

3D WARP INTERLOCK FABRIC FROM GENERAL DEFINITION TO VARIOUS TRANSPORTATION APPLICATIONS

François BOUSSU

francois.boussu@ensait.fr

**Ensait, Gemtex, Univ. Lille Hauts-de-France
F-59100, Roubaix, France**

2nd WORLD CONFERENCE

**World Textiles- Growth and Great Opportunities.
16 & 17 September, 2016 - Mumbai , India**

ENSAIT (www.ensait.fr)



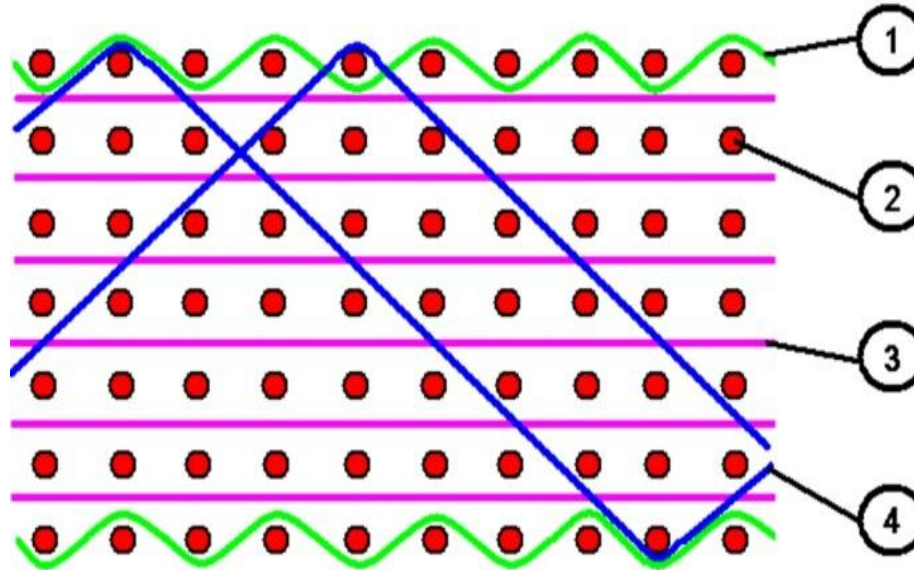
Since 1881
National Textile Engineer College



Plan

- Definition of 3D warp interlock fabric
- 3D fabrics as fibrous reinforcement for transportation applications




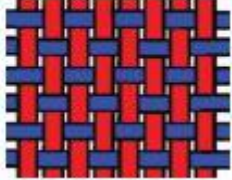

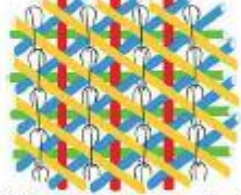


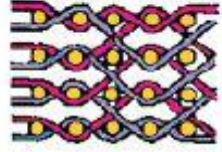
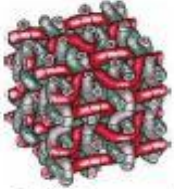
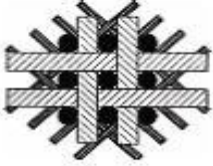



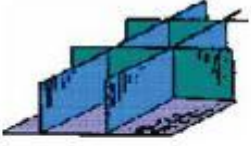

General definition of 3D warp interlock fabrics



3D warp interlock $X1-X2 \{N\} Y1_k-Y2_k$
 Binding $Wb_k \{B_k i\}$ - Surface $Ws \{Ci\}$ - Stuffer $\{Si\}$

F. Boussu, I. Cristian, and S. Nauman, "General definition of 3D warp interlock fabric architecture," Composites Part B, vol. 81, pp. 171-188, July 2015

Different types of textile architectures

Axis Dimension		0 Non-axial	1 Mono-axial	2 Biaxial	3 Triaxial	4 Multi-axial
1D			 Roving yarn			
2D		 Chopped strand mat	 Pre-impregnation sheet	 Plain weave	 Triaxial weave knit /12/	 Multi-axial weave, knit /13/
3D	Linear element		 3-D braid /14/	 Multi-ply weave	 Triaxial 3D-weave /15/	 5-Direction construction
	Plane element		 Laminate type	 H or I Beam /16/	 Honeycomb type	 Integral throat exit for nuclear missile /17/

