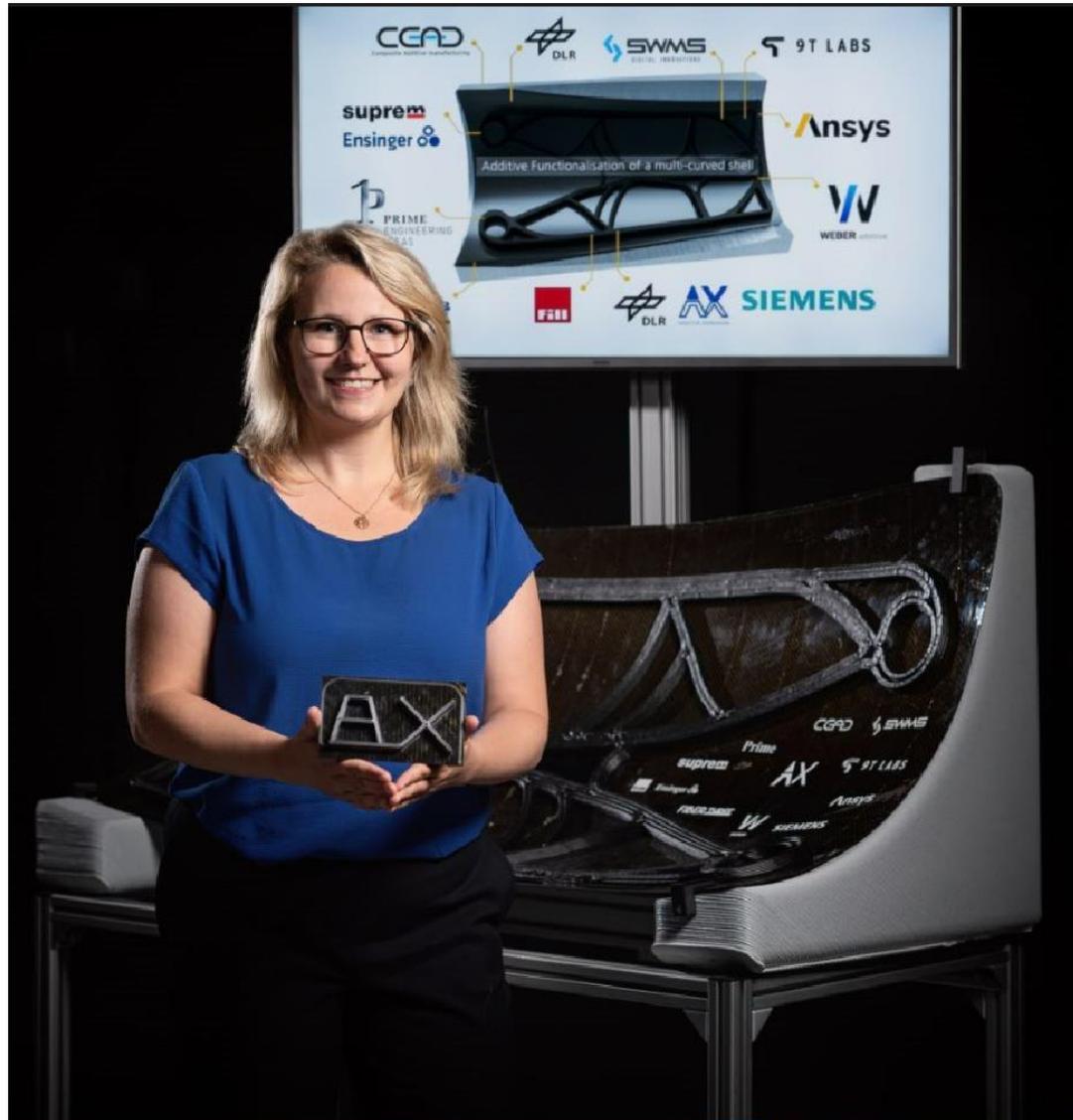




**Additive Functionalisation –  
A concept for cost-efficient and  
resource-saving lightweight construction**



# The Speaker



**Xenia Sophia Köneke**

Telephone +49 531 295-3368

[xenia.koeneke@dlr.de](mailto:xenia.koeneke@dlr.de)

**Deutsches Zentrum für  
Luft- und Raumfahrt (DLR)**

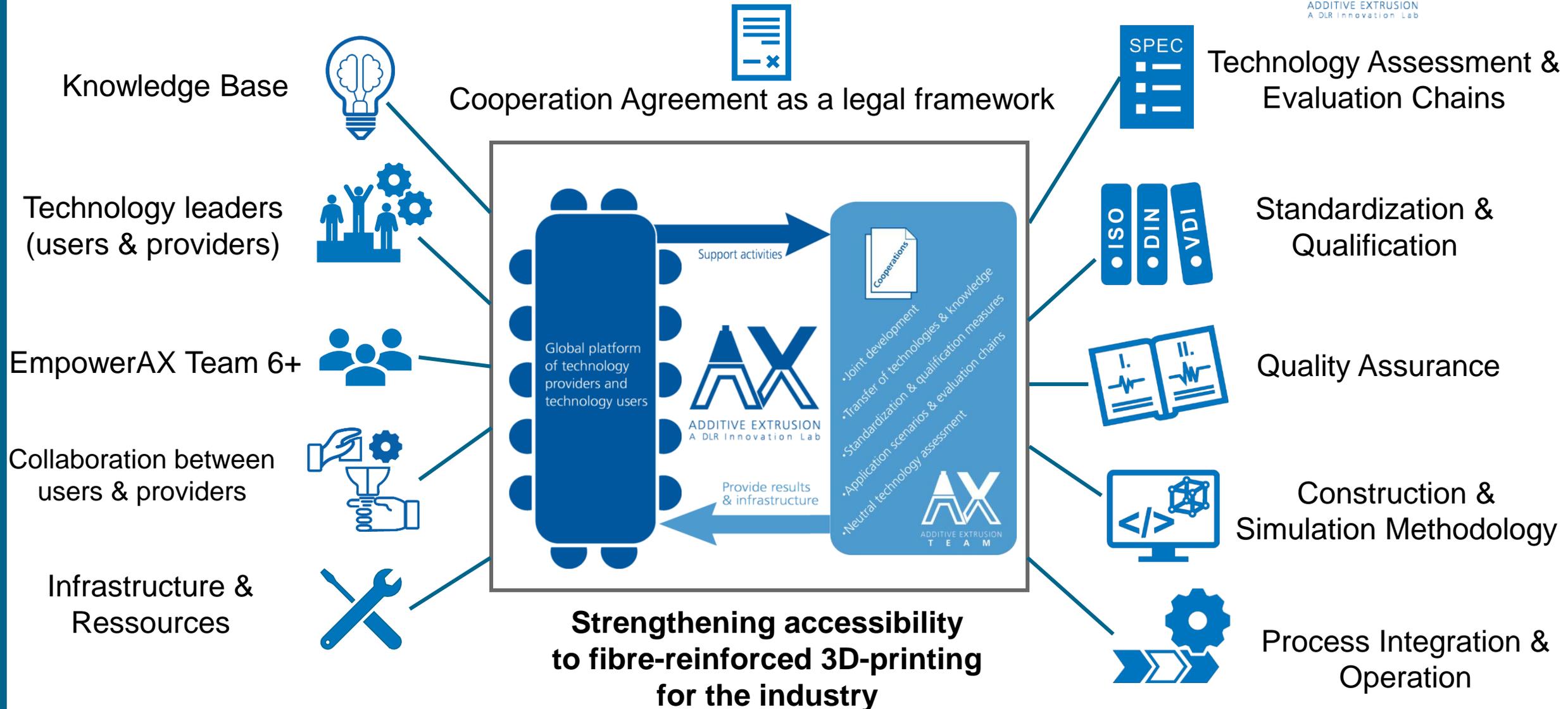
German Aerospace Center

Institute of Lightweight Systems | Innovation

Lilienthalplatz 7 | 38108 Braunschweig

Germany

# DLR Innovation Lab EmpowerAX – An overview



*“The real value of Additive Manufacturing is not in replacing all conventional composites manufacturing processes –*

***The real value of Additive Manufacturing is in developing the right combination of established methods with Additive Functionalisation.”***

