



Additive Funktionalisierung – Kombination statt Substitution

Vorstellung der Referentin



Xenia Stumpf, M.Sc.

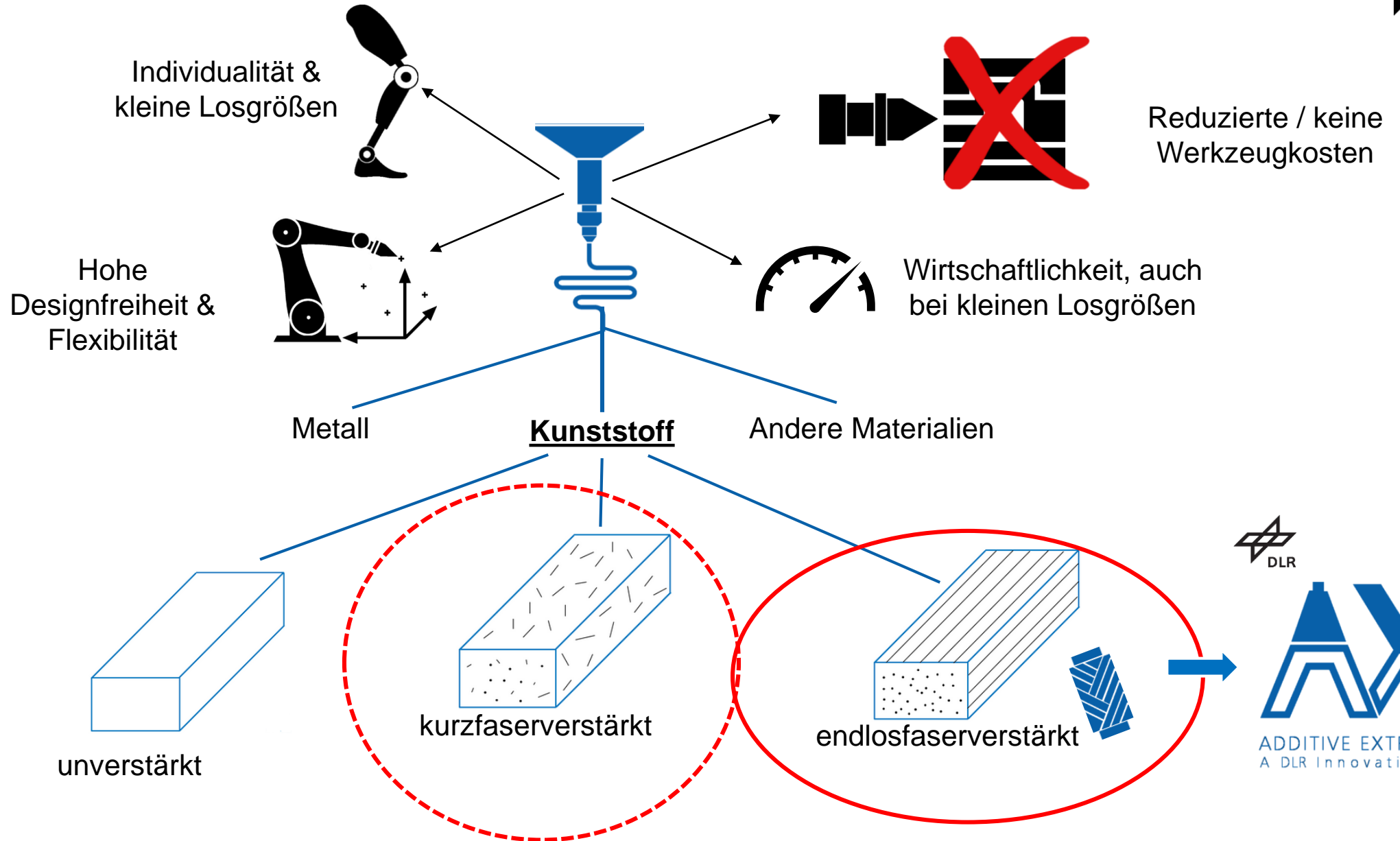
**Lab Managerin
DLR Innovation Lab EmpowerAX**

Deutsches Zentrum für
Luft- und Raumfahrt

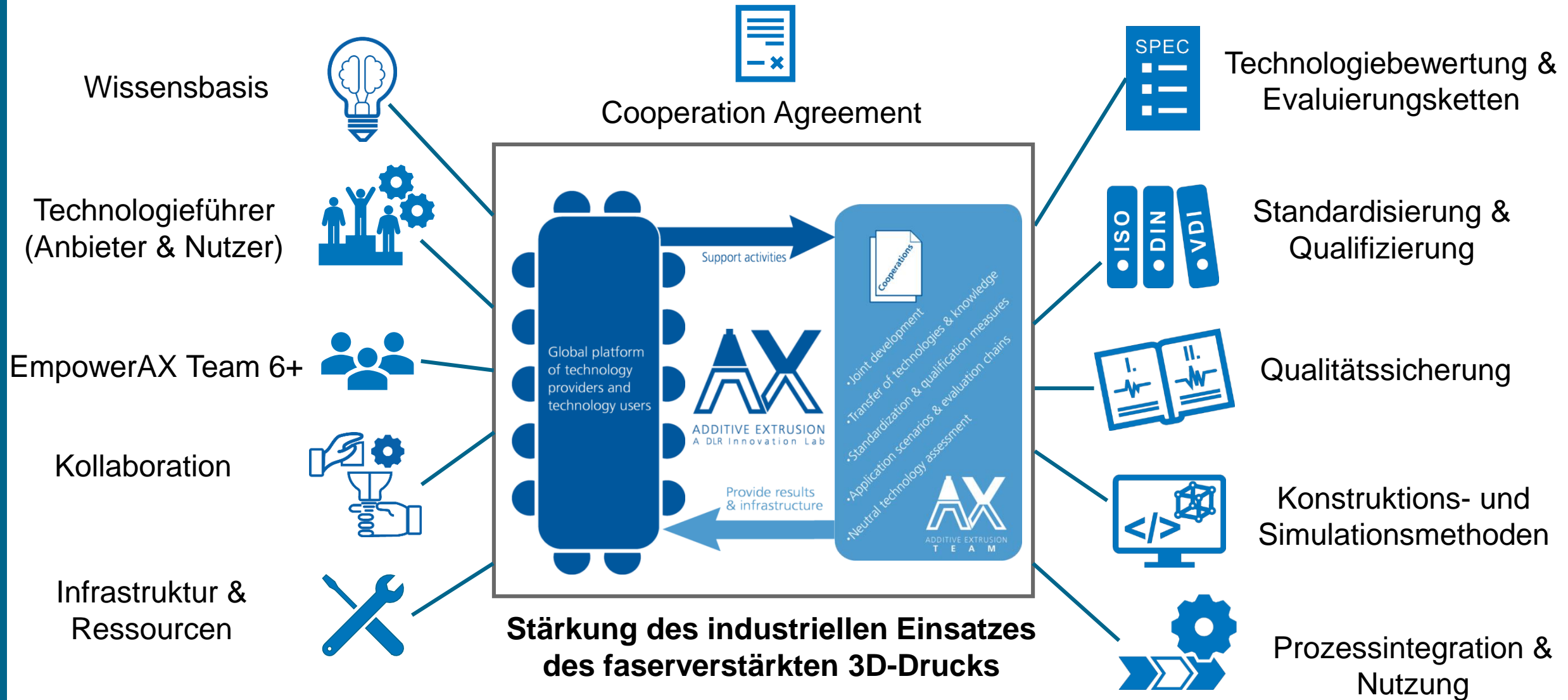
Institut für Systemleichtbau

Braunschweig

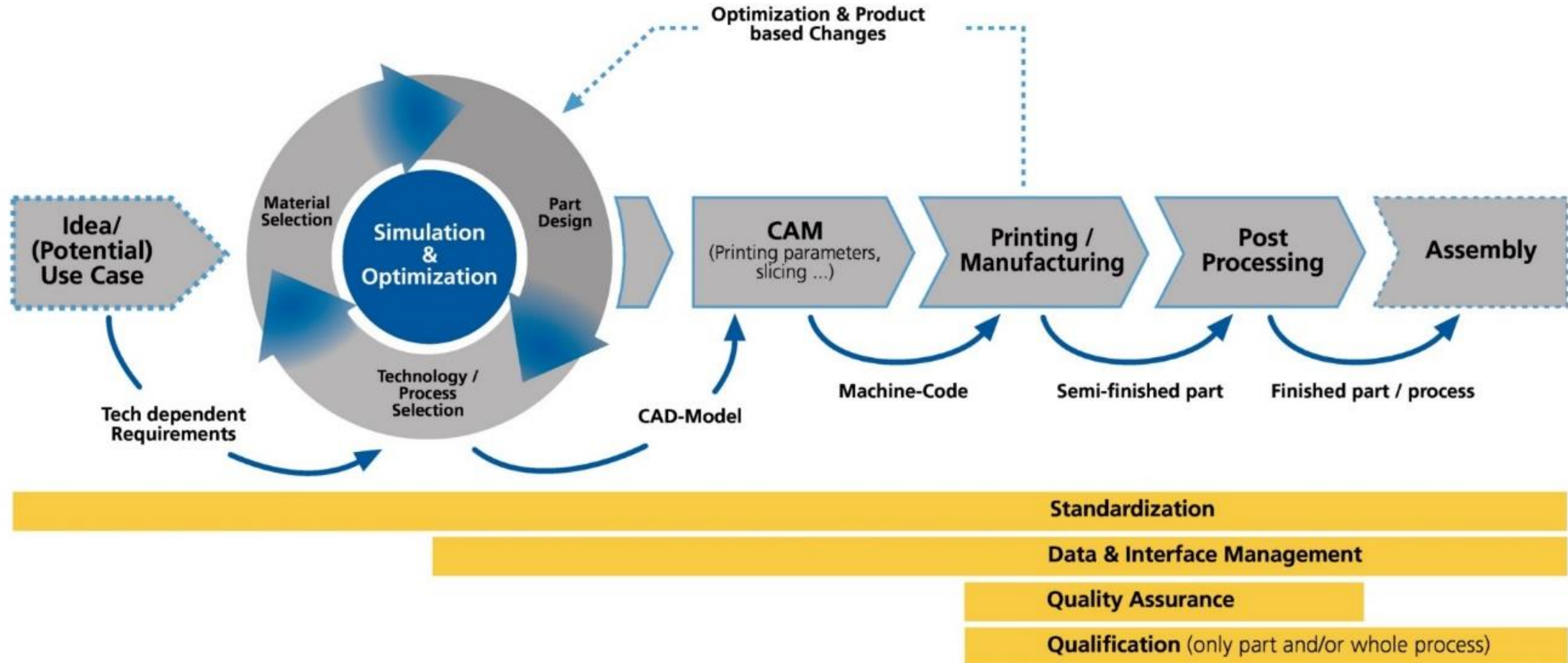
(Faserverstärkter) 3D-Druck eröffnet neue Möglichkeiten



DLR Innovation Lab EmpowerAX – ein Überblick



EmpowerAX: Technologiekompetenz entlang der Prozesskette



“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.”



