CleanSky2

LPA - Platform 1

Next generation wings for long range aircraft: hybrid laminar flow control technology drivers

Session: DLR-Beiträge zu CleanSky 2

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www.cleansky.eu

Agenda

- Introduction/Motivation
- Actual project status
- Key technolgies DLR investigates
  - Inductive heating for wing ice protection
  - Tubeless suction system
  - Aircraft performance assessment
- Summary
- Outlook

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Introduction

- Why hybrid laminar flow control?
  - Reduced friction drag
  - Reduced block fuel consumption
  - Reduced C02 and NOX emissions

- Why hasn't this technology been flying for a long time?
  - High manufacturing cost
  - Integration into the wing leading edge very complex
  - Operational requirements

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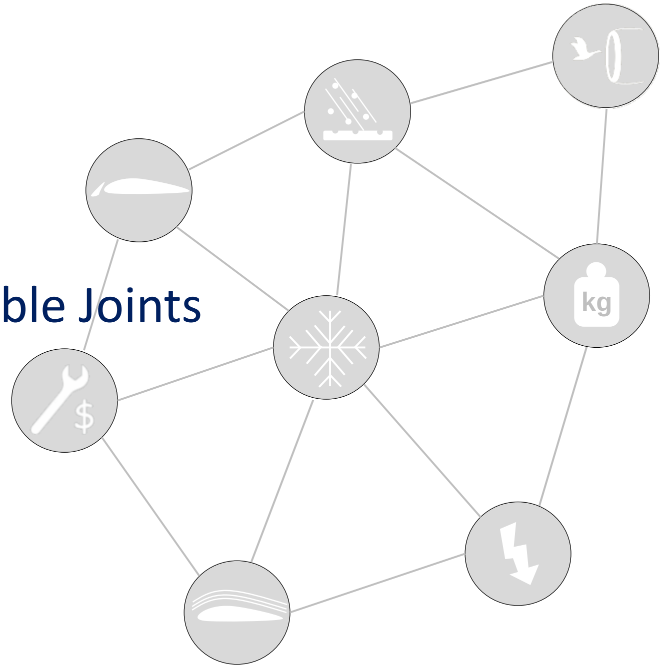
Challenges of a HLFC-Leading edge

- Requirements
  - Light Weight
  - Manufacturing Cost
  - Wing Integration: High-Lift System
  - High Surface Quality & Laminar Compatible Joints
  - Maintenance & Repair (Accessibility)
  - Bird Strike Protection
  - Ice Protection
  - Erosion Protection
  - Lightning Strike Protection
  - …



-> Multi-physics interdisciplinary design required

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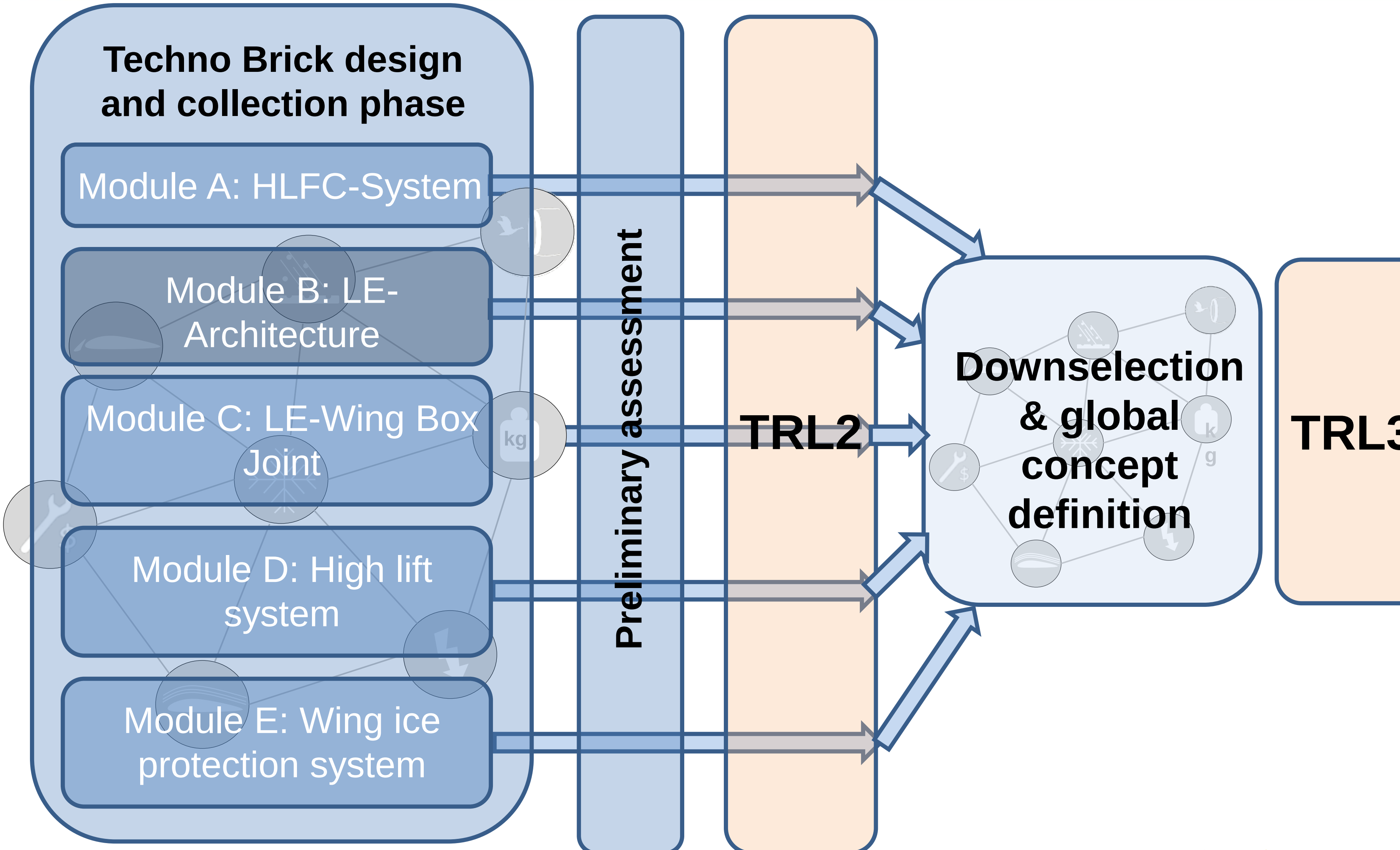
Actual project status