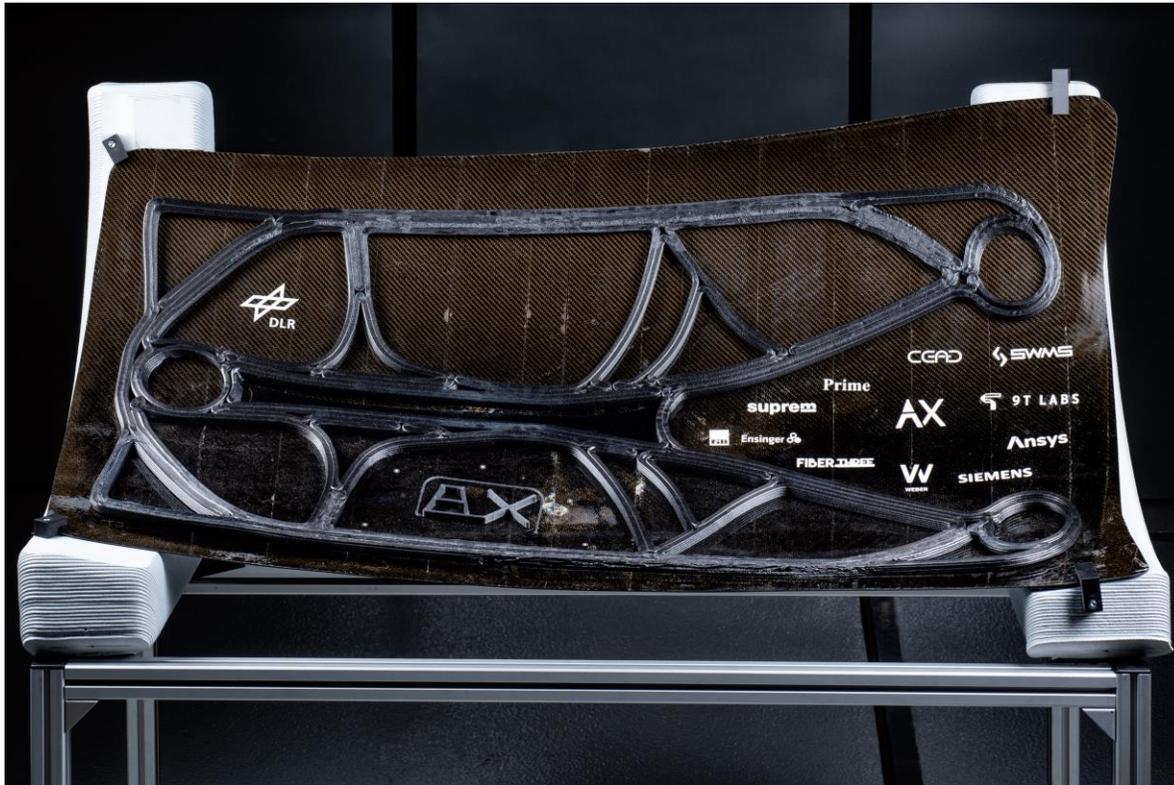




# ADDITIVE FUNCTIONALISATION COMBINATION INSTEAD OF SUBSTITUTION

# The concept of Additive Functionalisation

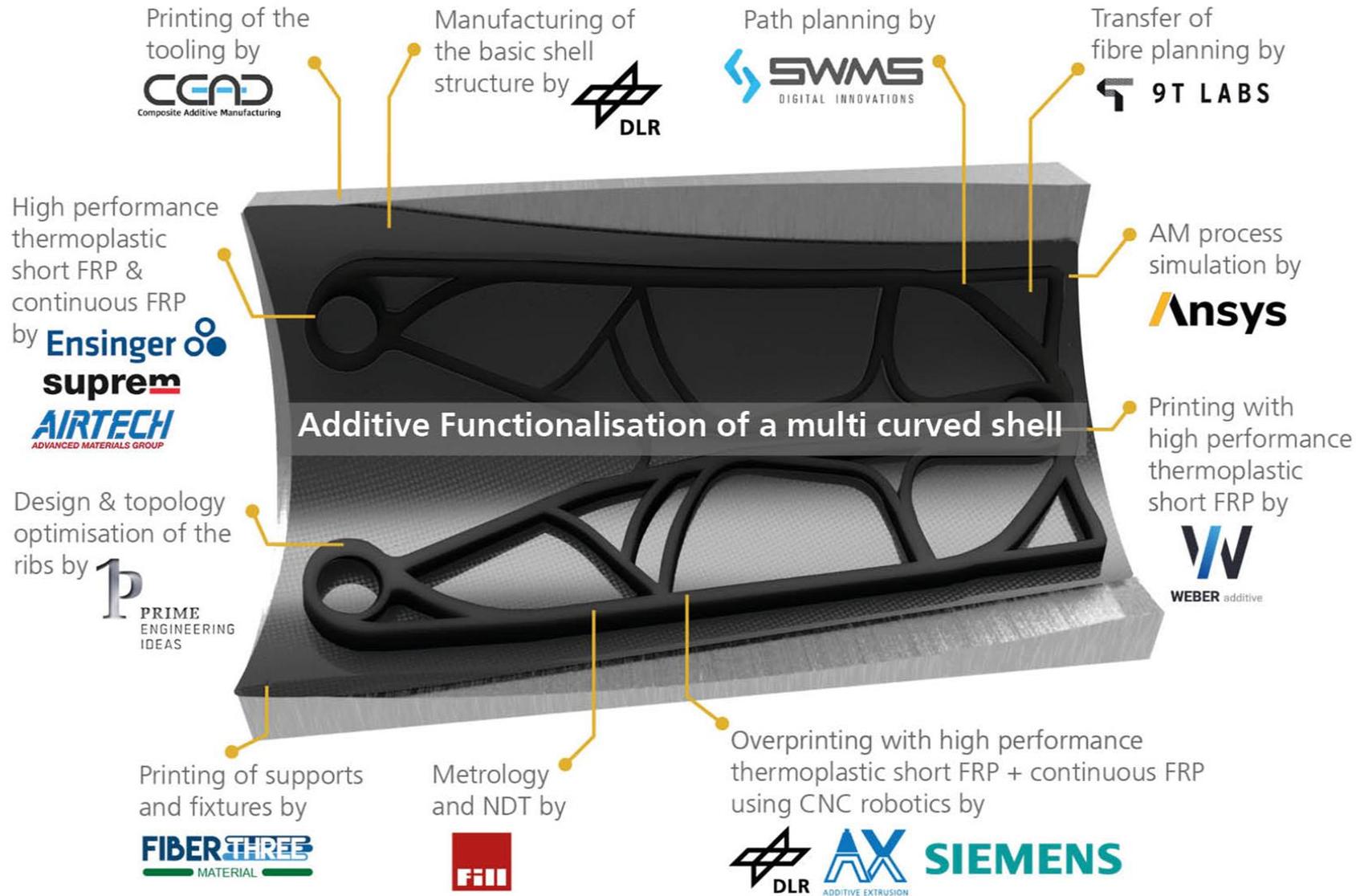
## Combination instead of substitution



- Combination of conventional & additive manufacturing processes
- Combination of different materials
  - Thermoset + thermoplast
  - Short and continuous fibre-reinforced material (SFRP + CFRP)
- Overprinting of a multi-curved Shell

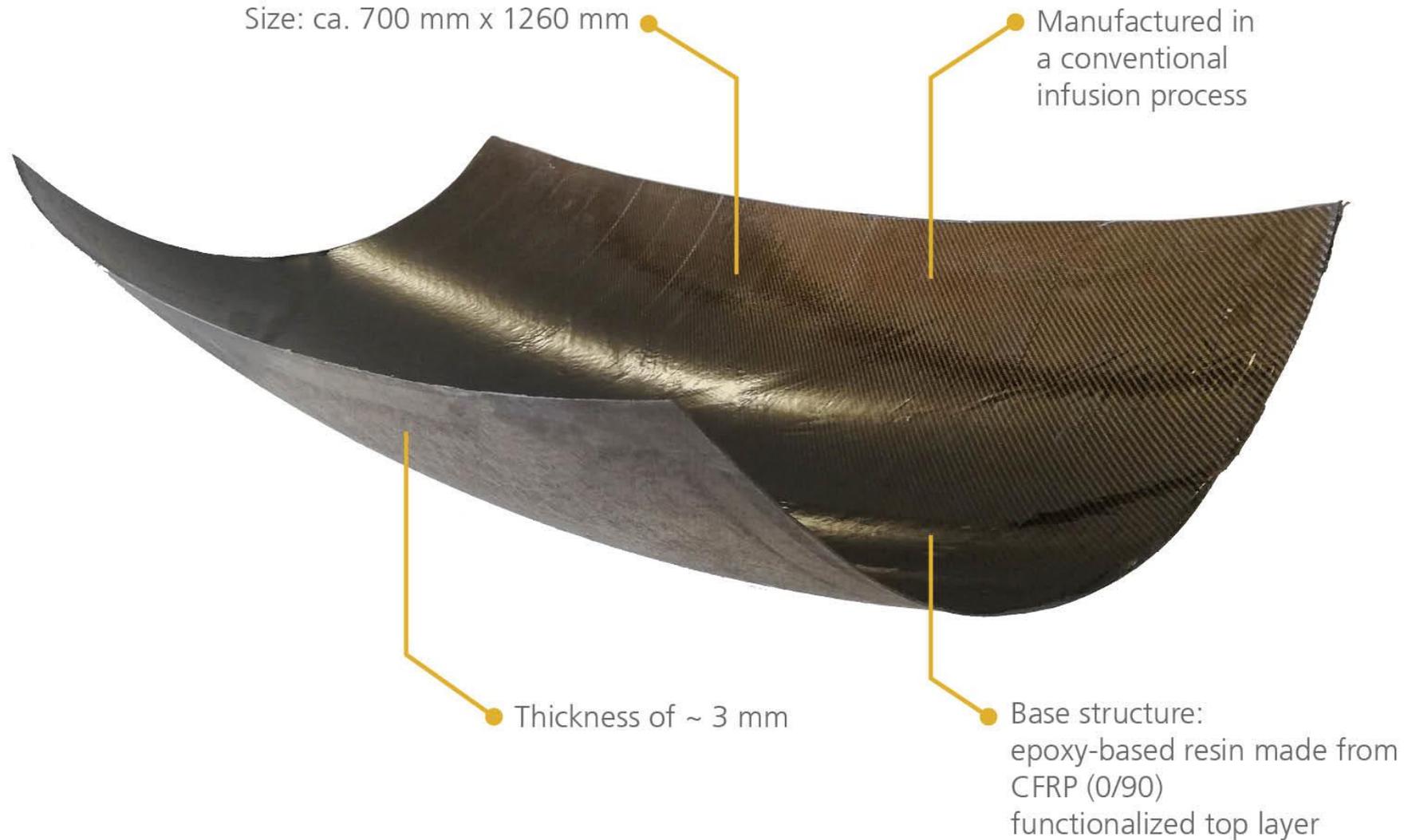
EmpowerAX Demo Part  
„Additive Functionalisation of a multi-curved shell“