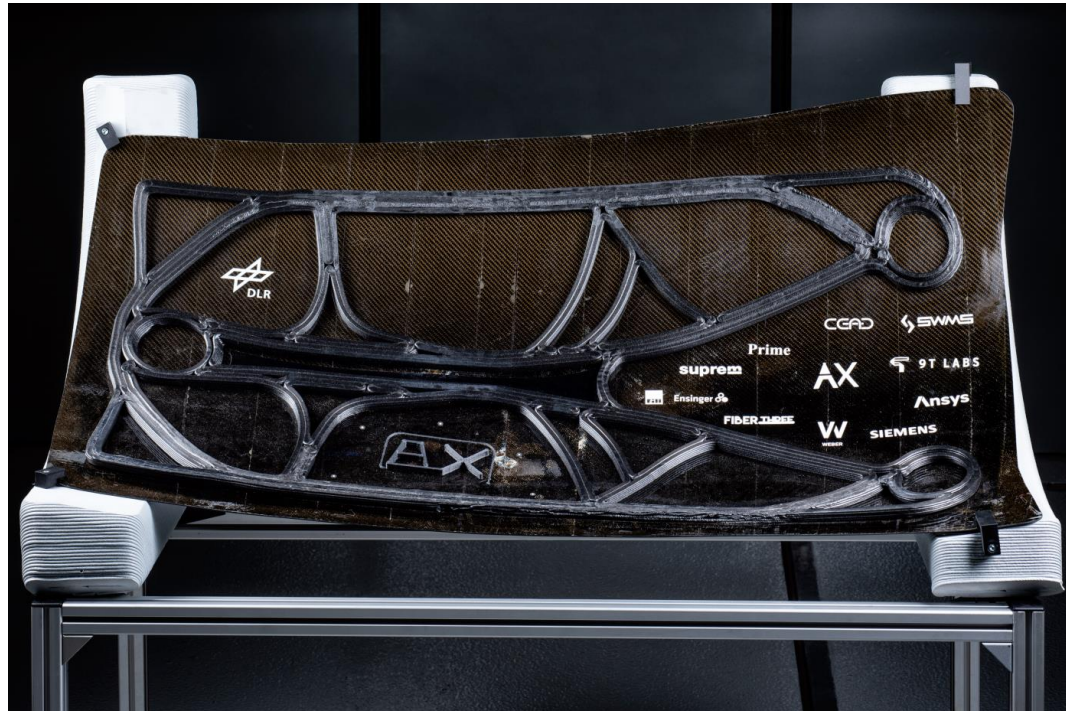
Additive Funktionalisierung

Das richtige Material mit dem richtigen Prozess am richtigen Platz



- Kombination konventioneller mit additiven Fertigungsverfahren
- Kombination von Materialien abhängig von Bauteilfunktion
- Facetten der Additiven Funktionalisierung
 - Aufdrucken lokaler Versteifungsrippen
 - Integration von Montage- und Klebehilfen
 - Einbringen elektrischer Leiterbahnen
 - u.v.m

Additive Funktionalisierung am Beispiel des EmpowerAX Demo Parts

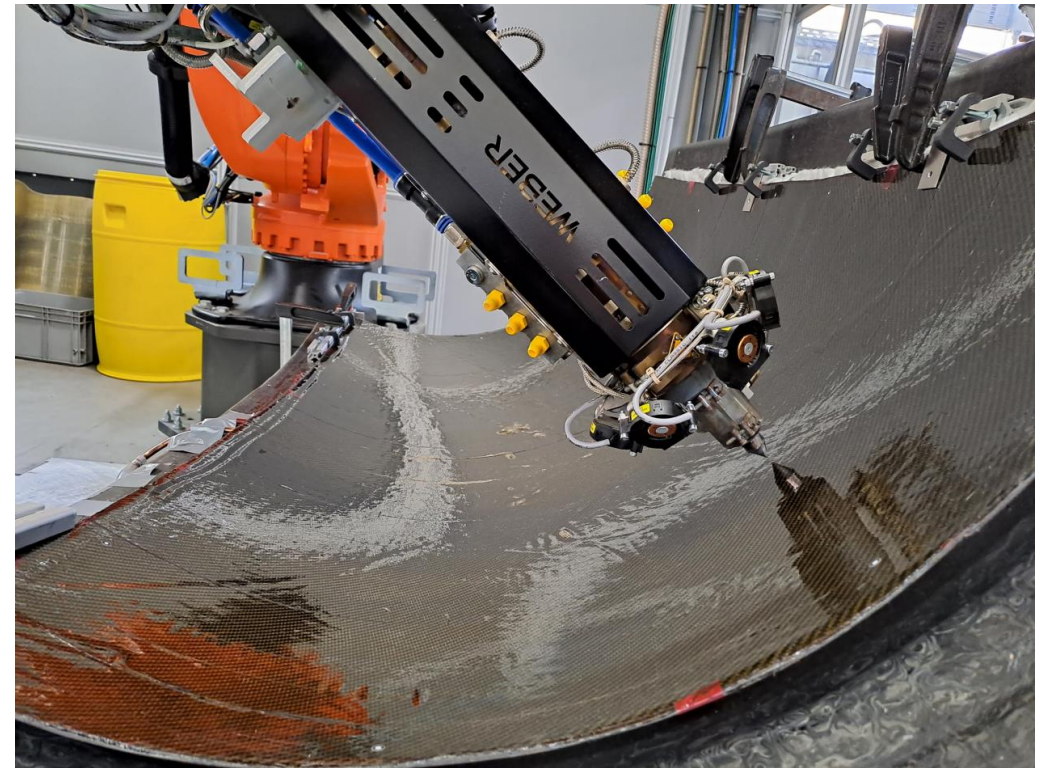
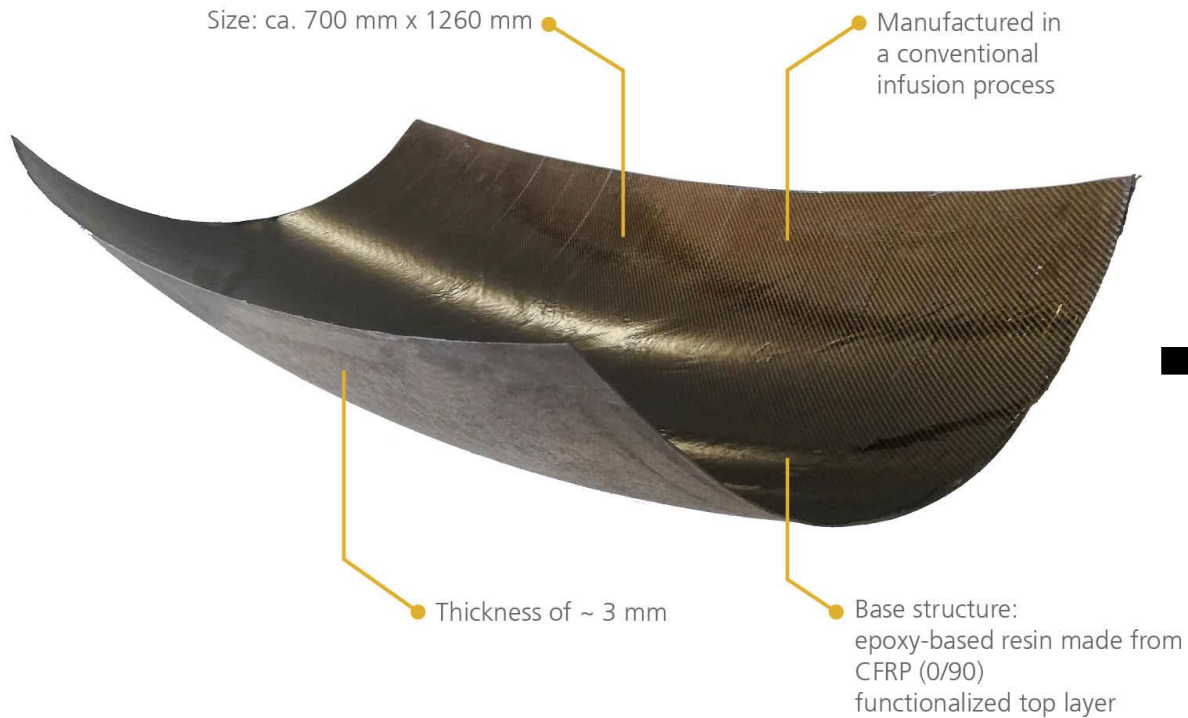


- Additive Funktionalisierung für die kosteneffiziente Fertigung von Kompositbauteilen
- Überdrucken einer mehrfach gekrümmten Schale mit kurz – und endlosfaserverstärkten Materialien
- Kombination von Thermoset und Hochleistungsthermoplast
- Demonstration einer industriell verfügbaren Prozesskette

EmpowerAX Demo Part

Die Grundidee

Funktionalisierung einer mehrfach gekrümmten Thermosetschale
mittels faserverstärkten 3D-Druck mit Hochleistungsthermoplast