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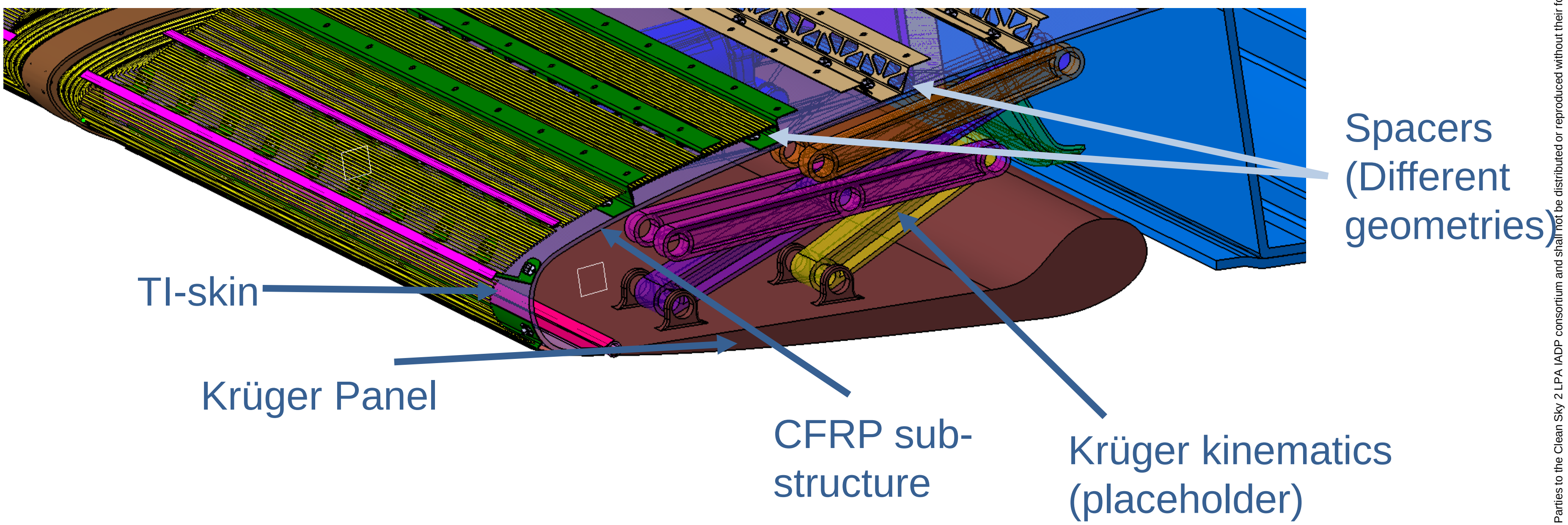
General concept overview



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Key technologies: Inductive heating

- Common wing ice protection systems
  - Hot-air (integration of tubes, temperature resistance of the leading edge materials)
  - Electro-thermal heating (directly glued to the outer skin, induce blockage in the mirco-perforrated TI-Skin)
- Investigation of a „decoupled“ WIPS
  - Less influence on material selection
  - Less blockage

  → Inductive heating
  - Low maturity of technology

    → Feasibility test should show the potential of inductive heating

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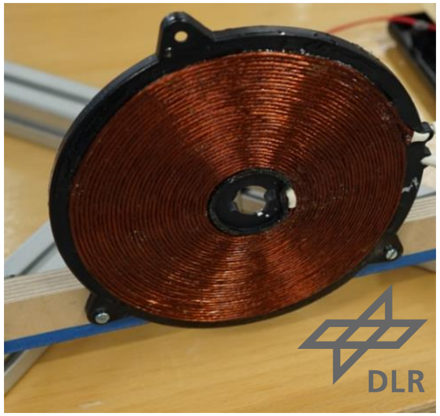
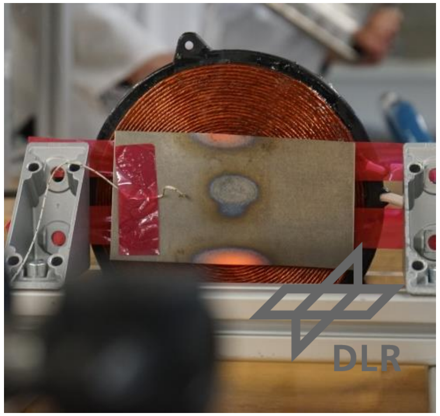
Key technologies: Inductive heating

- A first step:
  - Check heating of different LE materials

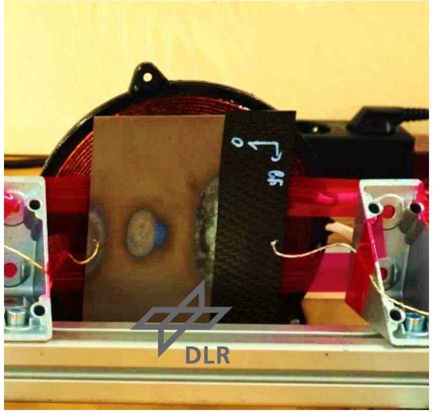


Simple “cooktop style” pancake coil

Insignificant energy take-up



Significant heat up with high temp gradients



Direct comparison

Used parameters:

- 200 V amplitude excitation
- Frequency approx. 23 kHz

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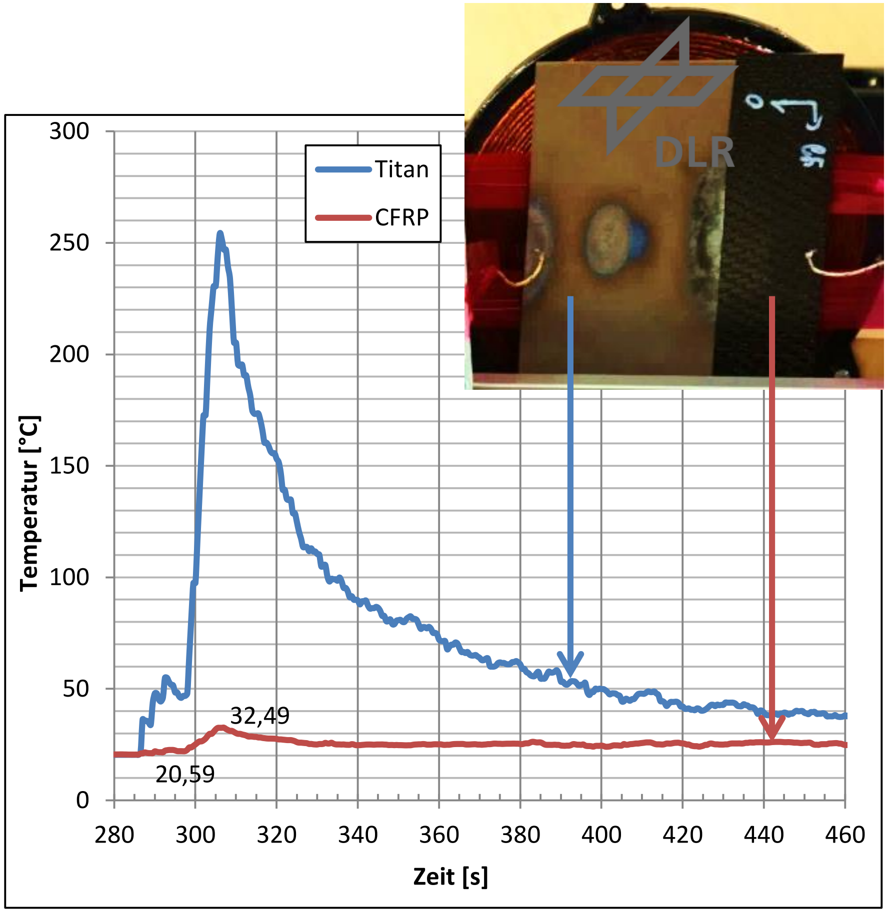
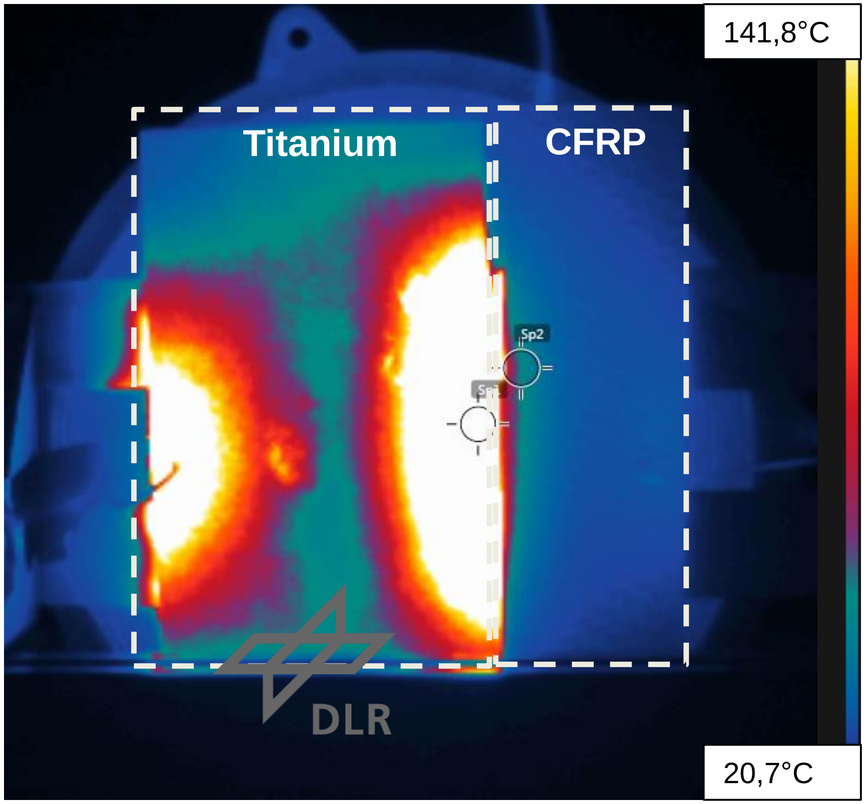
Key technologies: Inductive heating

- A second step:
  - Check heating of different LE materials at the same time





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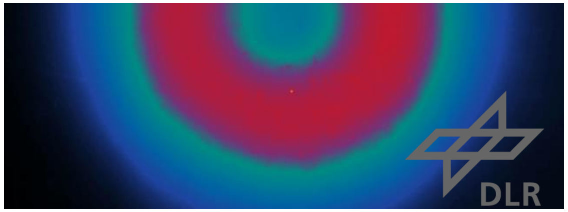
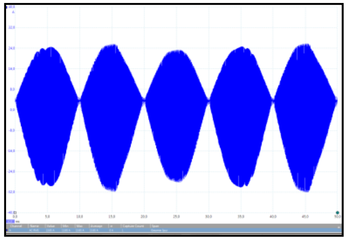
Key technologies: Inductive heating

