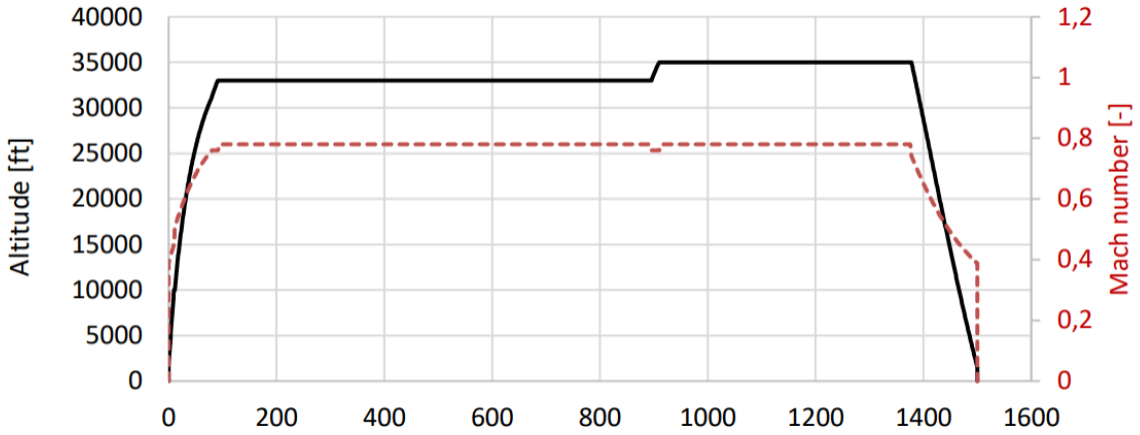


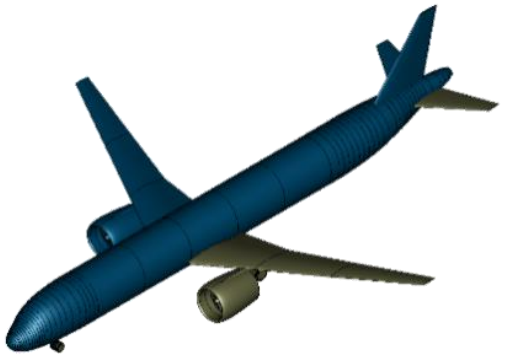
D70-LH2-5A-2040



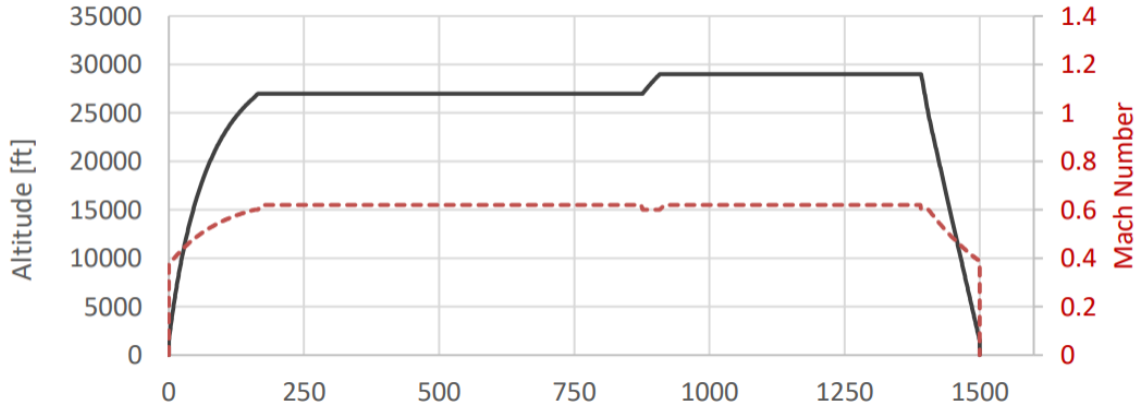
D70-FC10-2040

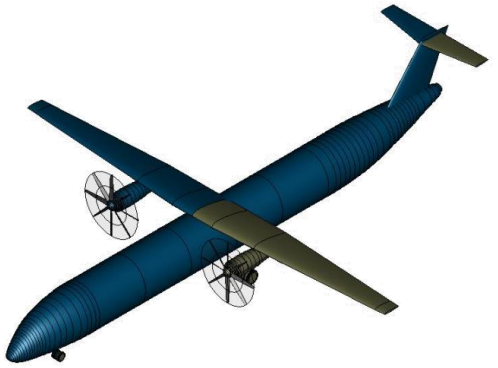
The Baseline Scenario