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

AM process simulation by
Ansys

Additive Functionalisation of a multi-curved shell

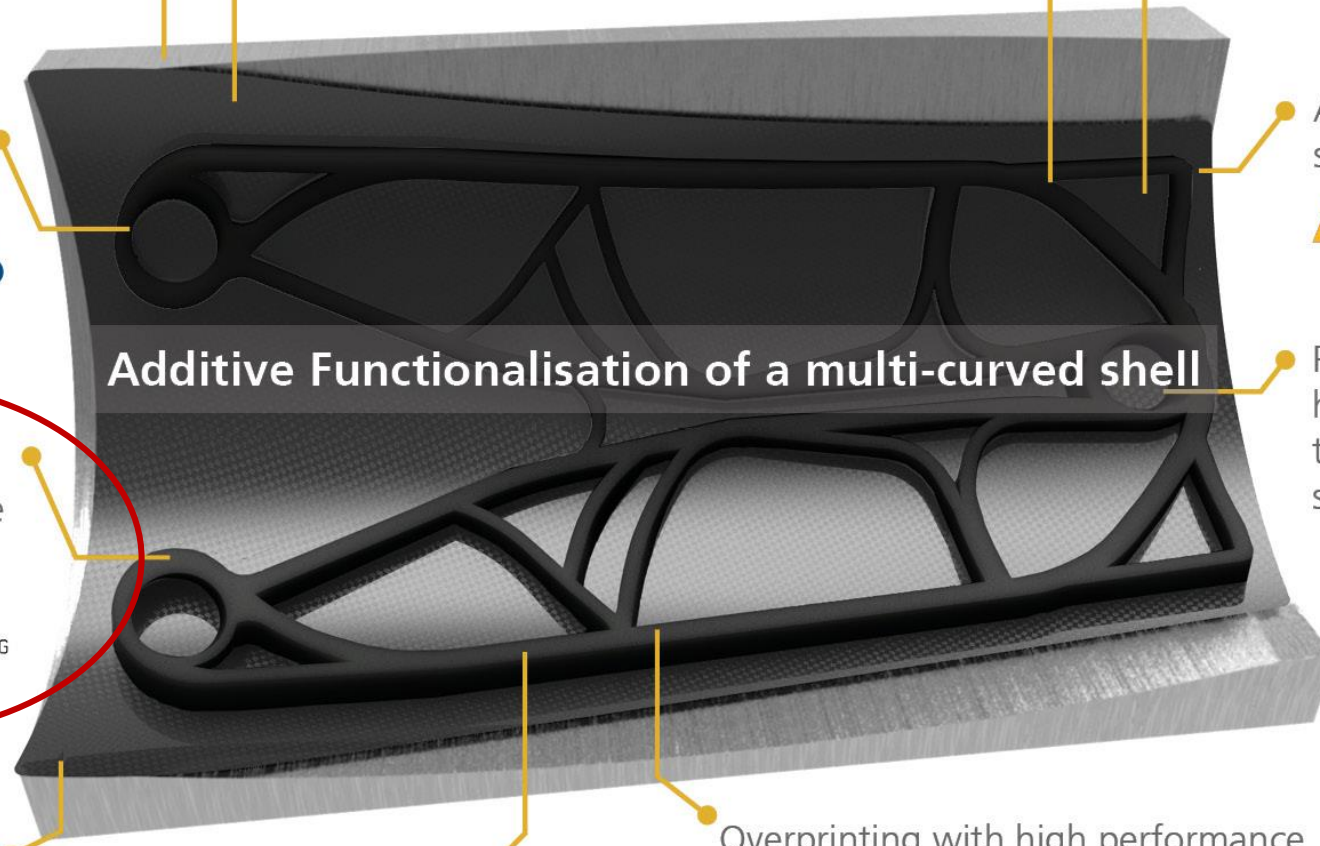
Printing with high performance thermoplastic short FRP by
WEBER additive

Design & topology optimisation of the ribs by
PRIME ENGINEERING IDEAS

Printing of supports and fixtures by
FIBER THREE MATERIAL

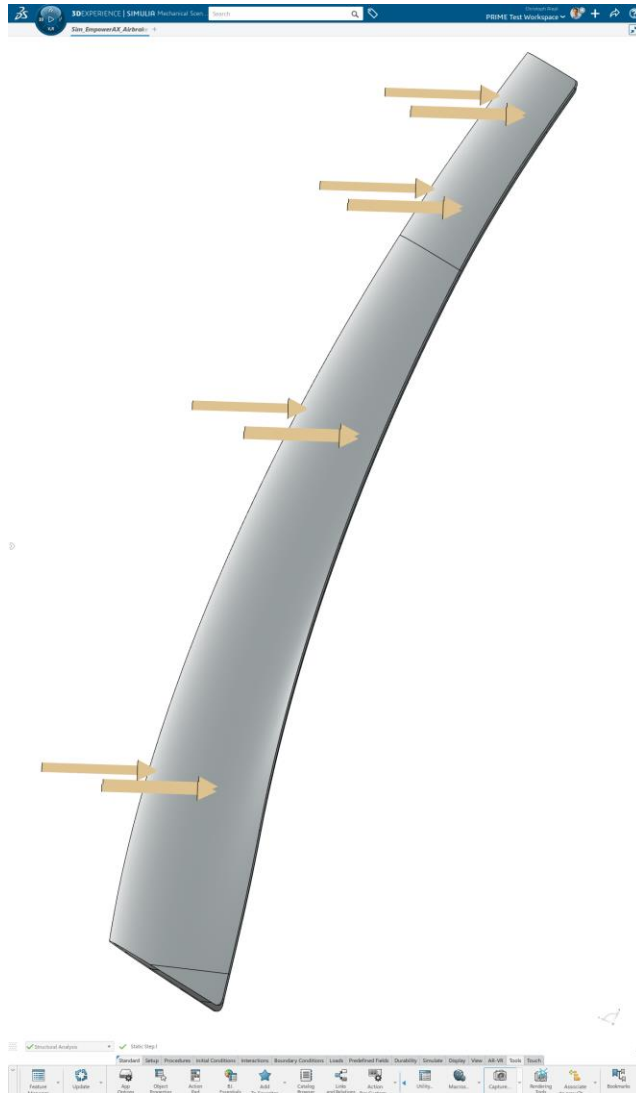
Metrology and NDT by
fill

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



EmpowerAX Demo Part

Ausgangspunkt: Topologie-optimiertes Design by PRIME

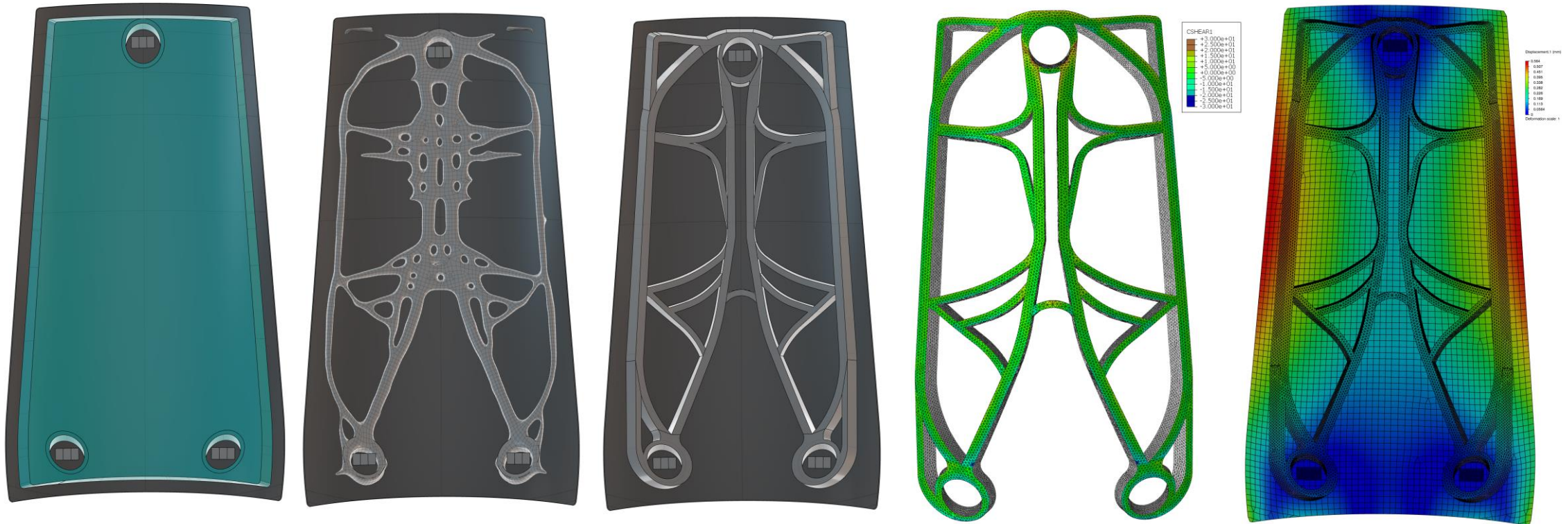


Grundannahmen für den Lastfall als Designanforderung:

- Generischer Anwendungsfall aus der Luftfahrt
- Landung eines Flugzeuges bei 360 km/h
- Luftwiderstand kombiniert mit gleichzeitigen Front- und Seitenwinden

EmpowerAX Demo Part

Ausgangspunkt: Topologie-optimiertes Design



- Die Festigkeit der Grundstruktur reicht nicht aus, um dem angenommenen allgemeinen Lastfall standzuhalten
- Daher ist eine Struktur zur lokalen Verstärkung erforderlich

Ergebnis: Topologie-optimiertes Design, um Material nur dort einzusetzen, wo es wirklich benötigt wird

