



TECHNOLOGIES DESIGN AND MATERIALS EUROPEAN RESEARCH CENTRE

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What is CETMA

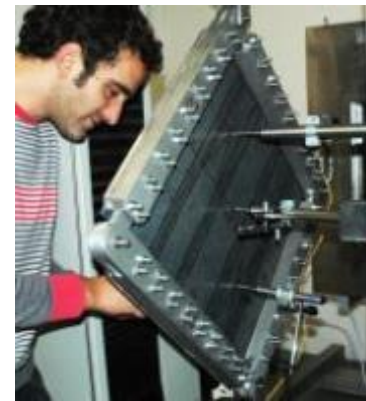
Departments:

☐ Materials and Structure Engineering

- ☐ TEC - Technologies and Processes
- ☐ SIM - Modelling and Simulation
- ☐ DCE - Diagnostics and Civil Engineering

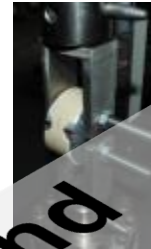
☐ Computer Science and Engineering

☐ Industrial Design



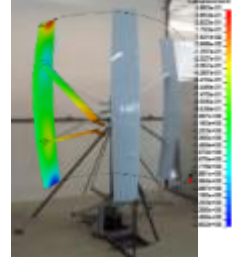
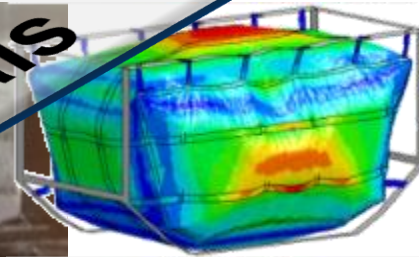
TEC - Technologies and Processes

Development and testing of polymer and composite materials and components



Modelling and simulation for designing of materials, components and processes

Polymeric and composite materials



Scaling-up, process technologies, prototyping



...what we do

TEC - Technologies and Processes

- ❑ Material developers
- ❑ Equipment producers
- ❑ Component/products manufactures
- ❑ Software developers
- ❑ University / Research center

CUSTOMERS / PARTNERS

- ❑ Aeronautics 60% of the activities
- ❑ Automotive
- ❑ Nautical field
- ❑ Sport and leisure
- ❑ Furniture
- ❑ Plastic recycling
- ❑ ...

FIELDS

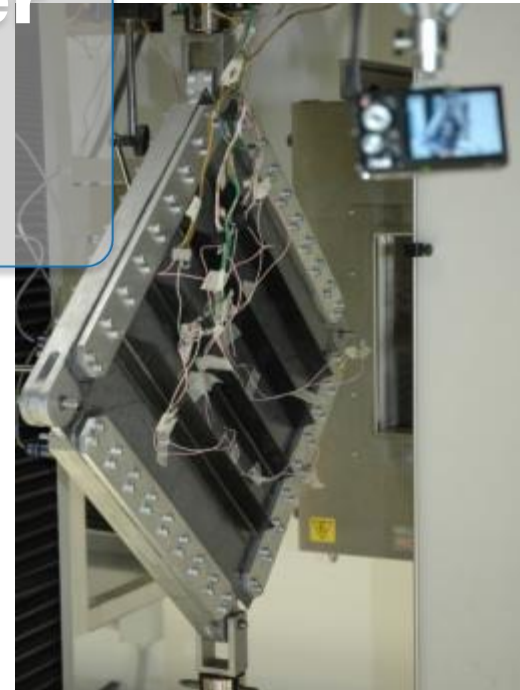
TEC - Technologies and Processes

- ❑ Compression moulding lines - lab and pilot scale
- ❑ RTM
- ❑ Industrial induction welding equipment
- ❑ Autoclave
- ❑ Rotational moulding
- ❑ Extrusion

COMING
SOON!

**Certified supplier
for aeronautic
companies**

- ❑ Dynamometers
- ❑ DSC, TGA, DMA
- ❑ Thermographic camera
- ❑ HDT e VICAT temperature
- ❑ MFI
- ❑ Chromatography (GPC - HPLC)

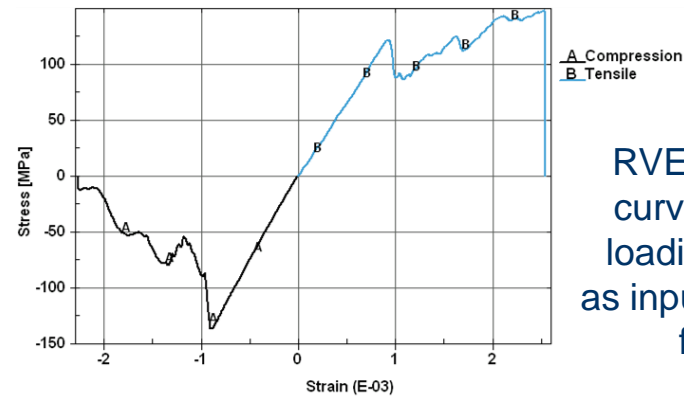
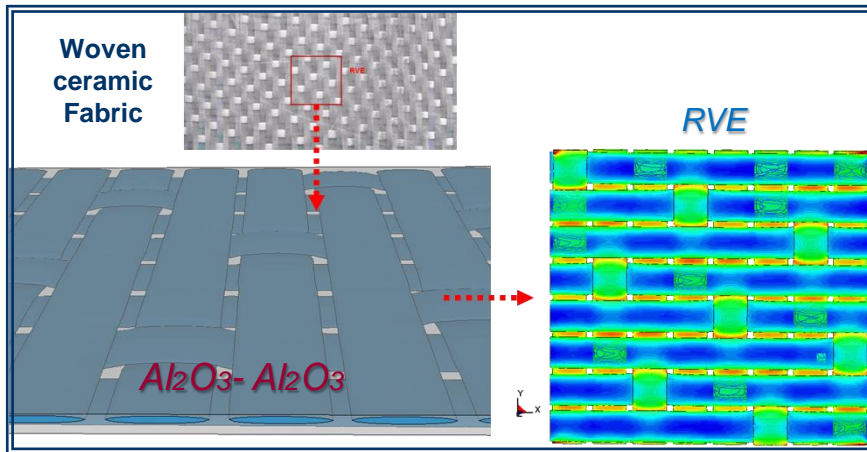


equipment

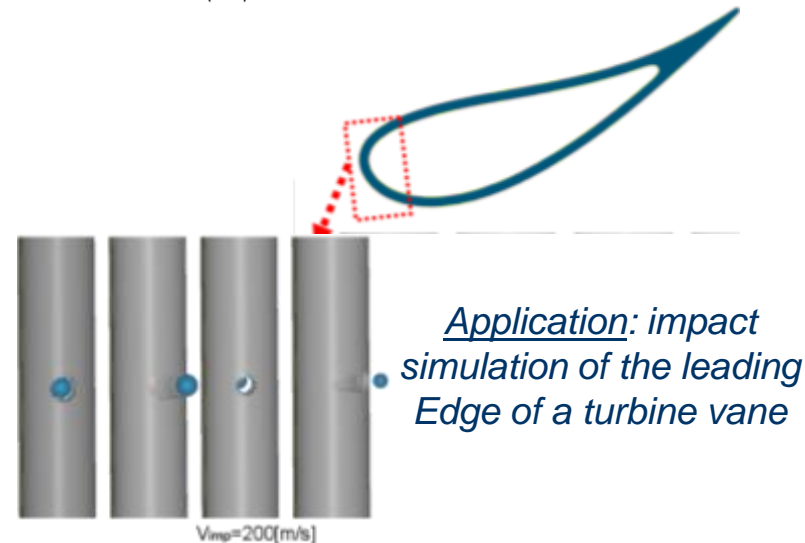
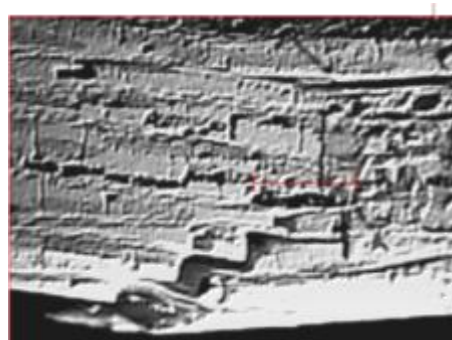
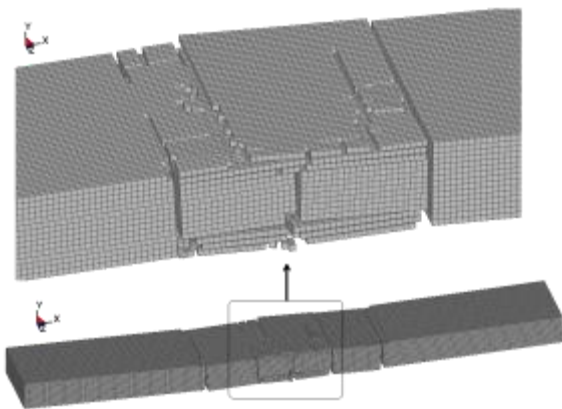
SIM - Modelling & Simulation

Numerical modelling – LS DYNA

Modelling of Ceramic Matrix Composite for Aerospace Applications



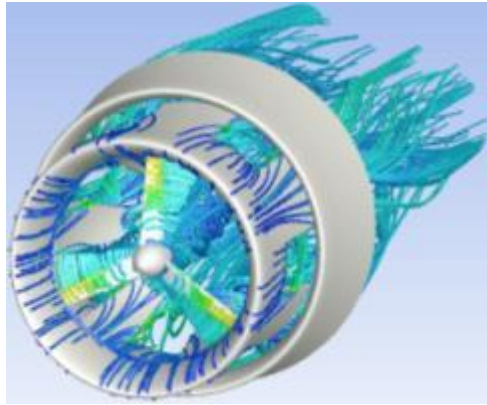
RVE Stress-strain curves in different loading conditions, as input for the macro f.e. model



