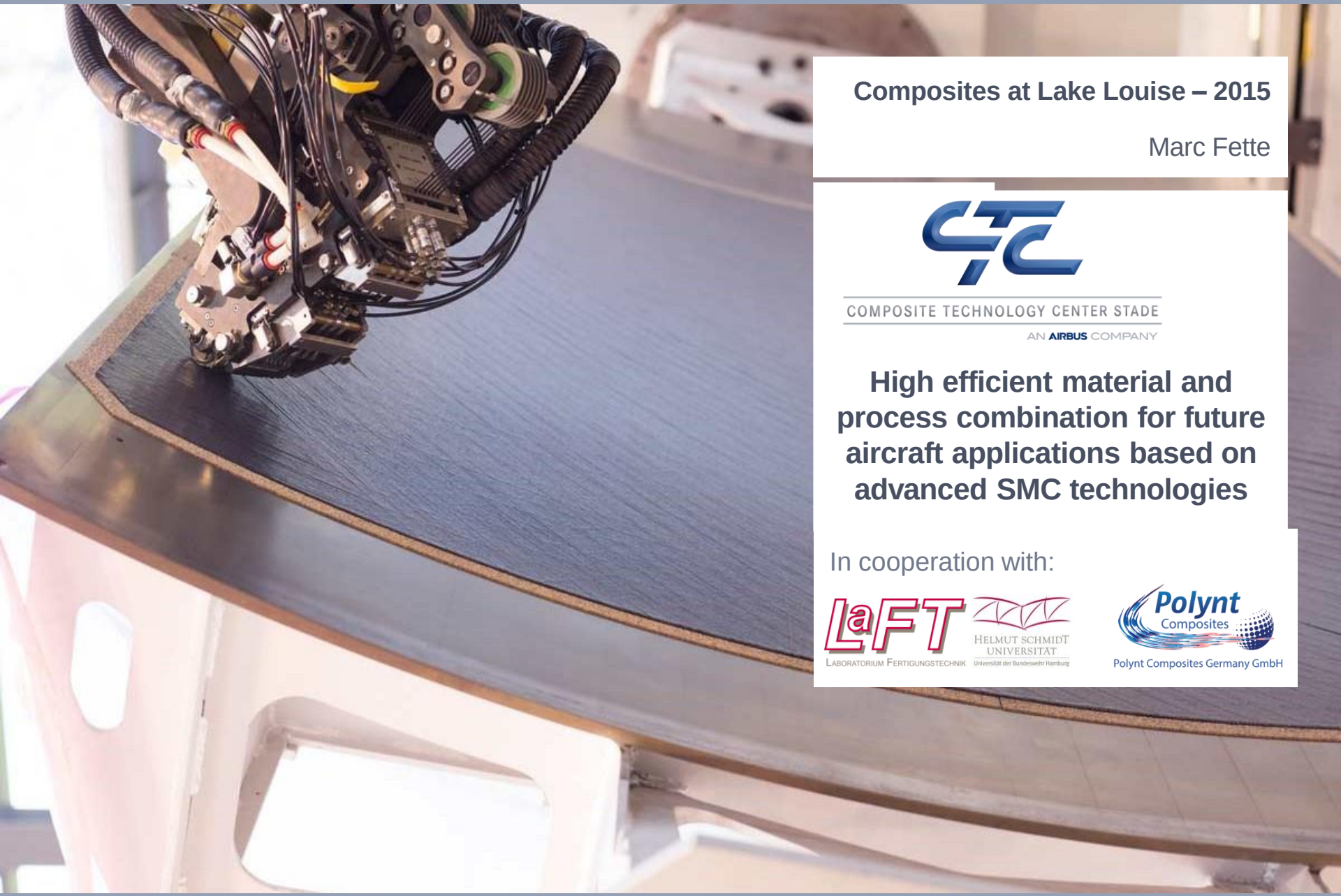
Fall 11-9-2015

High efficient material and process combination for future aircraft applications based on advanced sheet molding compound technologies

Marc Fette
Helmut Schmidt University



Composites at Lake Louise – 2015

Marc Fette

COMPOSITE TECHNOLOGY CENTER STADE
AN AIRBUS COMPANY

High efficient material and process combination for future aircraft applications based on advanced SMC technologies

In cooperation with:

LaFT Laboratorium Fertigungstechnik – Helmut Schmidt Universität Universität der Bundeswehr Hamburg

Polynt Composites Germany GmbH

AIRBUS

Agenda

1. **Motivation**
2. **SMC technology**
3. **Hybrid Composite Processes**
4. **Potential and benefits**
5. **Applications**
6. **Current investigations**
7. **Summary and Outlook**

Agenda

1. **Motivation**
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Motivation

Source: Airbus

Source: Airbus

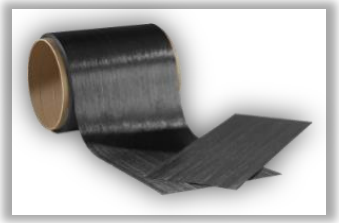
Complex and functional cabin and cargo components

Motivation

We need new materials and processes!