# EmpowerAX Demo Part – An example of successful collaboration



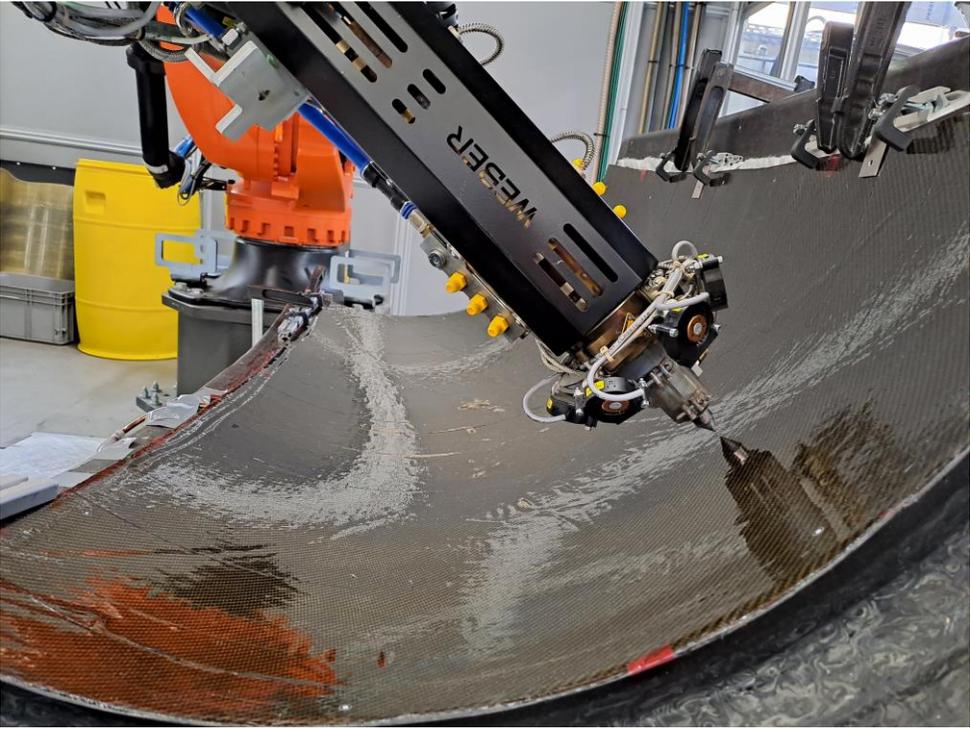
# EmpowerAX Demo Part

## The Basic Idea



# EmpowerAX Demo Part

## The Basic Idea



Printing of the tooling by  
**CCAD**  
Composite Additive Manufacturing

Manufacturing of the basic shell structure by  
**DLR**

Path planning by  
**SWMS**  
DIGITAL INNOVATIONS

Transfer of fibre planning by  
**9T LABS**

High performance thermoplastic short FRP & continuous FRP by  
**Ensinger**  
**suprem**  
**AIRTECH**  
ADVANCED MATERIALS GROUP

AM process simulation by  
**Ansys**

## Additive Functionalisation of a multi curved shell

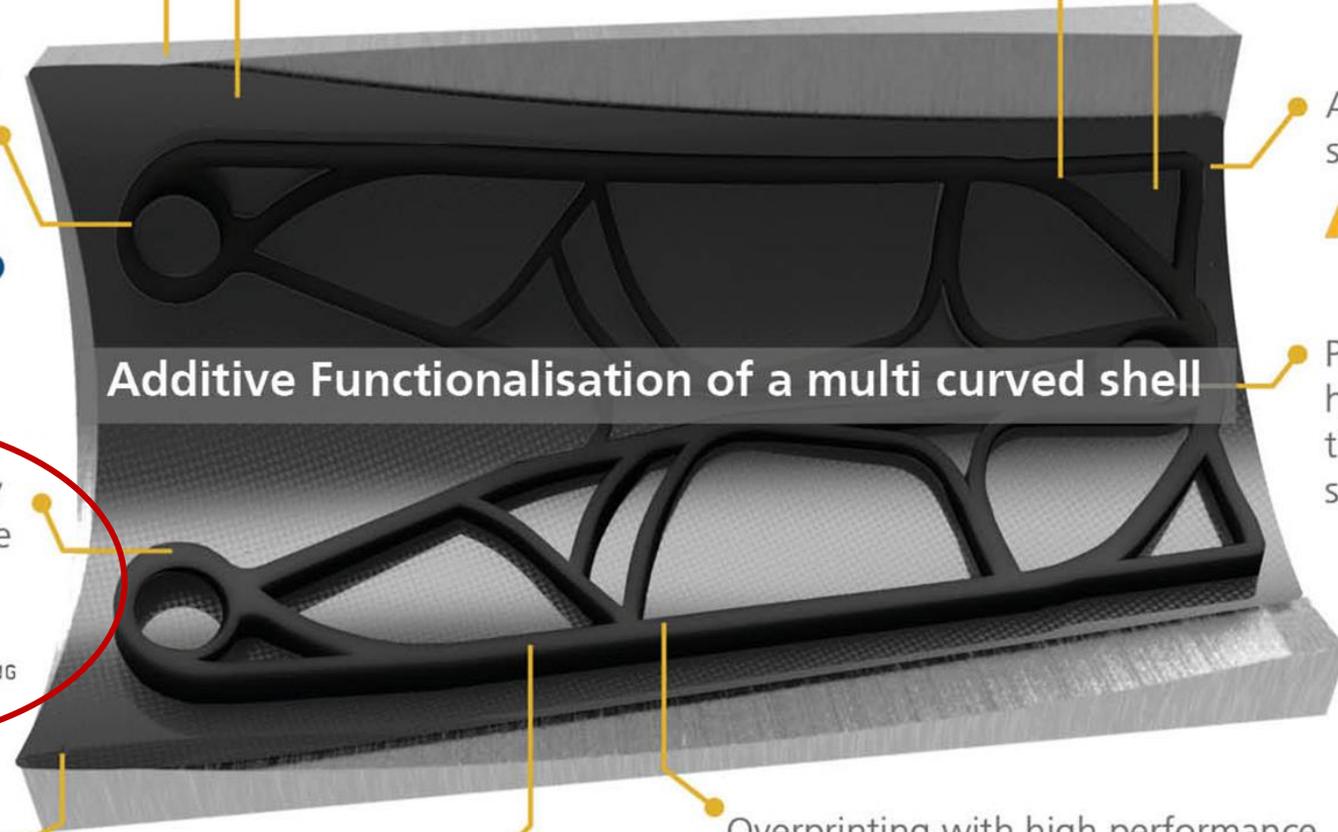
Printing with high performance thermoplastic short FRP by  
**WEBER** additive