Structural analysis

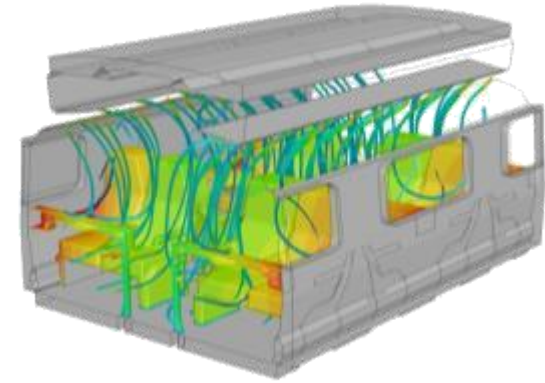
SIM - Modelling & Simulation

CFD and Discrete Element modelling - FLUENT

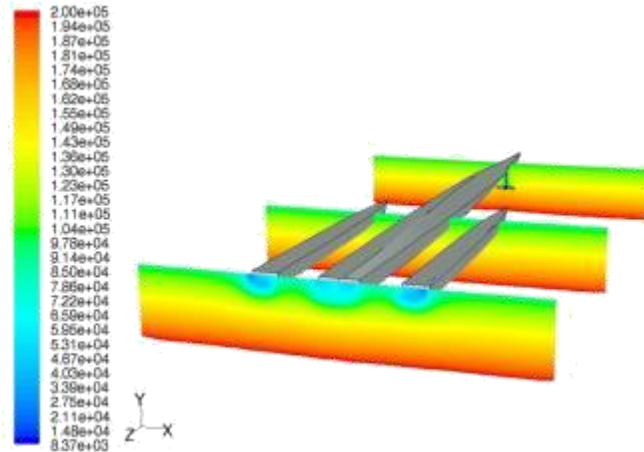


Fluid-Dynamic Analysis of Wind Turbines

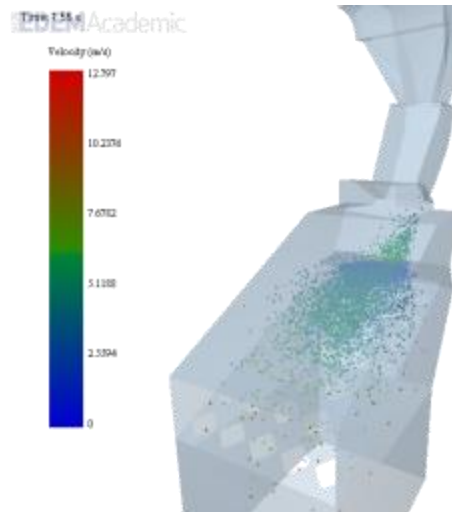
- Heat Exchange
- Fluid-Dynamics and Hydrodynamics
- Gas Dispersion
- Fluid-Structure Interaction
- Industrial particle handling



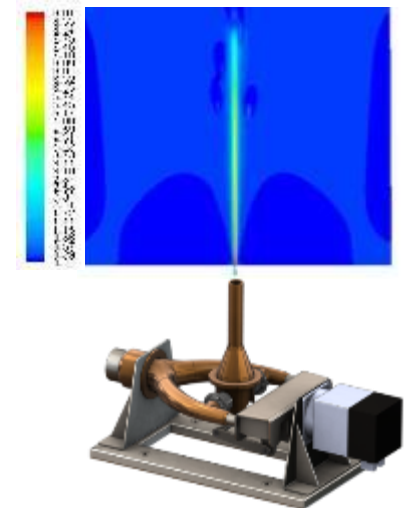
HVAC system analysis of a passenger coach



Hydrodynamic behavior analysis of a Fast Ship and its T-Foil system (Pressure contour (Pa))



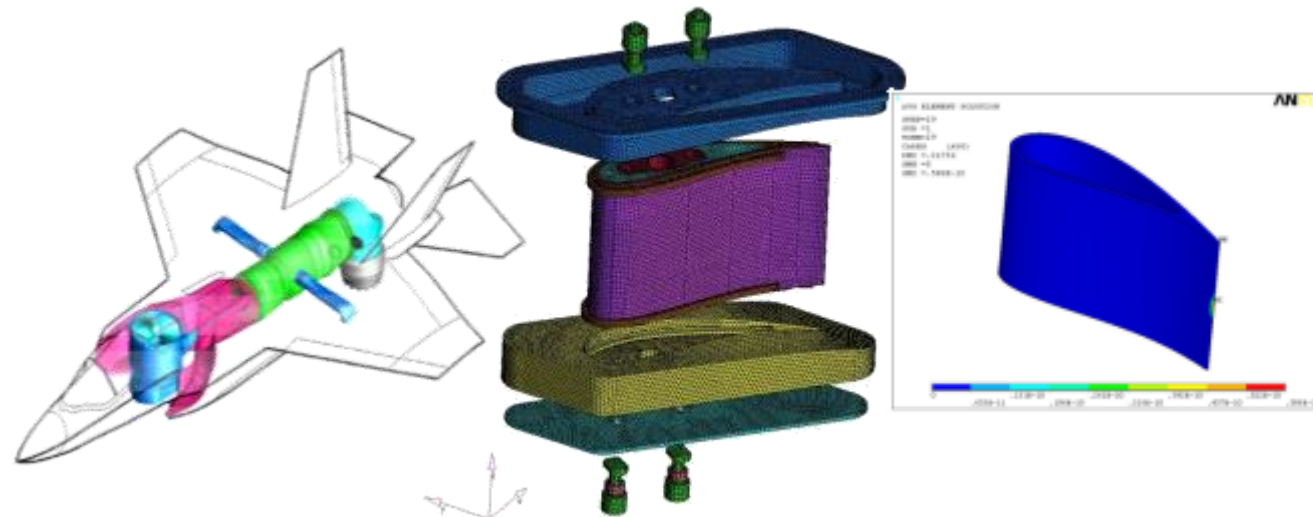
DE simulation results of a vibrating screen



Multiphase analysis of an high performance Water Nozzle

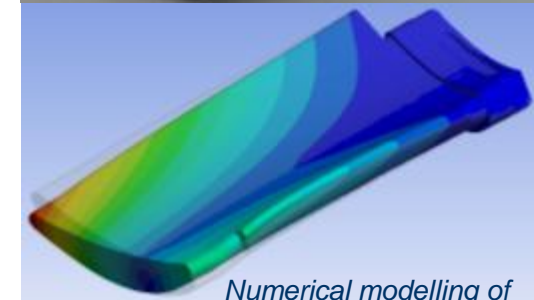
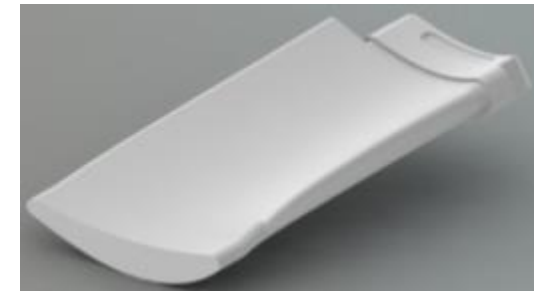
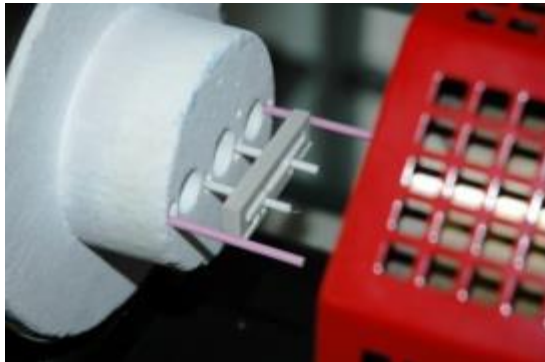
SIM - Modelling & Simulation

Thermo-structural and reliability analysis of a ceramic vane for aeronautic turbine - ANSYS



European Patent : “Numerical-experimental methodology to study the viscous behavior of materials”

LOCAL SOLUTION
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KEYW=0
POLYLO/ADLOC
DEPU2=1
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DMS=2.004
-4.025
-2.258
-2.504
-1.763
-1.063
-1.20194
-4.4754E
5.193
5.936
3.806



Numerical modelling of ceramic core for turbine vane

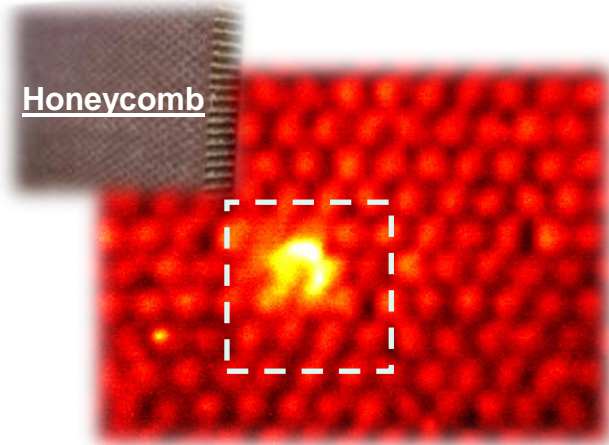
DCE - Diagnostics and Civil Engineering

NON DESTRUCTIVE EVALUATION OF COMPONENTS

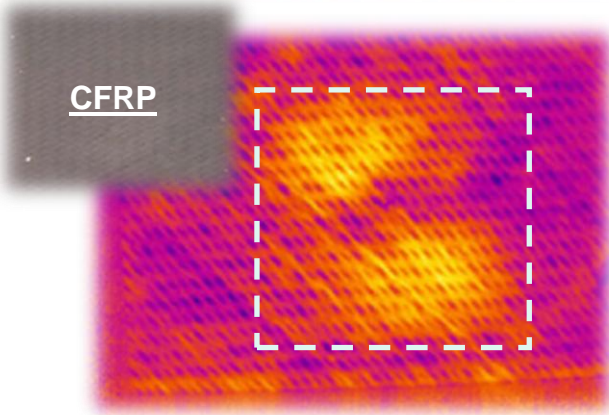
Structural integrity evaluation and quality control

Impact Fault

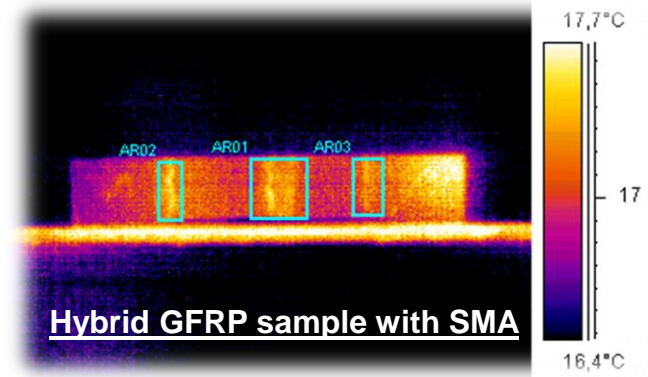
Honeycomb



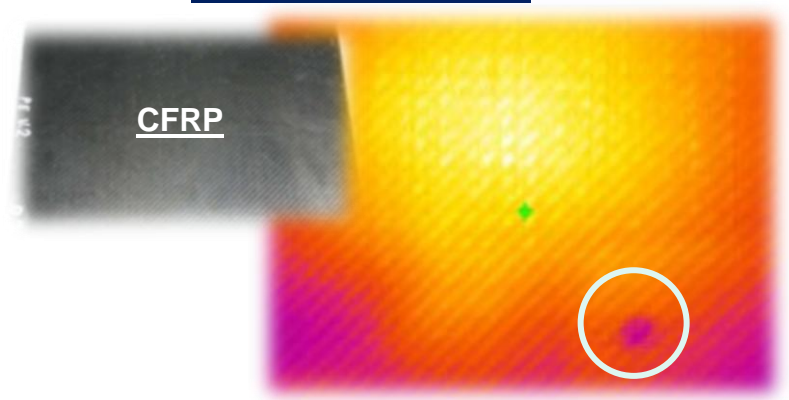
CFRP



Delamination



Void/detachment



DCE - Diagnostics and Civil Engineering

STRUCTURAL HEALTH MONITORING

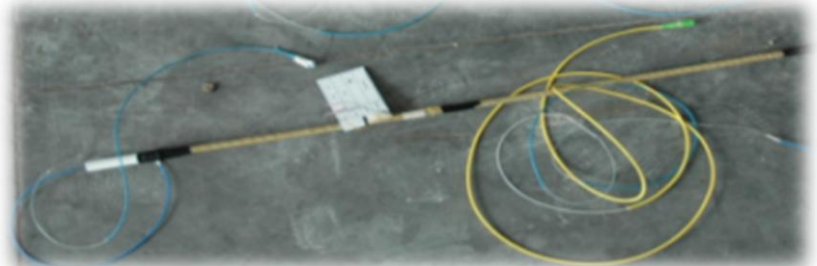
FRP materials with embedded optical fiber sensors for both reinforcing and real time monitoring functionalities