Sheet Moulding Compound (SMC) with carbon or glass fibres

Compression moulding of pre-impregnated carbon fibre fabrics



Source: Zoltek

Hybrid Composite Processes

Complex composite components:
- **Cost-saving**
- **Lightweight potential**
- **High production rates**

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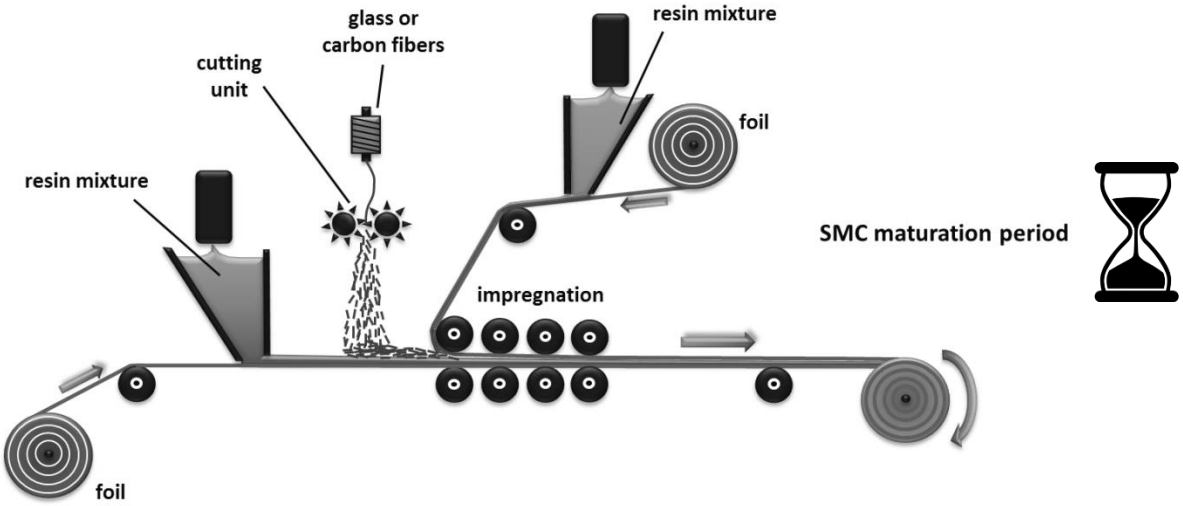
SMC technology

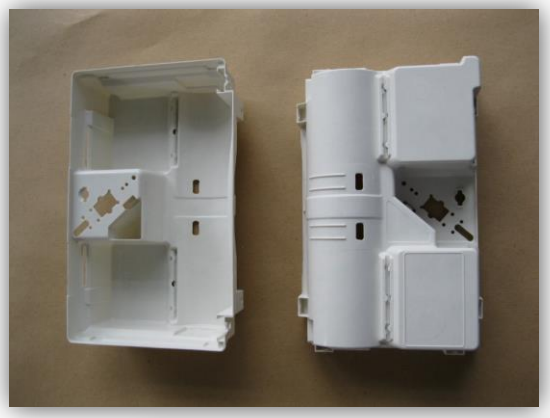


SMC maturation period

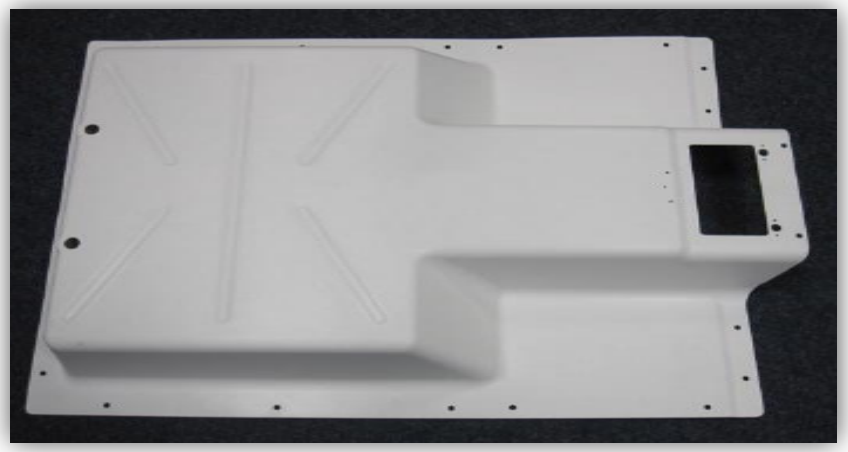
SMC technology

Current SMC applications

SMC technology



Current glass fibre SMC components



Cargo door actuator lining (Source: Airbus)

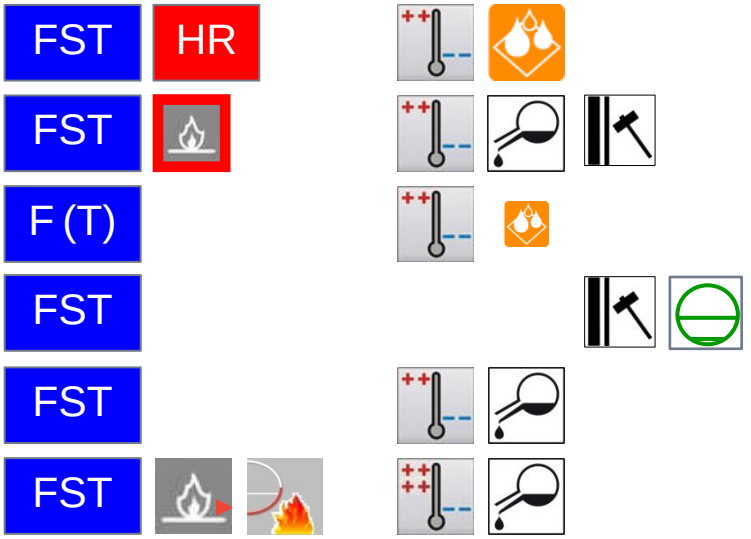
Monolithic cabin parts (Source: Airbus)

SMC technology

Area/Application:

- Cabin
- Cargo
- Cockpit
- Floor
- (System) Installation
- T/A-Insulation

Main Requirements:



FST - Flammability, Smoke Density, Toxicity

HR - Heat Release

- Cargo Fire Containment

- Flame Propagation

- Burnthrough

- Climate (Temperature & Humidity)

- Media (Food, Beverages, Cleaning Agents)