Design & topology optimisation of the ribs by  
**PRIME**  
ENGINEERING  
IDEAS

Printing of supports and fixtures by  
**FIBER THREE**  
MATERIAL

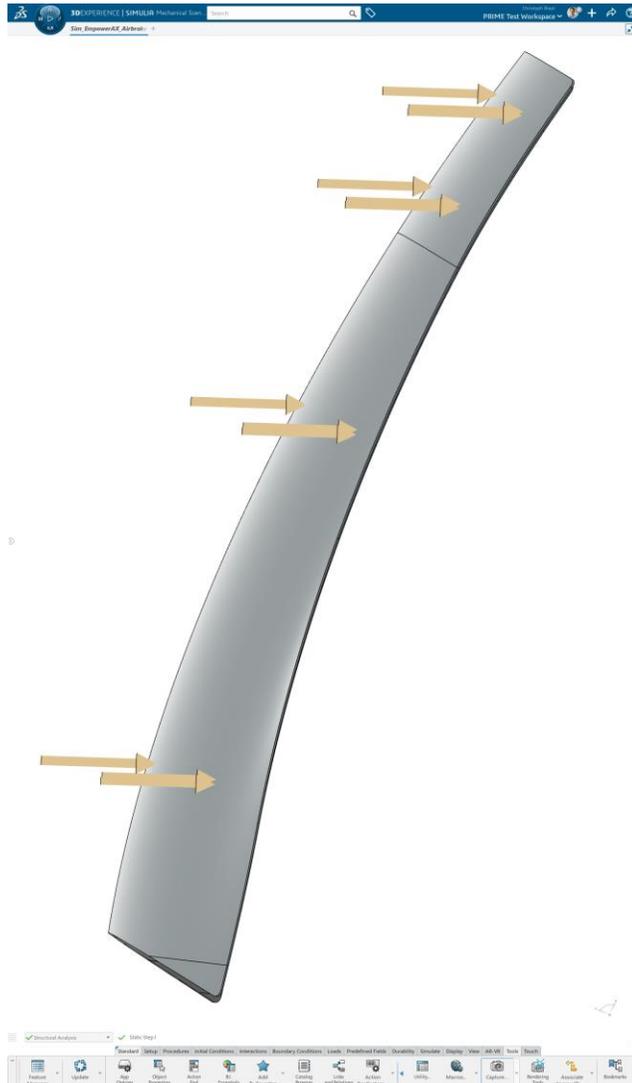
Metrology and NDT by  
**Fill**

Overprinting with high performance thermoplastic short FRP + continuous FRP using CNC robotics by  
**DLR** **AX** **SIEMENS**  
ADDITIVE EXTRUSION



# EmpowerAX Demo Part

## Starting point: Topology-optimised Design by PRIME



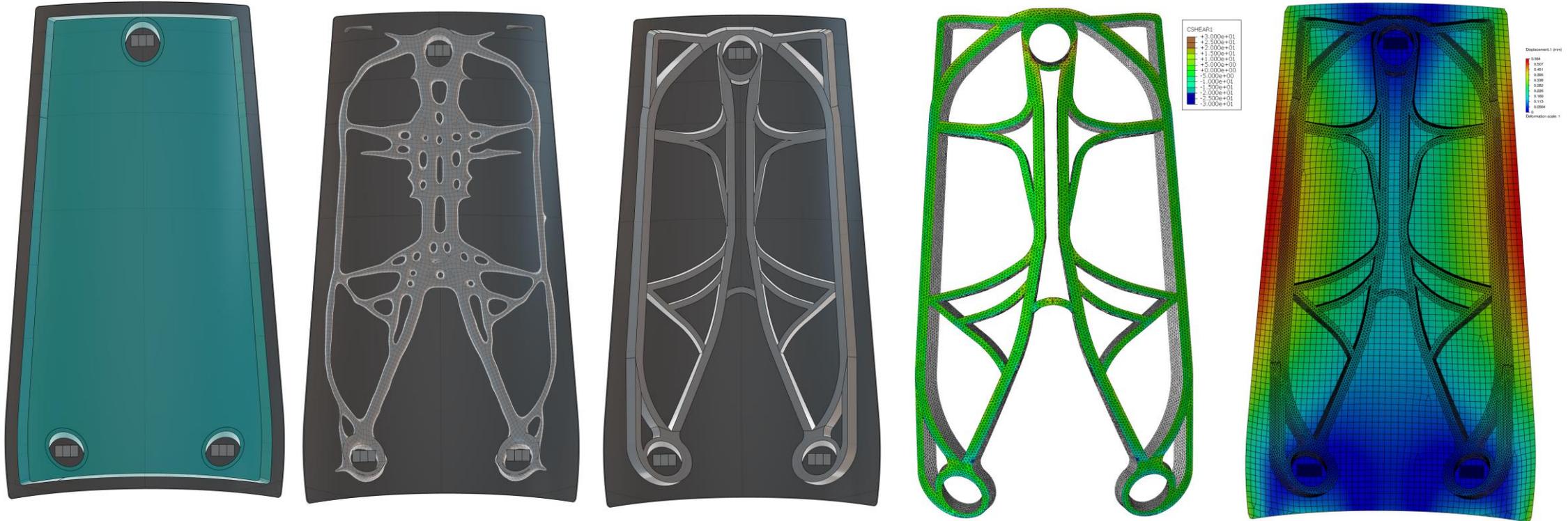
### Basic assumptions for loadcase as design requirements:

- Aeronautical application
- During a landing of 360 km/h
- Aerodynamic drag force combined with simultaneous front and side winds



# EmpowerAX Demo Part

## Starting point: Topology-optimised Design by PRIME



**Topology-optimised design to use material only where it is really needed**

Printing of the tooling by  
**CCAD**  
Composite Additive Manufacturing

Manufacturing of the basic shell structure by  
**DLR**

Path planning by  
**SWMS**  
DIGITAL INNOVATIONS

Transfer of fibre planning by  
**9T LABS**

High performance thermoplastic short FRP & continuous FRP by  
**Ensinger**  
**suprem**  
**AIRTECH**  
ADVANCED MATERIALS GROUP

AM process simulation by  
**Ansys**

Design & topology optimisation of the ribs by  
**P**  
PRIME  
ENGINEERING  
IDEAS

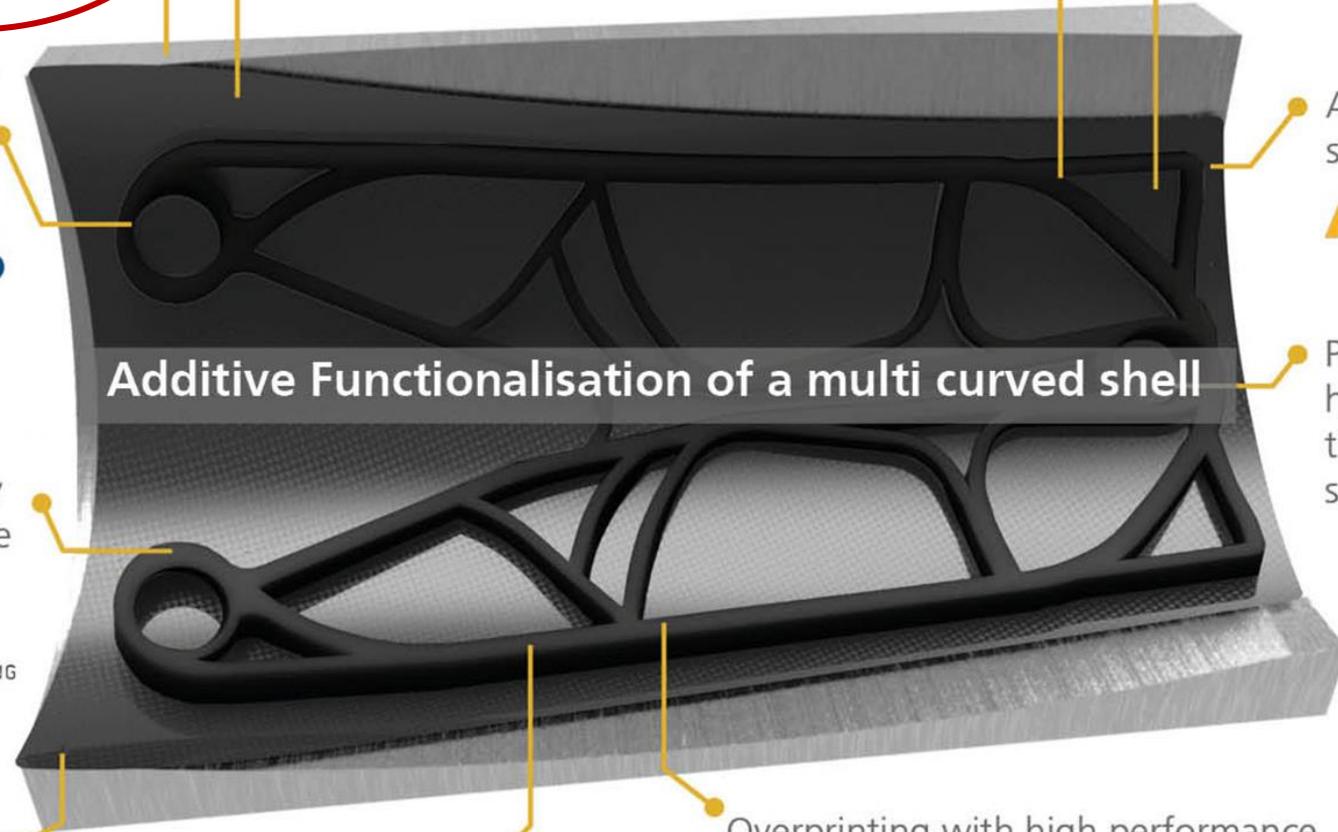
Printing with high performance thermoplastic short FRP by  
**W**  
WEBER additive