3D FABRICS AS FIBROUS REINFORCEMENT FOR TRANSPORTATION APPLICATIONS



Source: Volvo Trucks ©



Source: Alstom ©

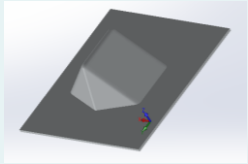
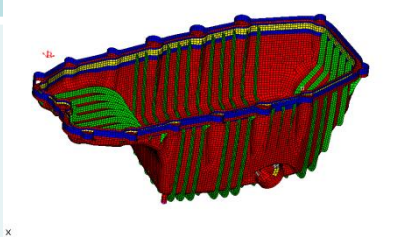


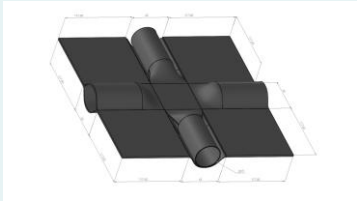
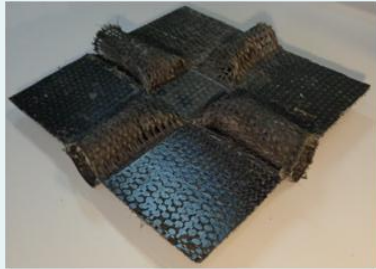


Source: Airbus ©



Source: Boeing ©

MAPICC Solutions (EUROPEAN Project) pilot scale development

End Users	MAPICC solutions (pilot scale)		Partner
AUTO- MAPICC			MECAPLAST
TRUCK- MAPICC			VOLVO TRUCKS
RAIL- MAPICC			ALSTOM