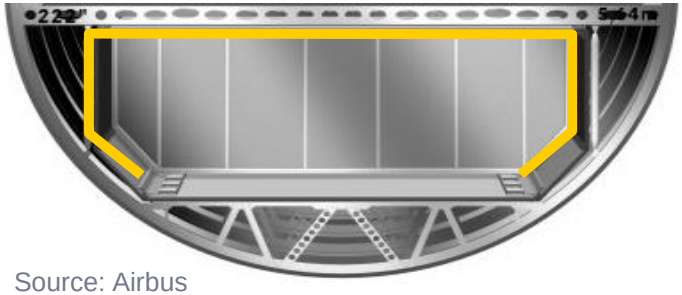
- Hydraulic Fluids & Fuel

- Impact

- Structural Loads

SMC technology

UP-based HUP 27 with glass fibre reinforcements from Polynt meets Airbus FST requirements for cargo materials



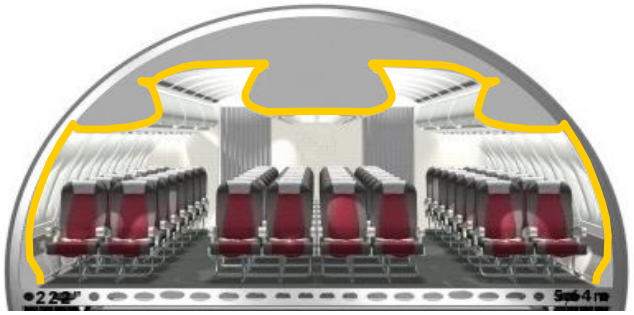
Source: Airbus

Properties exposed to fire			
FST	Flammability vertical, 60 s test A	AITM 2.0002	ABD0031
	Flammability vertical, 12 s test	AITM 2.0002	
	Flammability horizontal	AITM 2.0003	
	Smoke density, flaming mode	AITM 2.0007	
	Smoke density, non flaming mode		
	Toxicity, flaming mode	AITM 3.0005	
	Toxicity, non flaming mode		
	Flame Penetration Resistance of Cargo Compartment Liners	AITM 2.0010	

Source: Airbus

SMC technology

UP-based HUP 63 with glass fibre reinforcements from Polynt meets Airbus FST requirements for cabin materials



Source: Airbus

Properties exposed to fire			
FST	Flammability vertical, 60 s test A	AITM 2.0002	ABD0031
	Flammability vertical, 12 s test	AITM 2.0002	
	Flammability horizontal	AITM 2.0003	
	Heat release	AITM 2-0006	
	Smoke density, flaming mode	AITM 2.0007	
	Smoke density, non flaming mode		
	Toxicity, flaming mode	AITM 3.0005	
	Toxicity, non flaming mode		

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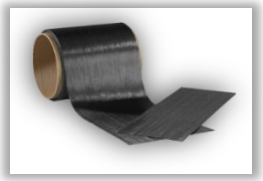
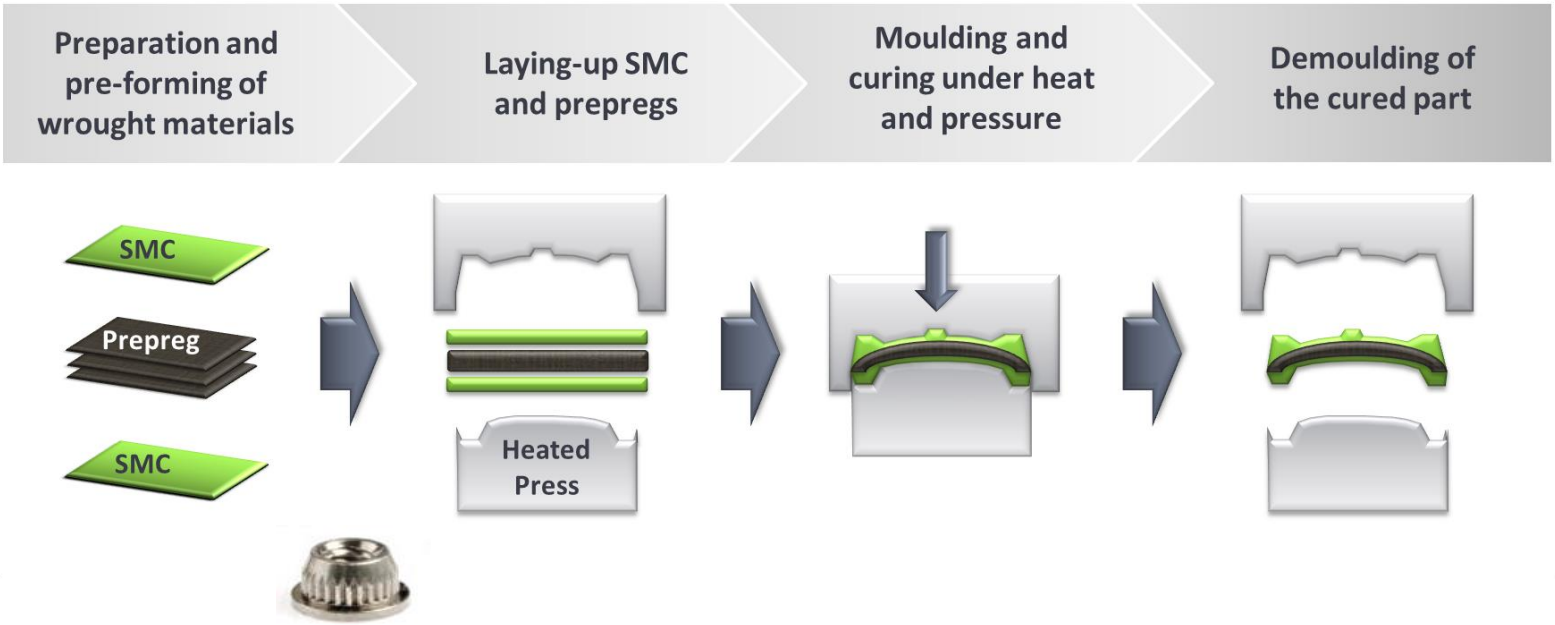
A hybrid process for hybrid materials