smart patch



smart textile



smart rebar

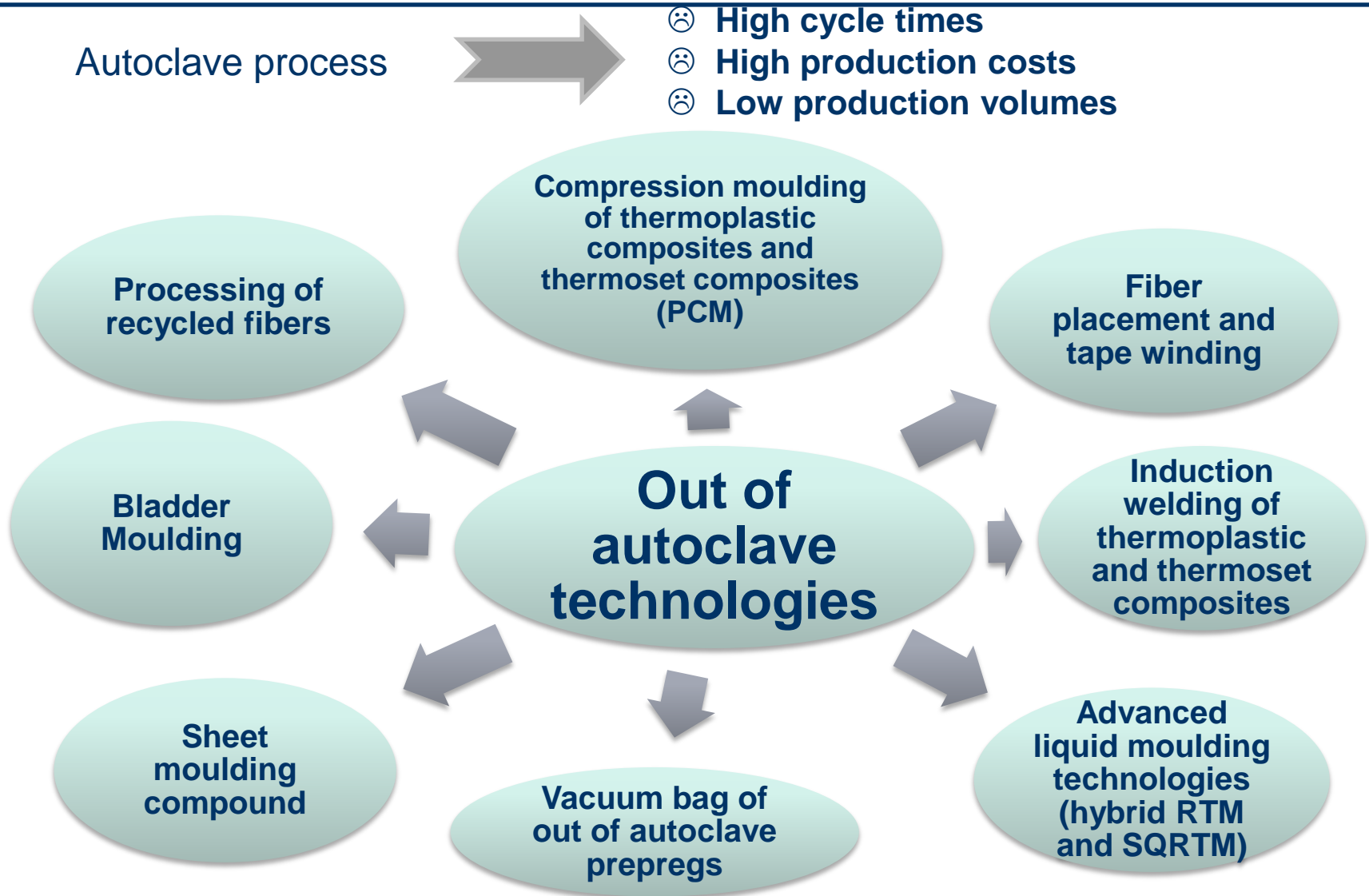


Smart patch for composite repairing
and real – time monitoring



Smart materials

Development of Out of Autoclave processes for the Aerospace sector

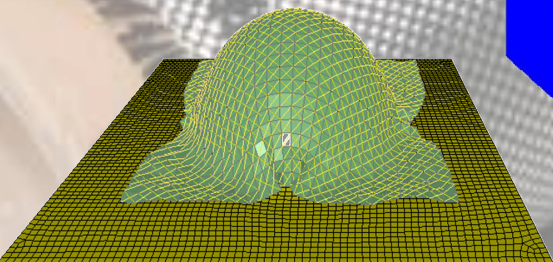


CETMA is a leader at European level in the development of OOA processes optimized for aeronautical components

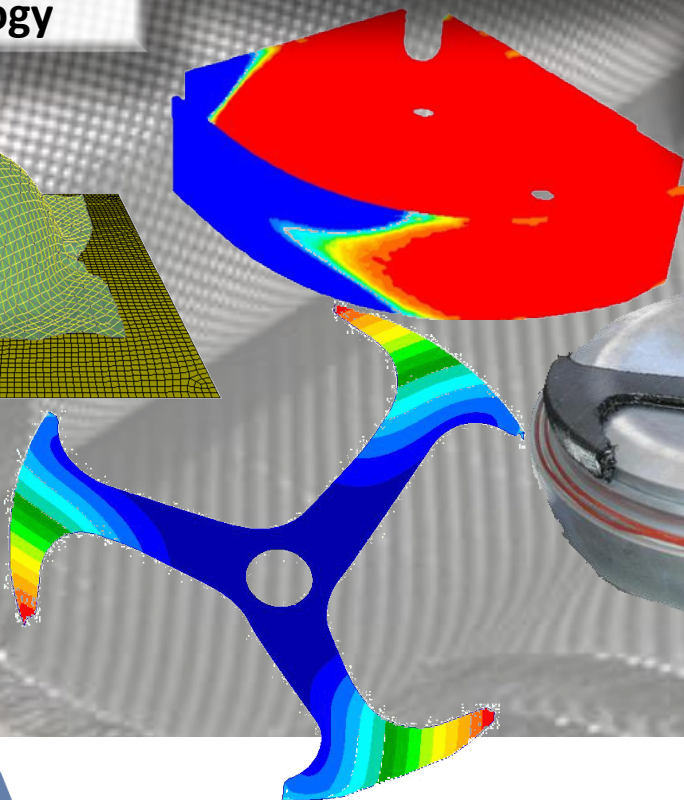
RTM

..Advanced components for Aerospace sector...

Advanced design
methodology



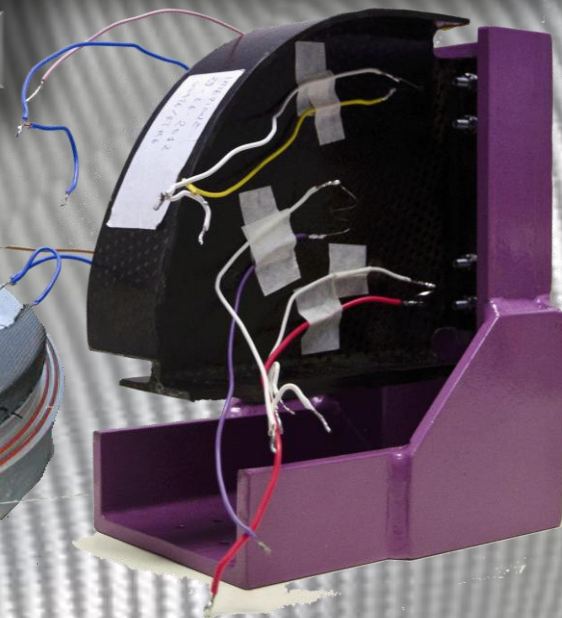
Process
optimization



Tools



Parts manufacturing and
validation



Requirements

Experimental activities

Materials

Resins, Reinforcements, Binders, Inserts

Experimental activities

Physical and mechanical tests for allowables generation

Preliminary component design

Experimental activities

Reinforcement permeability
Resin properties

Modelling

Structural FEM analysis

Modelling

Draping analysis

Modelling

Fluydodinamic process analysis

Final component design

Mould design

Preform design

Process design

Component manufacturing and validation

Experimental activities for materials properties evaluation

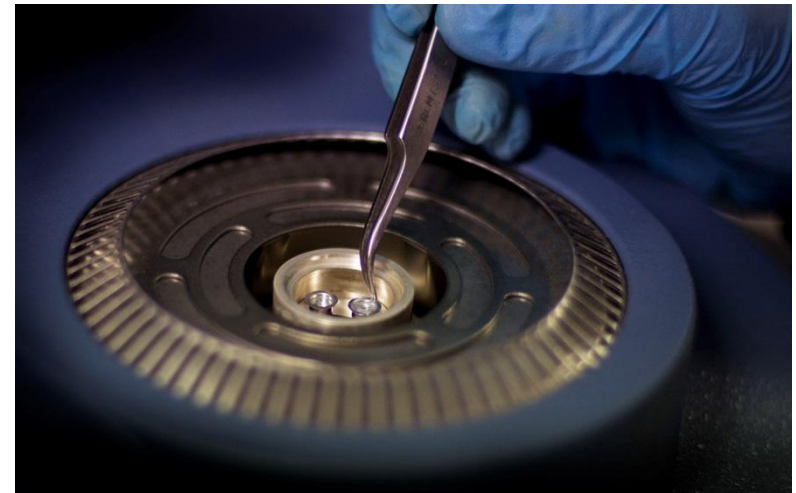
Matrices

RTM6 epoxy resin by Hexcel
RTM6-2 epoxy resin by Hexcel
BZ9110 benzoxazine resin by Henkel
BZ9130 benzoxazine resin by Henkel
EP2004 Epoxy resin by Cytec
Elium 150 acrylic resin by Arkema
Elium C1 acrylic resin by Arkema
EC114W340 epoxy resin by Elantas

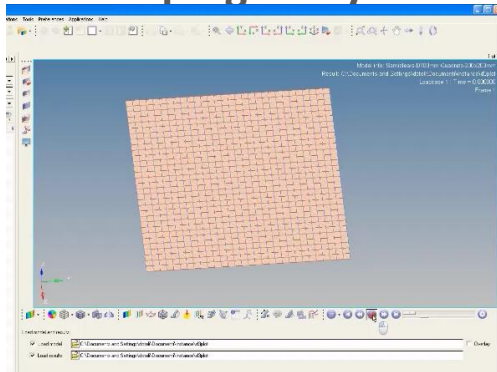
Reinforcements

G0926 carbon fabric by Hexcel
G0803 carbon fabric by Hexcel
G0947 UD carbon by Hexcel