Induction Heating (10mm Distance; 10s)

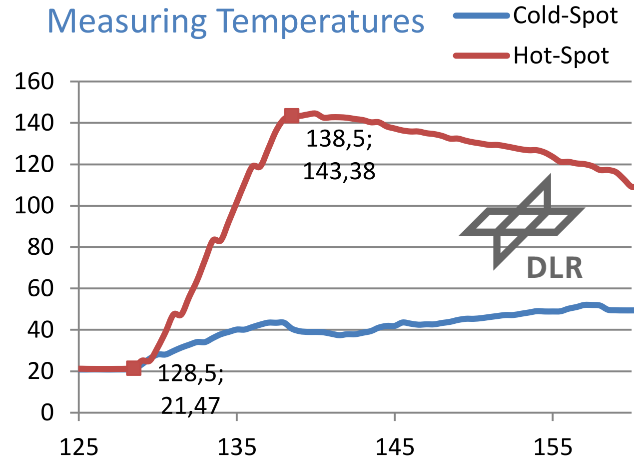


Measuring eff. ACRMS – 13,8 A

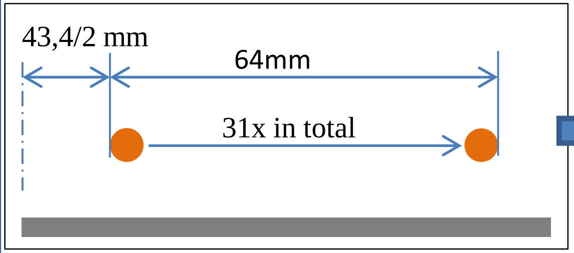


Excitation in Coil ACRMS – 13,8 A

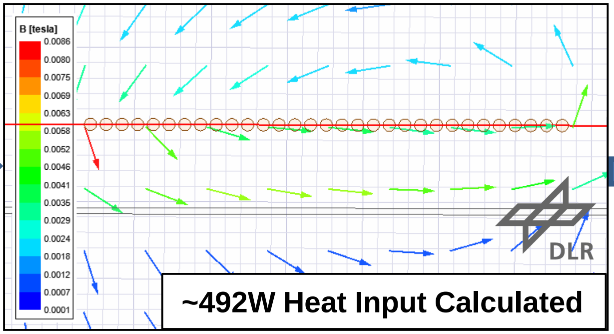
Measuring Temperatures



138,5°C via TC – 136,17°C via Simulation

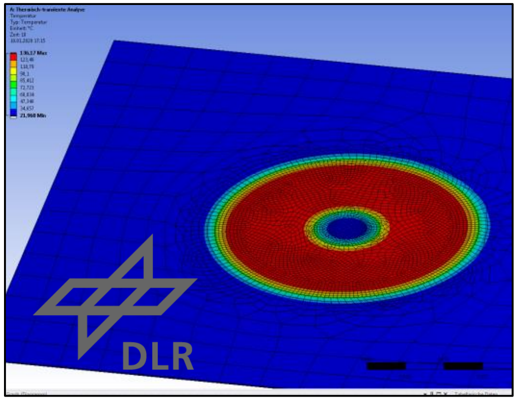


Model of the Test Setup



~492W Heat Input Calculated

Solving Maxwell Equations for Eddy Current Heating with measured Input (ACRMS) (Ansys Maxwell 19.2)



Transient thermal heat Analysis in Ansys WB 19.2 – calc. Hot-Spot Temperature

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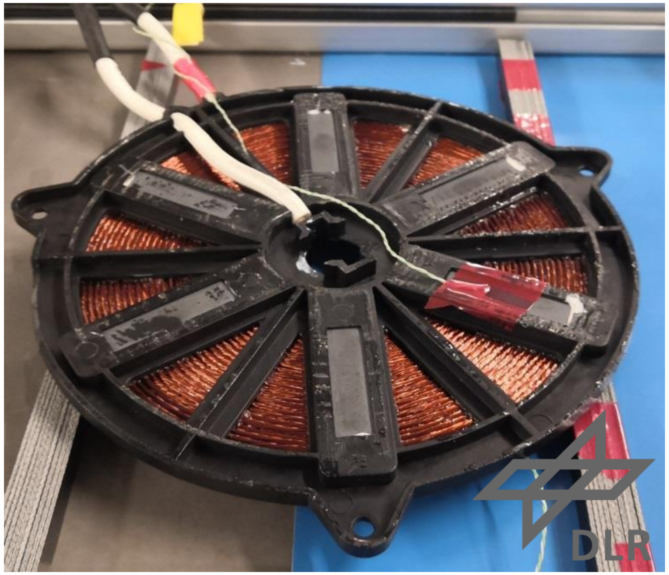
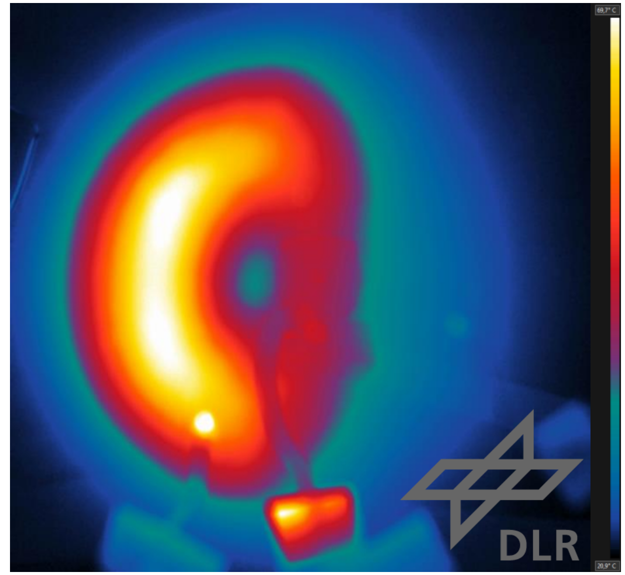
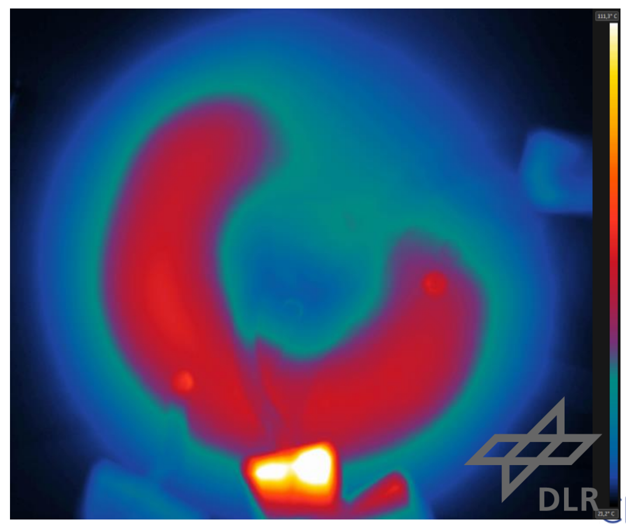
Key technologies: Inductive heating