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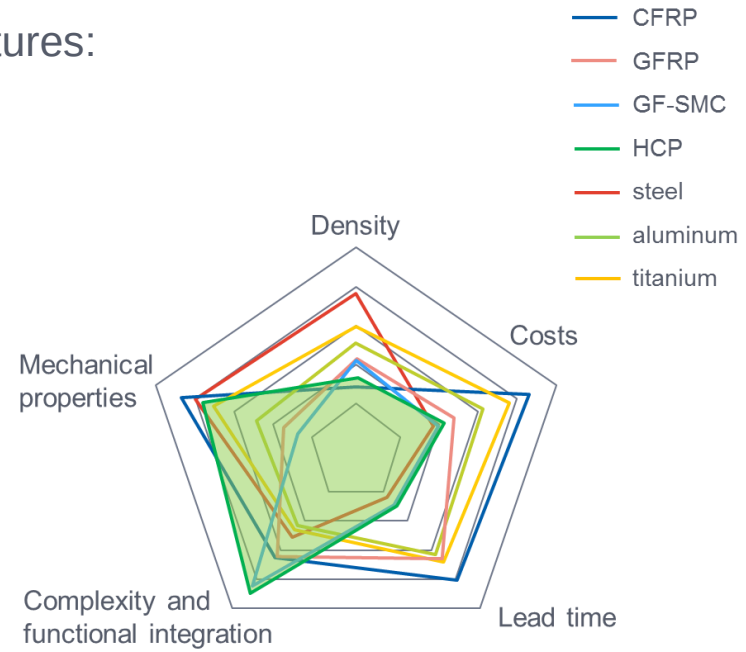
Potential and benefits

Production of composite components with following features:

- **Light weight**
- **Complex shape and design freedom**
- **Integration of functions**
- **Hybridisation of metal and CFRP**
- **Lower production and material costs**
- **Excellent buy-to-fly ratio**
- **Higher production rates**
- **Efficient and fully automated**
- **Less energy consumption**
- **Reduced time and costs for assembly and finishing**
- **Possibility to use recycled carbon fibres**



SMC-metal hybrids

Potential and benefits

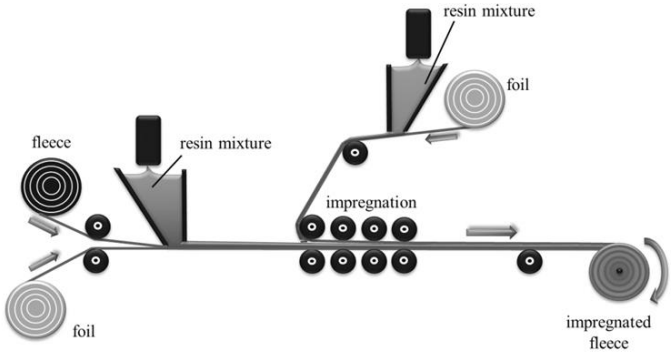
Carbon fiber scrap

Pyrolized C-fibers

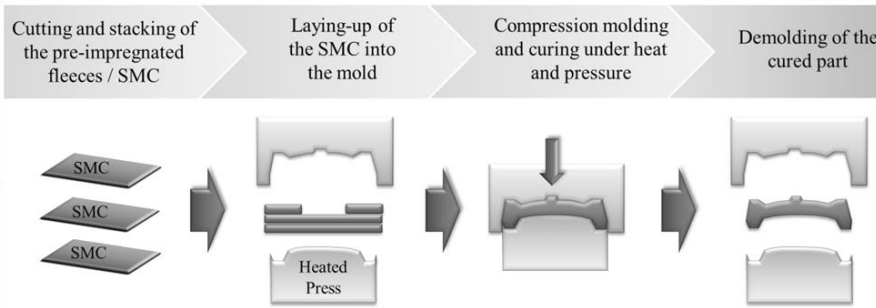
Possibilities for reusing recycled carbon fibers by the production of veils and a modified SMC impregnation process