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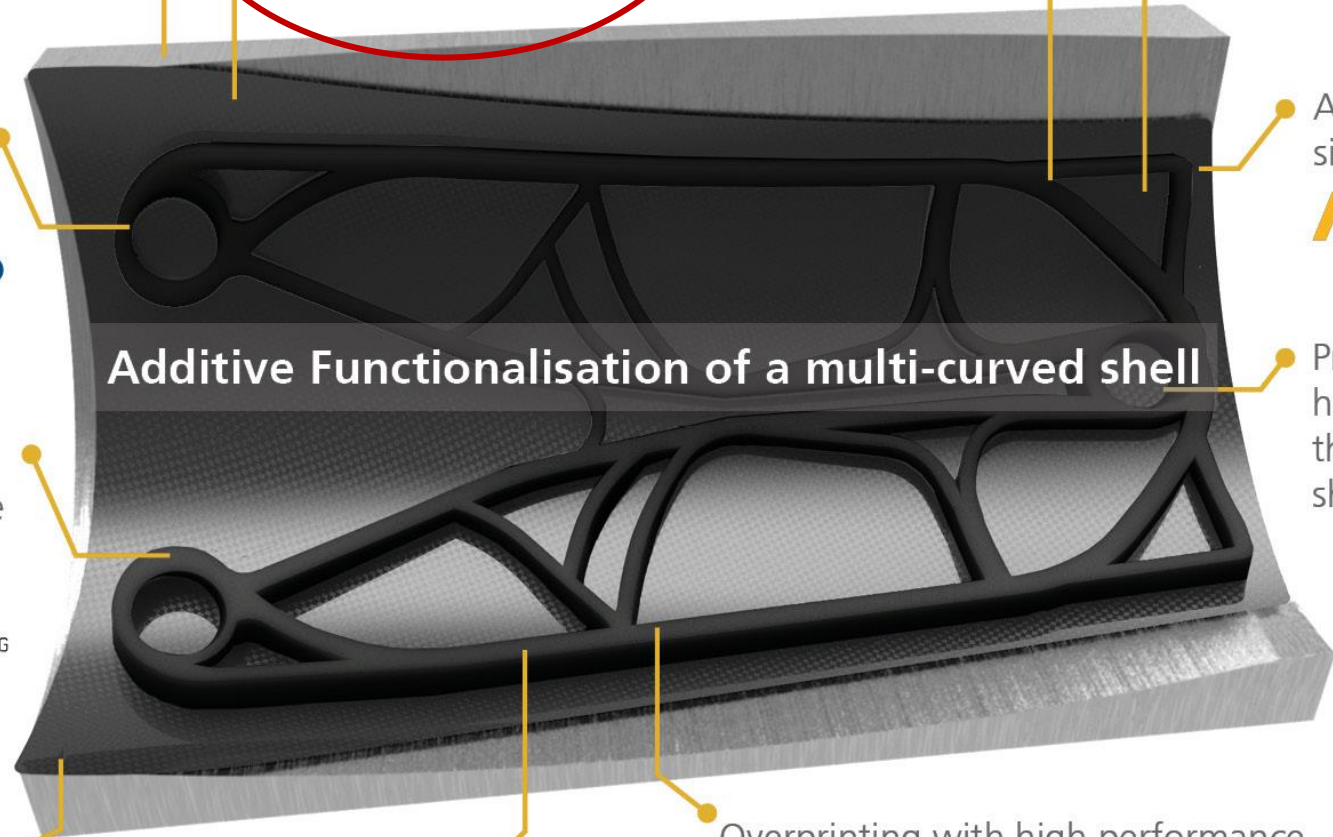
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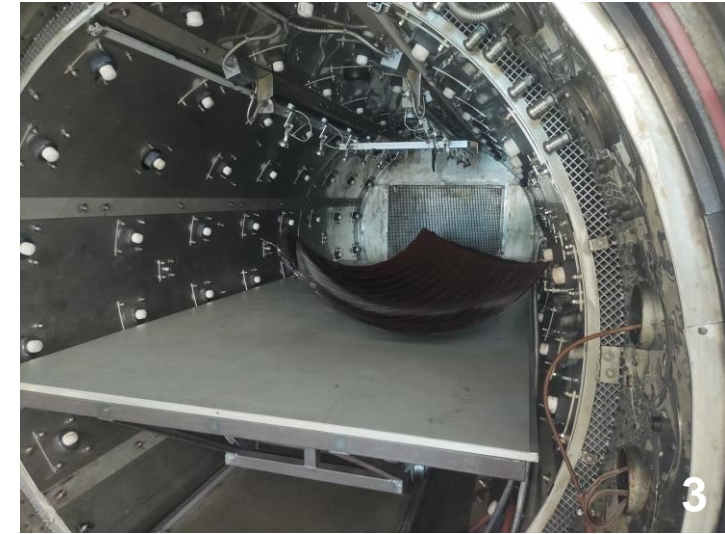
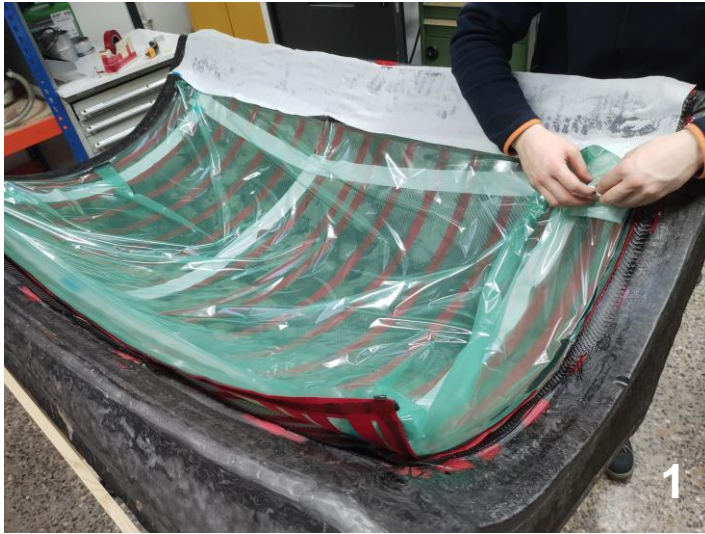


EmpowerAX Demo Part

Fertigung der mehrfach gekrümmten Basisstruktur by DLR



EmpowerAX Demo Part Fertigung der mehrfach gekrümmten Basisstruktur by DLR



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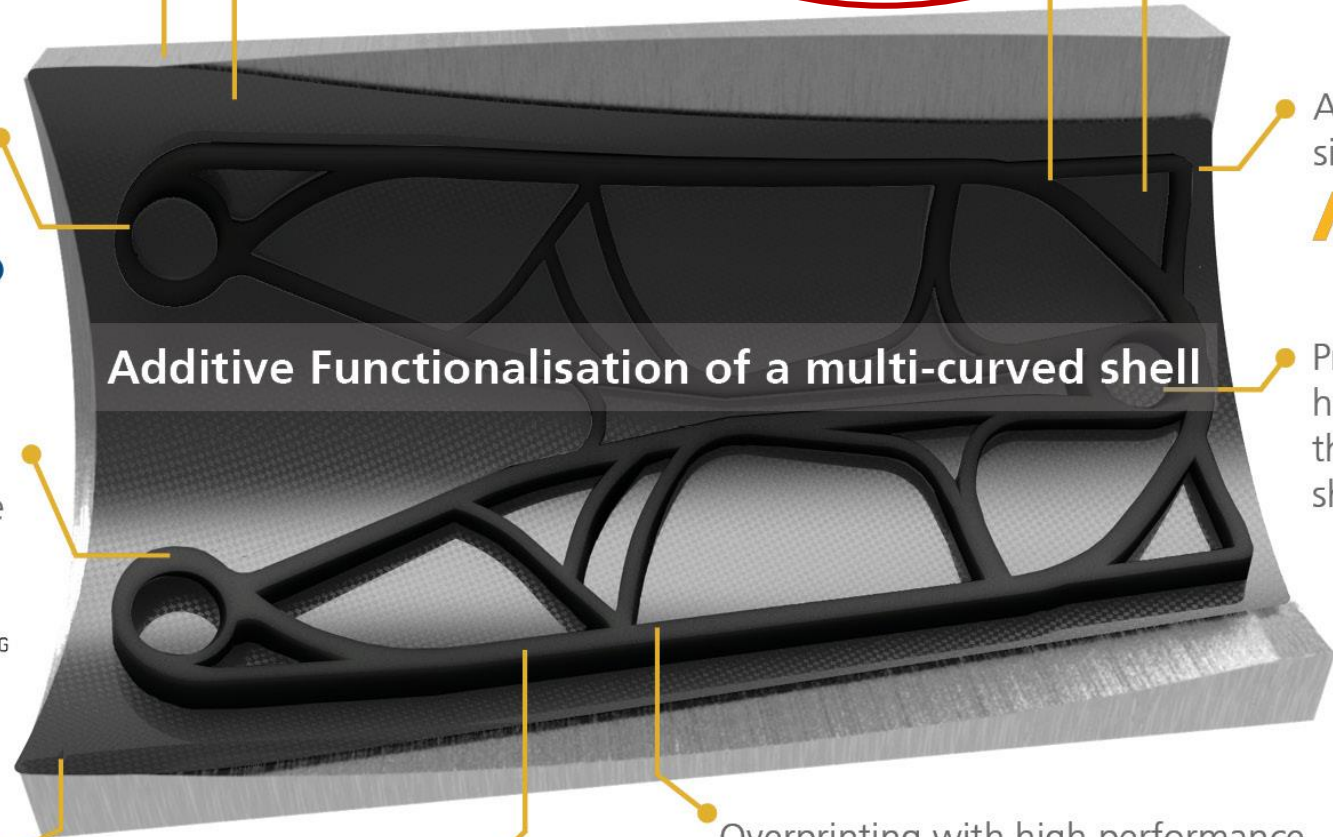
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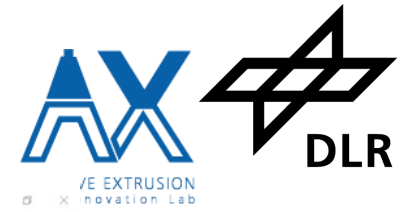
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EmpowerAX Demo Part Pfadplanung für den robotischen 3D-Druck by SWMS



The screenshot displays the EmpowerAX software interface for path planning in robotic 3D printing. The main window shows a 3D simulation of a KUKA robotic arm positioned over a printing bed. The interface includes a top menu bar (File, Start, View, Help), a toolbar with various simulation controls, and a left-hand Navigator tree. The Navigator tree lists the project structure, including 'Weber DRX30', 'Process', '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 Robotertelle JEC', 'Process Configurations', 'Weber Config', 'Filaments', and 'PEI-GF'. The Properties panel on the right shows settings for the 'Result/Rib Body', including 'Index' (1), 'Name' (Result/Rib Body), 'Product instance' (Result), and playback controls. A circular inset provides a magnified view of the robotic arm's nozzle printing a dark, curved part on a light-colored base. The bottom right corner of the interface shows a coordinate system and a 'CAESA' logo.