AUTO-MAPICC solution



**Curent
steel**



weight = 1350g

**2015
Plastic injected**

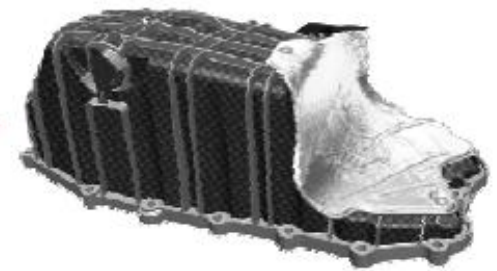
Prototype



weight = 850g

**2018
Composite + over molding**

Work in progress



weight = 600g

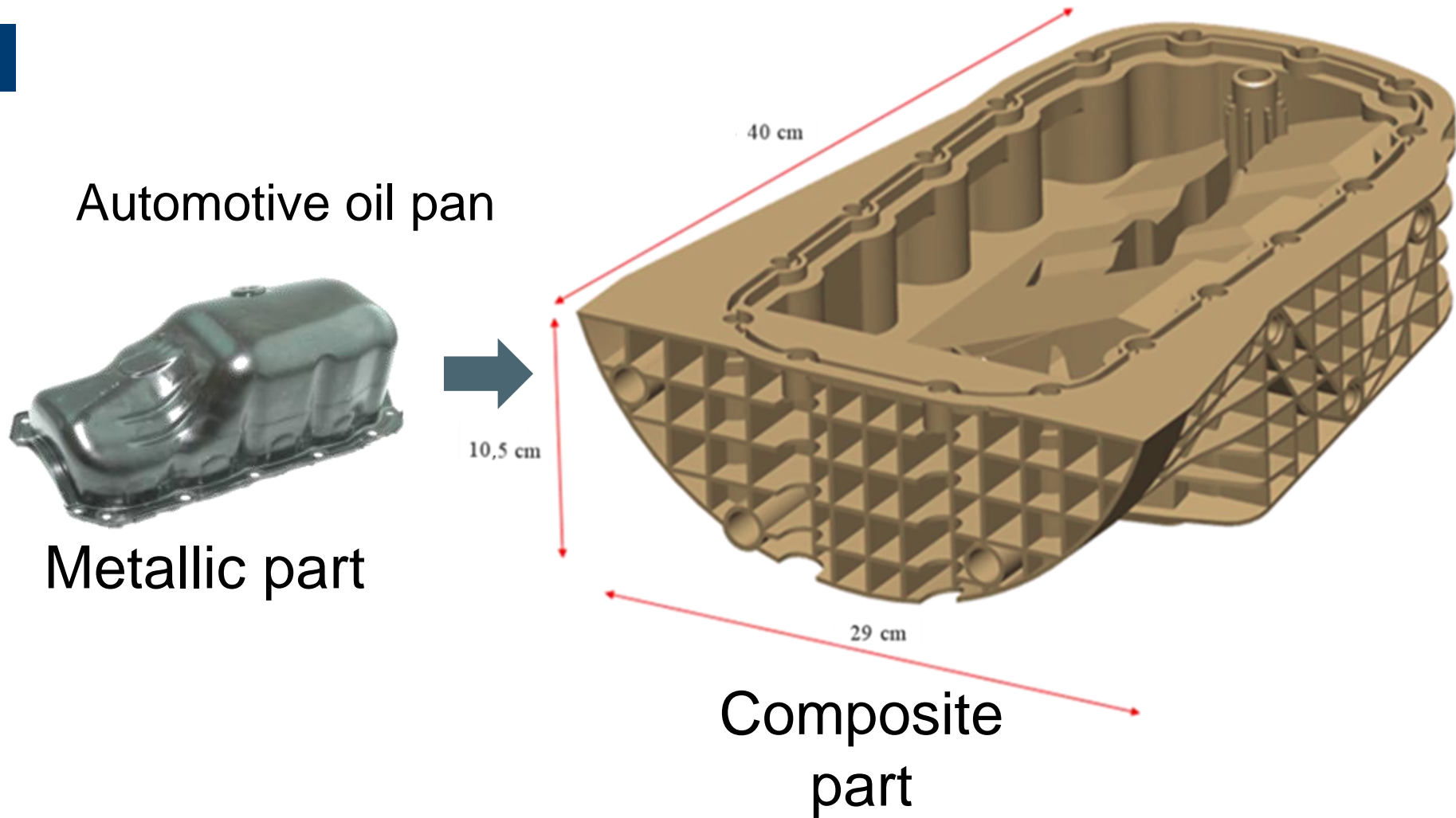
-37%

-30%

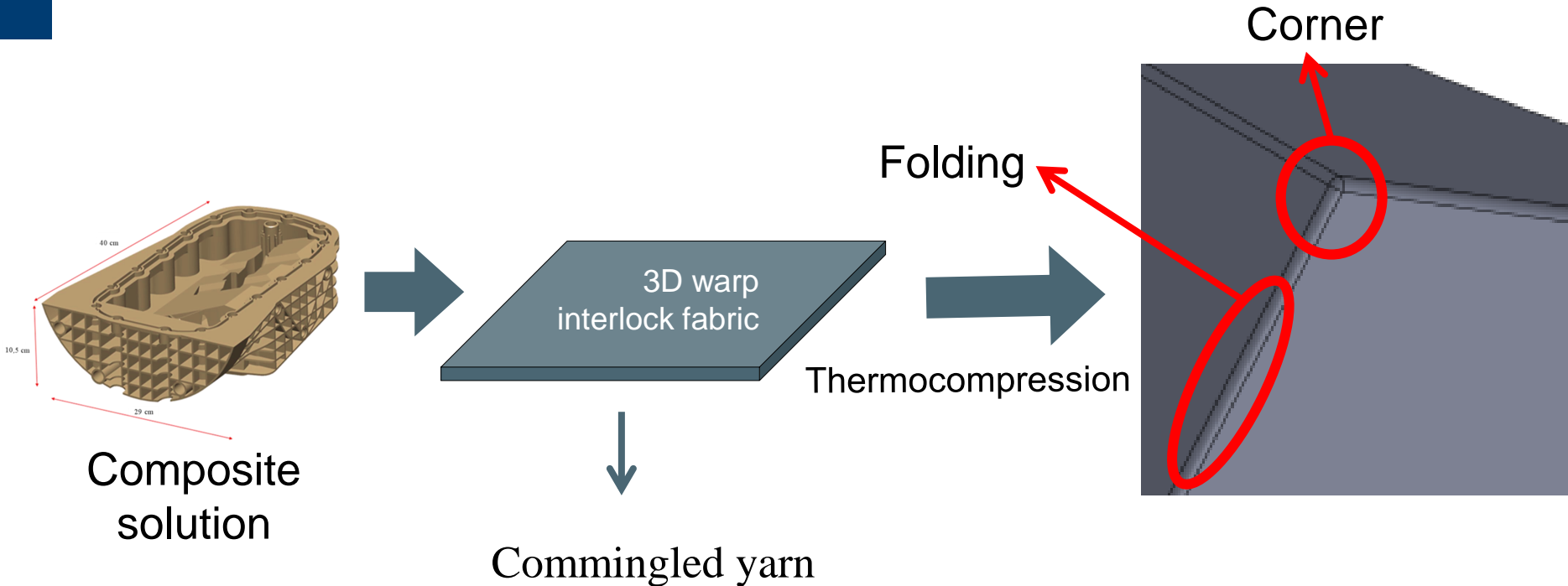
-55%

Souce : P. Pineau, G. Huguet, LIGHTWEIGHT MATERIALS FOR ENGINE AND