Shielding the half- and a quarter of the Coil with 2x35µm Copper

IR-Picture of Heating Process







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Key technologies: Inductive heating

- Summary
  - Inductive heating seems suitable for the chosen material combination
  - Blockage can be avoided
  - Additional shielding is possible to avoid heaing of other components

-> Results are presented to industrial partners

-> Inductive heating was selected as WIPS system

-> Industrial partners will further address important design challenges

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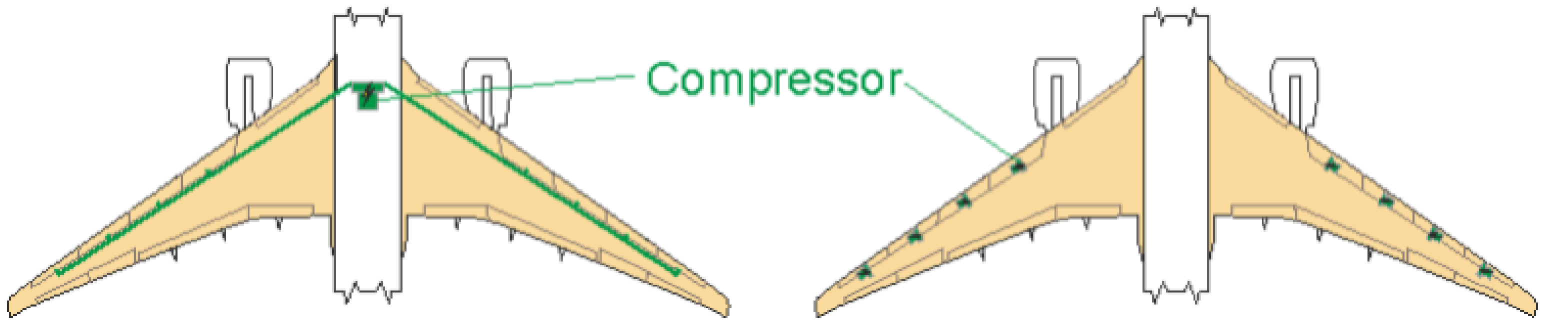
Key technologies: Tubeless suction system



- Vacuum transport require very thick tubes in order to avoid losses
- Space allocation issues in earlier projects

→ Distributed compressors to enable tubeless suction system

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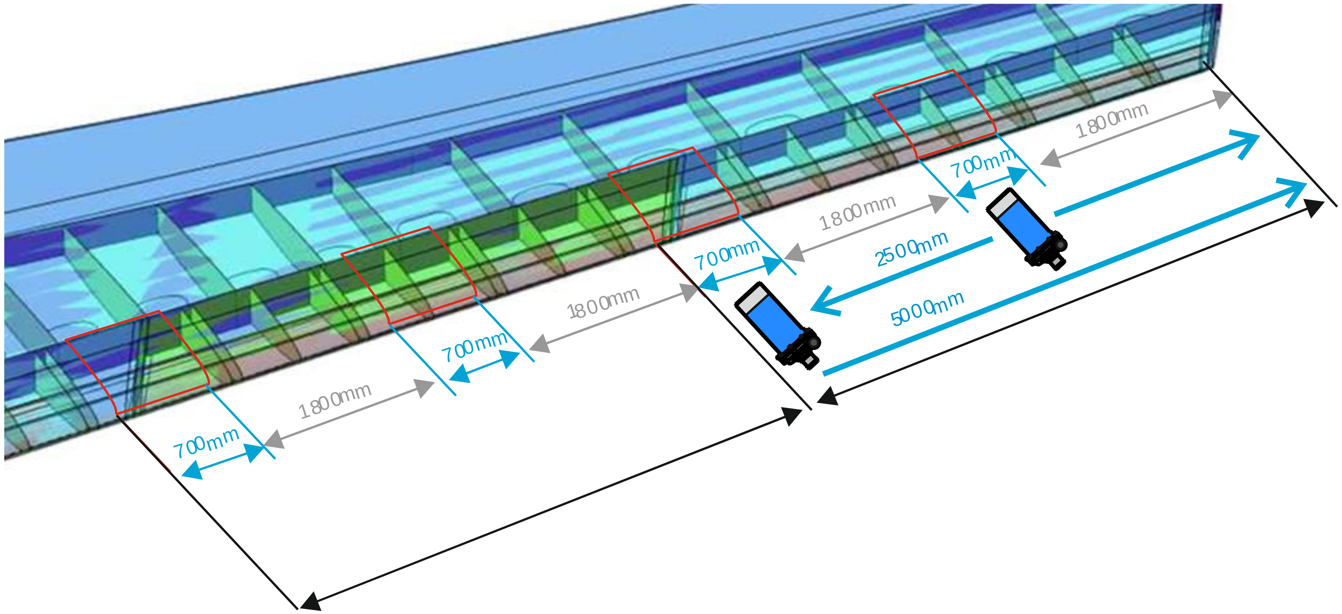
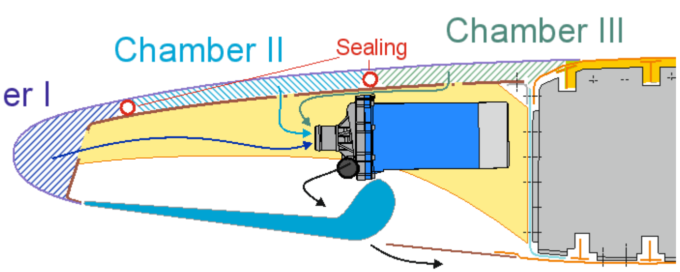
Key technologies: Tubeless suction system