## Additive Functionalisation of a multi curved shell

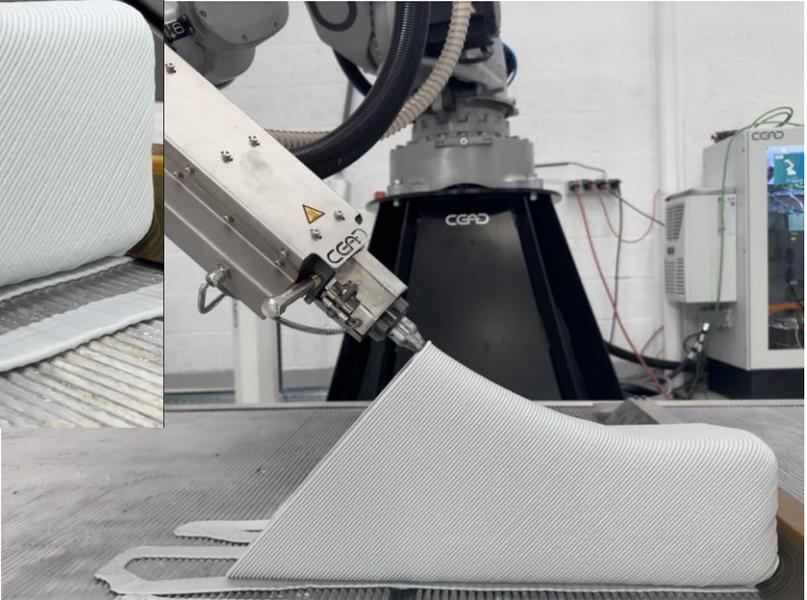
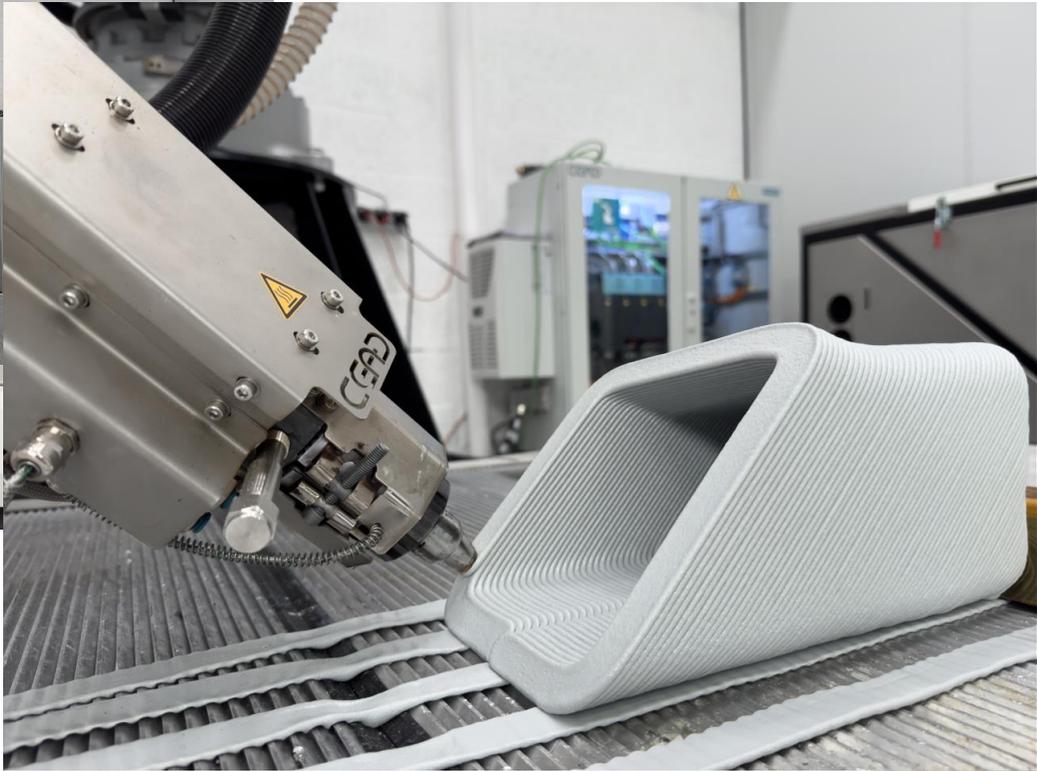
Printing of supports and fixtures by  
**FIBER THREE**  
MATERIAL

Metrology and NDT by  
**Fill**

Overprinting with high performance thermoplastic short FRP + continuous FRP using CNC robotics by  
**DLR** **AX** **SIEMENS**  
ADDITIVE EXTRUSION



# EmpowerAX Demo Part Printing of the tooling by CEAD



Printing of the tooling by  
**CCAD**  
Composite Additive Manufacturing

Manufacturing of the basic shell structure by  
**DLR**

Path planning by  
**SWMS**  
DIGITAL INNOVATIONS

Transfer of fibre planning by  
**9T LABS**

High performance thermoplastic short FRP & continuous FRP by  
**Ensinger**  
**suprem**  
**AIRTECH**  
ADVANCED MATERIALS GROUP

AM process simulation by  
**Ansys**

Design & topology optimisation of the ribs by  
**P**  
PRIME  
ENGINEERING  
IDEAS

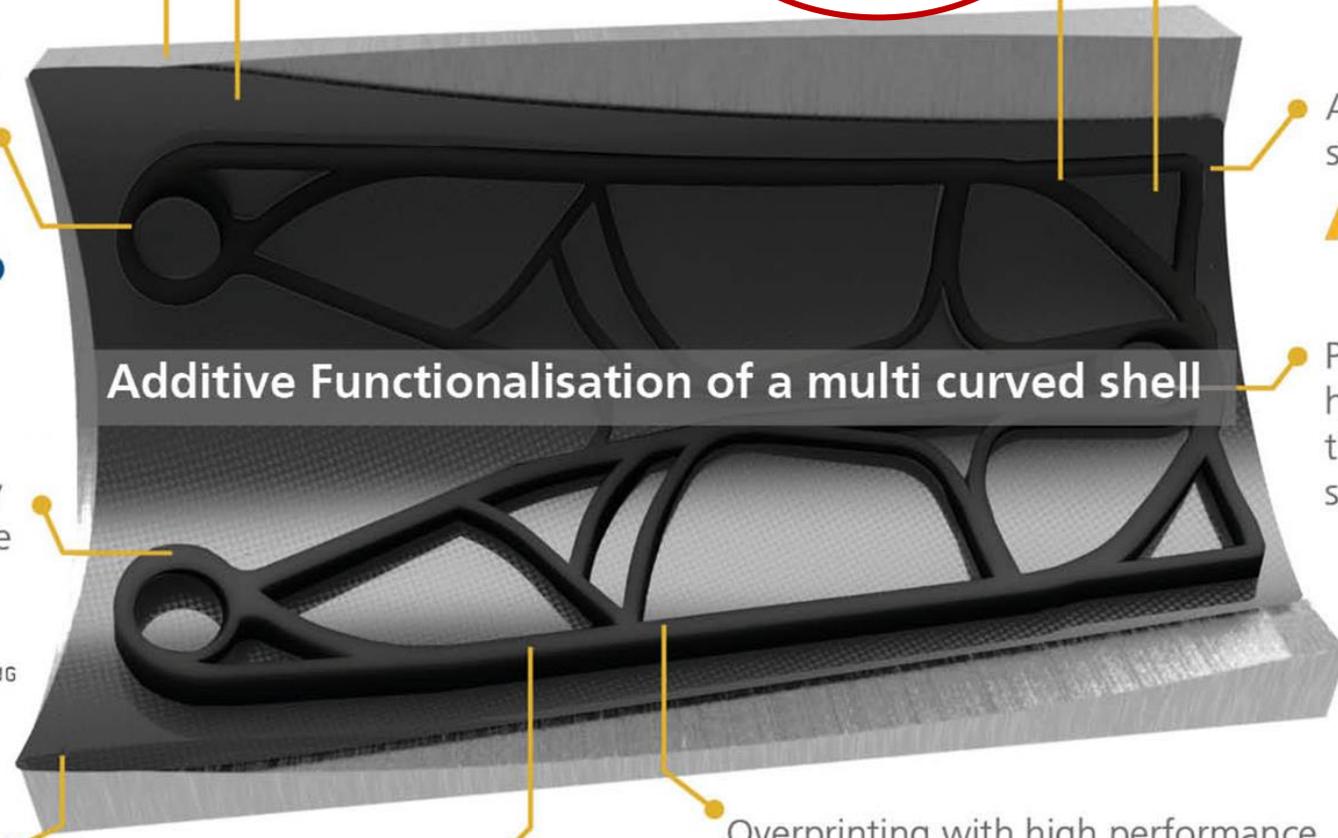
Printing with high performance thermoplastic short FRP by  
**W**  
WEBER additive

### Additive Functionalisation of a multi curved shell

Printing of supports and fixtures by  
**FIBER THREE**  
MATERIAL

Metrology and NDT by  
**Fill**

Overprinting with high performance thermoplastic short FRP + continuous FRP using CNC robotics by  
**DLR** **AX** **SIEMENS**  
ADDITIVE EXTRUSION