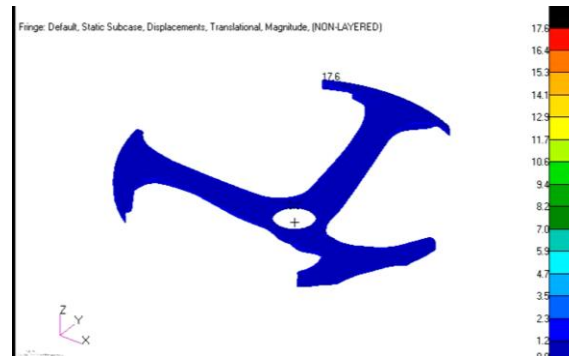
Allowables definition (RTD HTW)
Fatigue properties evaluation
Physical and chemical properties



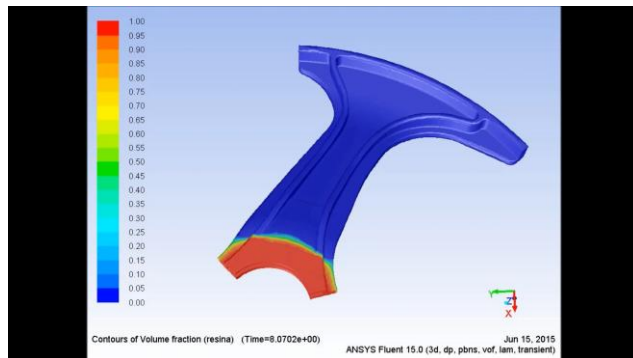
Draping analysis



Structural analysis



Process simulation



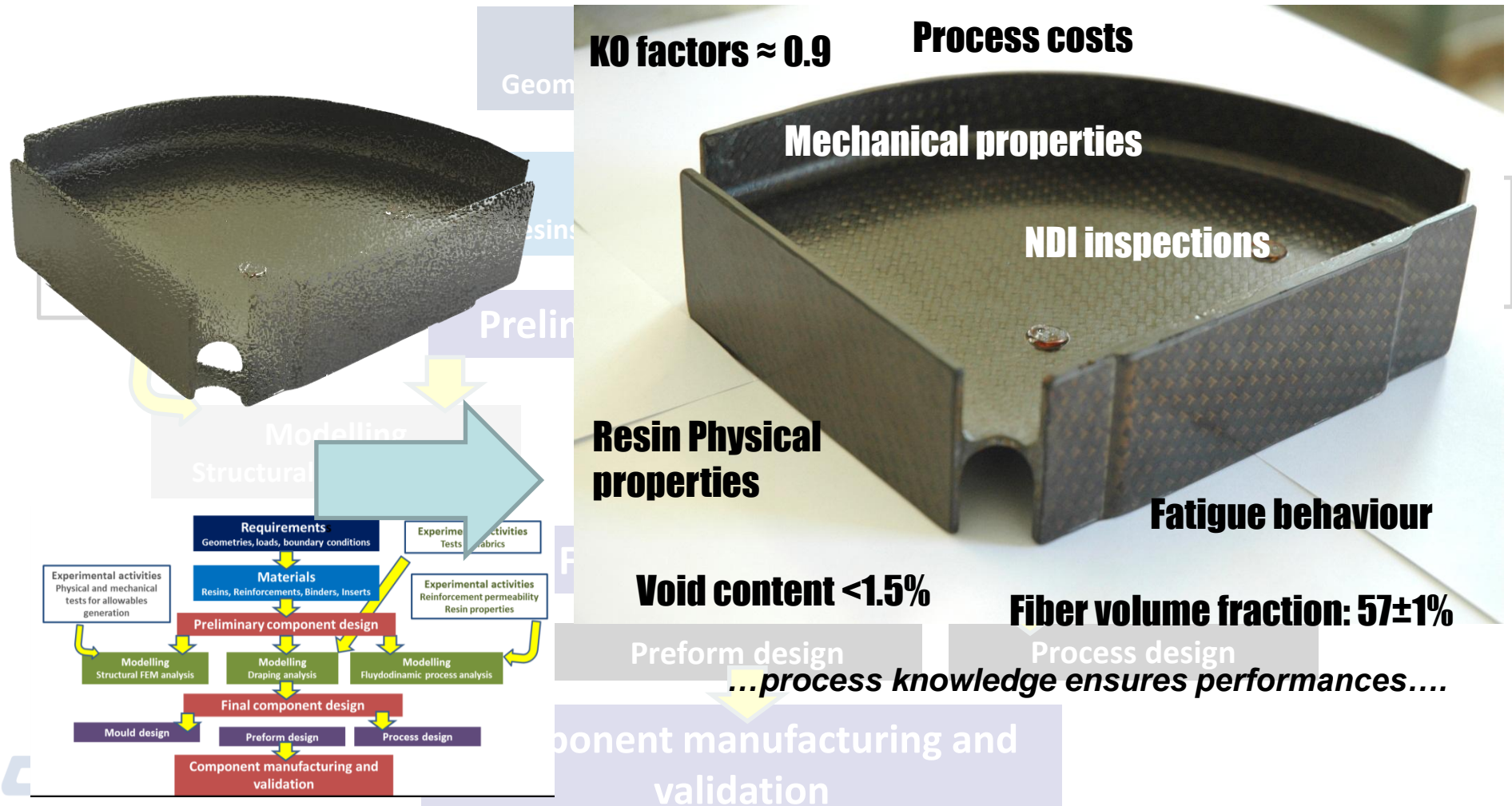
Dynamic analysis



FEM TOOLS

RTM

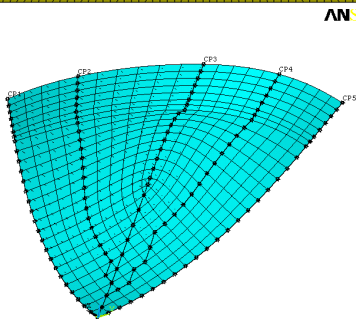
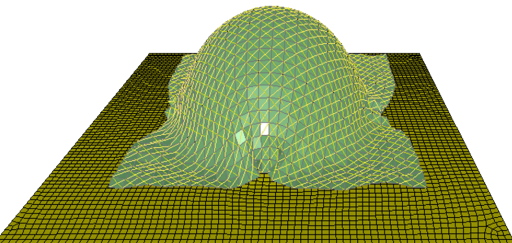
..Advanced components for Aerospace sector...



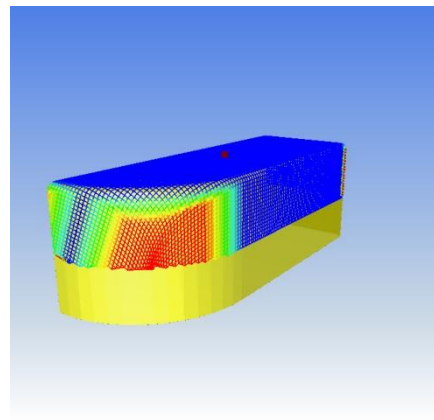
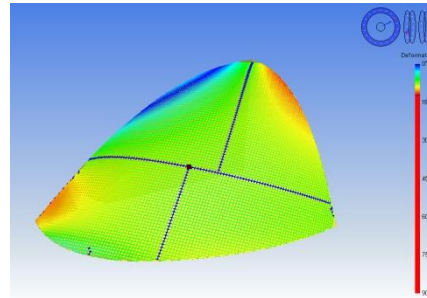
Compression Moulding

..Advanced components for Aerospace sector...

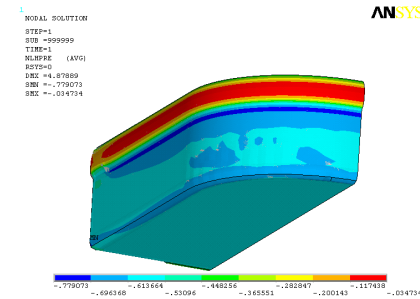
Advanced design methodology



Process optimization



Tools



Parts manufacturing and validation



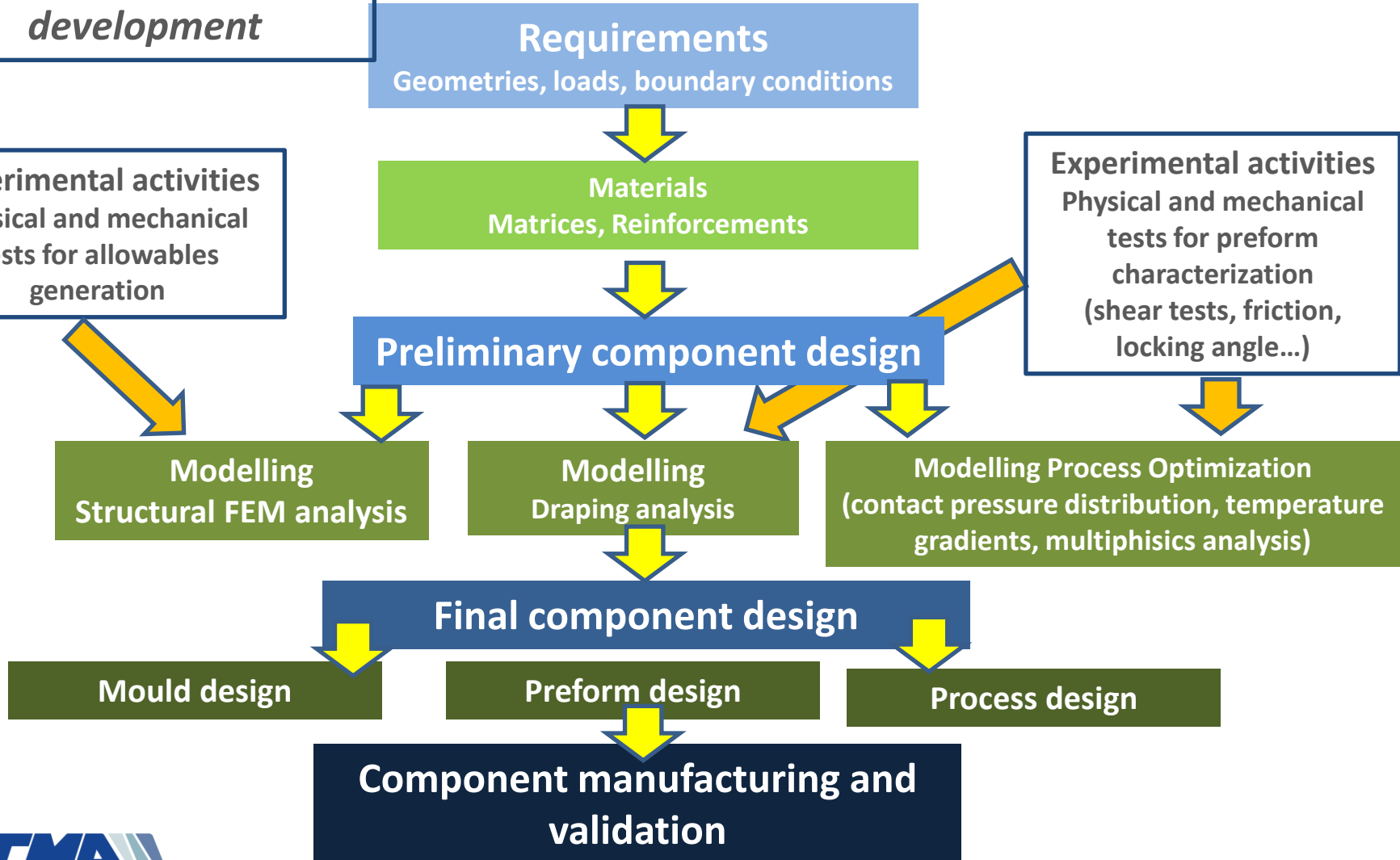
Compression Moulding

..Advanced components for Aerospace sector...