- Tubeless suction system -> design idea





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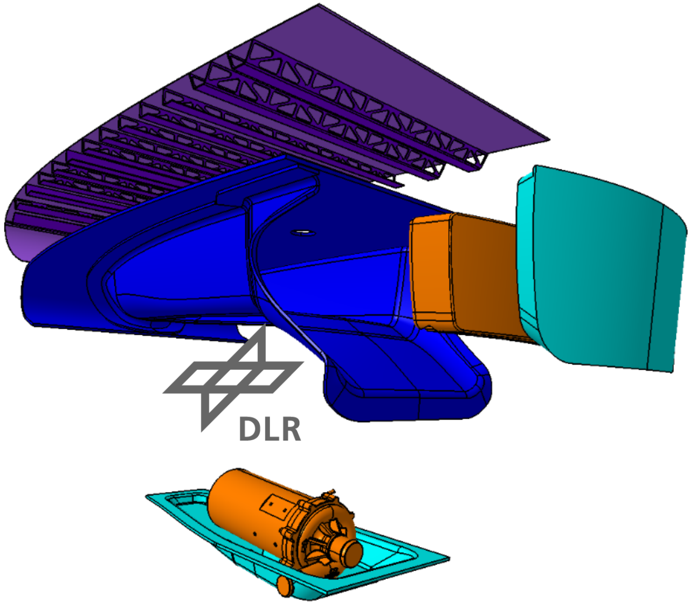
Key technologies: Tubeless suction system

- Suction rib is connected to the chambers
- Cable Routings, Krüger panel and pump integration require a complex shaped rib

- Lightweight suction rib -> manufacturing feasibility is under investigation



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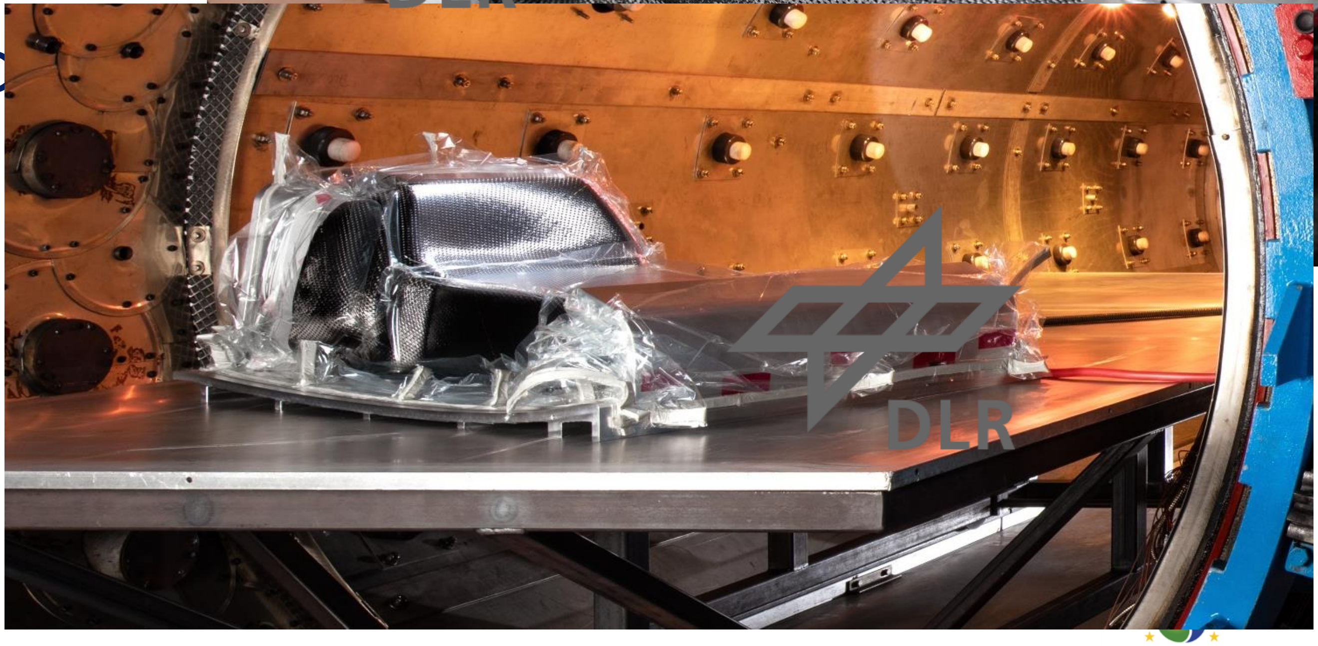
- Pre-form tests