BODYWORKS, Composite materials congress, December 2014, Koln, Germany. www.mecaplastgroup.com

AUTO-MAPICC solution



AUTO-MAPICC solution



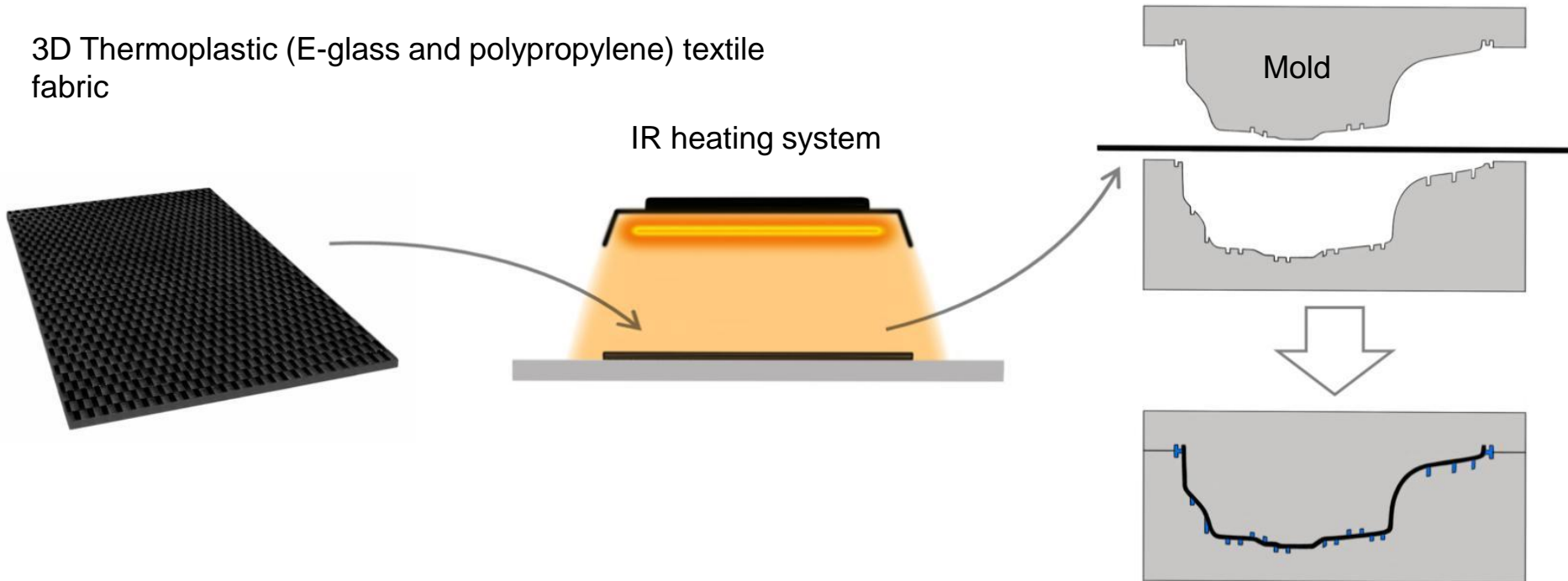
Yield	842 Tex
% E-glass / % Polypropylene (% volume)	46 % / 54 %
Diameter E-glass /polypropylène filaments	14,5 μm / 43,0 μm
Young modulus	10,5 GPa
Elongation at strength	3,22 %
Tensile Tenacity	20,78 cN/tex