*Integrated Approach to
composite component
development*

Experimental activities
Physical and mechanical
tests for allowables
generation

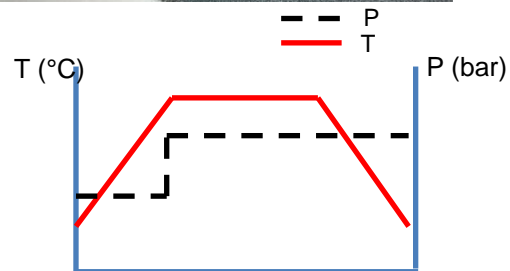
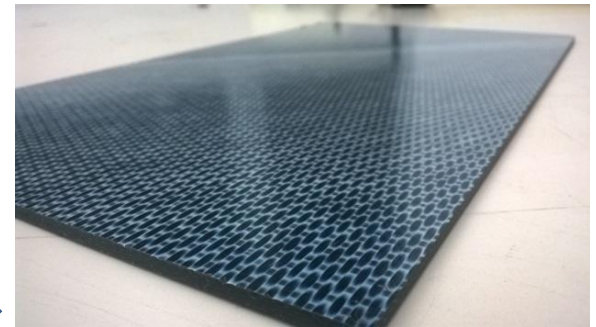
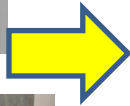
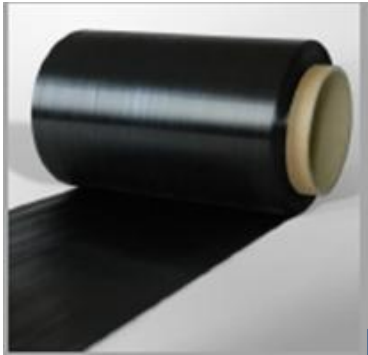
Experimental activities
Physical and mechanical
tests for preform
characterization
(shear tests, friction,
locking angle...)



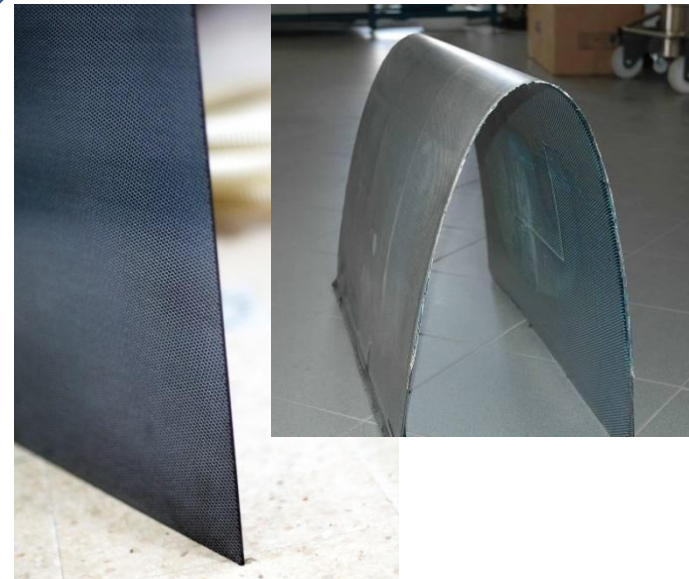
Compression Moulding

..Advanced components for Aerospace sector...

Isothermal compression molding



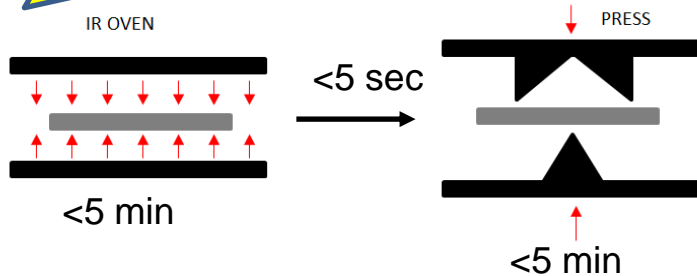
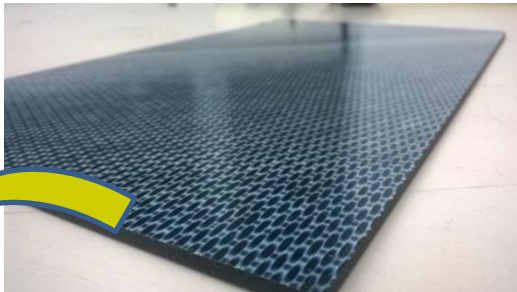
Tmax= 450 °C
Max force=1000 tonn



Compression Moulding

..Advanced components for Aerospace sector...

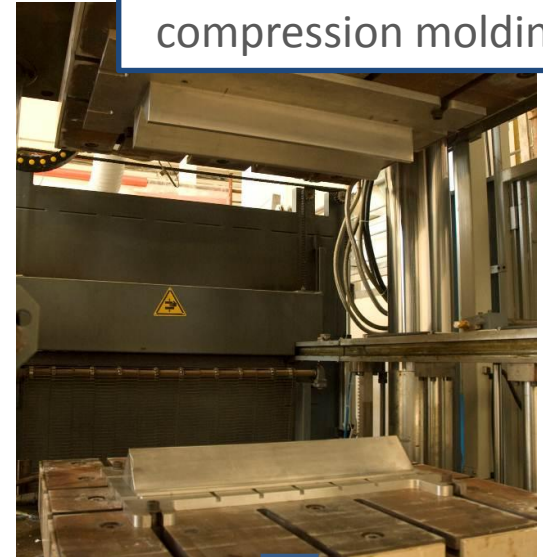
Non-Isothermal
compression molding



Rubber forming
compression
molding



Match-die
compression molding



Compression Moulding

..Advanced components for Aerospace sector...

Weldability
(e.g. Induction Welding)

High temperature
service

Process costs

Repairability

Mechanical properties

Fiber volume
fraction $\approx 60\%$

NDI
inspections

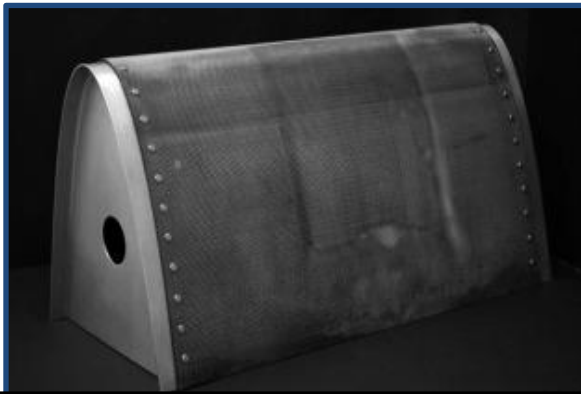
*...process knowledge
ensures
performances....*

Low Void content

FST properties

Compression Moulding

Examples of thermoplastic composite components developed at CETMA



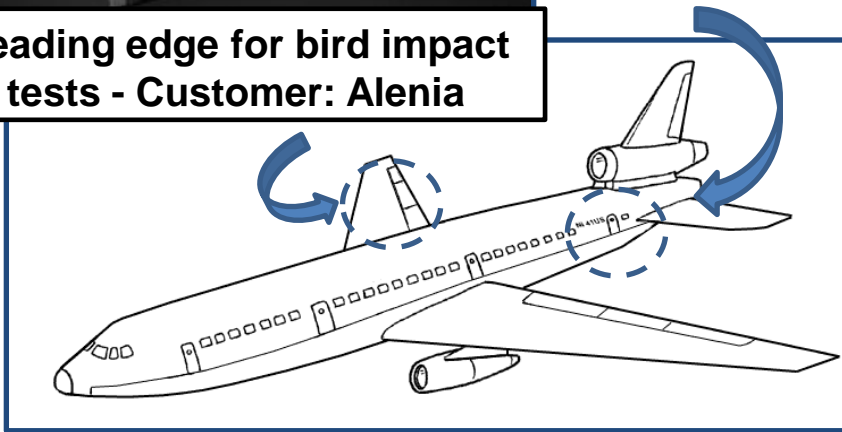
Leading edge for bird impact tests - Customer: Alenia



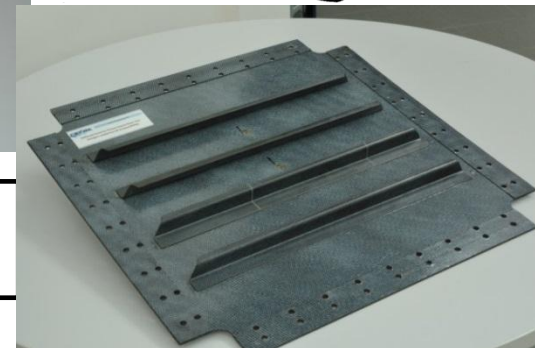
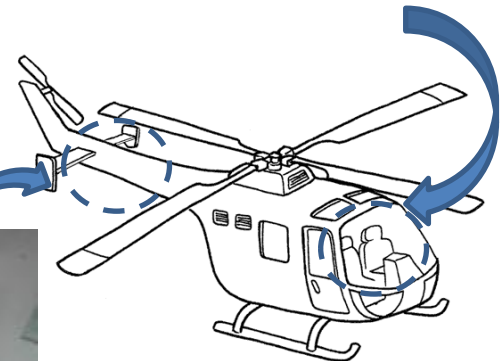
Lower edge beam
Customer: Alenia



Thermoplastic rib
Customer: AW



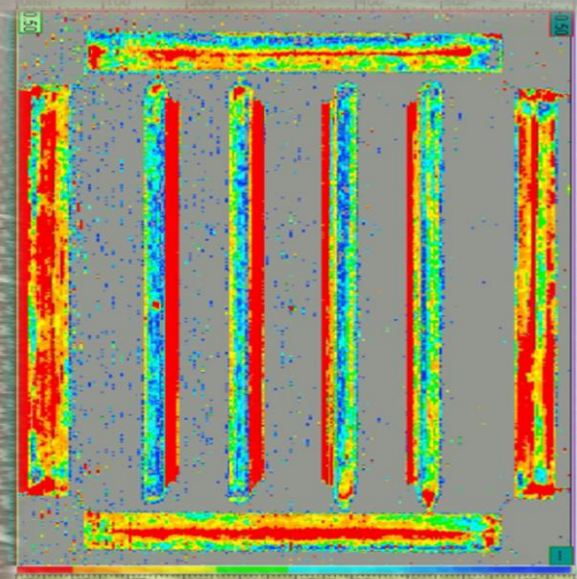
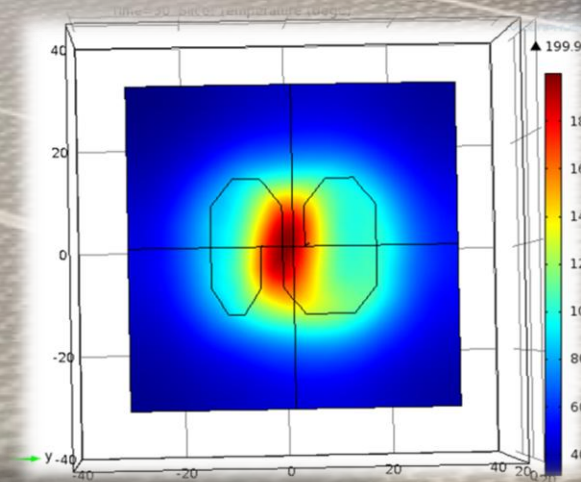
Stringers for stiffened panel
Customer: AW