rC-veil

carboNXT®

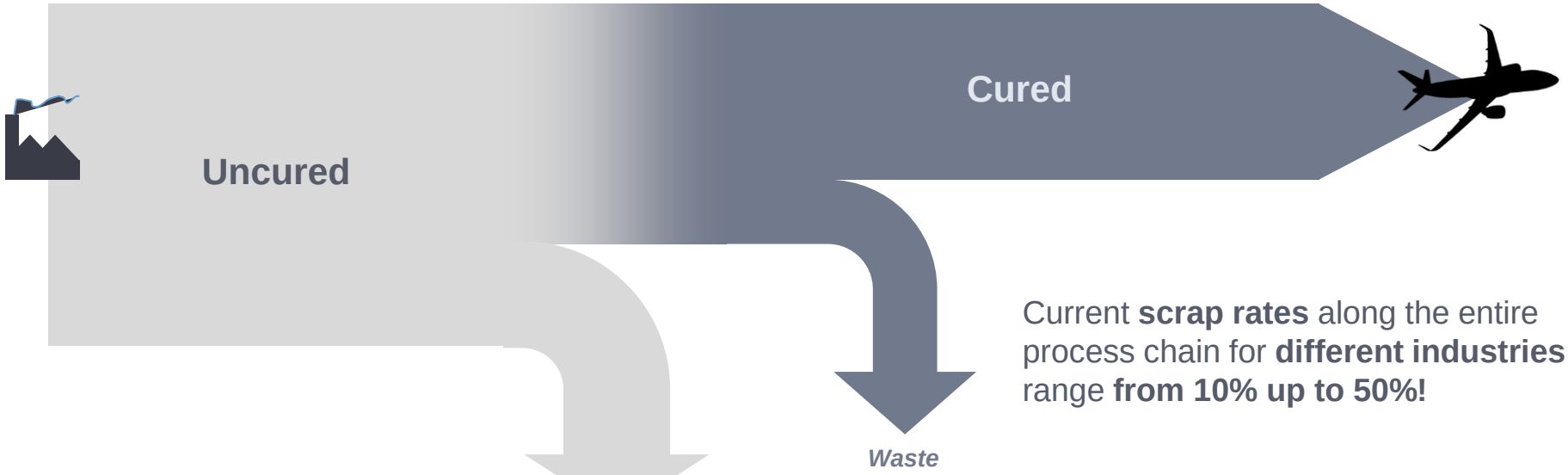


rC-veil SMC



Potential and benefits

CFRP material efficiency of today: high scrap rates



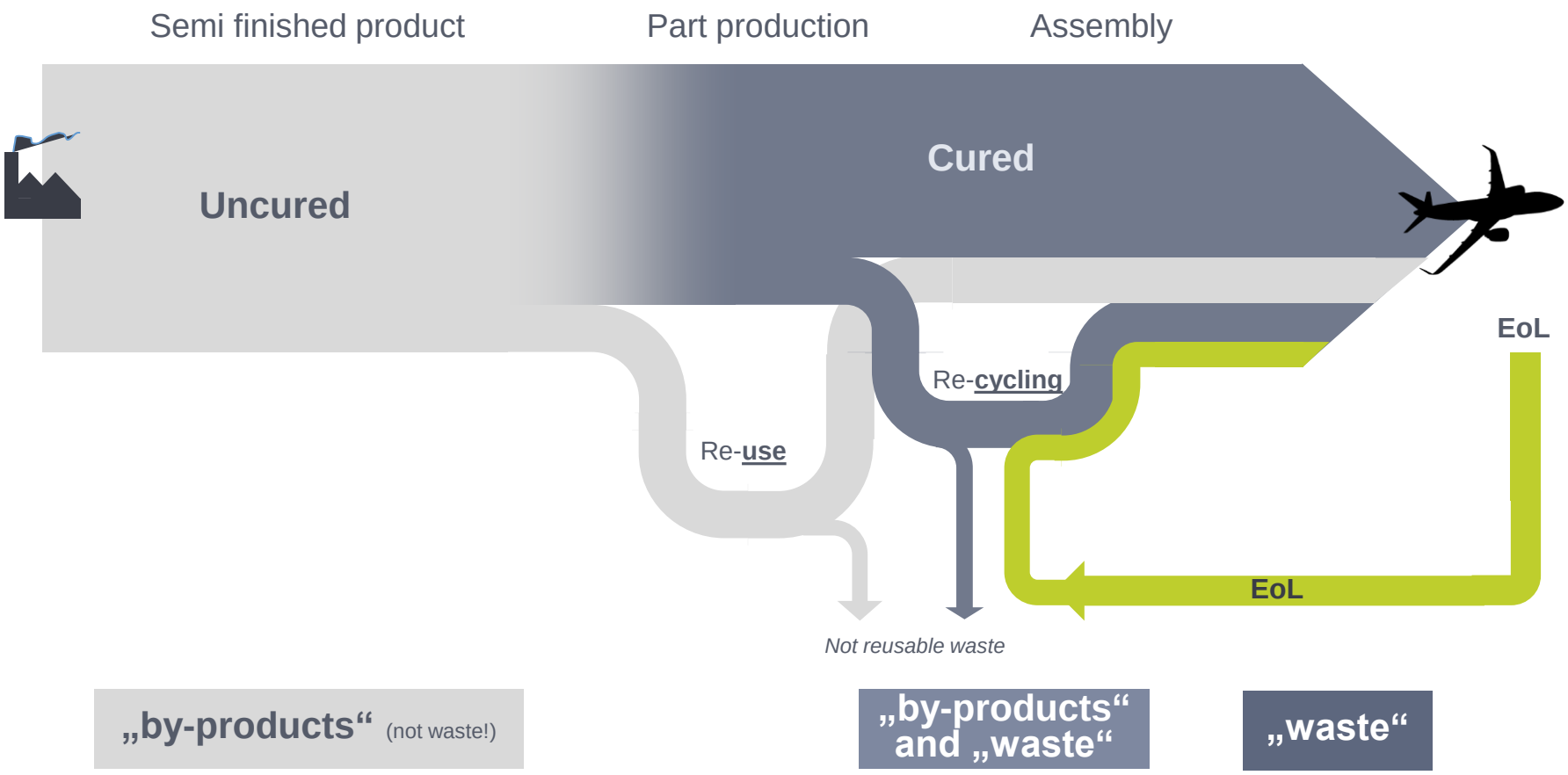
Current **scrap rates** along the entire process chain for **different industries** range **from 10% up to 50%!**

- Clearly defined materials (no „mix“)
- No pollution of the material
- Extensive knowledge of material constituents (REACH)
- High value, high performance
- High “By-to-Fly-Ratio” achievable by use of by-products

- Multiple types and forms of material
- Segregation required
- Variable curing/“freshness“ state
- Traceability and quality inspection required
- Potential volumes to be identified
- Logistics implementation required

Potential and benefits

CFRP material efficiency for future manufacturing



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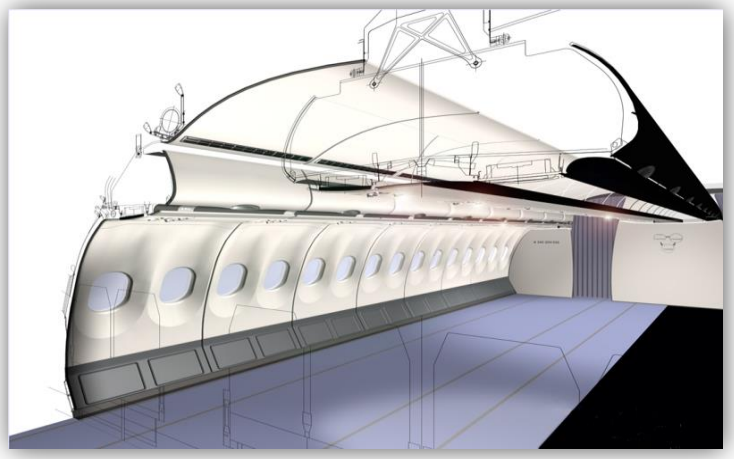
Applications