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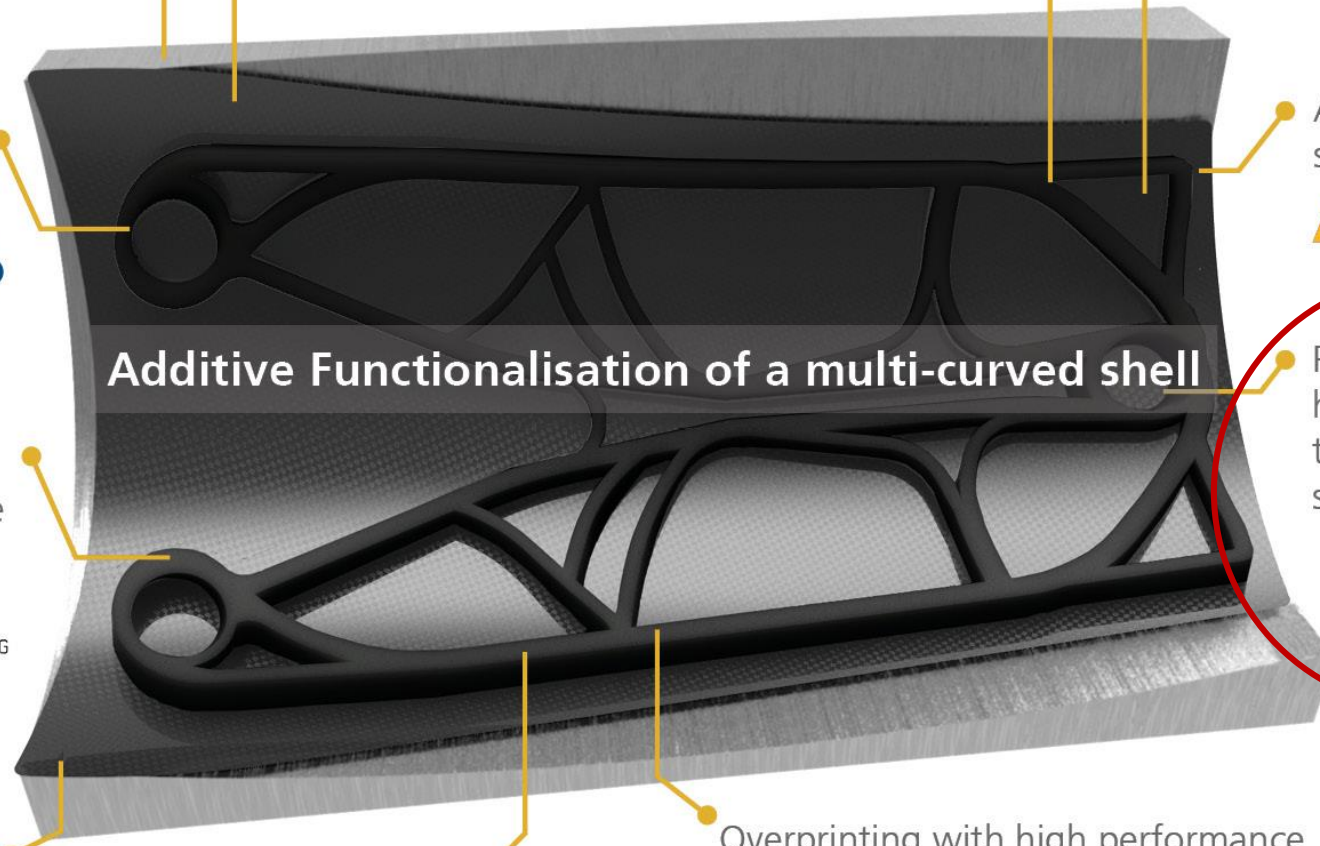
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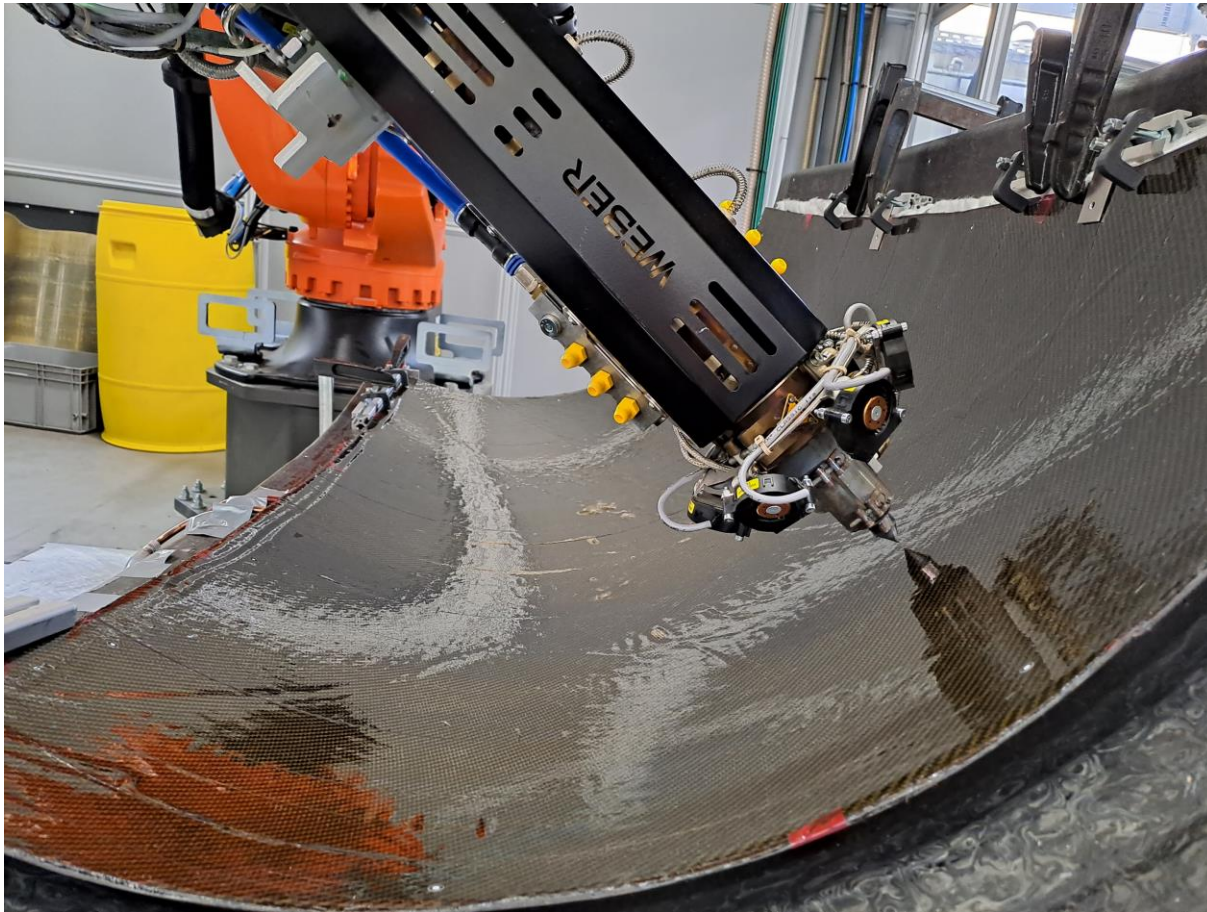
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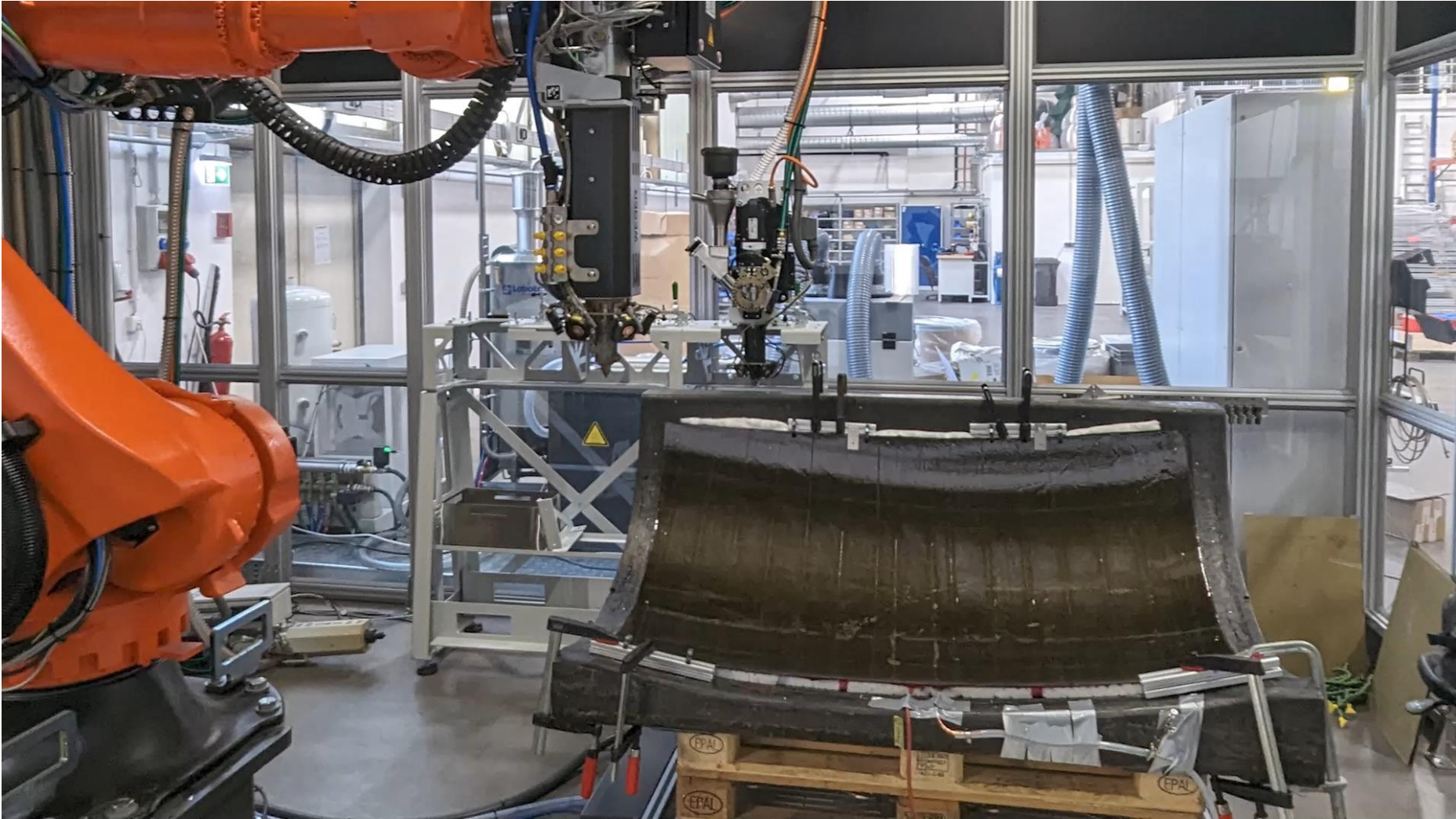
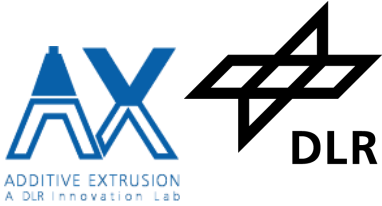
Druck der Versteifungsrippen by WEBER