AUTO-MAPICC Solution

3D Thermoplastic (E-glass and polypropylene) textile fabric

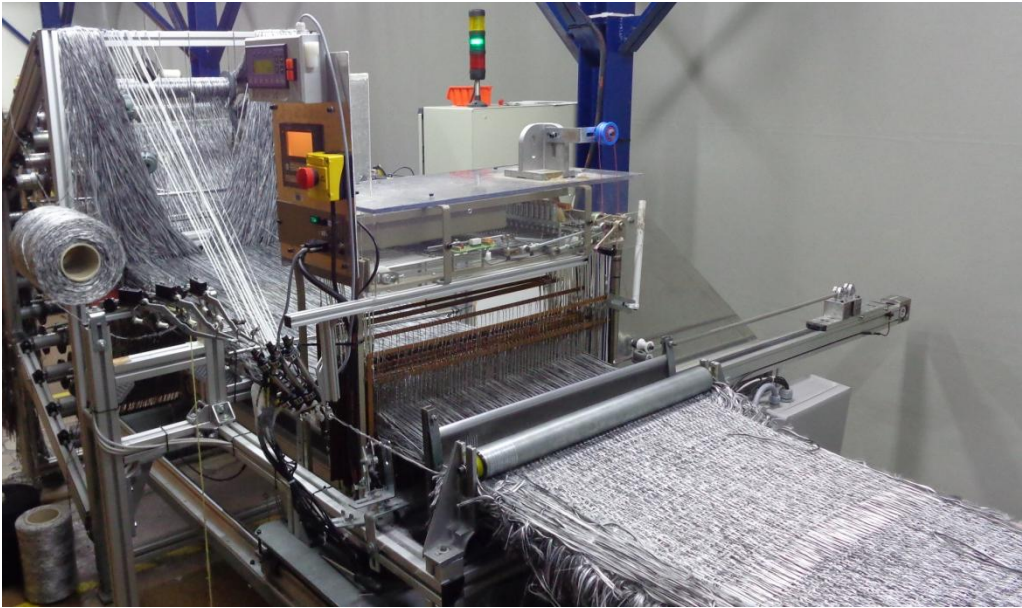
IR heating system

Mold

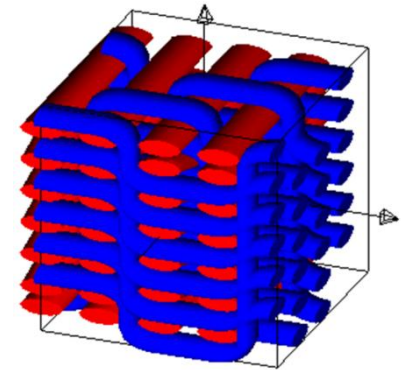


AUTO MAPICC Solution

Production of 3D warp interlock fabrics



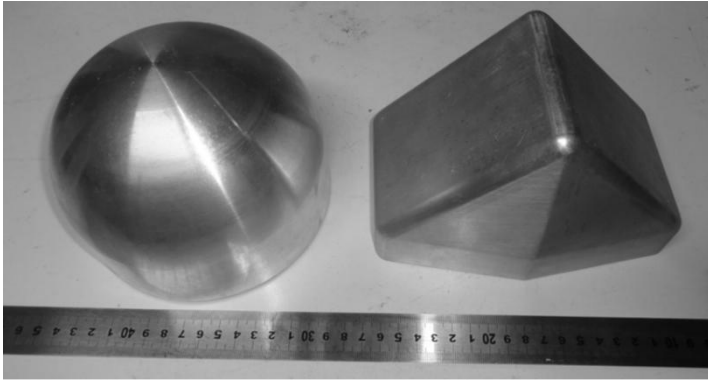
3D warp interlock A-L 6
2-2 Twill 2-2



3D warp interlock fabric made with E-glass and Polypropylene commingled yarns

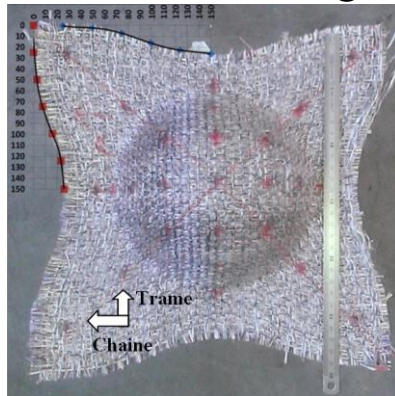
AUTO MAPICC Solution

Different dry preform shapes (hemispherical and gusset) have been done in one step production.

