Structural concept of ECHO - Hybrid bonding and laminar joints

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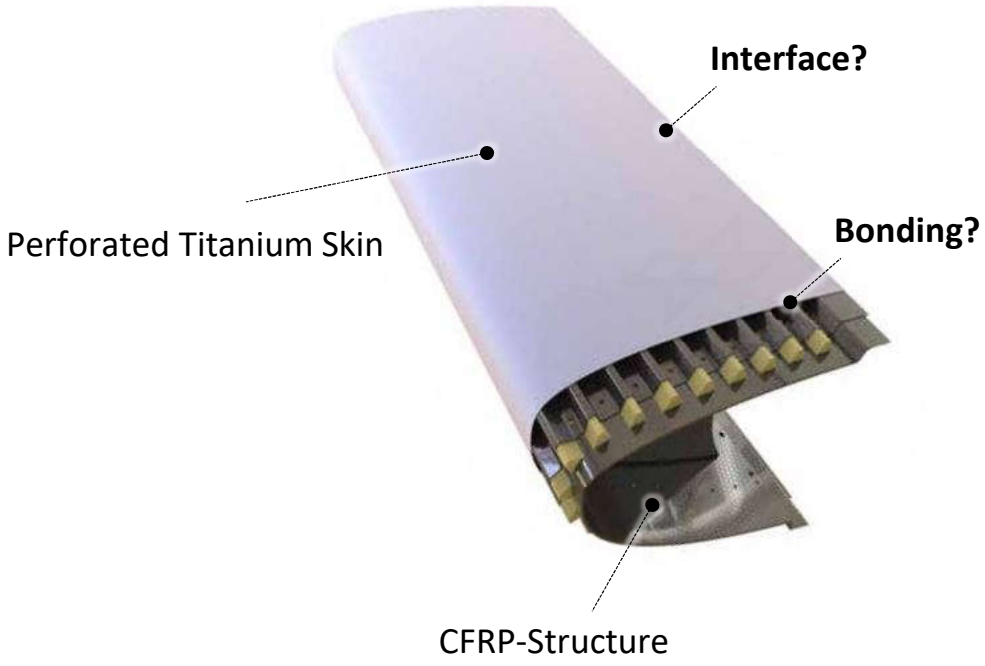
Overview

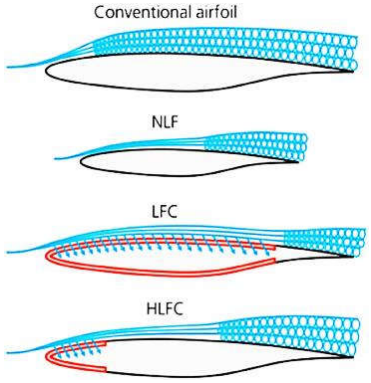
- Introduction
- Bonding of hybrid structures
- STFD - Demonstrator
- Interface of LE-HTP
- ISSD - Demonstrator
- Conclusions and Outlook

Introduction

- Horizon 2020 LPA Project: Manufacturing of a Demonstrator for a retrofit HLFC-Leading Edge for A350 HTP



Horizontal Tail-Plane (HTP)
Leading Edge on a A320

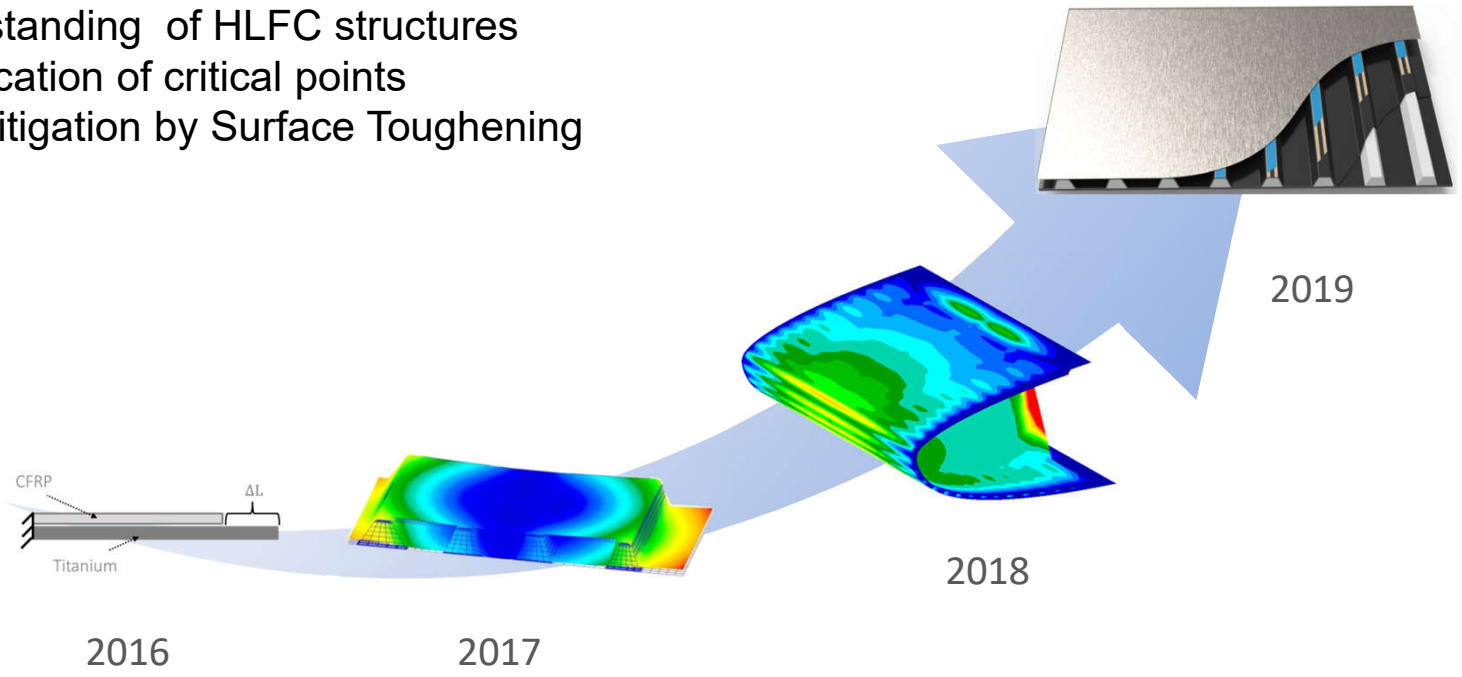


Hybrid Laminar Flow
Control

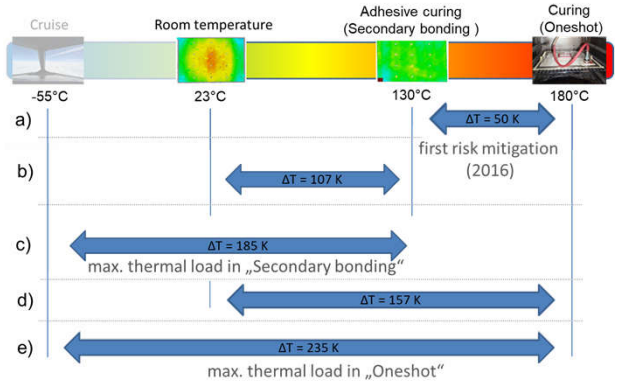
Challange of hybrid structural bonding

What are the structural challenges and how do we handle them?