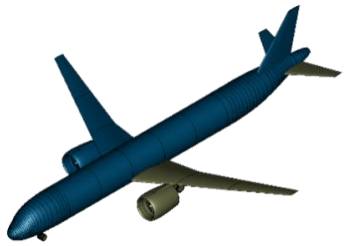
D250-321TF-2040





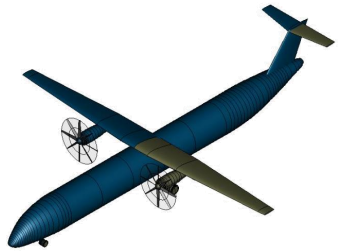
D250-321TP-2040

What makes a solution a good one?



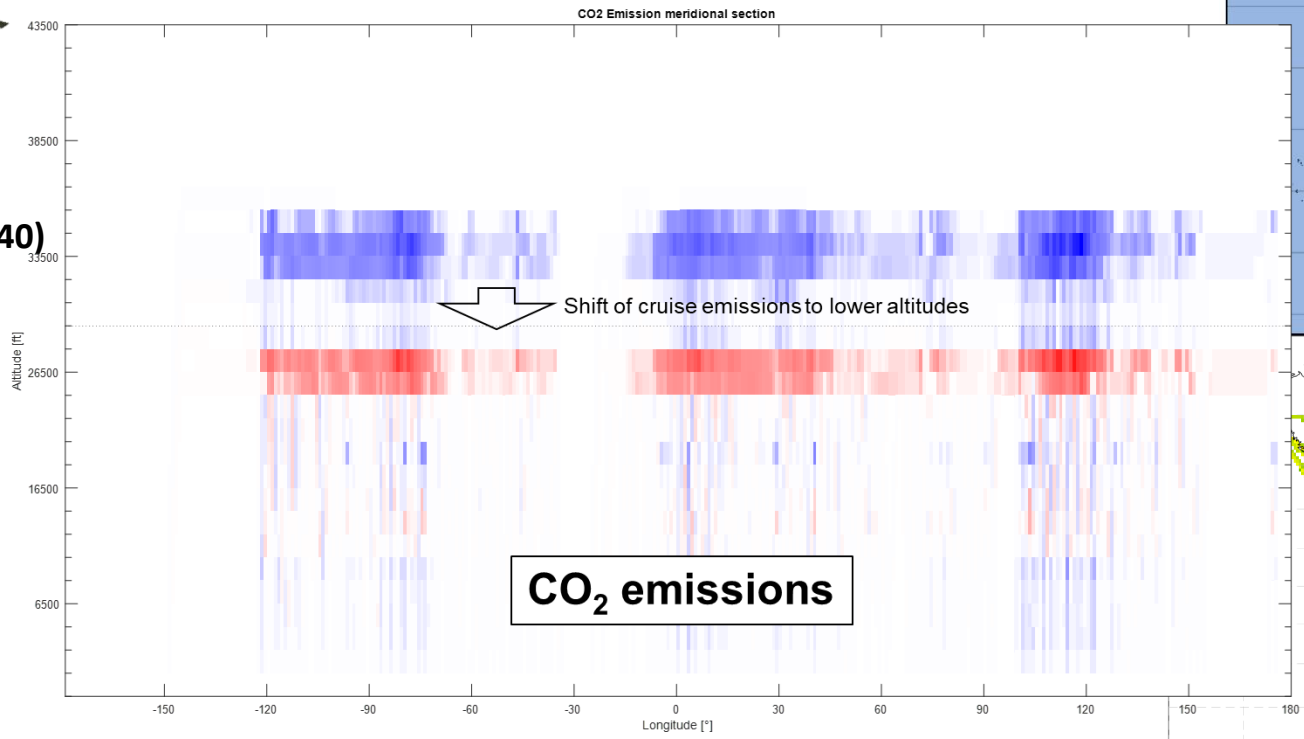
250 PAX TF (baseline 2040)