# EmpowerAX Demo Part Path planning for robotic 3D-Printing by SWMS



The screenshot displays the CAESA Composites software interface for a robotic 3D printing simulation. The main window shows a 3D model of an orange KUKA robotic arm positioned over a printing bed. The printing bed contains a partially completed black lattice structure. A circular inset provides a magnified view of the printing head and the lattice structure. The interface includes a top menu bar with 'File', 'Start', 'View', and 'Help'. Below the menu is a 'Context' toolbar with various settings like 'Show Origin', 'Enable shadows', and 'Show FPS'. On the left, a 'Navigator' tree lists the project structure, including 'Weber DRX30', 'Process.2', 'Product Instances', 'Operations', 'Exports', 'Products', 'JEC Demonstrator', 'Imported Geometry', 'Base Surface', 'Rib structure', 'Alignment Points', 'Configurations', 'Product', 'Layup Configuration', 'Print Configuration', 'Overrides', 'Additive Overrides', 'Analysis', 'Analysis Configuration', 'Stacking', 'Rib Body', 'Gap Management', 'Resources', 'Tapes', 'Prepreg.2', 'End Effectors', 'Weber AE 30', 'Machines', 'Kuka KR 150 R2700-2', 'Manufacturing Cells', 'Weber Roboterzelle JEC', 'Process Configurations', 'Weber Config', 'Filaments', and 'PEI-GF'. On the right, a 'Properties' panel for 'Result/Rib Body' shows 'Index: 1', 'Name: Result/Rib Body', 'Product instance: Result', and playback controls. Below the main view, a 'CAESA Composites - TapeStation - DRX 85 EmpowerAX' window shows a different view of the simulation with a white robotic arm and a yellow printing bed. This window includes a 'Navigator' tree, a 'Context' toolbar, and a 'Properties' panel. The 'Properties' panel for 'JEC Demonstrator/Rib Body' shows 'Index: 1', 'Name: JEC Demonstrator/Rib Body', 'Product instance: JEC Demonstrator', and playback controls. A table of coordinates is visible on the right side of this window:

Coordinate	Value	Unit
A11	9520	910
A12	9520	13200
A13	9520	1800
A14	2200	2200
A15	11600	11600
A16	11600	11600
A17	11600	11600
A18	11600	11600
A19	11600	11600
A20	11600	11600

Printing of the tooling by  
**CCAD**  
Composite Additive Manufacturing

Manufacturing of the basic shell structure by  
**DLR**

Path planning by  
**SWMS**  
DIGITAL INNOVATIONS

Transfer of fibre planning by  
**9T LABS**

High performance thermoplastic short FRP & continuous FRP by  
**Ensinger**  
**suprem**  
**AIRTECH**  
ADVANCED MATERIALS GROUP

AM process simulation by  
**Ansys**

Design & topology optimisation of the ribs by  
**P**  
PRIME  
ENGINEERING  
IDEAS

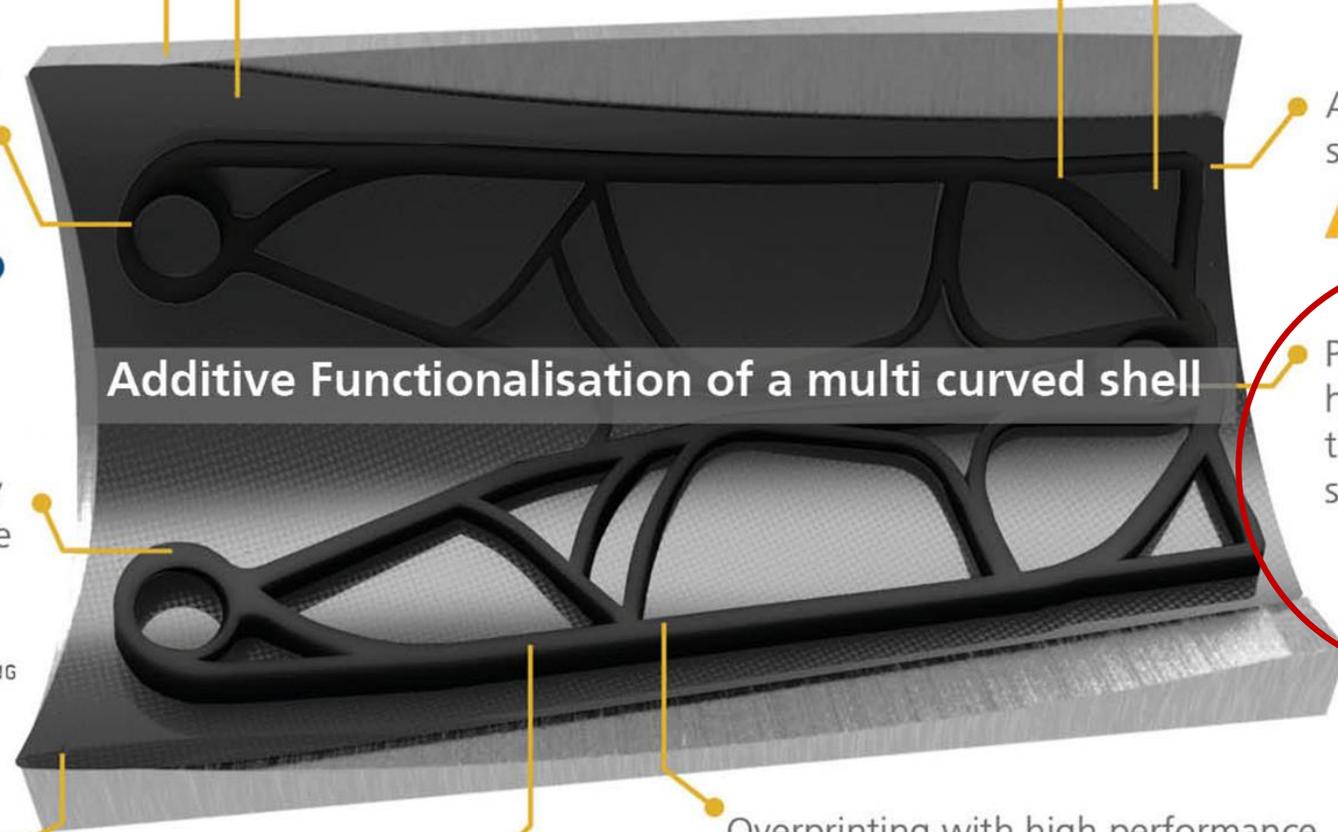
Printing with high performance thermoplastic short FRP by  
**W**  
WEBER additive

## Additive Functionalisation of a multi curved shell

Printing of supports and fixtures by  
**FIBER THREE**  
MATERIAL

Metrology and NDT by  
**Fill**

Overprinting with high performance thermoplastic short FRP + continuous FRP using CNC robotics by  
**DLR** **AX** **SIEMENS**  
ADDITIVE EXTRUSION



# EmpowerAX Demo Part Printing of the stiffening ribs by WEBER



Printing of the tooling by  
**CCAD**  
Composite Additive Manufacturing

Manufacturing of the basic shell structure by  
**DLR**

Path planning by  
**SWMS**  
DIGITAL INNOVATIONS

Transfer of fibre planning by  
**9T LABS**

High performance thermoplastic short FRP & continuous FRP by  
**Ensinger**  
**suprem**  
**AIRTECH**  
ADVANCED MATERIALS GROUP

AM process simulation by  
**Ansys**

Design & topology optimisation of the ribs by  
**P**  
PRIME  
ENGINEERING  
IDEAS

Printing with high performance thermoplastic short FRP by  
**W**  
WEBER additive