1. Understanding of hybrid structures
2. Understanding of HLFC structures
3. Identification of critical points
4. Risk mitigation by Surface Toughening

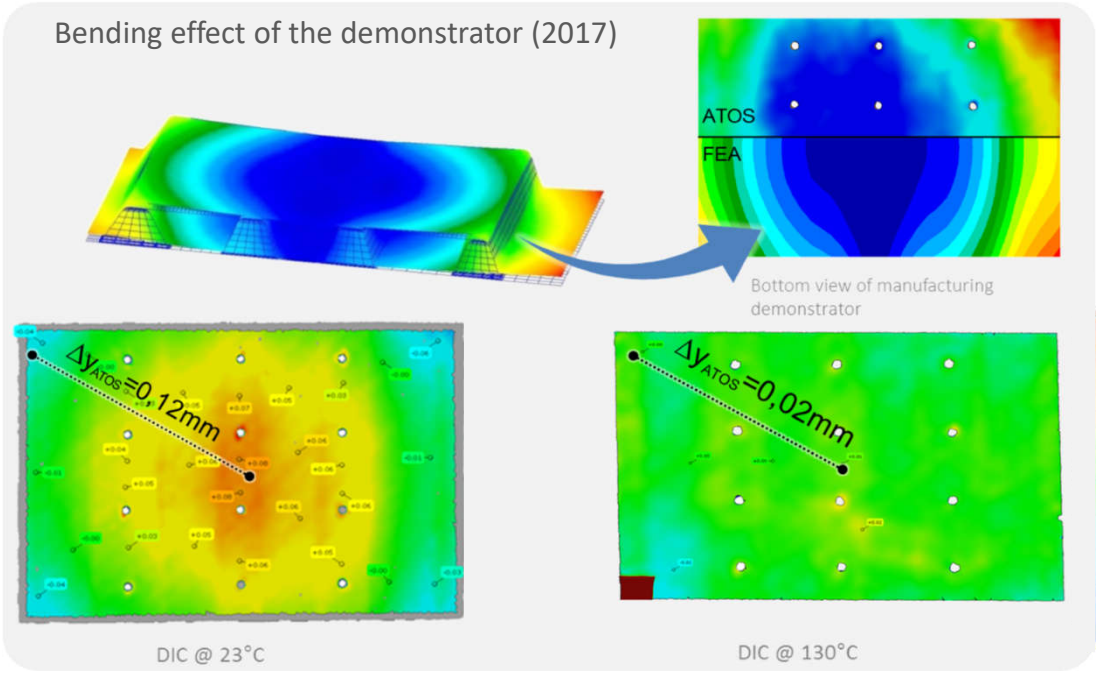


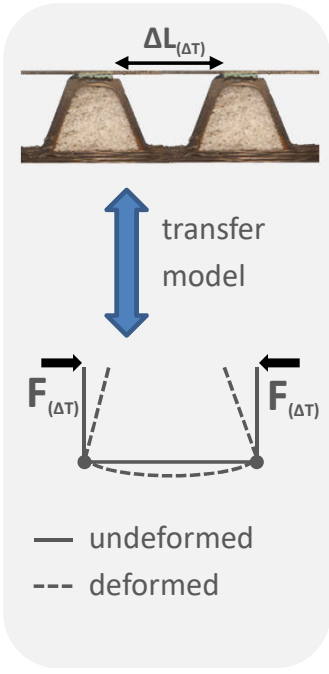
Understanding of HLFC-Structures



Challenge: Strong deformation in structure after cooldown

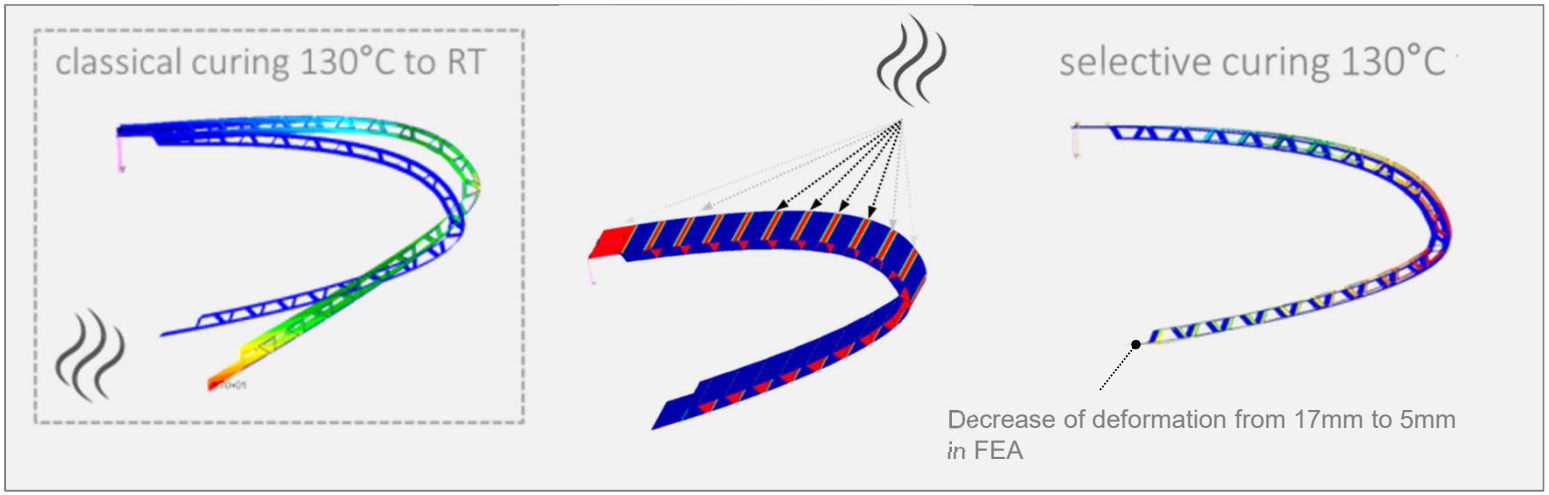
- Effect is reversible and can be calculated
- Deformations induces stress to the bondline





Understanding of HLFC-Structures

- Selective curing of bonded areas ⇒ Reduction of deformations
- Stress investigation of bondline ⇒ Identification of critical points

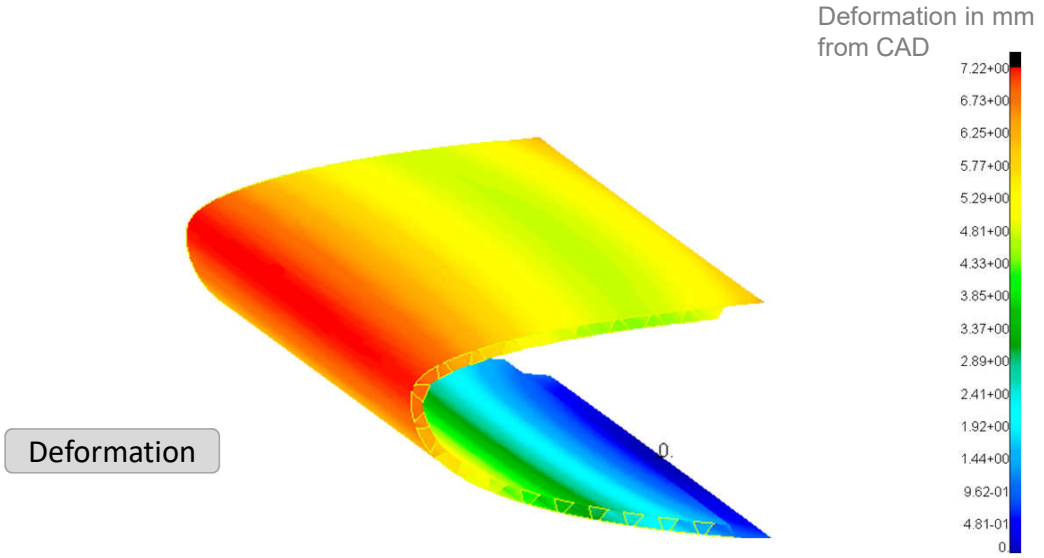


Whole structure cures in vacuum bag in autoclave

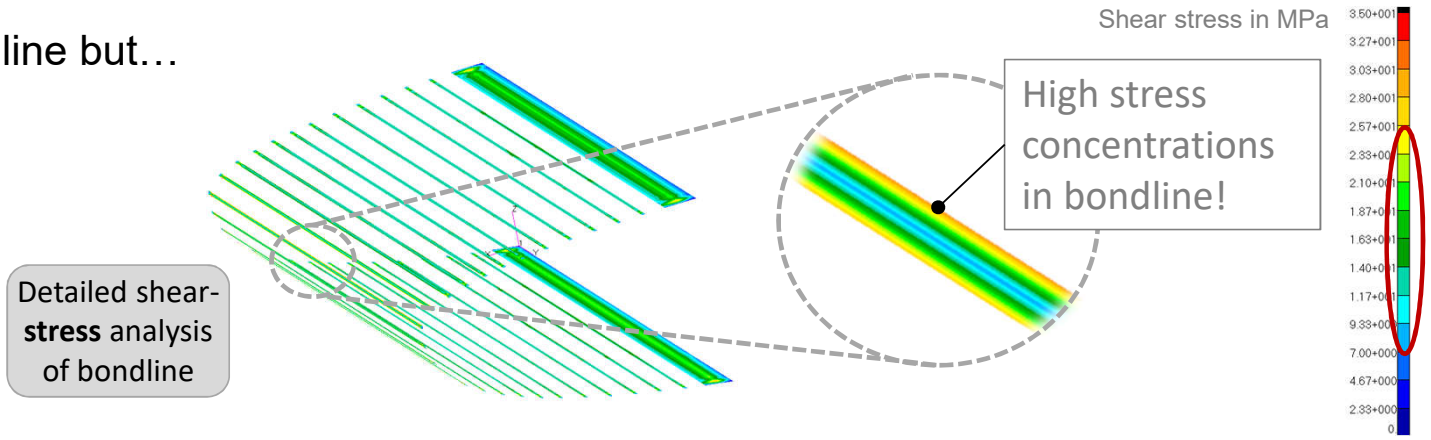
Only the bondine areas are heated up, significantly less deformation in structure