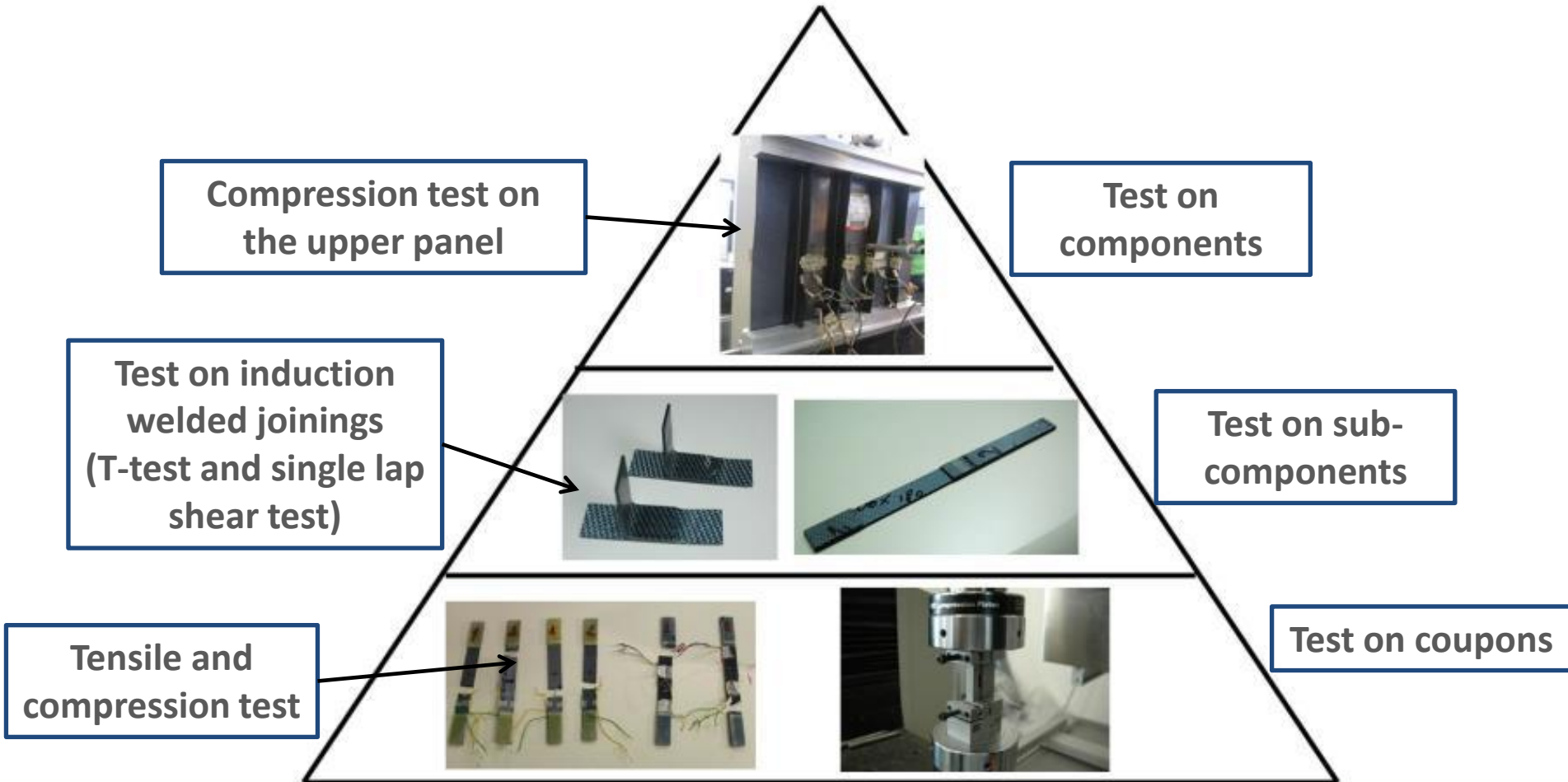
Process Optimization



Allowables generation



Certification of induction welding process by building block approach



Properties

IW

Process costs
optimization

Automation
Possibility to weld
complex shapes

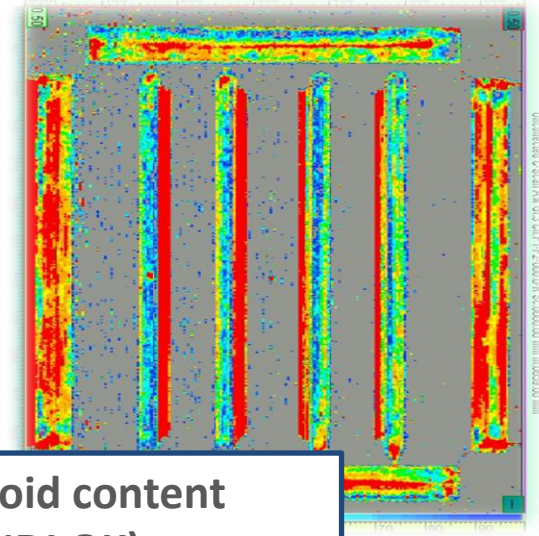
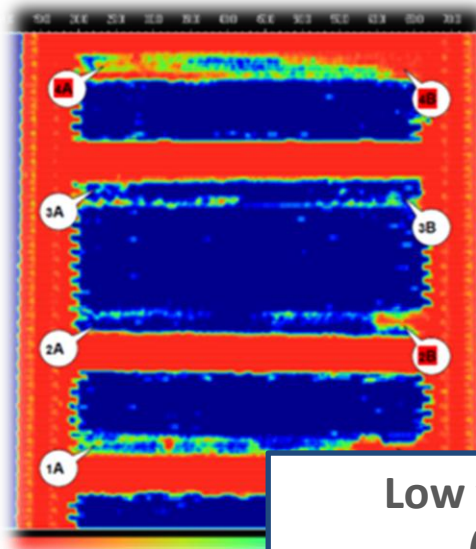
Possibility to weld
thick laminates
(> 4 mm)

T joint
strength
10N/mm

Single lap
shear strength
30 MPa

High mechanical properties

Possibility to weld
Thermoplastic and
Thermoset composites



Low void content
(NDI OK)

6-Axis Robot

Innovative continuous IW machine patented by CETMA



Possibility to install the welding head on a robotic arm (1° option)

Possibility to move small components around the induction head (2° option)



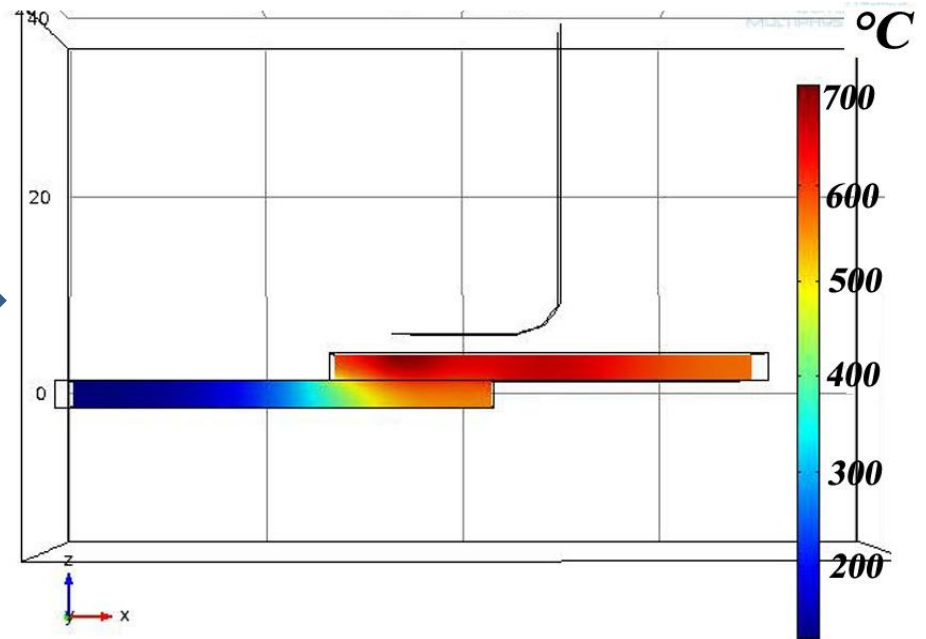
The new induction welding machine is equipped with an innovative control & cooling system (PATENT PENDING)



**Optimal temperature distribution within the material!
No edge effect!**



Traditional Induction welding technology: Temperature distribution in a single lap joint

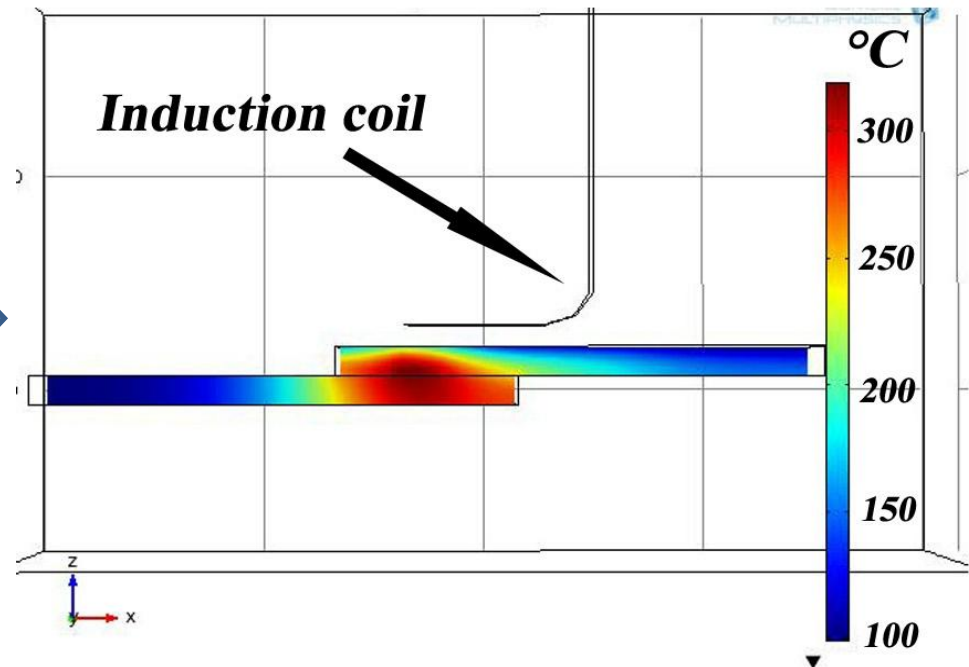
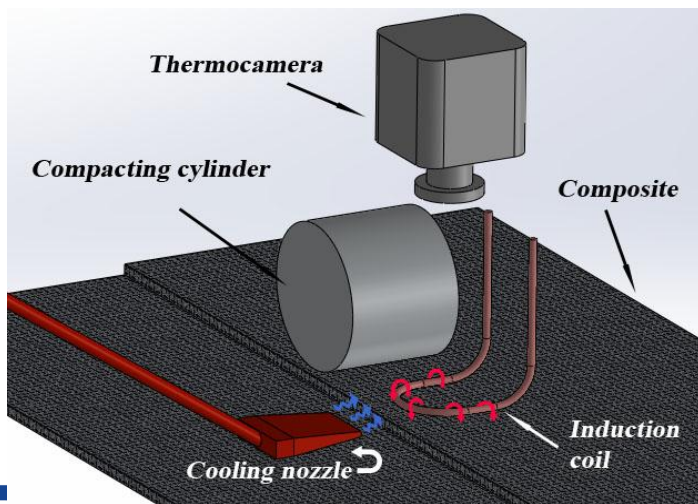