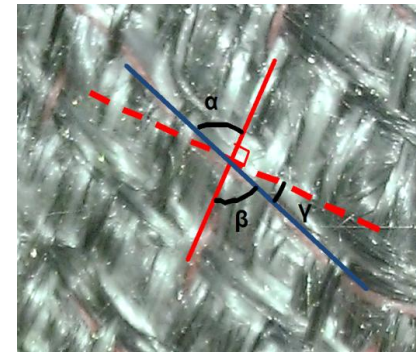


Measurements of 3D forming parameters

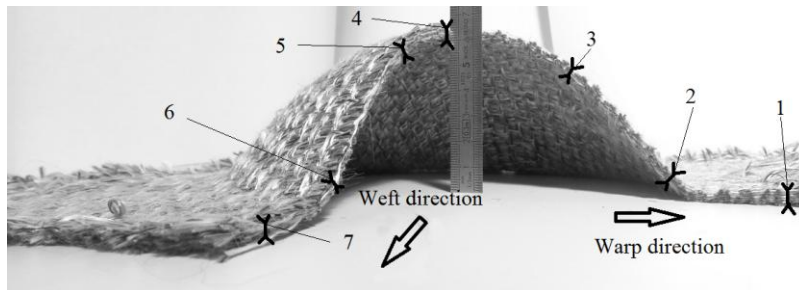
Material drawing-in



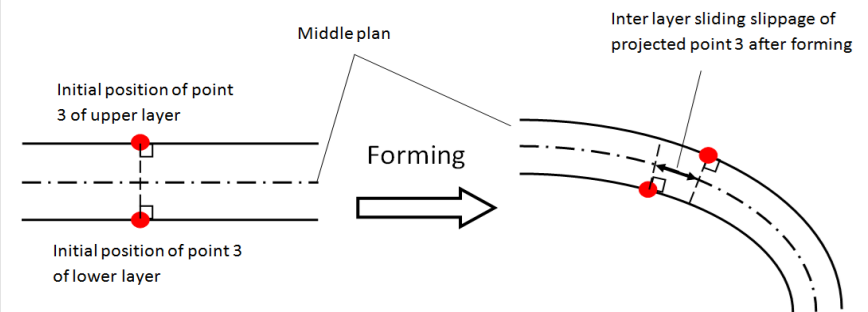
Warp and weft yarns shearing



Thickness variation



Sliding between external layers



C. Dufour, P. Wang, F. Boussu, and D. Soulat, "Experimental investigation about stamping behaviour of 3D warp interlock composite preforms," *Applied Composite Materials*, vol. 21, no. 5, pp. 725-738, 2014.