Identification of critical points

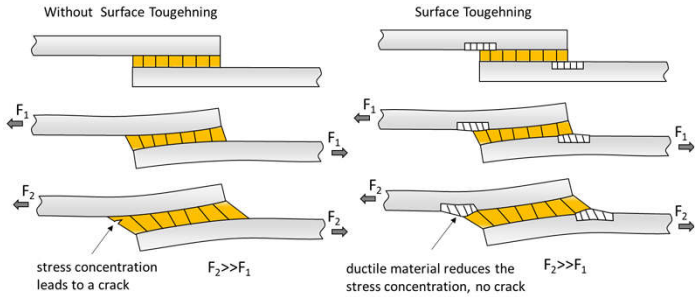
- Bonding analyses on 800mm Demo Level
- Selective curing @ 130°C then cool down to RT



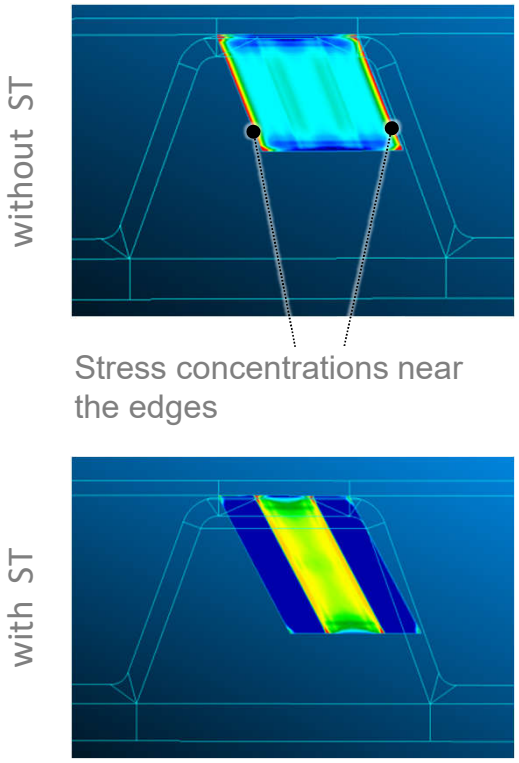
- Moderate shear stress to bondline but…

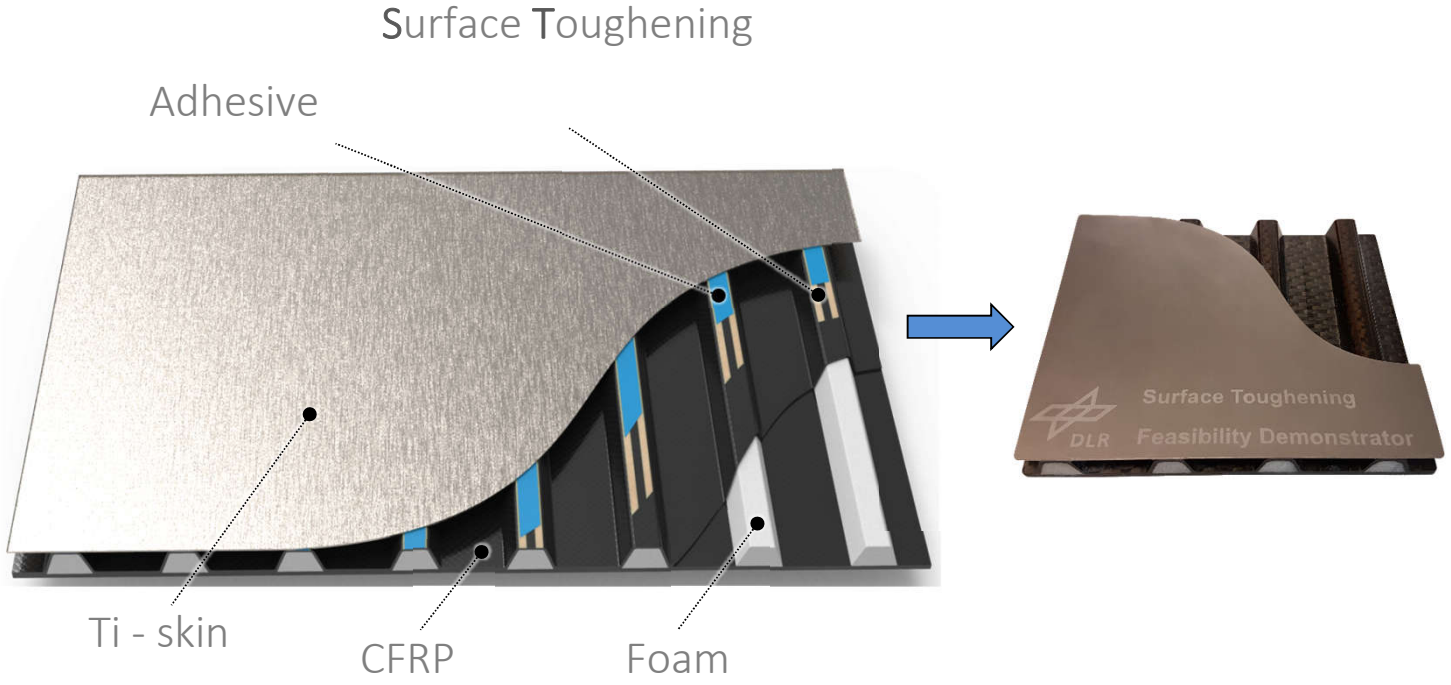


Risk mitigation by Surface Toughening



- Bondline shear stress selective curing @ 130°C then cool down



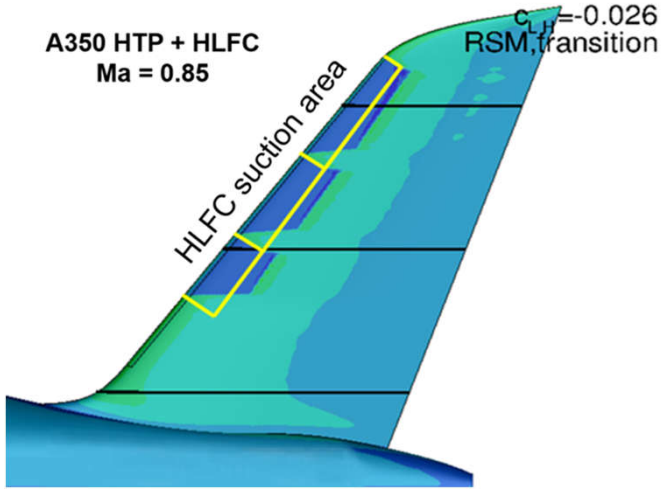


Ductile material e.g. PVDF **absorbs stress concentration** and transfer them homogeneous to the stiffer area in the middle of the joint

Motivation for laminar Joint

- Why is the Interface so important?
- The laminar boundary layer must extend beyond the interface to provide the benefit of drag reduction.
- What are the difficulties?

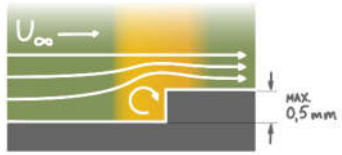
Example for airfoil distortions



Laminar airflow in dark blue

Requirements

- Strict requirements from Aerodynamic Department
- Forward facing step max. 0.5mm*

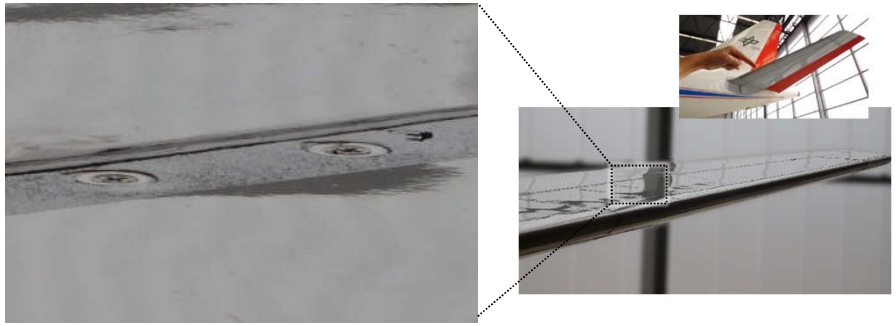


- Backward facing step of max. 0.12mm*

- <u>Result:</u>
  - difficult for manufacturing!
  - difficult for MRO!