Cargo foot steps



Source: Airbus

Guide arm cover

Door frame linings
(Source: Diehl Aircabin)

Hatrack housings / endcaps

Hatracks

CF-SMC cleat

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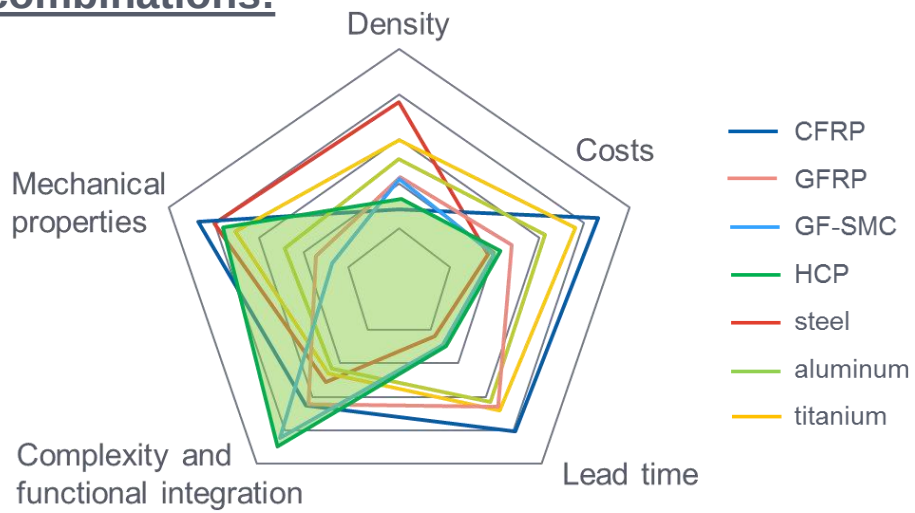
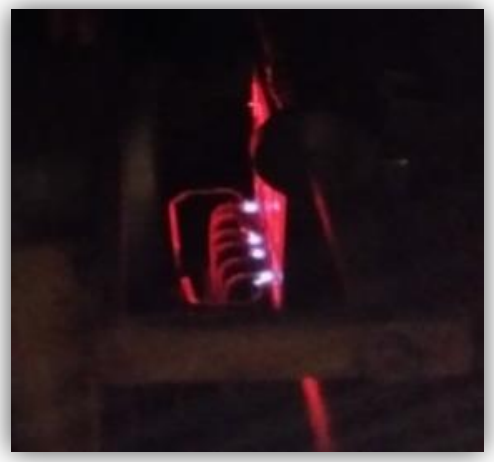
Current investigations

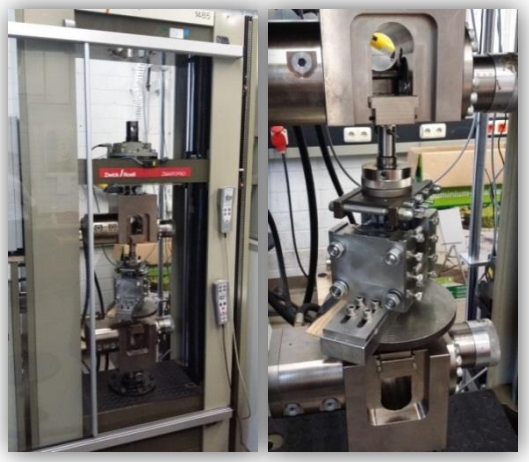
Testing properties of different hybrid SMC combinations:

- Specific density
- Shrinkage
- Fibre volume content
- Bending behaviour
- Tensile behaviour
- Compression behaviour
- Impact behaviour
- Interlaminar shear strength
- Compression after impact
- SEM and ultra sonic analysis
- FST etc.