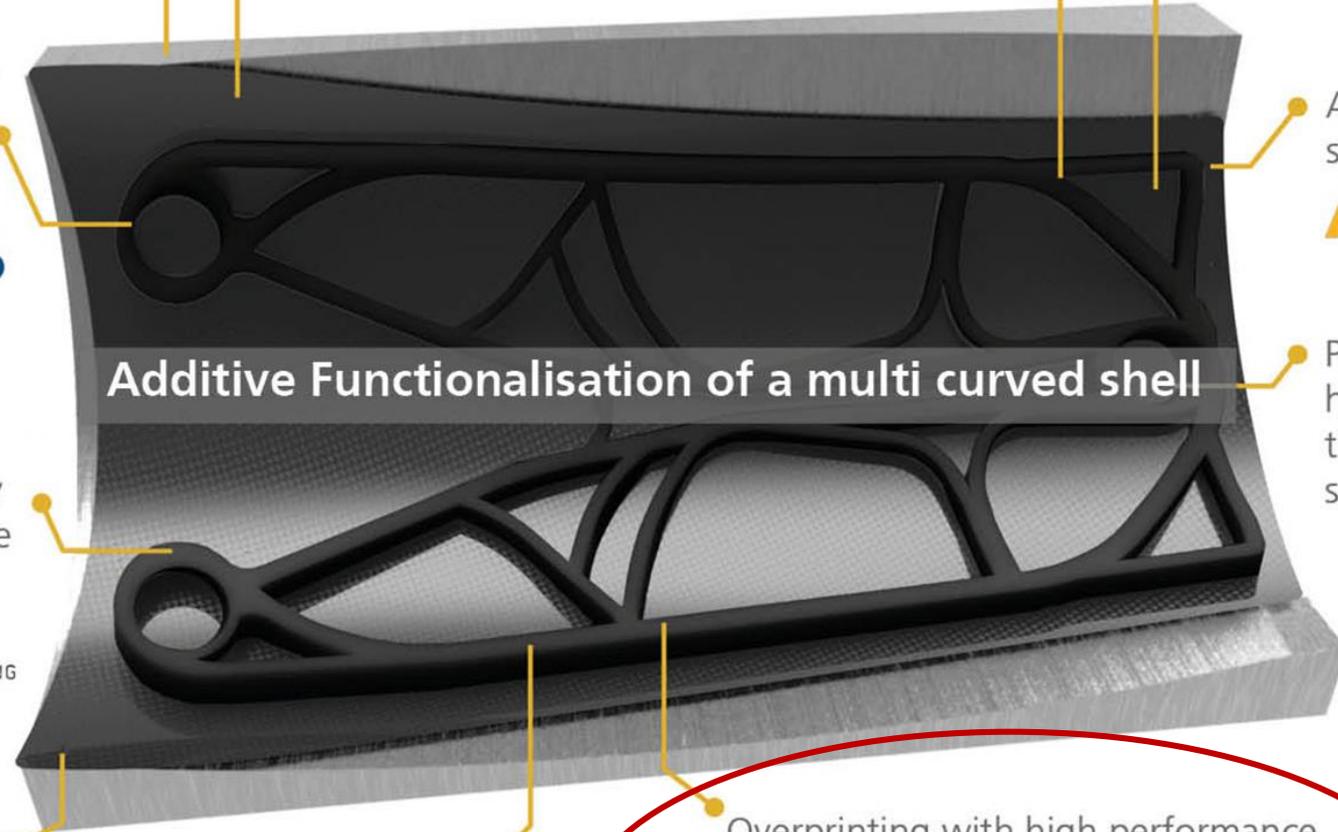
## Additive Functionalisation of a multi curved shell

Printing of supports and fixtures by  
**FIBER THREE**  
MATERIAL

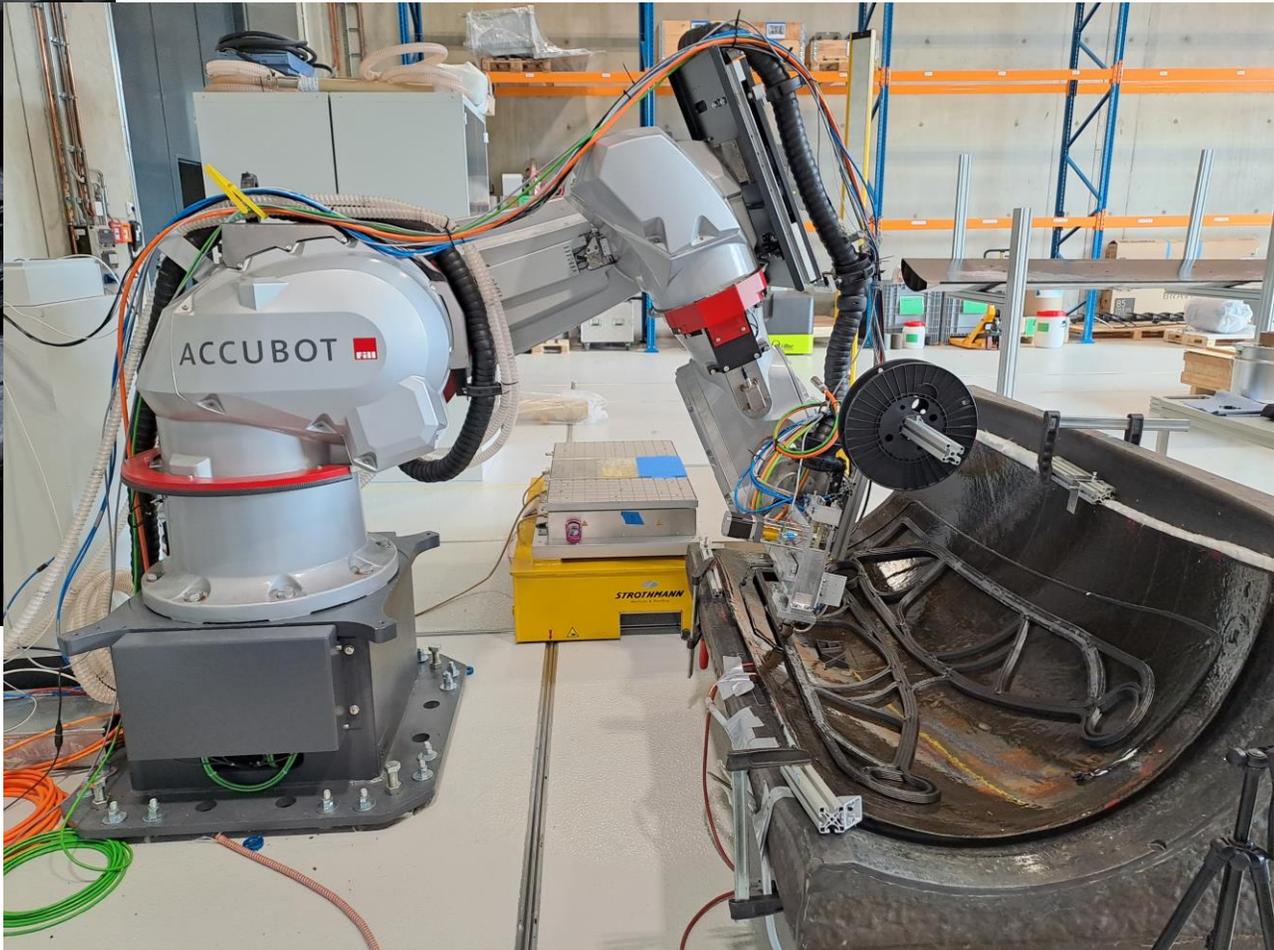
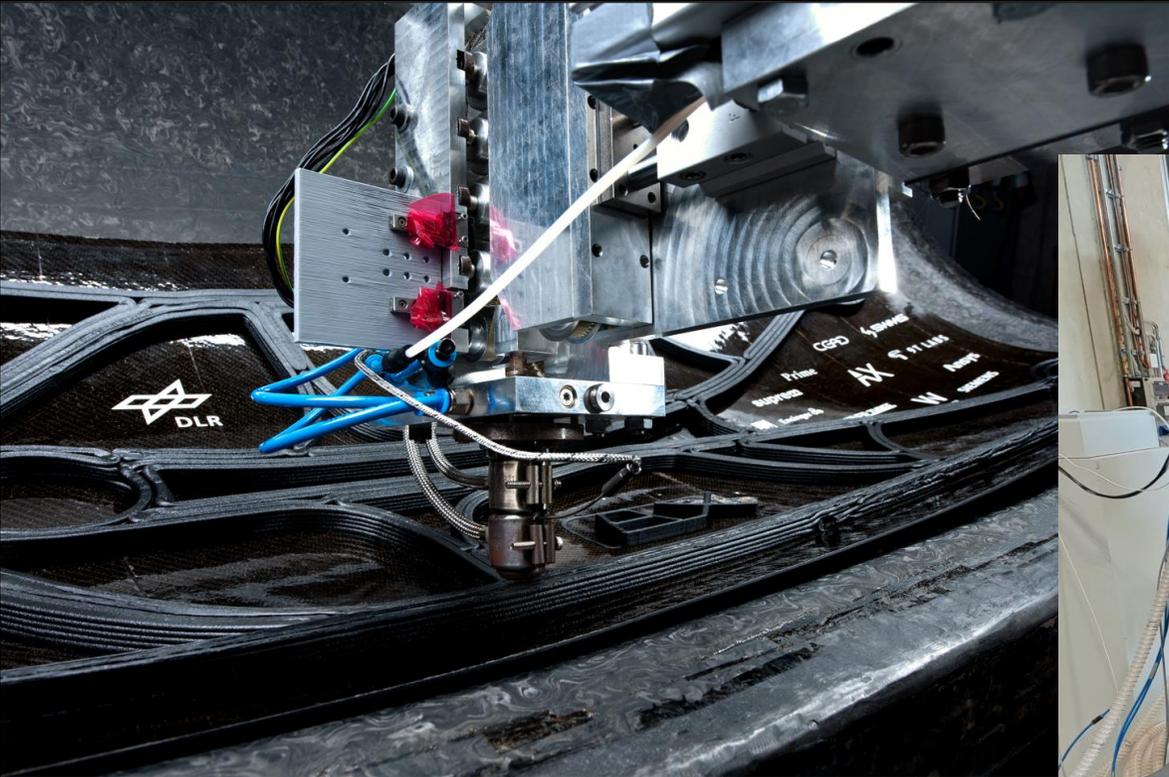
Metrology and NDT by  
**Fill**