The new induction welding machine is equipped with an innovative control & cooling system (PATENT PENDING)

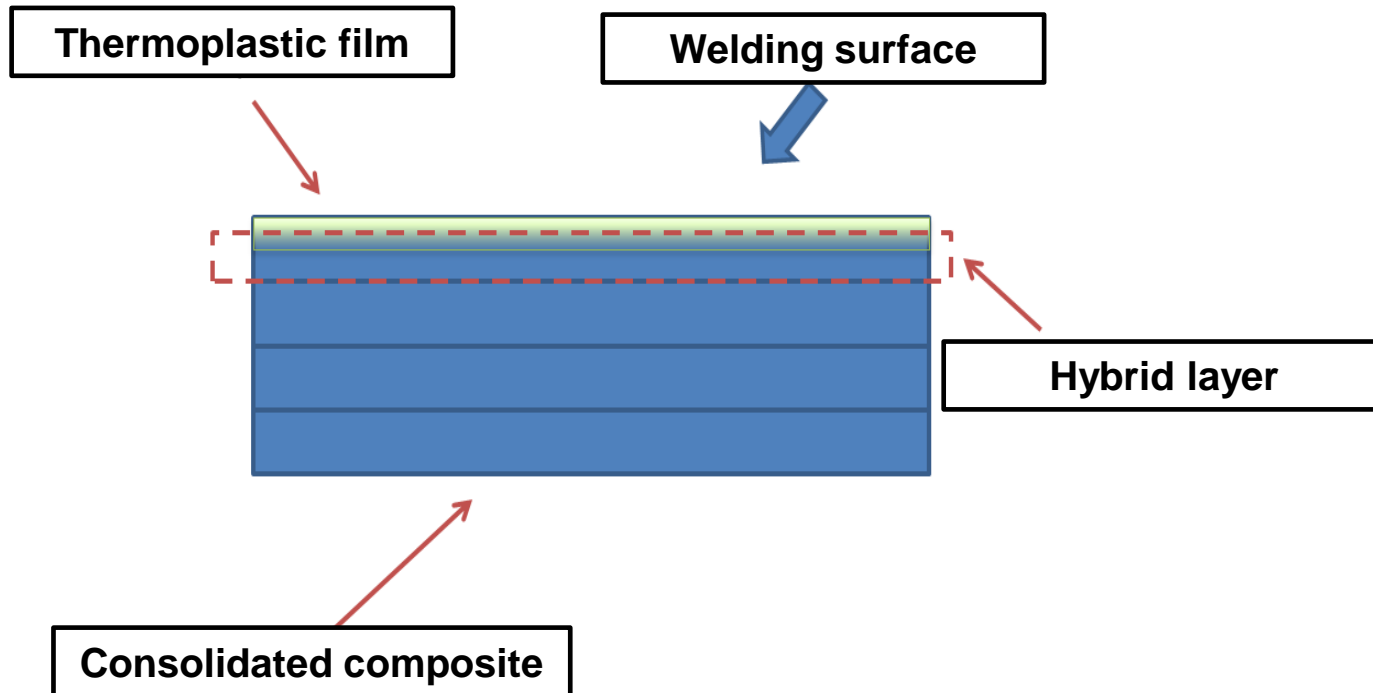
**Optimal temperature distribution within the material!
No edge effect!**



CETMA continuous IW technology



“Welding of thermoset substrates by a suitable thermoplastic hybrid interlayer”



Welding of thermoset components made according to the traditional cycles (autoclave, RTM), using a thermoplastic film in the area to be joined.

Materials

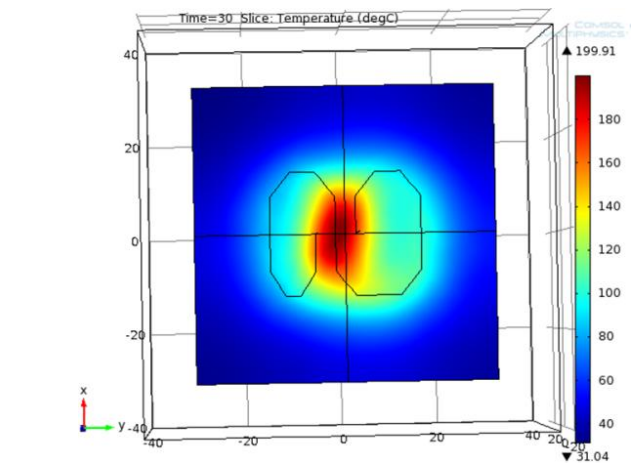
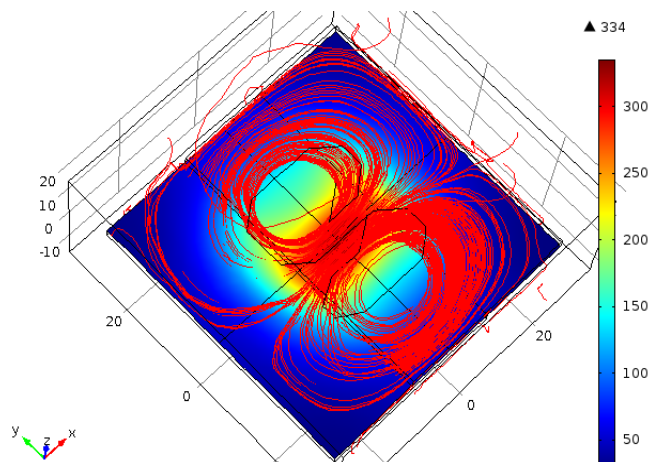
Matrices

PPS by Tencate (TenCate Cetex® TC1100)
PEEK by Toho Tenax (Vestakeep® 2000)
PEI
PEKK
PP
PA6 by Tencate (TenCate Cetex® TC910)
PA12 by Griltex-EMS
Epoxy/PVB (polyvinyl butyral) hybrid system

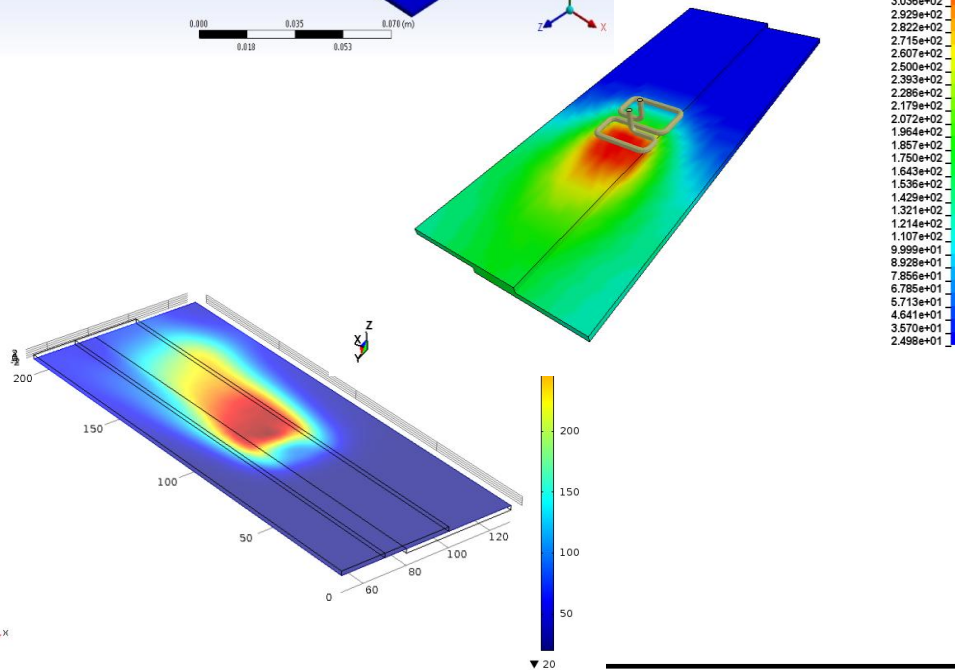
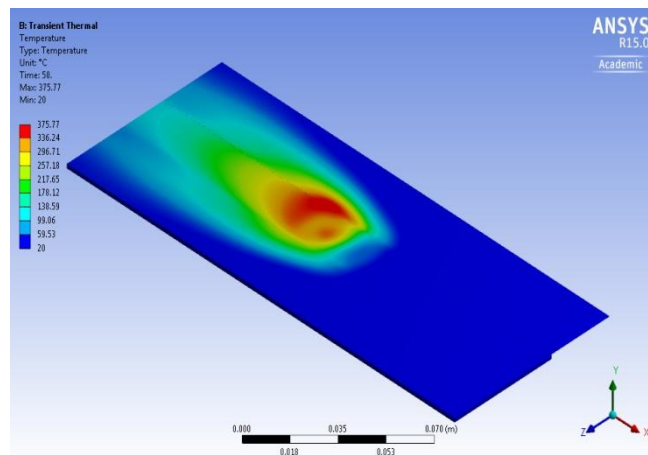
Reinforcements

5HS Weave Carbon Fiber Fabric by Toho Tenax (Tenax®-E HTA40 3K)
UD Carbon Fibers by Toho Tenax (Tenax®-E HTS45 12 K)
5HS Weave Carbon Fiber Fabric by Tencate (TenCate Cetex® TC1100)
UD Carbon Fibers by Tencate (TenCate Cetex® TC910)