*only for our cruise flight case on A350 HTP

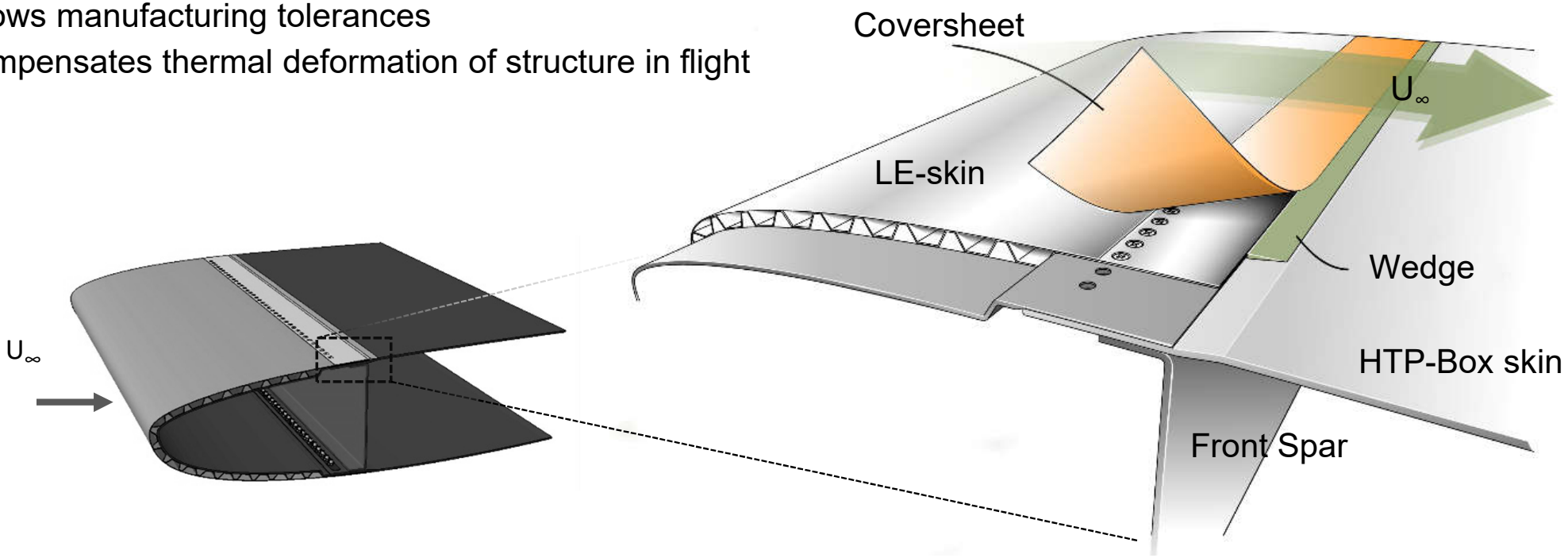
Paint line erosion of a Vertical Tail-Plane (A320)



Distortion of airfoil by steps and gaps of Horizontal Tail Plane Leading Edge to box Joint (A320)

Laminar Interface Concept

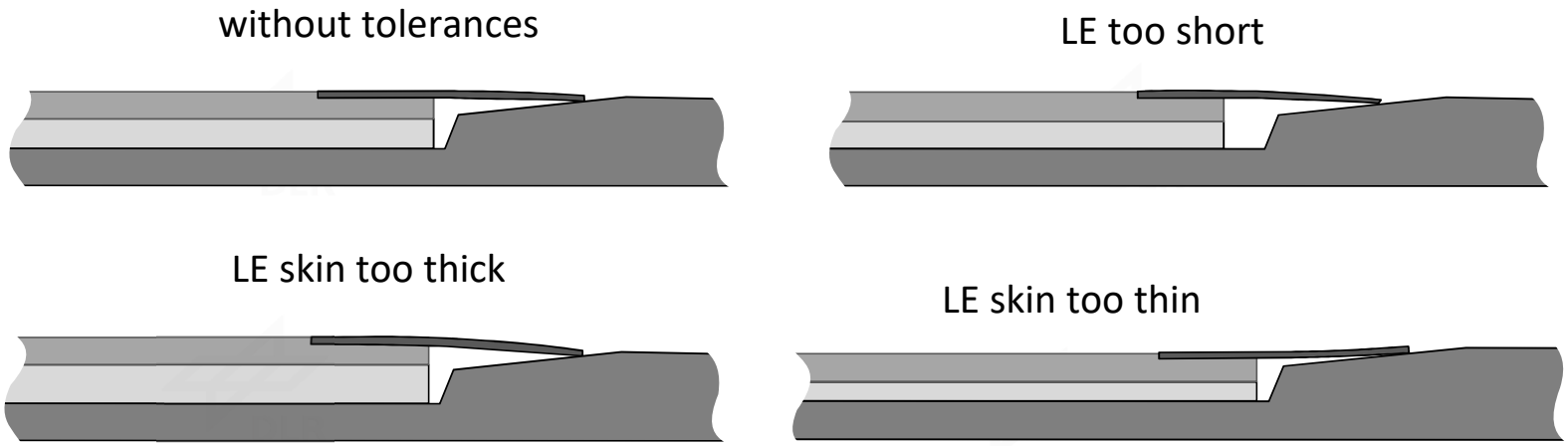
- Removable cover concept
- From Outside accessible Joint for Horizontal Tail Plane (HTP)
- allows manufacturing tolerances
- compensates thermal deformation of structure in flight



Laminar Interface Concept for A350 Leading Edge – HTP Joint

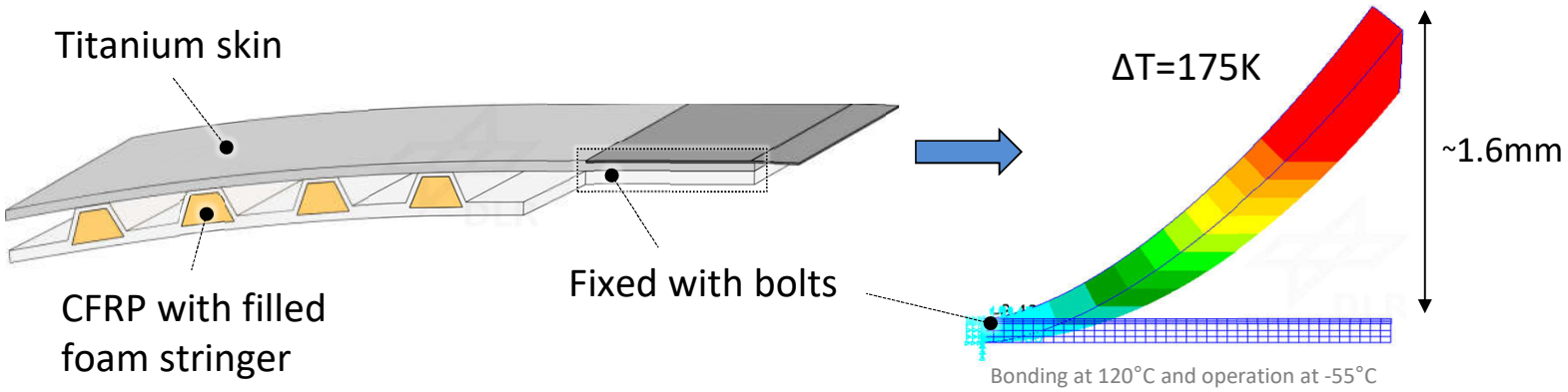
Compensation of manufacturing tolerances

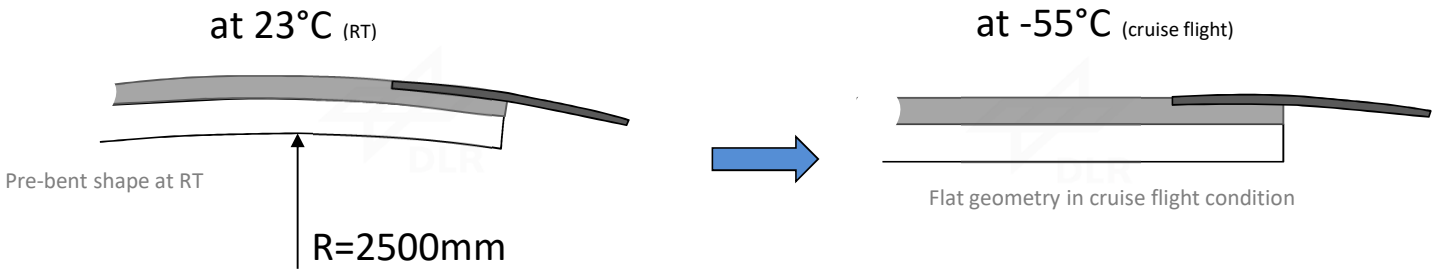
- The coversheet compensates the manufacturing tolerances
- Coversheet = pre bent steelfoil