TRUCK MAPICC Solution



Cabin truck seat reinforcement



Metallic
part



Composite
solution

Lightweight

Crash resistant



TRUCK MAPICC Solution



Composite solution



3D warp Interlock fabric

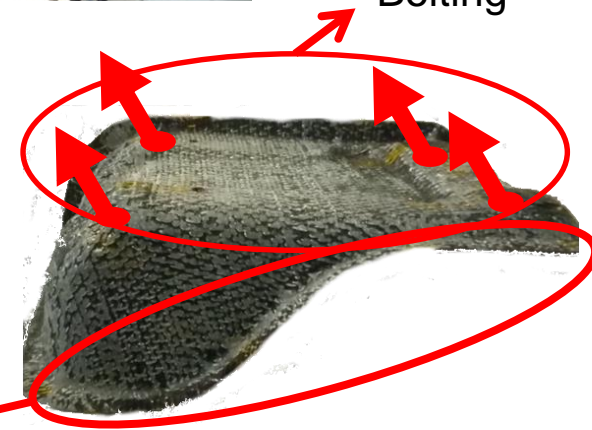
Commingled yarn

Yield	842 Tex
% E-glass / % Polypropylene (% volume)	46 % / 54 %
Diameter E-glass /polypropylène filaments	14,5 µm / 43,0 µm
Young modulus	10,5 GPa
Elongation at strength	3,22 %
Tensile Tenacity	20,78 cN/tex

Thermo-compression

Gluing

Bolting



TRUCK MAPICC Solution

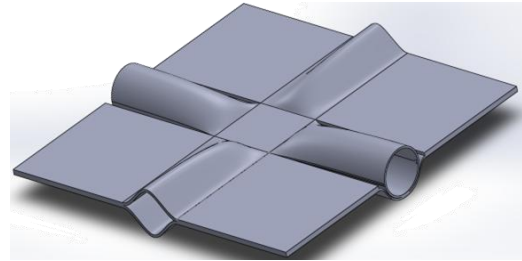
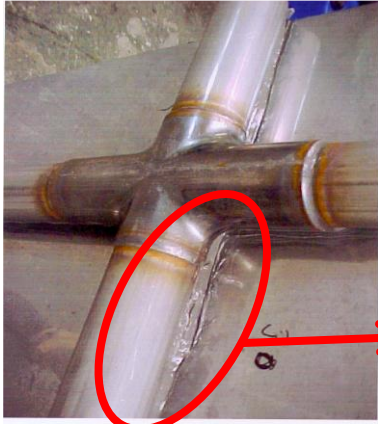
Weight reduction
3,46 Kg \rightarrow 1,54 Kg

Crash test resistant

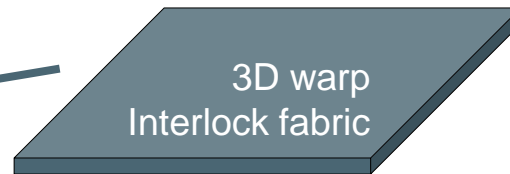


RAIL MAPICC Solution

ALSTOM



Composite solution



3D warp
Interlock fabric



Metallic pat

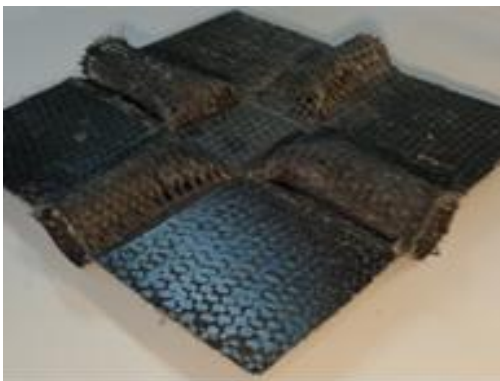
Commingled yarn

Yield	960 Tex
% E-glass / % Polyamide (% volume)	41 % / 59 %
Diameter E-glass / polypamide filaments	16,7 μm / 31,6 μm
Young modulus	10,5 GPa
Elongation at strength	3,22 %
Tensile Tenacity	20,78 cN/tex

Thermo-
compression



RAIL MAPICC Solution



Version 1



Version 2





Thank you for your attention

François BOUSSU

Engineer, Ph-D, HDR, Professor

ENSAIT - France

Mobile Phone: +33 626883959

More info: [http://francois-boussu.com/
francois.boussu@ensait.fr](http://francois-boussu.com/francois.boussu@ensait.fr)