- Vacuum c



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Key technologies: Tubeless suction system

- Summary:
  - Lightweight compliant multifunctional rib designed
  - Pre-form test and optimization done
  - Compression test started
- Next steps:
  - Infusion tests
  - Manufacturing trials
  - Cost assessment

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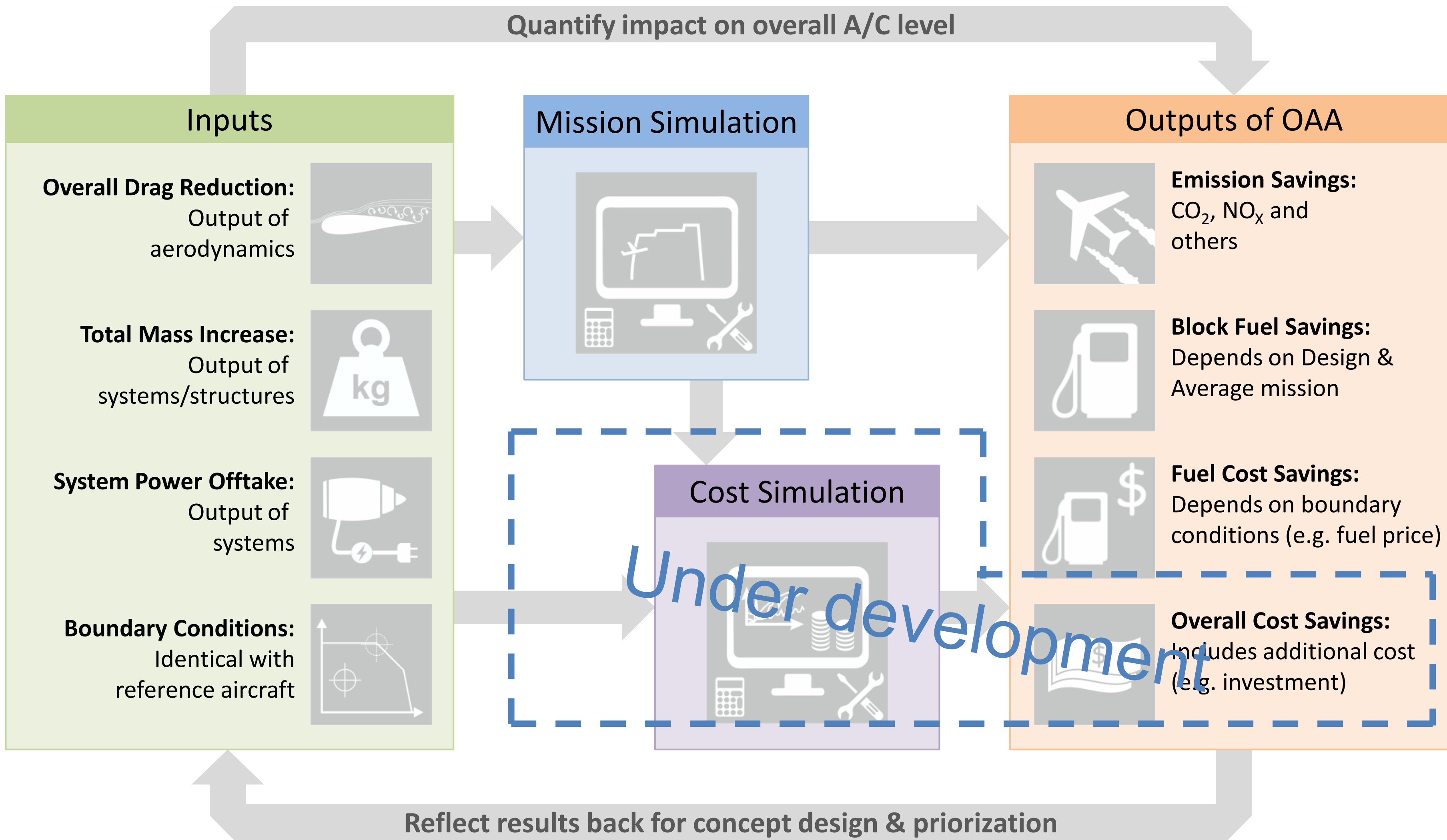
Key Technologies: Aircraft Assessment



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Key Technologies: Aircraft Assessment

HLFC–WIN

Clean Sky 2 | WP1.4.4. | HLFC-Win
Estimation of Fuel (and Economic) Efficiency

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Main Inputs

Parameter	Unit	*enter below or use slider*	Value used
Drag savings	[%]	3,50%	3,50%
Mass	[kg]	500	500
Power	[kW]	83	83
Range	[NM]	5400	5400
Payload	[kg]	31500	31500