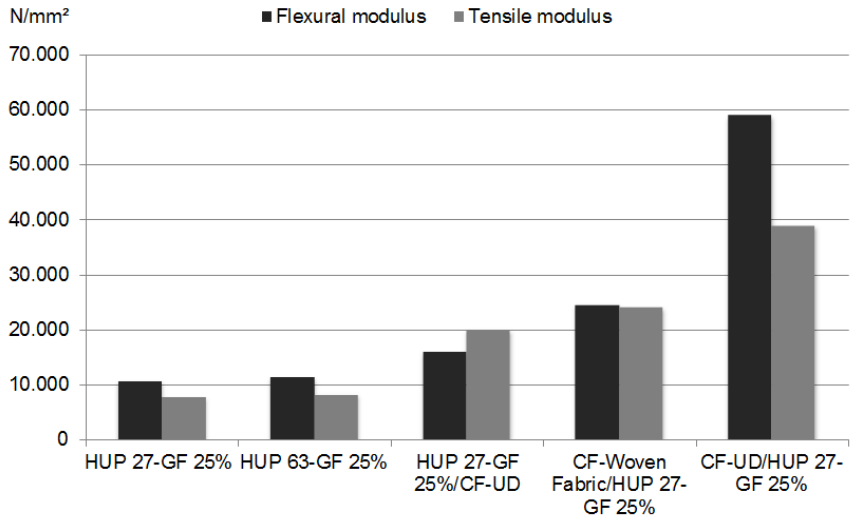


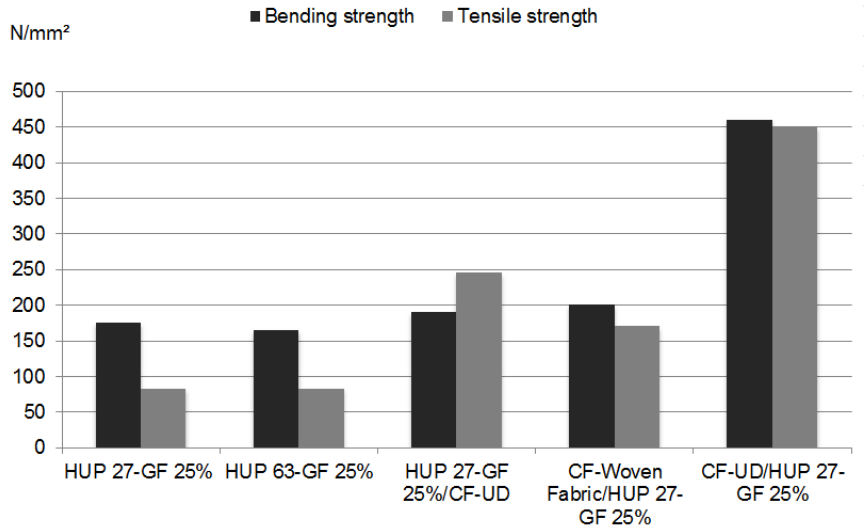
FST test chamber



Testing machine and equipment for CAI

Current investigations





Exemplary results of the investigations on mechanical properties

Density:

- Carbon fiber reinforced material: **1,7 g/cm³**
- Glass fiber reinforced material: **2,1 g/cm³**

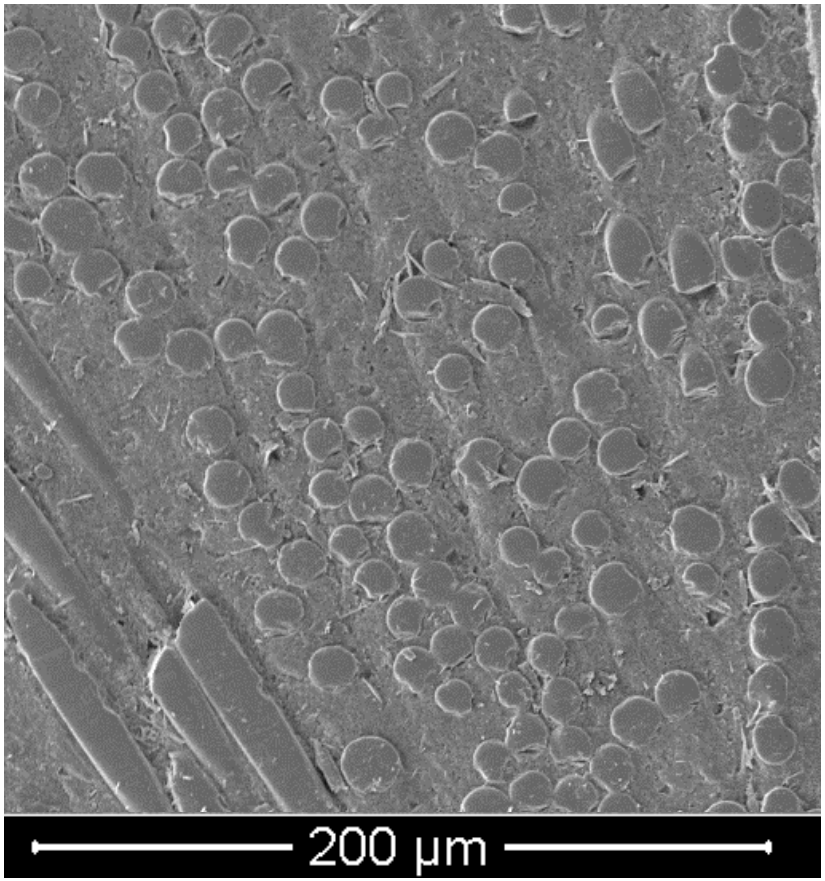
Fiber volume content:

- HUP27 and HUP63: **25 %**
- Carbon fiber woven fabric: **50 %**
- Carbon fiber UD: **50 %**

Test methods:

- **Bending behaviur** according to DIN EN ISO 14125:1998 + AC:2002 + A1:2011
- **Tensile behavior** according to DIN EN ISO 527-4:1997 and DIN EN ISO 527-5:1997

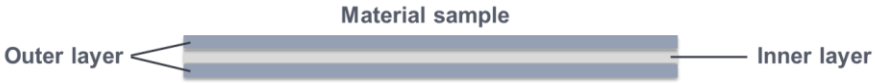
Current investigations



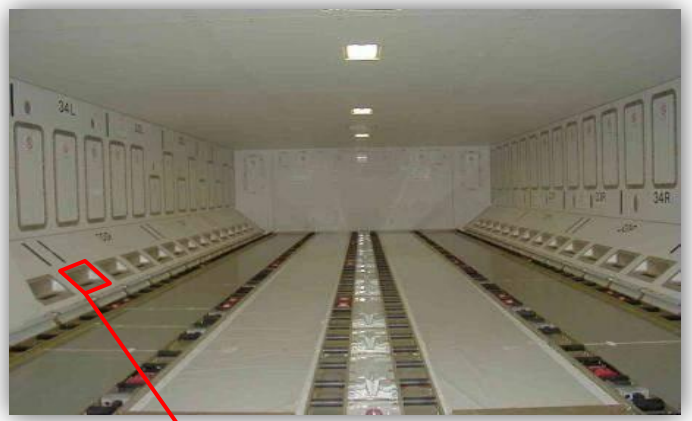
SEM picture of a specimen from carbon fiber SMC based on HUP27; 500x magnification

Optimization of material and process properties

- Chemical adaption of HUP27 and HUP63 to carbon fibers and process
  - optimized interlaminar connection and adhesion
  - better flowability
  - lower level of viscosity
- Optimized production process of the SMC mass
  - improved impregnation of the carbon fibers
  - optimized surface weight
- Adapted and optimized compression and curing process