Compensation of thermal deformation

- Strong „Bi metallic effect“ of CFRP structure and bonded titanium skin

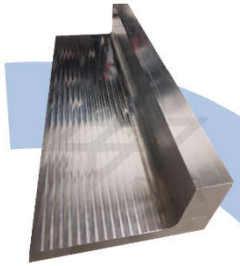


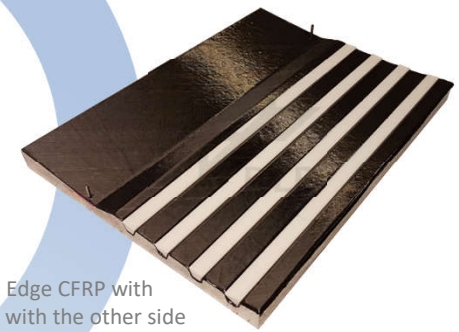


Demonstration with an Interface Small Scale Demonstrator (ISSD)

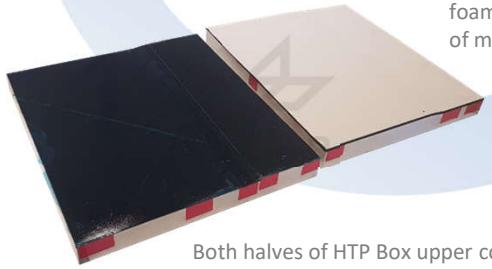
- Simple milled 500mm AL molds
- 8552 IM7 prepreg
- Curing in autoclave at 180°C
- Secondary bonding at 120°C

Cured in Autoclave





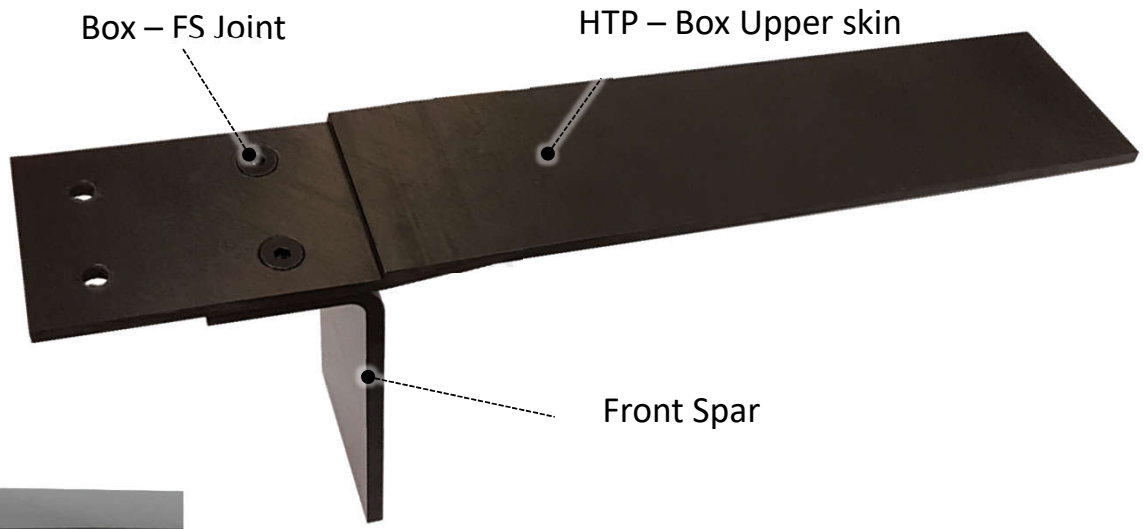
Compacted Leading Edge CFRP with foam before joining with the other side of mold

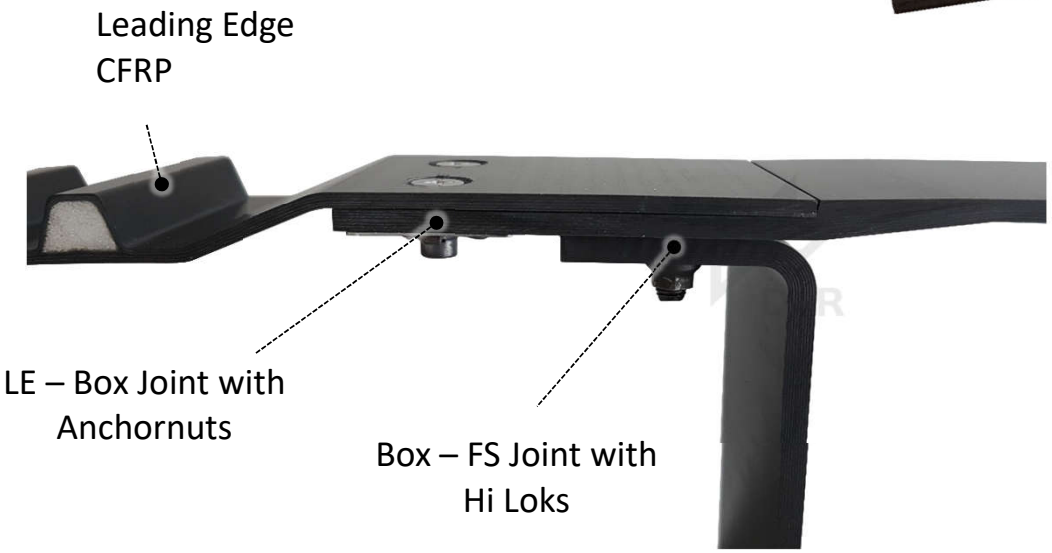


Both halves of HTP Box upper cover before joining

Manufacturing Approach - Joining CFRP

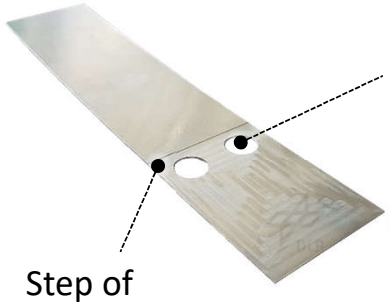
- Joining concept tested with 60mm edge part





Manufacturing Approach – Adhesive Bonding

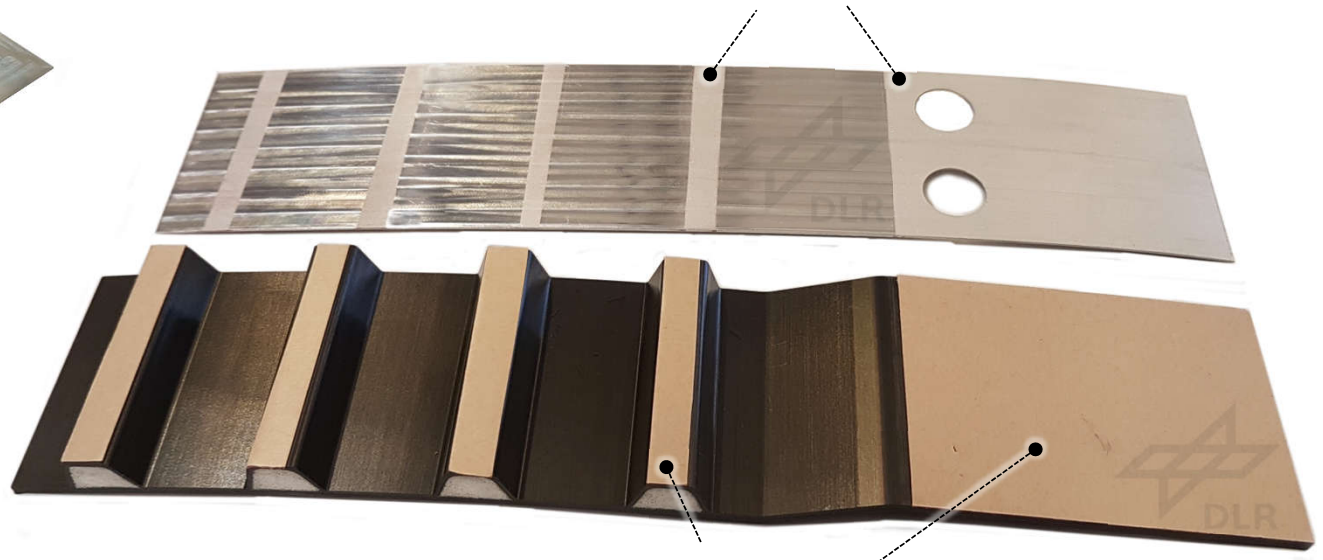
- Tested bonding process with an easy to manufacture Al Skin