Overprinting with high performance thermoplastic short FRP + continuous FRP using CNC robotics by

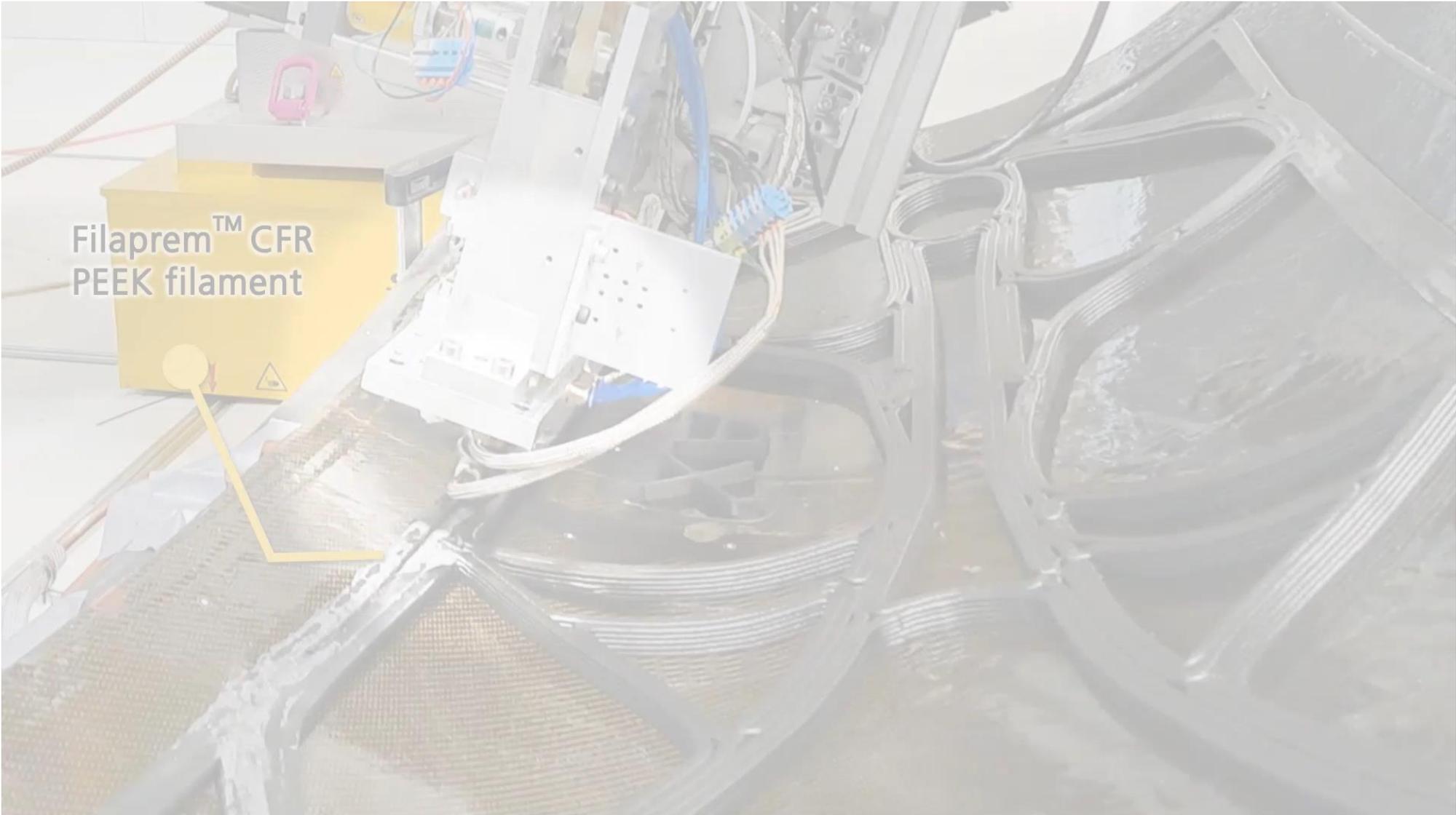
**DLR** **AX** **SIEMENS**  
ADDITIVE EXTRUSION



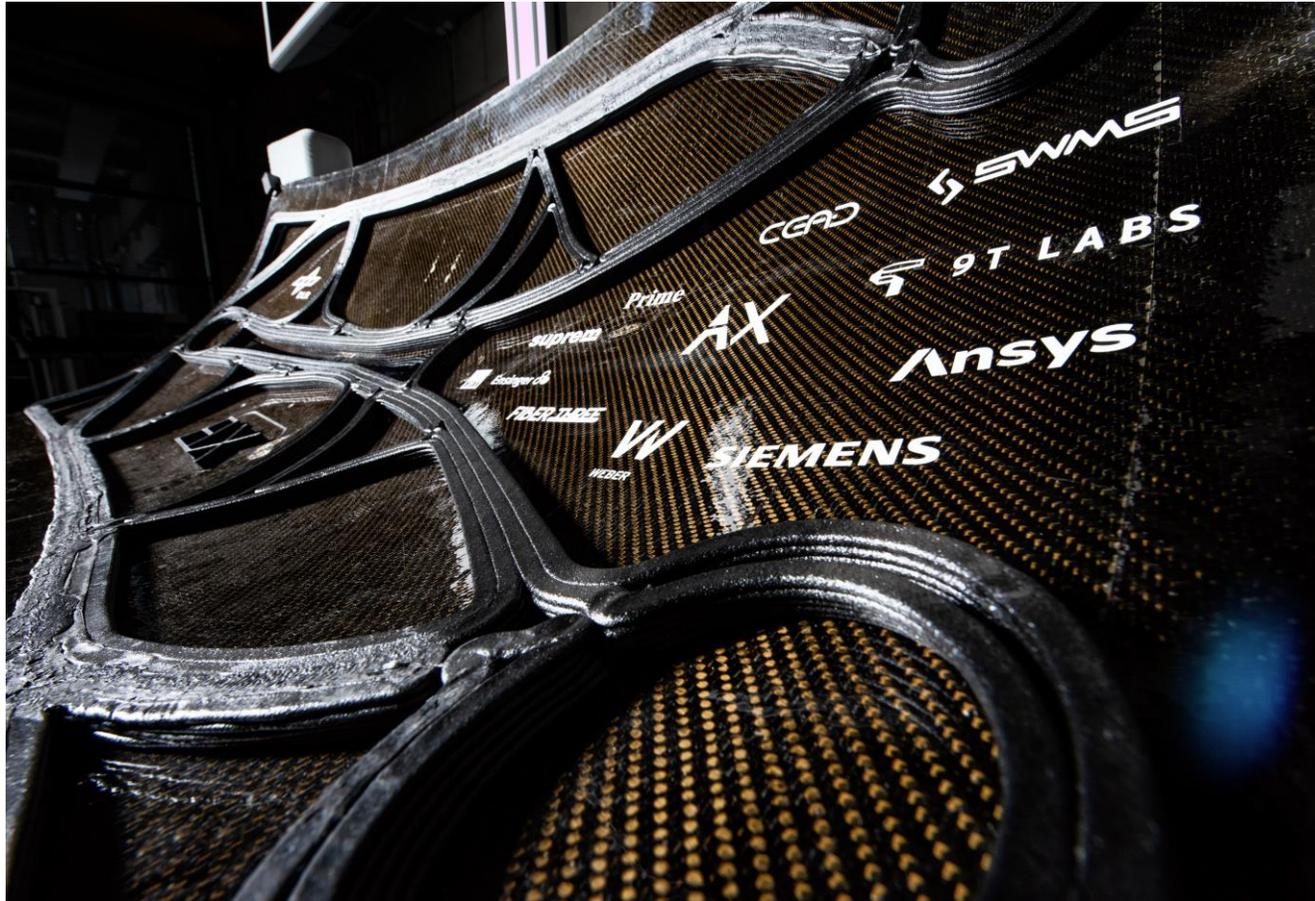
# EmpowerAX Demo Part Overprinting by DLR / EmpowerAX



# EmpowerAX Demo Part Overprinting by DLR / EmpowerAX



# EmpowerAX Demo Part Additive Functionalisation – Summary



- Additive Functionalisation for cost-efficient manufacturing of composites parts
- Overprinting of a multi-curved shell with short and endless fibre-reinforced materials
- Combination of thermoset and high performance thermoplastic
- Demonstration of an industrially available process chain

# EmpowerAX Demo Part Additive Functionalisation – a award winning concept



**09/2023:**

**Winner of Innovation Award Lower Saxony 2023**  
Category: Cooperation



**02/2024:**

**Winner of JEC Innovation Award 2024**  
Category: Aerospace Process



# WOULD YOU LIKE TO EXPERIENCE FIBRE-REINFORCED 3D PRINTING LIVE?



*Save the Date!*  
**25.09.2024**  
DLR  
Braunschweig

**EmpowerAX  
Science Day 2024**



**LinkedIn Event**