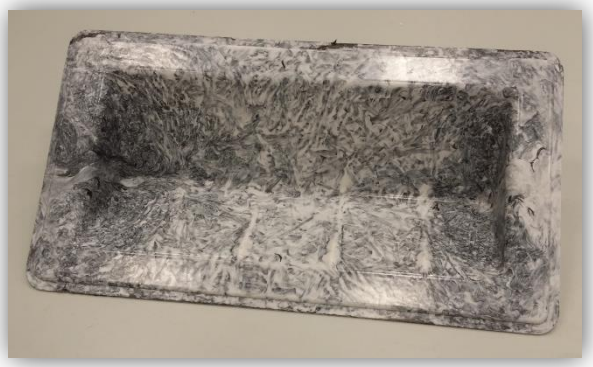
Current investigations



Cargo Area of an Airbus A330

Manufacturing trails with first research components made of carbon fibre SMC with tailored continuous fibres

Cargo foot step made of titanium (source: Airbus)



Cargo foot step made of carbon fibre SMC

Current investigations

Material modelling

Optistruct Model
- Linear elastic
- Material Law 8

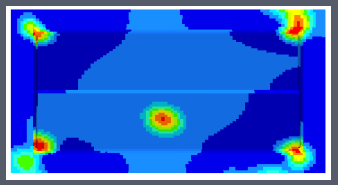
Radioss Model
- Elastic/plastic
- Material Law 25

Optimisation

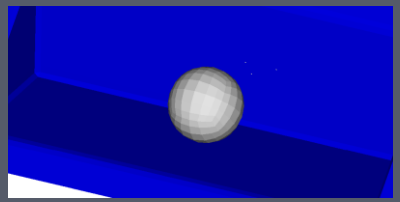
Objective	Constraints	Variables
Minimise mass	Displacement bending	Ply thickness
	Displacement torsion	Laminate thickness
	Displacement impact load	Member size (prepreg width)

Numerical optimisation methodology

Optimised design



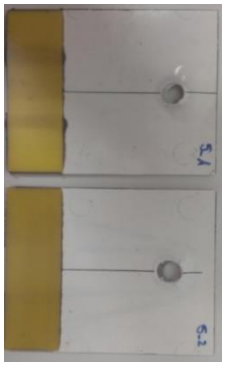
Impact optimisation



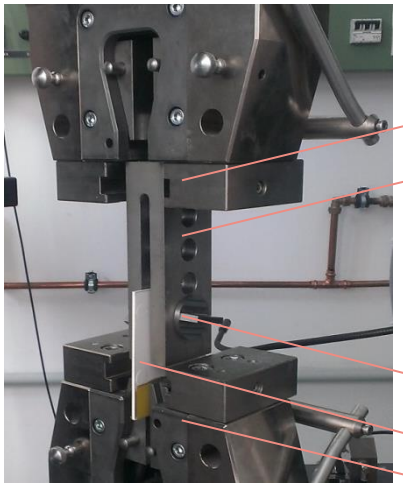
Current investigations

Feasibility analysis of metal insert integration

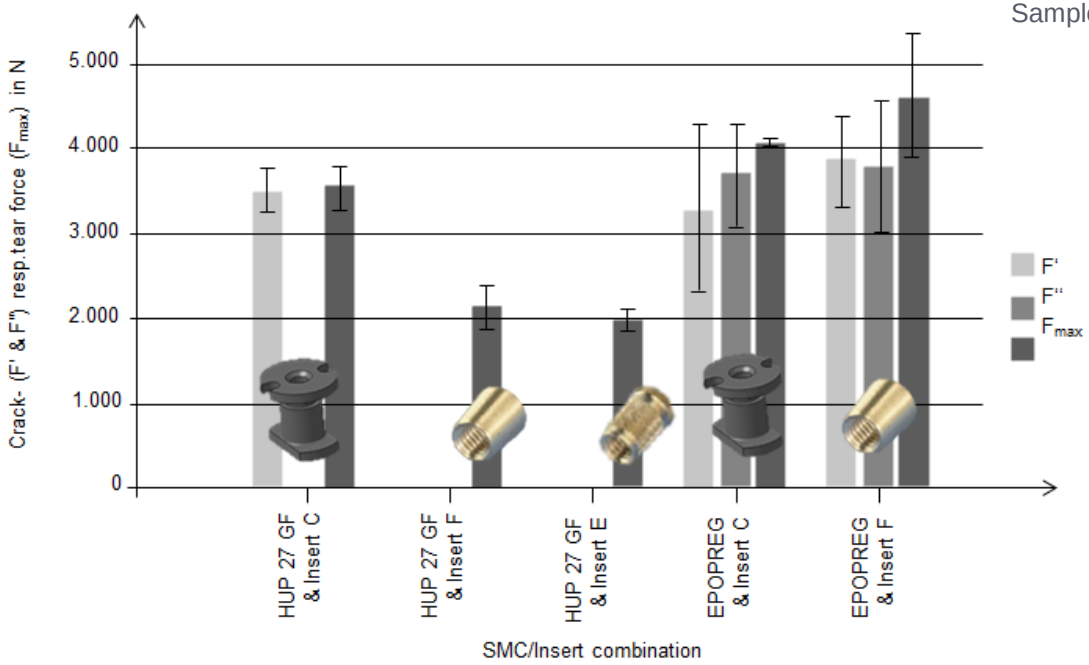
- Tensile tests
- Axial pull out / compression tests



Samples



Tensile tests



Axial pull out / compression tests

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Summary and outlook

- New hybrid process for multi-material combinations
- With commercial, technical and ecological benefits
- Production of light weight, complex and functional aircraft components
- Good automation capacity
- Substitution of different cabin, cargo and secondary structure components
- More comprehensive and aircraft-specific material and process tests
- Development of reliable design and simulation methods

Carbon fibre SMC with EP matrix

Carbon fibre SMC with UP matrix

Thank you very much!

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