- Druck der Versteifungsrippen mit kurzfaserverstärktem PEI (Granulat)
- Funktionalisierte Oberfläche der Schale ermöglicht das direkte Aufdrucken
- Umsetzung des Drucks in Kollaboration mit DLR & SWMS bei WEBER vor Ort

EmpowerAX Demo Part

Druck der Versteifungsrippen by WEBER



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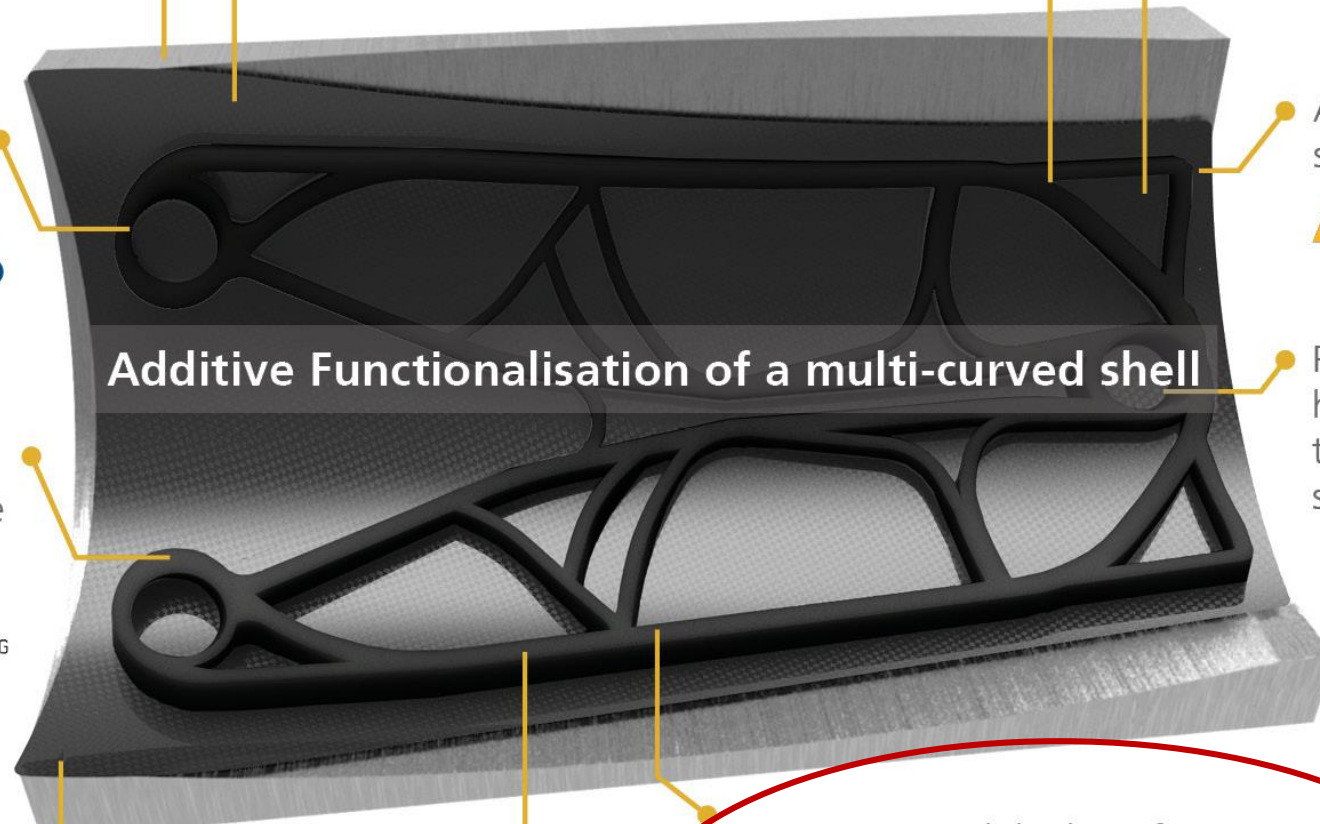
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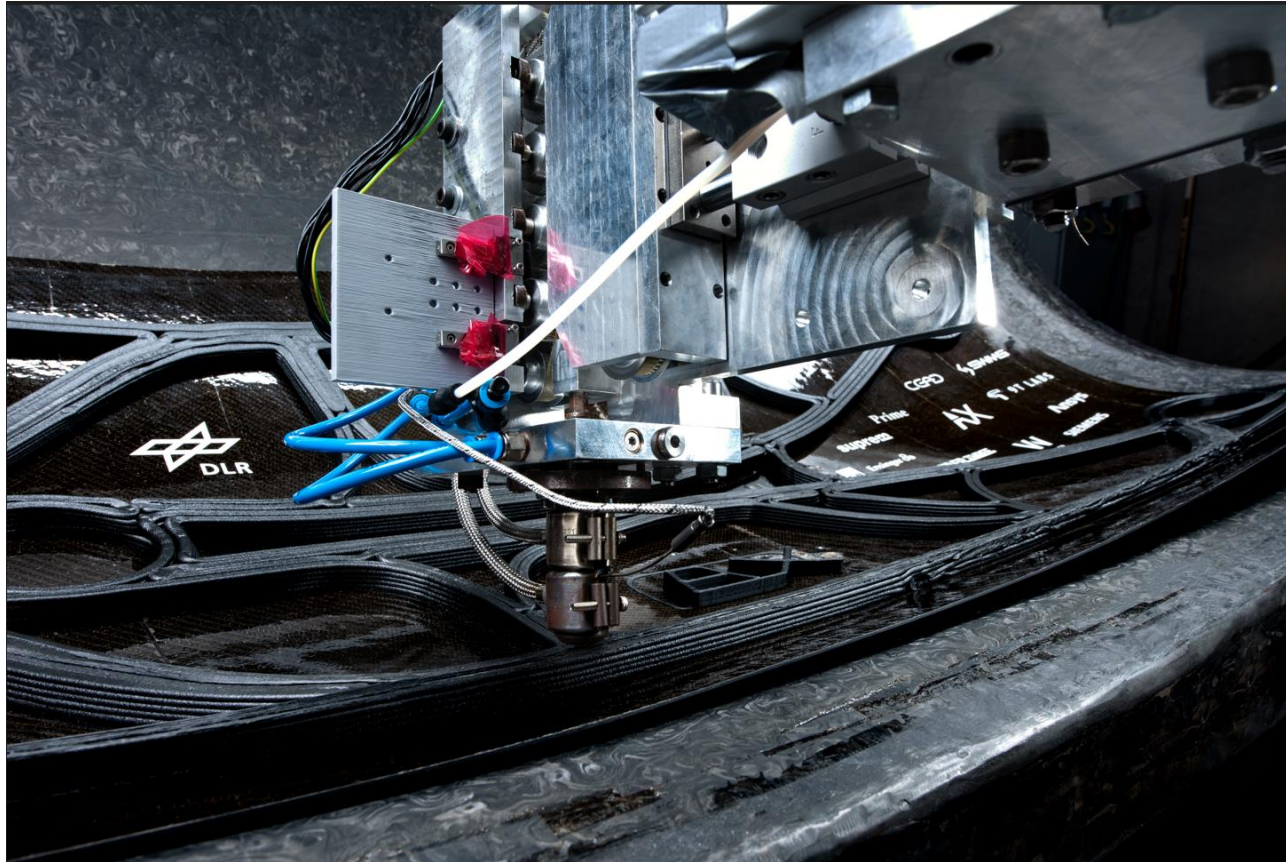
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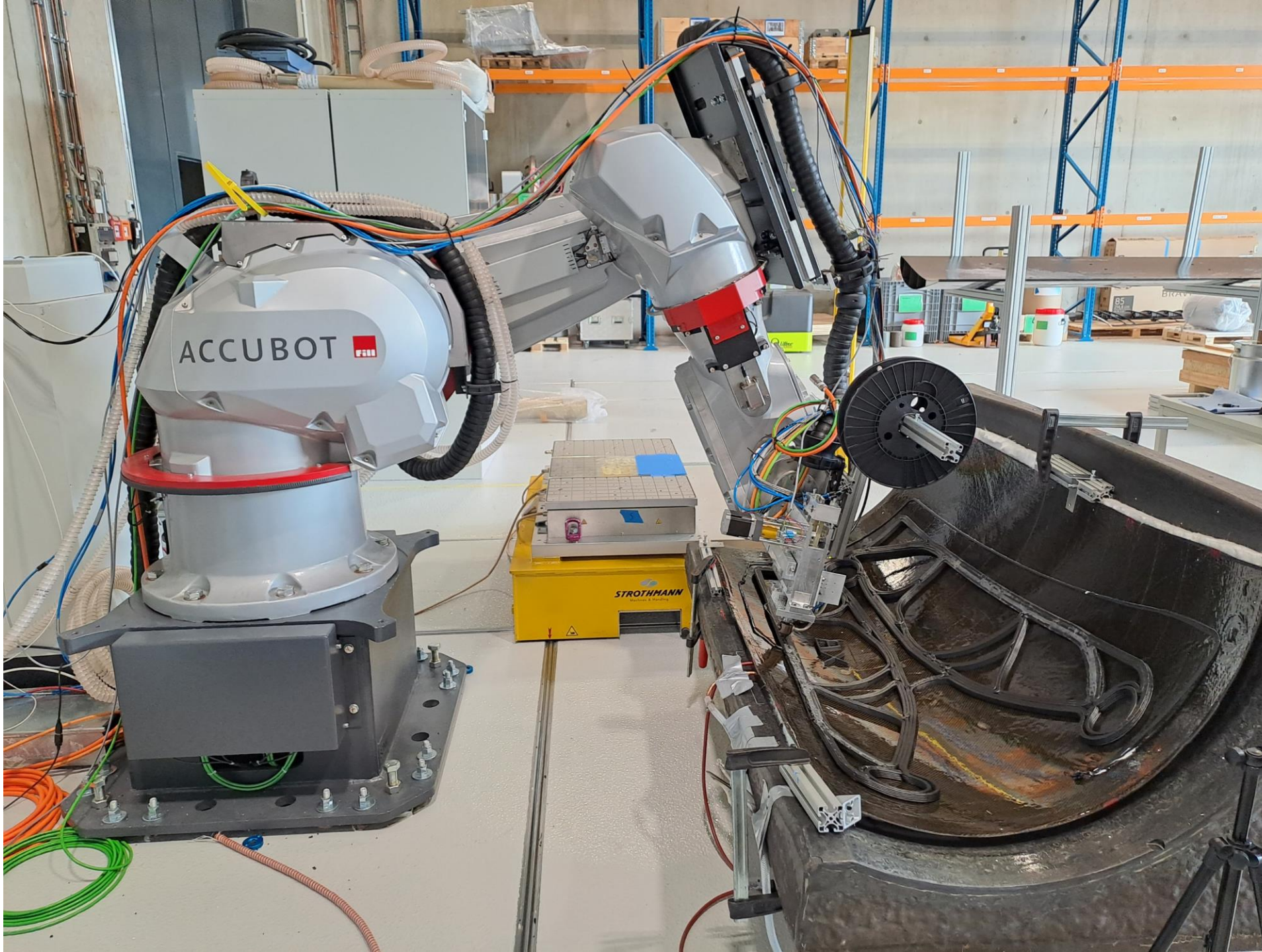
DLR AX SIEMENS
ADDITIVE EXTRUSION