Bolt head holes

Step of 0.16mm
(0.1mm Sheet + 0.06mm Adhesive)

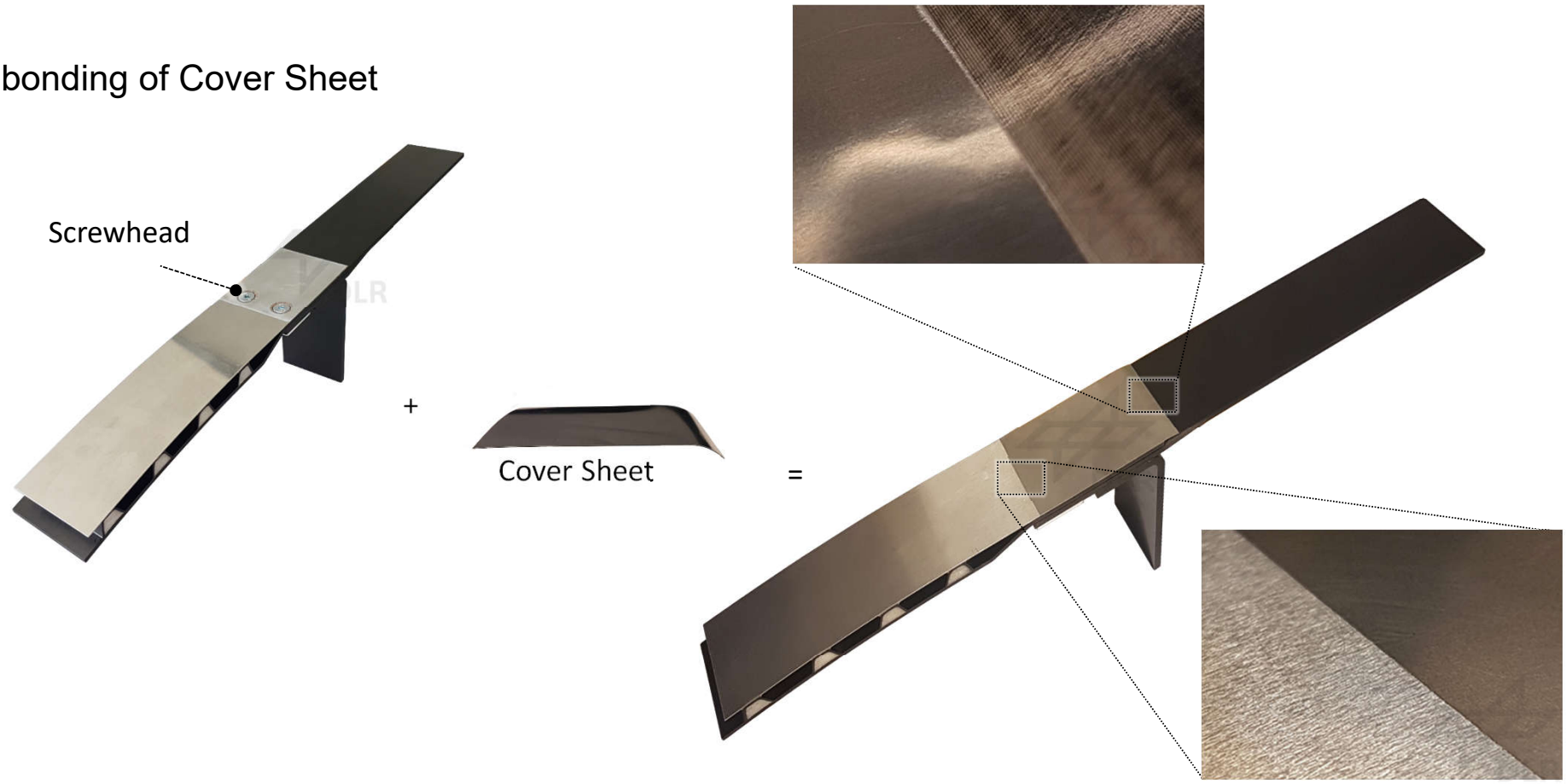
Sandblasted bonding areas



Applied film adhesive

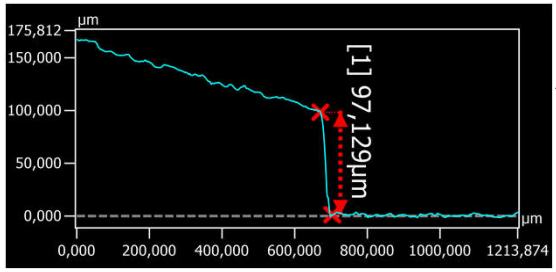
Manufacturing Approach – Applying the Cover sheet