Static process simulations

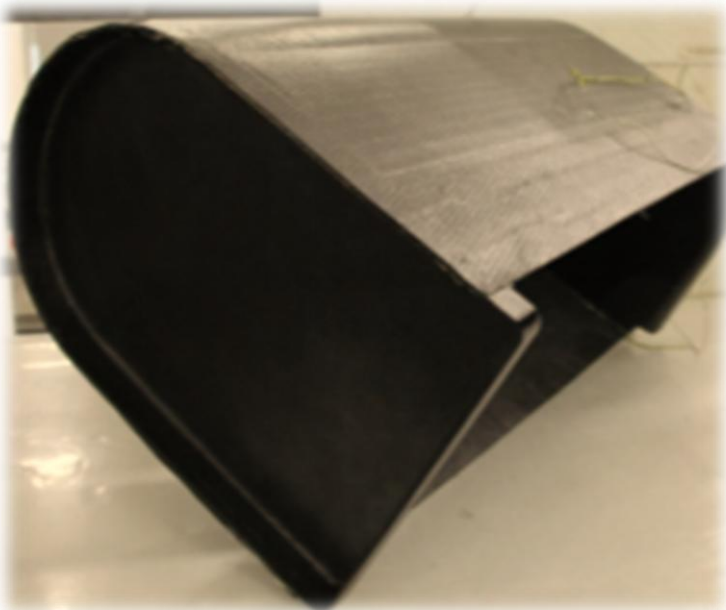
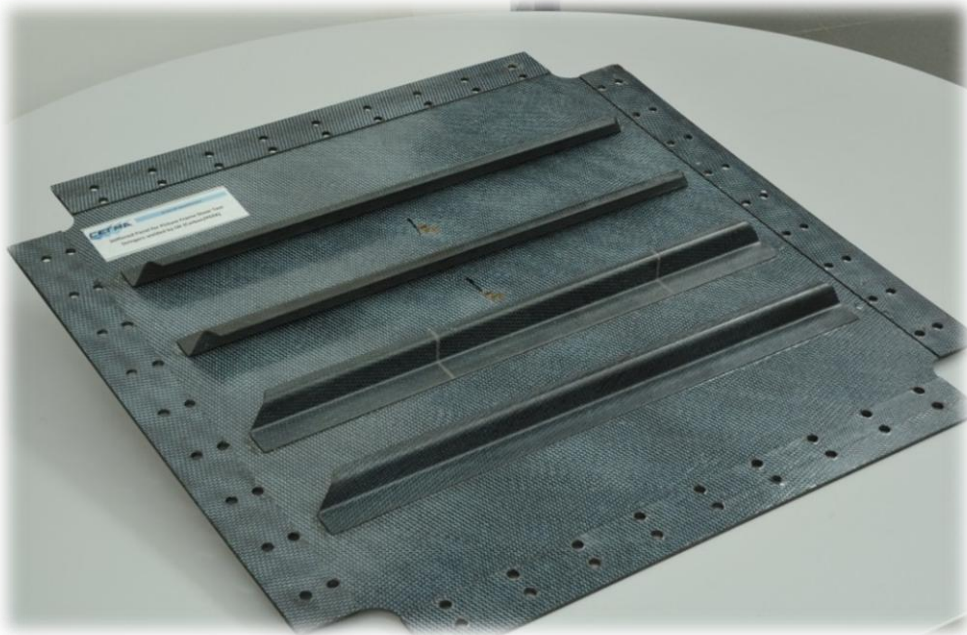


Dynamic process simulations



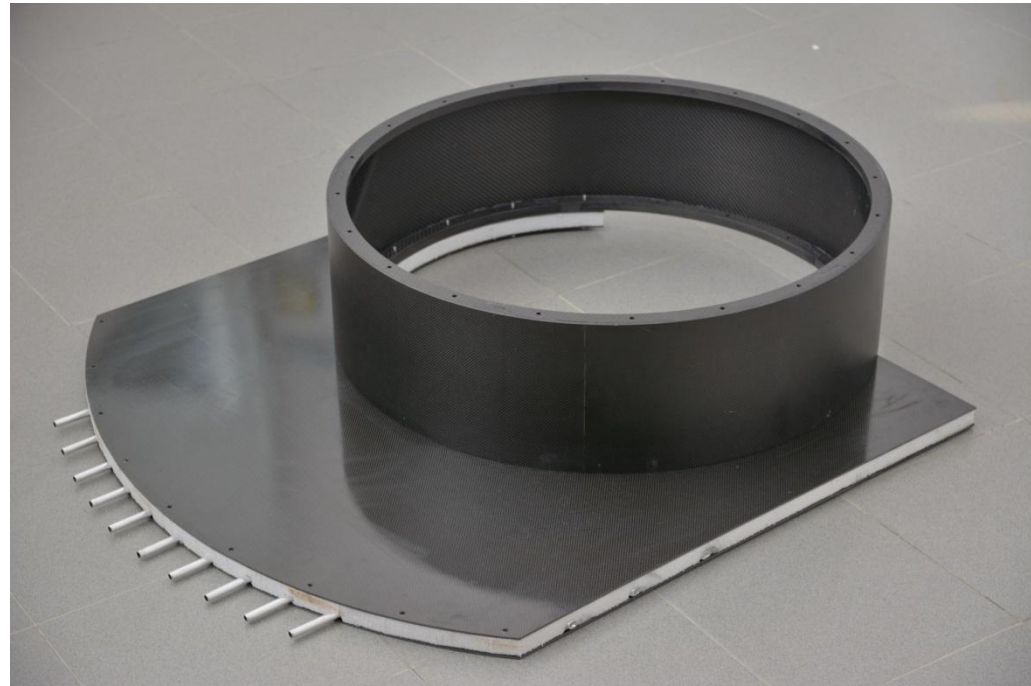
Prototypes

IW



Vacuum bag of OoA preregs

Development of a process for complex shape components with OOA prepreg



Sheet and bulk moulding compound

Development of prototypes with Sheet Bulk Compounds

- ✓ Complex shape
- ✓ Very low cycle times

Sheet moulding compound

Hexcel HEXMC 2000C
R1A system (carbon epoxy)



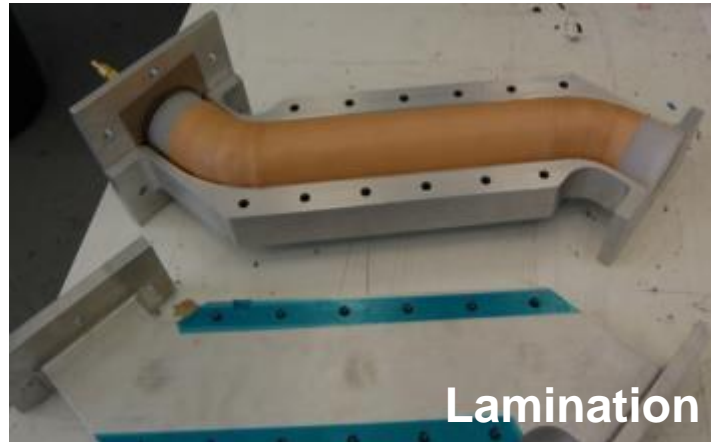
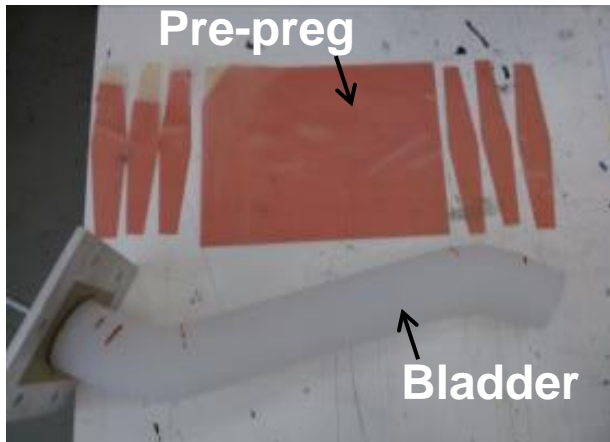
Sheet moulding compound

Polynt S8010
(glass vinylester)



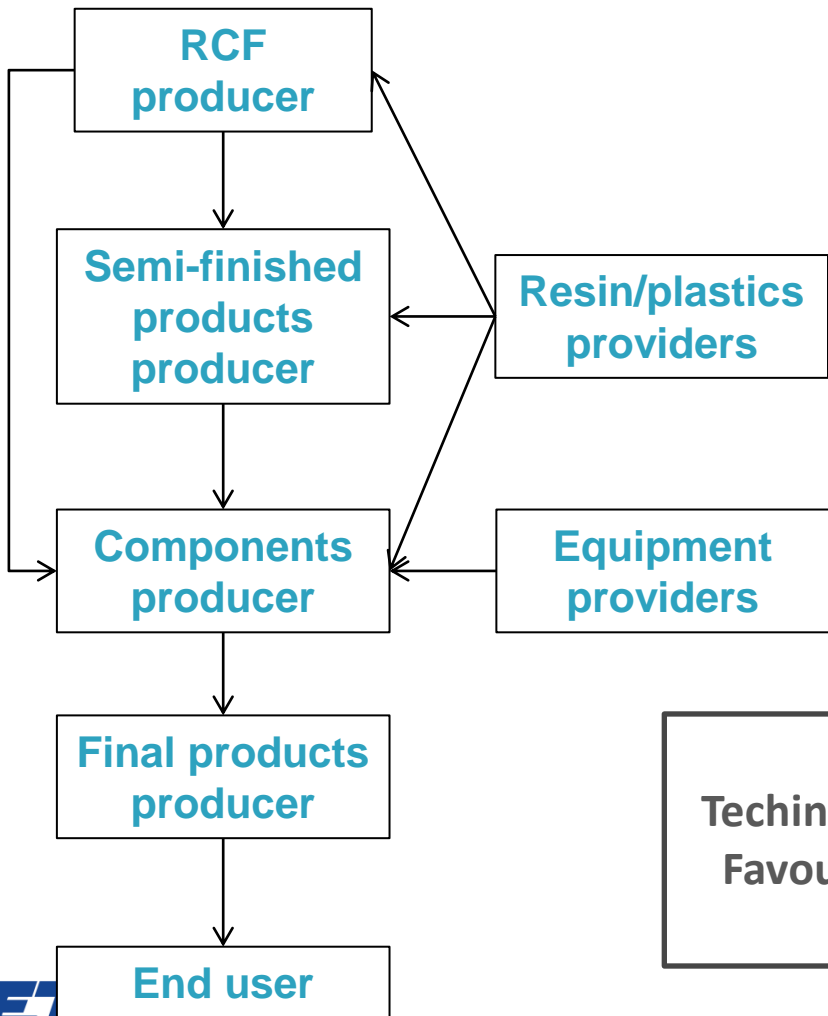
Bladder Moulding

Development and optimization of the process for of non-rectilineal tube



Processing of recycled fibers

CETMA is the technical partner for the value chain of recycled carbon fibers



CF recycling

- milled
- chopped
- mat

- BMC
- SMC
- prepreg

- Injection moulding
- Compression moulding
- Autoclave/vacuum bagging
- Infusion / RTM

- RCF components

CETMA's role:

Technical support for all the actors of the value chain
Favouring of an efficient communication among all the actors of the value chain

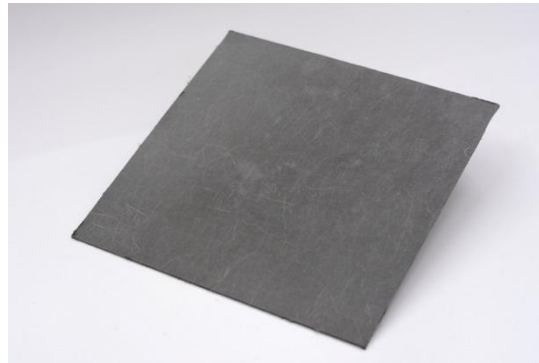
Processing of recycled fibers

Development of processes to impregnate recycled fibers

RTM

Reinforcement: Non-woven recycled carbon fibers (Carbiso M nonwoven mat, Karborek nonwoven mat);

Resin: RTM6-2 (Hexcel)



Compression Molding

ELG- Carbiso™ TM-PP
nonwoven mats (60%
polypropylene / 40% recycled
carbon fibre)

Vacuum bag infusion

Reinforcement: Non-woven recycled carbon fibers
(Carbiso M nonwoven mat,
Karborek nonwoven mat)

Resin: EC157 (Elantas)