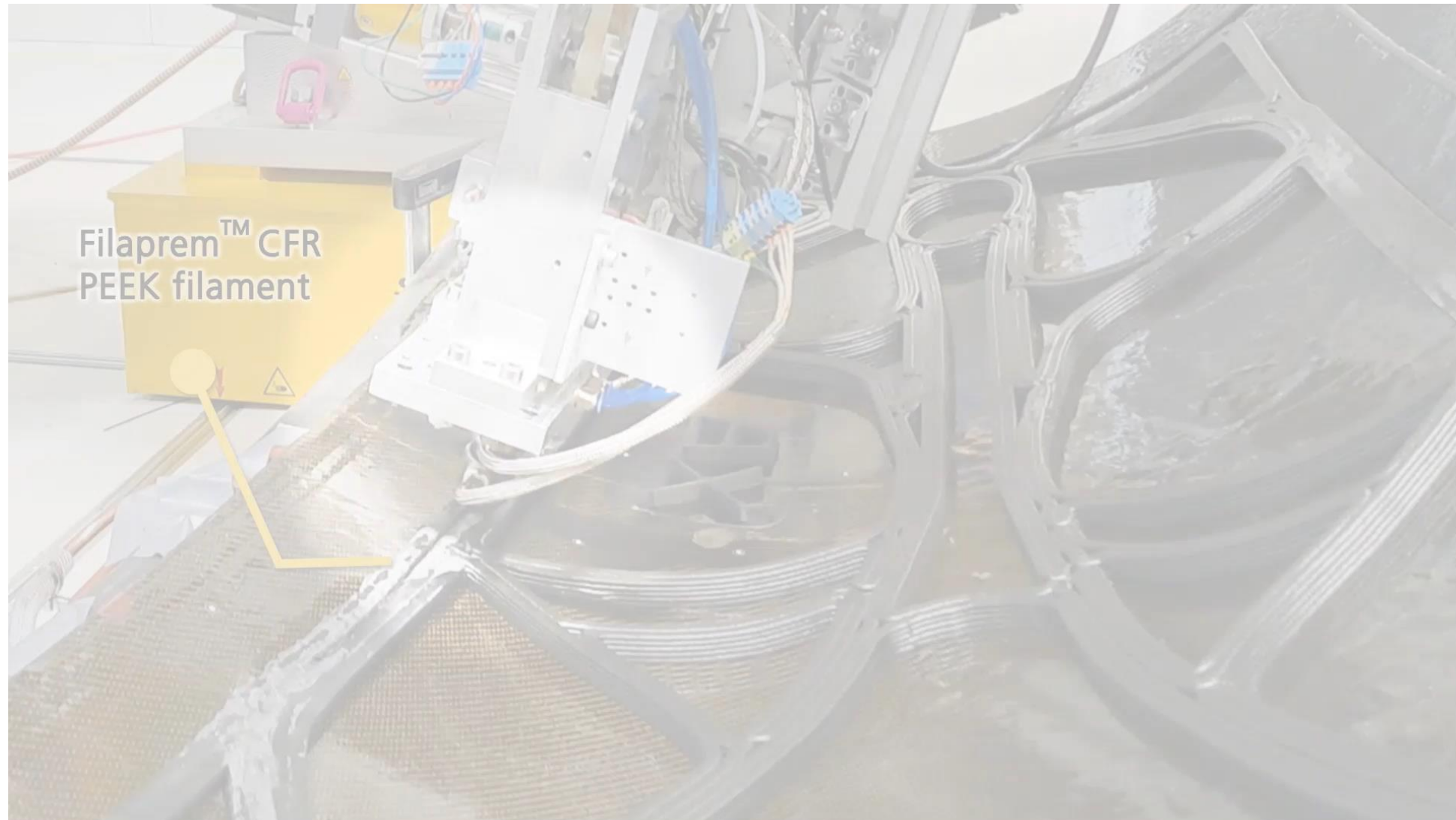
EmpowerAX Demo Part endlosfaserverstärktes Überdrucken by DLR



- DLR-Technologie ermöglicht direktes Überdrucken der duroplastische, mehrfach gekrümmte Schalen
- mit endlosfaserverstärktem Material
 - auf der Rippe: Suprem filaprem CFR PEEK Filament
- und kurzfaserverstärktem Material
 - AX-Logo: Ensinger TECACOMP PEEK-Granulat
- Einsatz eines CNC-Robotersystems mit selbstentwickelten Druckköpfen für die Granulat- und Filamentverarbeitung