- Tested bonding of Cover Sheet

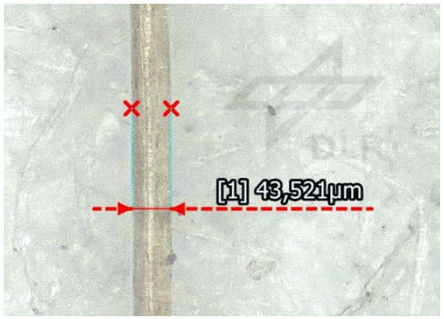


Manufacturing Approach – Step measuring

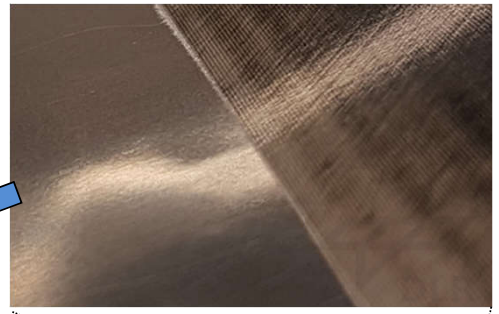
- Requirements achieved



Measured with Laser Scanning Microscope



Thickness of a human hair 0.04mm

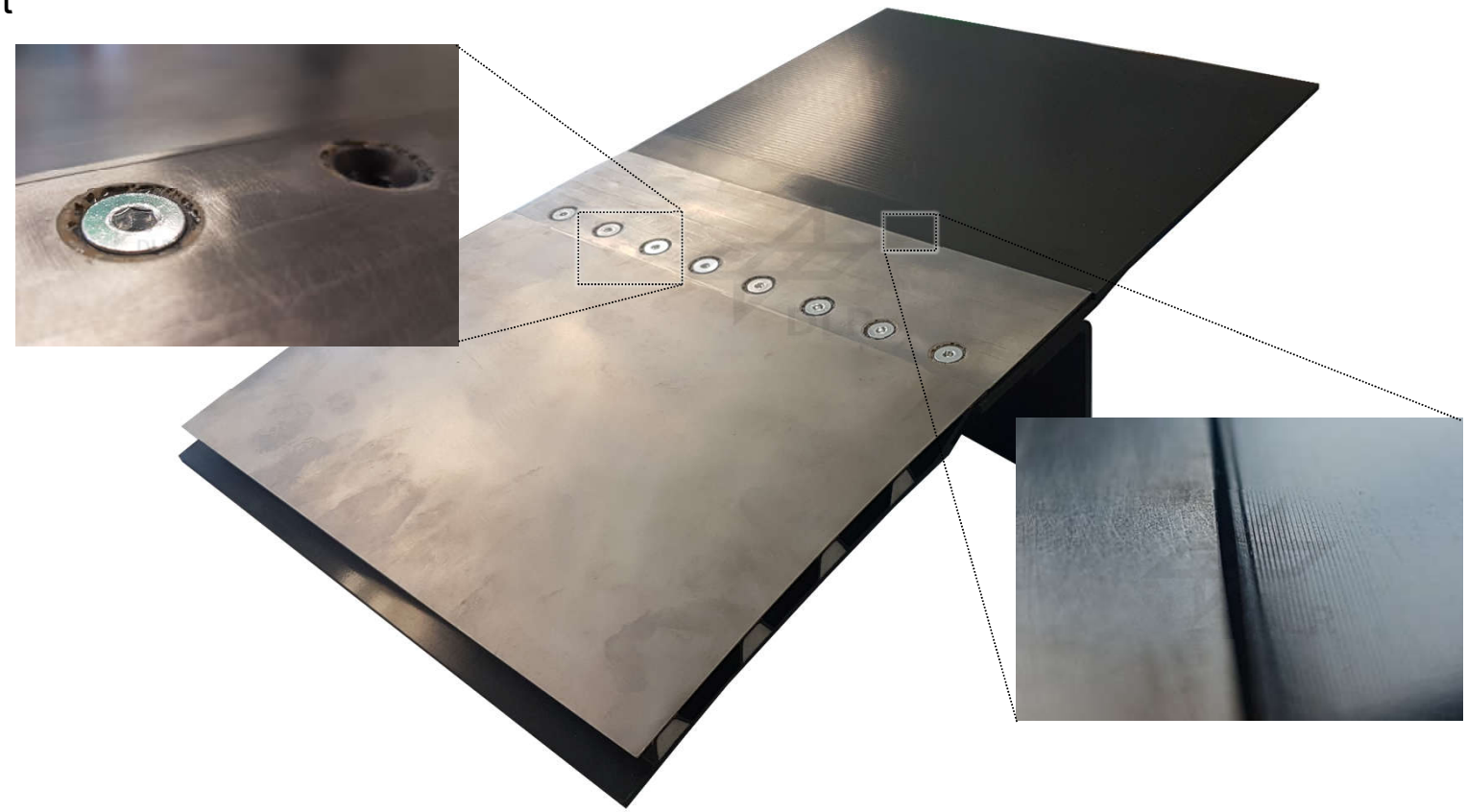


BFS of 0.097 mm
(Sheet thickness nominal 0.1mm)