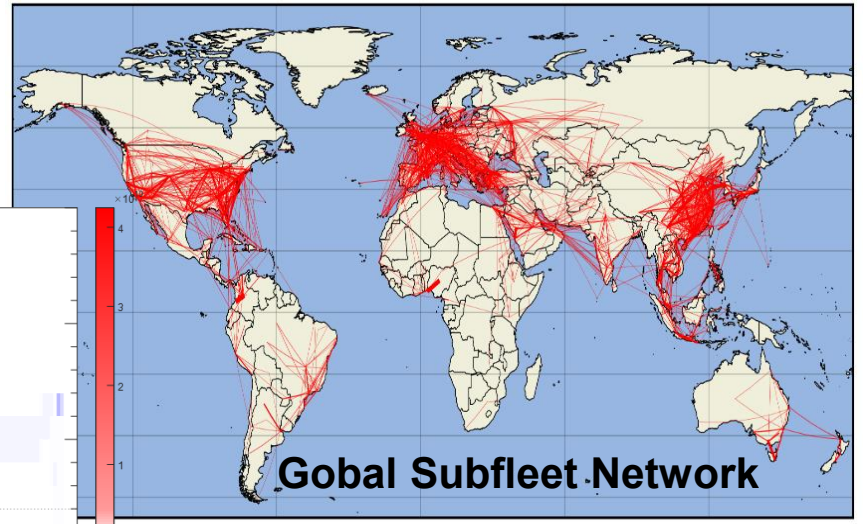
Ma = 0,78; R_{DP} = 1500NM

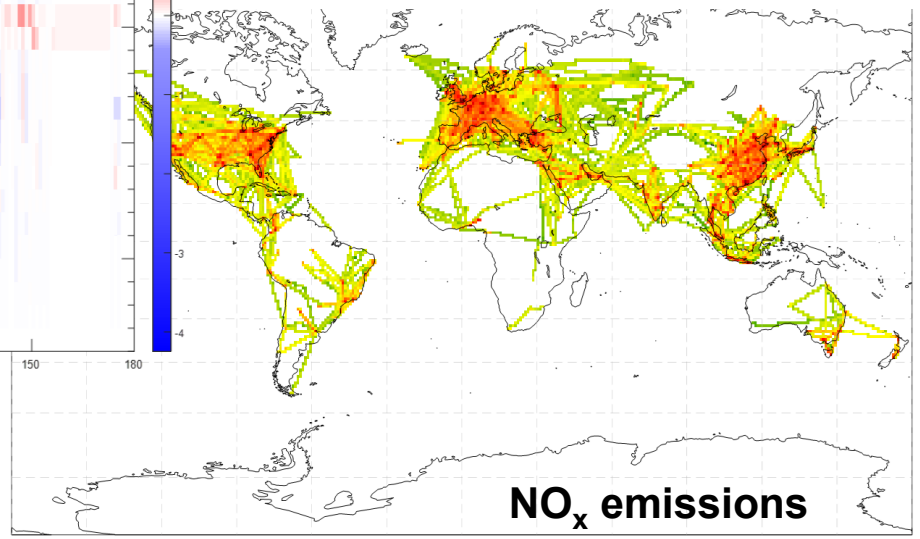


250 PAX TP

Ma = 0,62; R_{DP} = 1500NM







Thank You!

Reach out to: Johannes.hartmann@dlr.de