EmpowerAX Demo Part endlosfaserverstärktes Überdrucken by DLR



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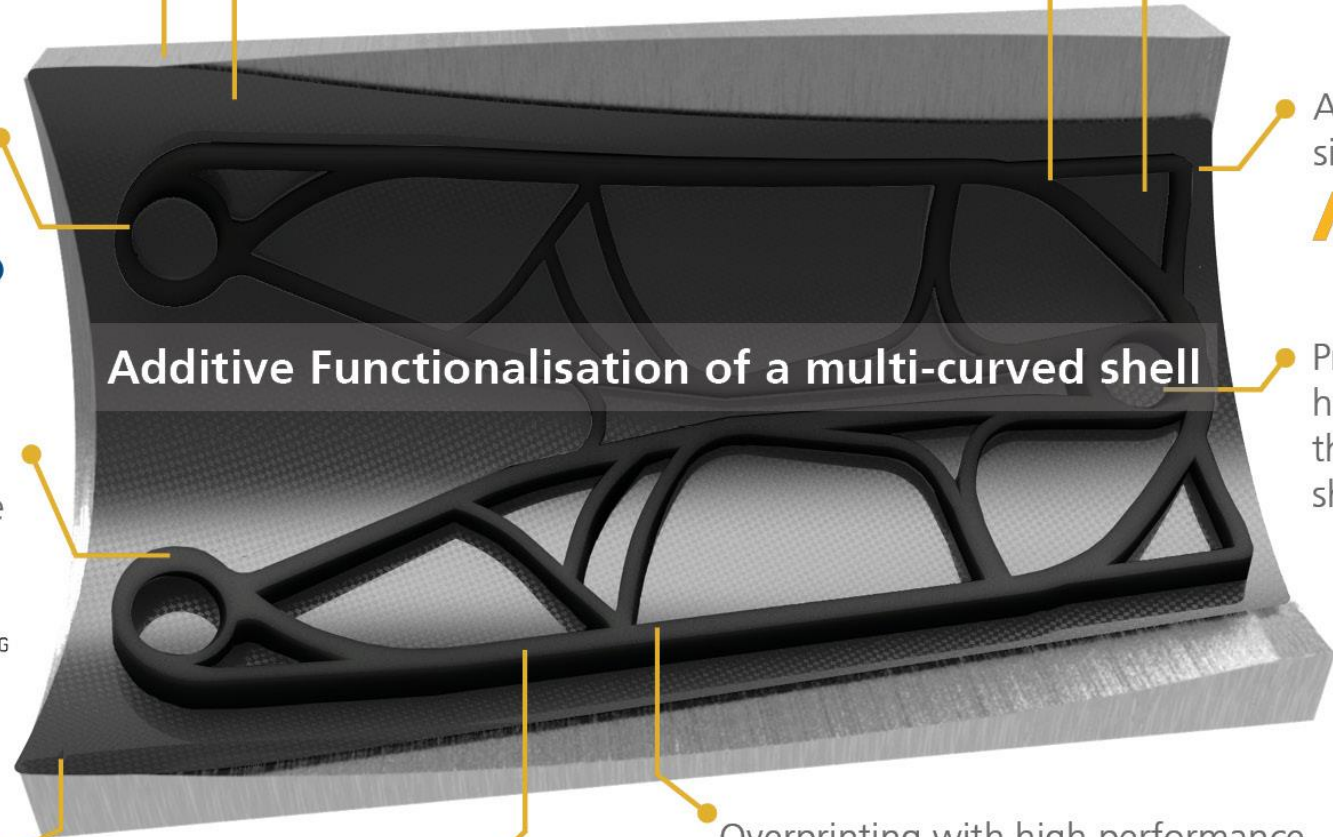
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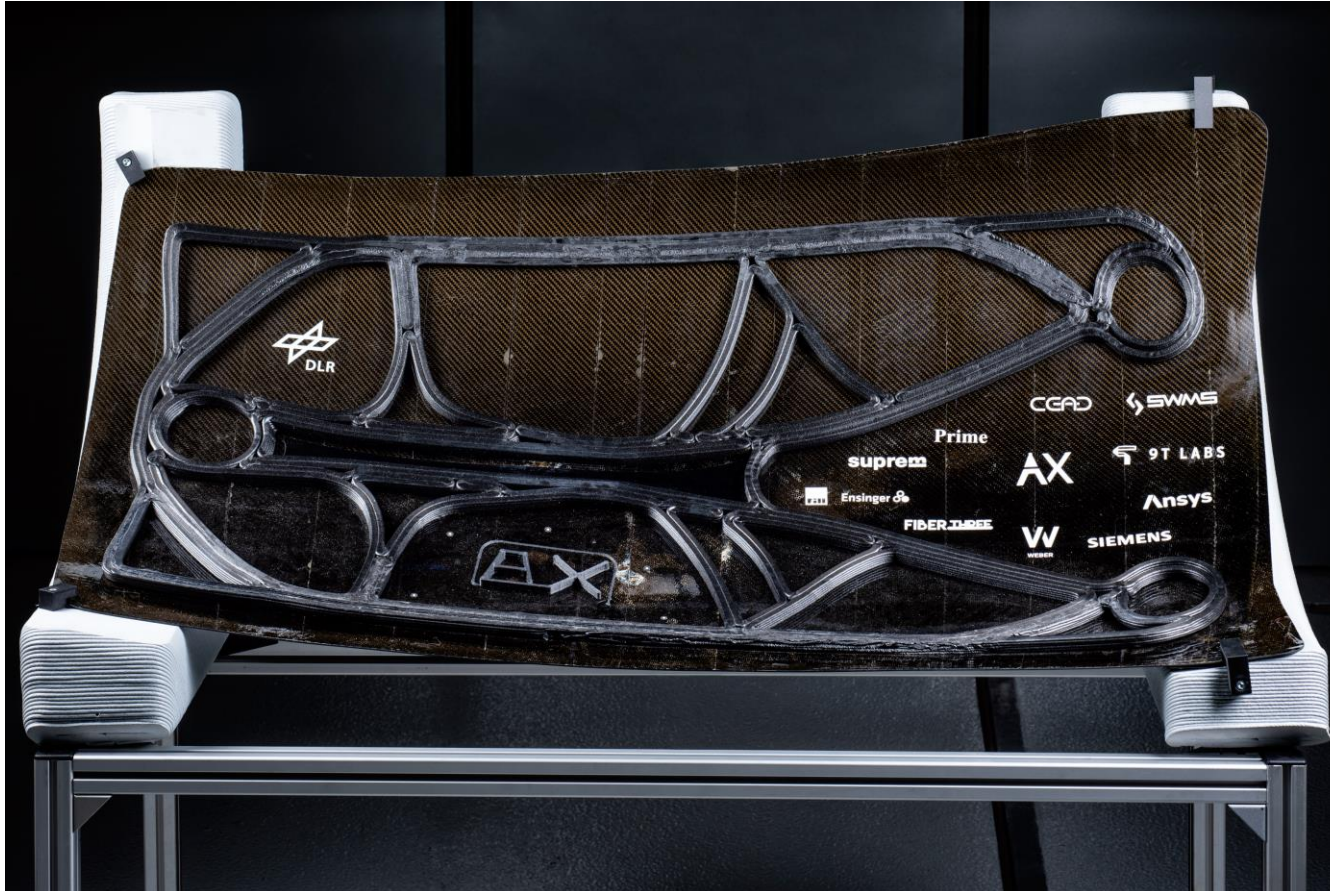
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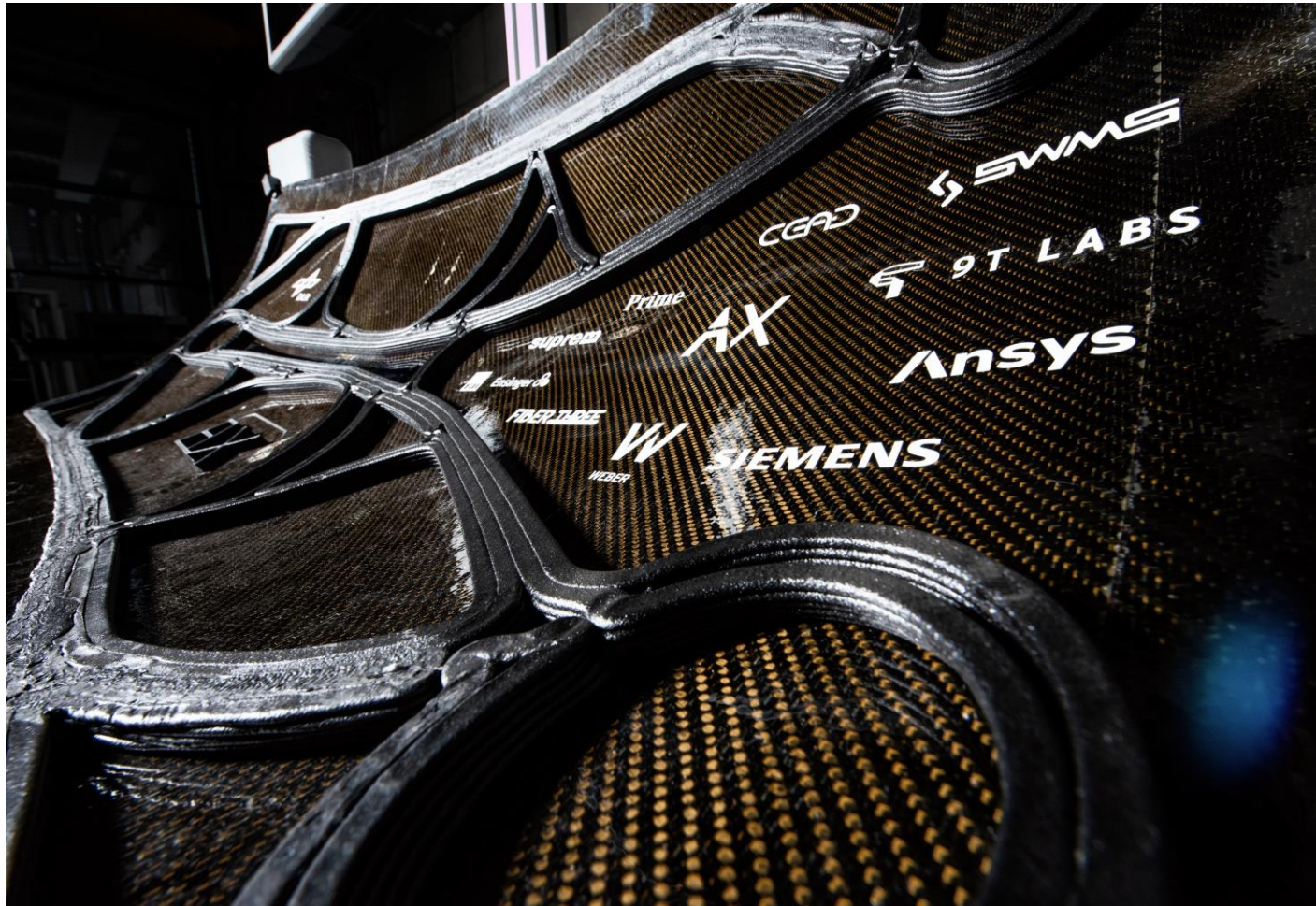
Additive Funktionalisierung - Zusammenfassung



- Additive Funktionalisierung für die kosteneffiziente Fertigung von Kompositbauteilen
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EmpowerAX Demo Part

Additive Funktionalisierung - Zusammenfassung



- Kombination der kosteneffizienten Herstellung der Grundstruktur mit der hoher Flexibilität und Designfreiheit der additiven Fertigung
- Paradigmenwechsel hin zu einem stärker integrierten Leichtbaukonzept

Additive Funktionalisierung – Wie geht's weiter?



Additive Funktionalisierung – Wie geht's weiter?



Relevante Themen für den industriellen Einsatz

- **Fertigungsgerechtes Design**
(Berücksichtigung von Fertigungsprozess und Maschinenrestriktionen)
- **Schnittstellendefinition**
(Austauschformate, Genauigkeit bei Übertragung...)
- **Prozessüberwachung & Qualitätssicherung**

EmpowerAX Demo Part on Tour



EmpowerAX Science Day zum Thema "faserverstärkter 3D-Druck in der Anwendung"

EmpowerAX Days
11. Oktober 2023
09:00 – 18:00 Uhr

Eine Veranstaltung in Kooperation mit:

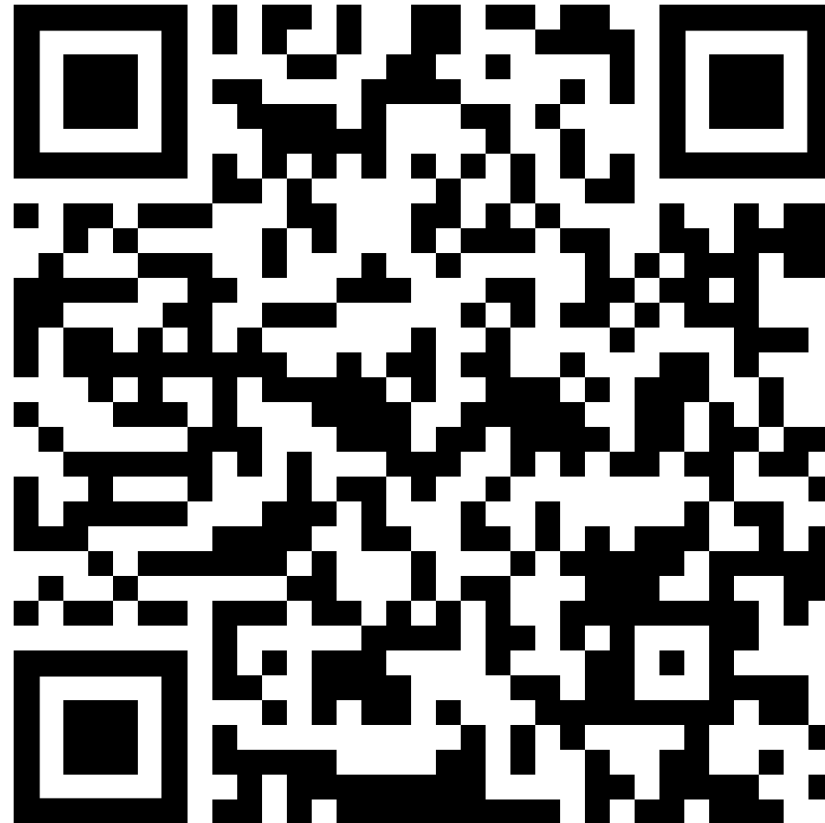
CU COMPOSITES UNITED
Niedersachsen ADDITIV

**Vorträge aus Wissenschaft und Industrie zu industriellen
Anwendungsbereichen des faserverstärkten 3D-Drucks**

EmpowerAX Demo Part on Tour



EmpowerAX Science Day zum Thema "faserverstärkter 3D-Druck in der Anwendung"



Vielen Dank für Ihre Aufmerksamkeit



Gibt es Fragen?