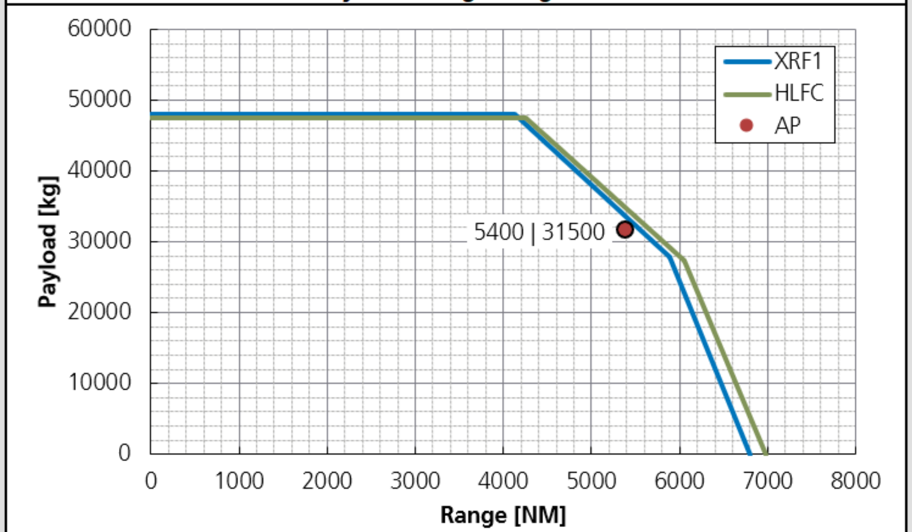
Assumptions

Parameter	Unit	*enter below or use slider*	Value used
Motor Eff.	[%]	80%	80%
Compr. Eff.	[%]	80%	80%
IDG Eff.	[%]	85%	85%
Total Eff.	[%]		54%
Power Req.	[kW]		153
SFCper100kW	[%]		0,53%
SFC Increase	[%]		0,81%

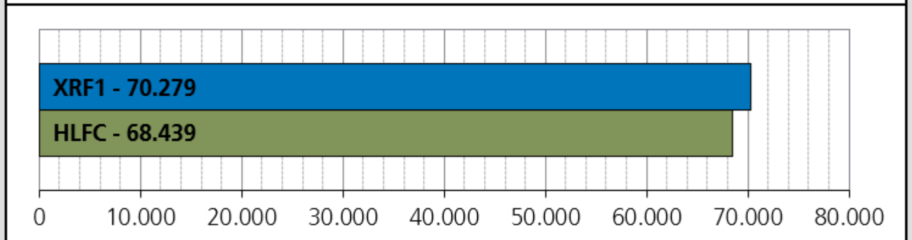
Operational Efficiency Results

		Delta (abs)	Delta (rel)	XRF1	HLFC
Block Fuel	[kg]	-1.840	-2,7%		
Block Time	[min]				
CO2 Emissions	[kg]				
Nox Emissions	[kg]				
CO Emissions	[kg]				
HC Emissions	[kg]				

Payload Range Diagram



Block Fuel



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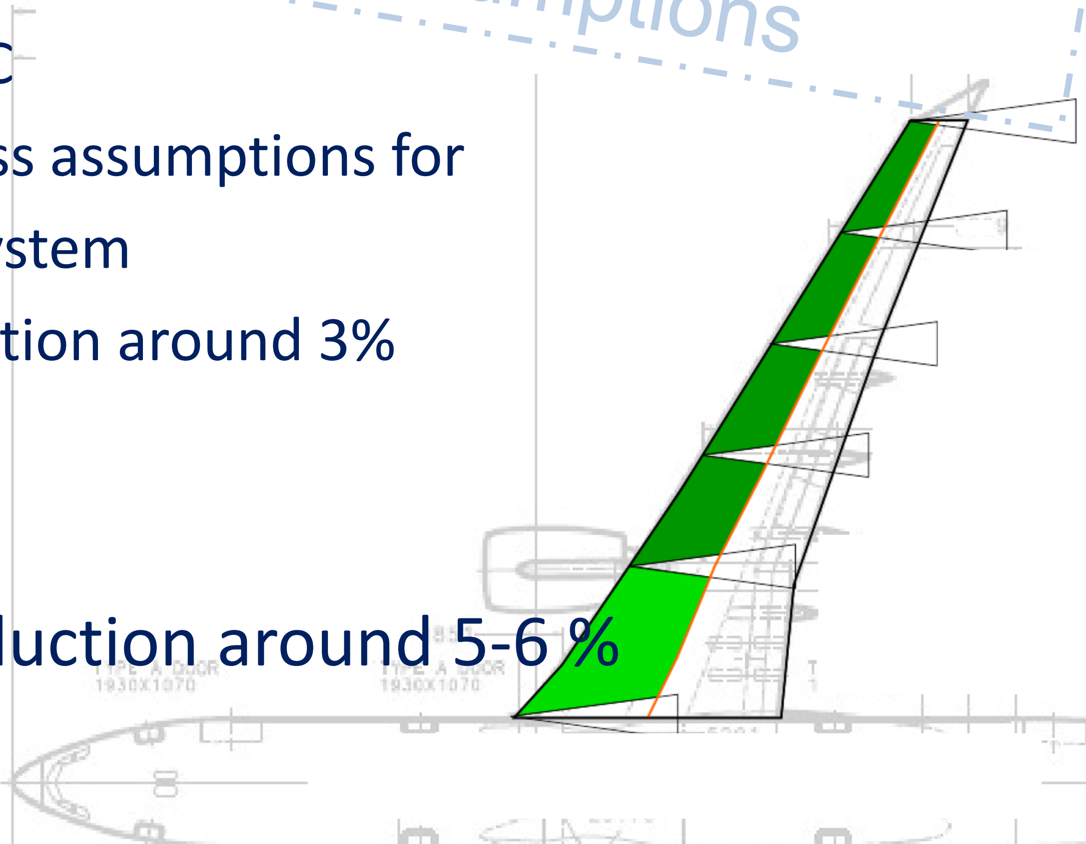
Key Technologies: Aircraft Assessment

- Summary:
  - Actual Case:
    - Outer Wing HLFC
    - 4 Segments, Mass assumptions for additional HLFC-System

    →Block fuel reduction around 3%
  - Envisaged Case
    - Full wing HLFC

    →Block fuel reduction around 5-6 %

Based on preliminary assumptions



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Next steps

- Integration of all elements in the DMU, space allocation check
- Small scale demonstrators to prove feasibilty of different concepts
  – Suction tests
  – Water uptake
  – Manufacturing trials
  – …
- TRL 3 review and global concept approval

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