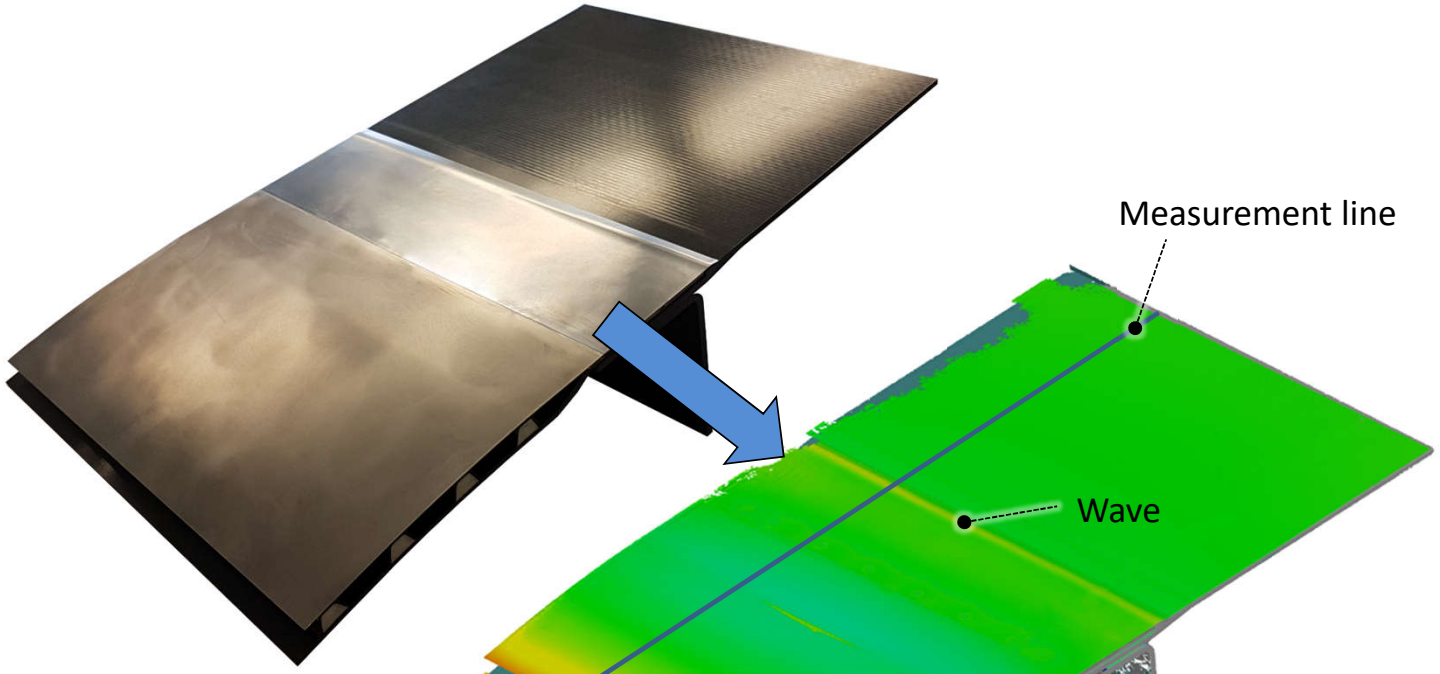
BFS of 0.03 mm

Interface Small Scale Demonstrator

- ISSD without Cover Sheet
- not finished right now



Interface Small Scale Demonstrator 3D measurment

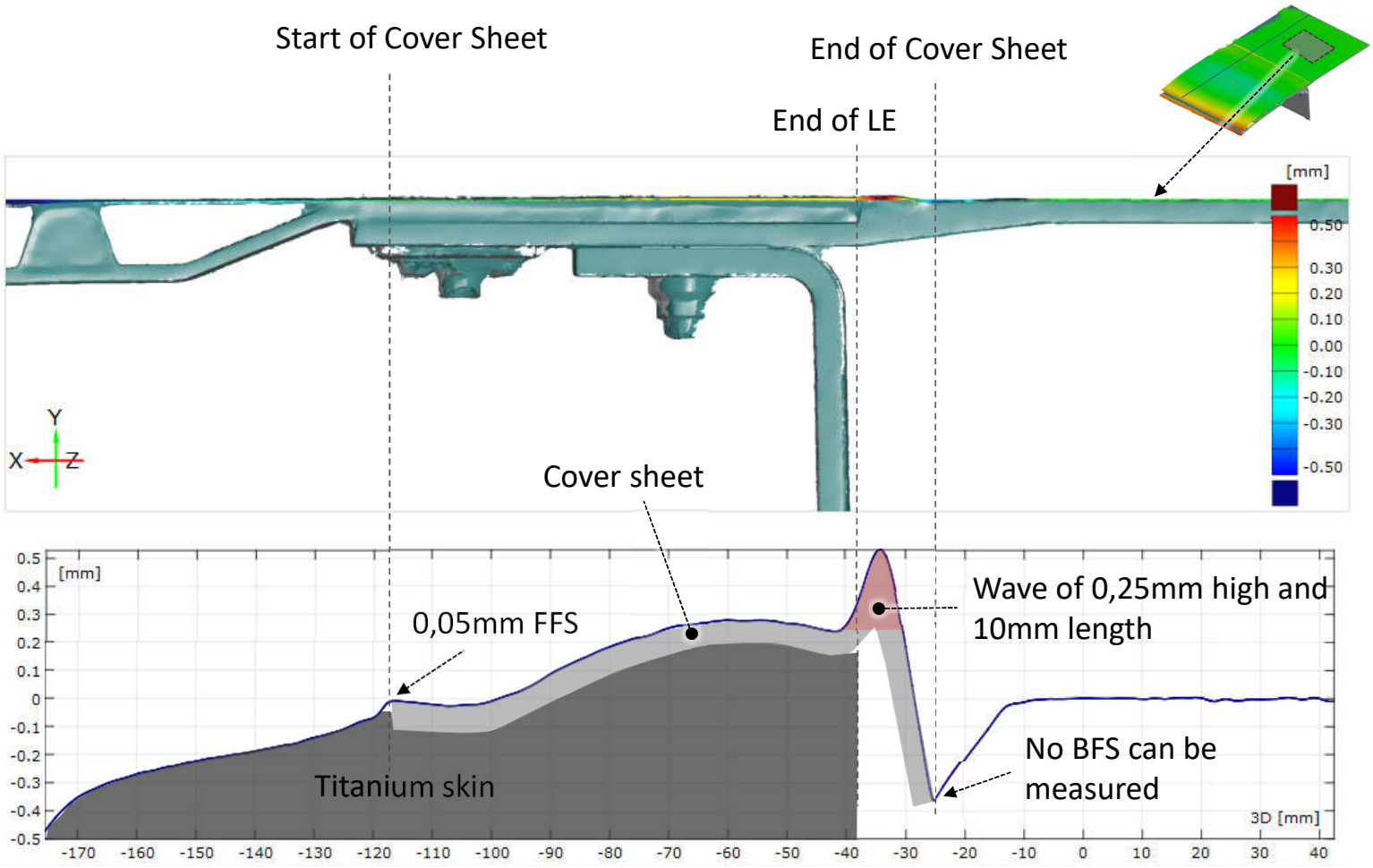


ISSD with Cover Sheet

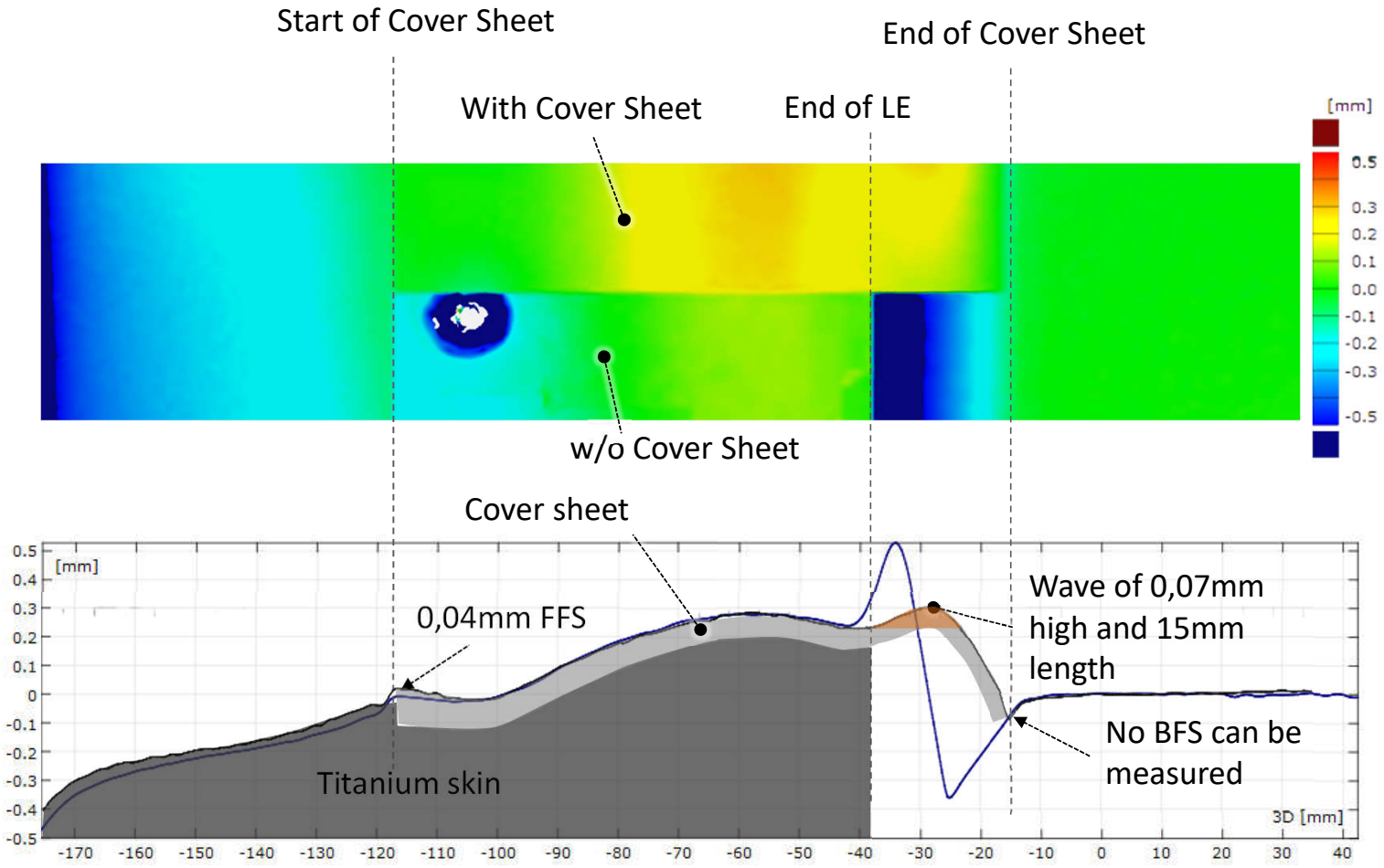
CAD geometry fit to 3D measuring

- Deviations from CAD geometry
- Wave occur at the interface

3D Measurment of steps - Trial 1

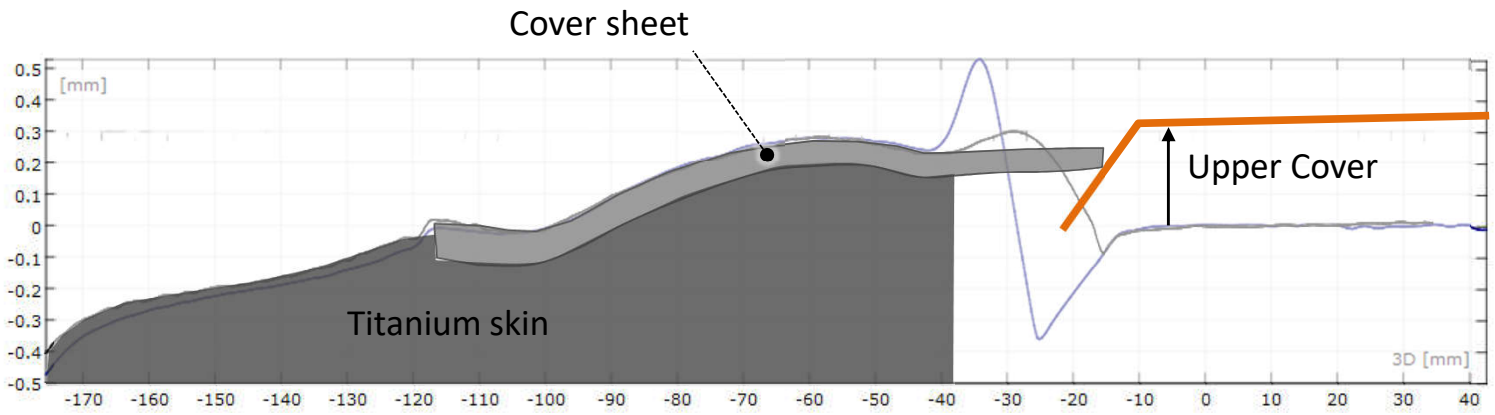


3D Measurment of steps - Trial 2



Improvement of Concept

- Increase the high of upper cover step to reach a more robust FFS
- The Cover Sheet does not need a high prebending
- Decrease in Waviness



Importance of thermal deformation compensation

- Compensation in molds was calculated for titanium!

Joining trial bonded with **Al skin**

ISSD bonded with **Ti skin**

Conclusion and Outlook

- Challenges of the ECHO HLFC design was shown
- Risk mitigation concept via Surface Tougehning was demonstrated
- A removable interface concept was presented for a HLFC LE
- A successful manufacturing approach was shown for all concepts
- Compensation of “Bi-metallic effect” was successful
- All steps agree with the requirements

<u>To Do’s:</u>

- Identify the stiffness of coversheet to avoid aeroelastic problems
- Reduce manufacturing effort of pre – bended Cover Sheet by design adaption
- Identify usability for NLF Joints

Thank You!

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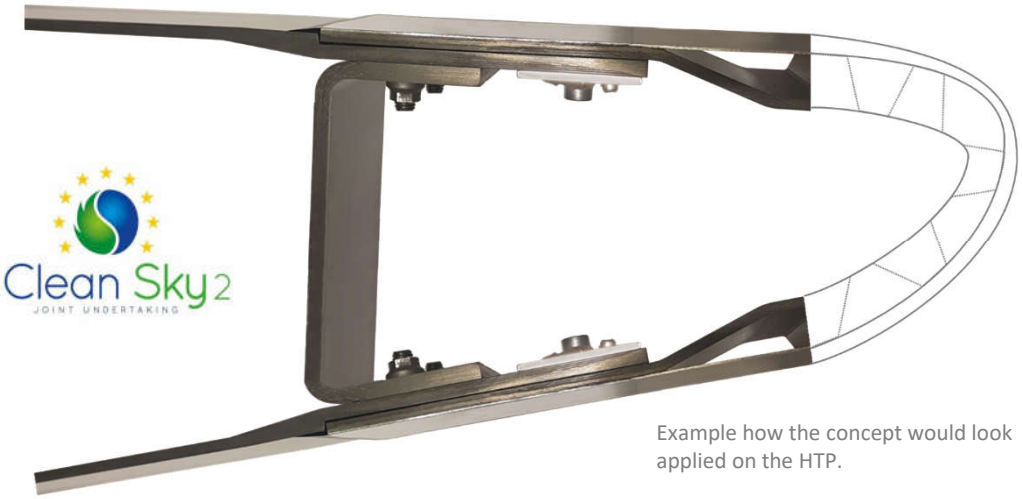

Example how the concept would look applied on the HTP.

Acknowledgement

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