A way to produce lightweight structures: from raw materials to final composite part

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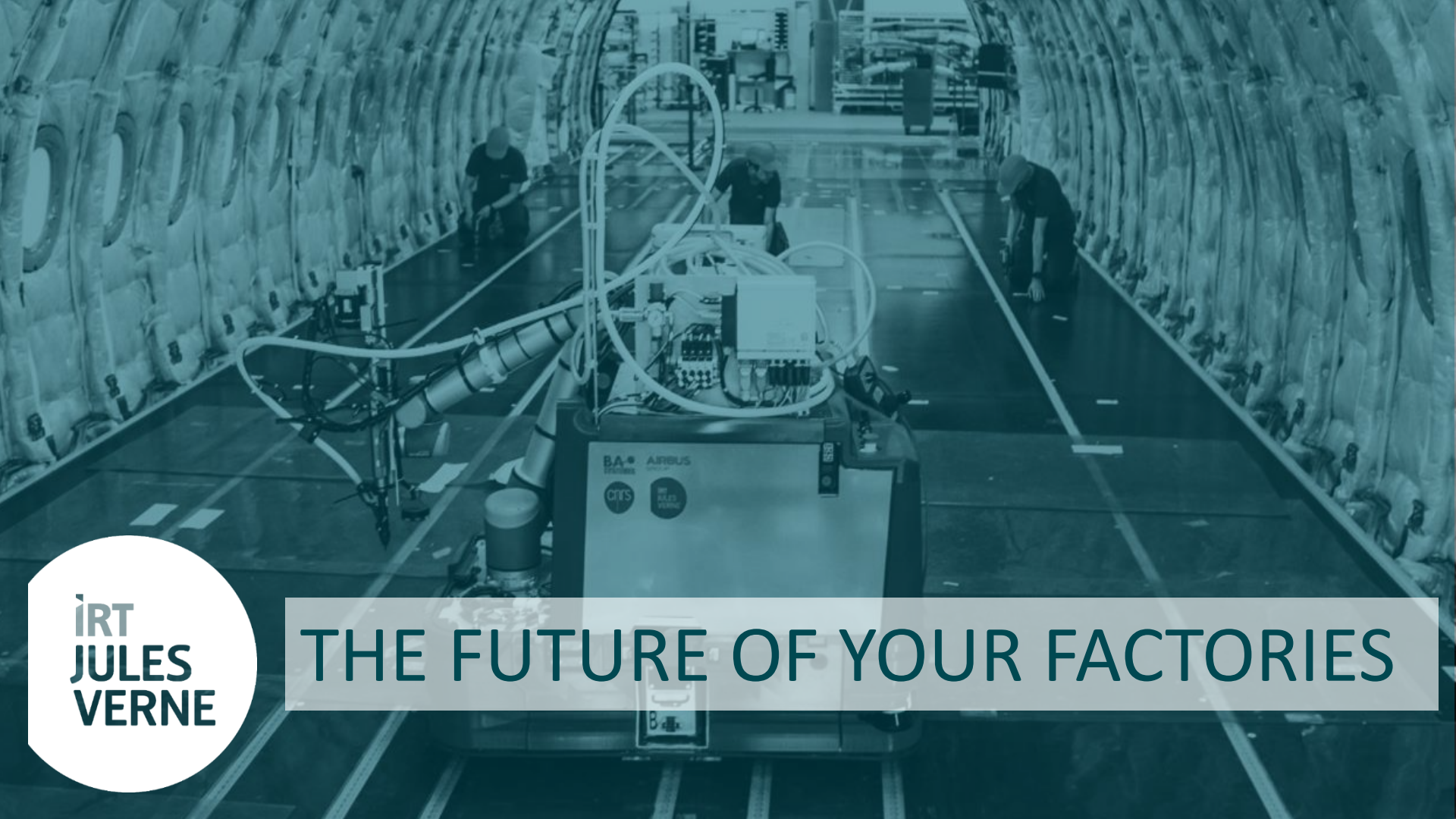


IRT JULES VERNE

THE FUTURE OF YOUR FACTORIES

The DNA of the Jules Verne Institute

Our Dedication to Manufacturing

OUR VOCATION
To reinforce the competitiveness of the French industry

OUR MISSION
To accelerate innovation and promote technology transfer to the factories

OUR CORE BUSINESS
Collaborative research

FRENCH INSTITUTES OF TECHNOLOGY

115M€ from the Programme of Investments for the Future

Our Market-oriented Roadmap

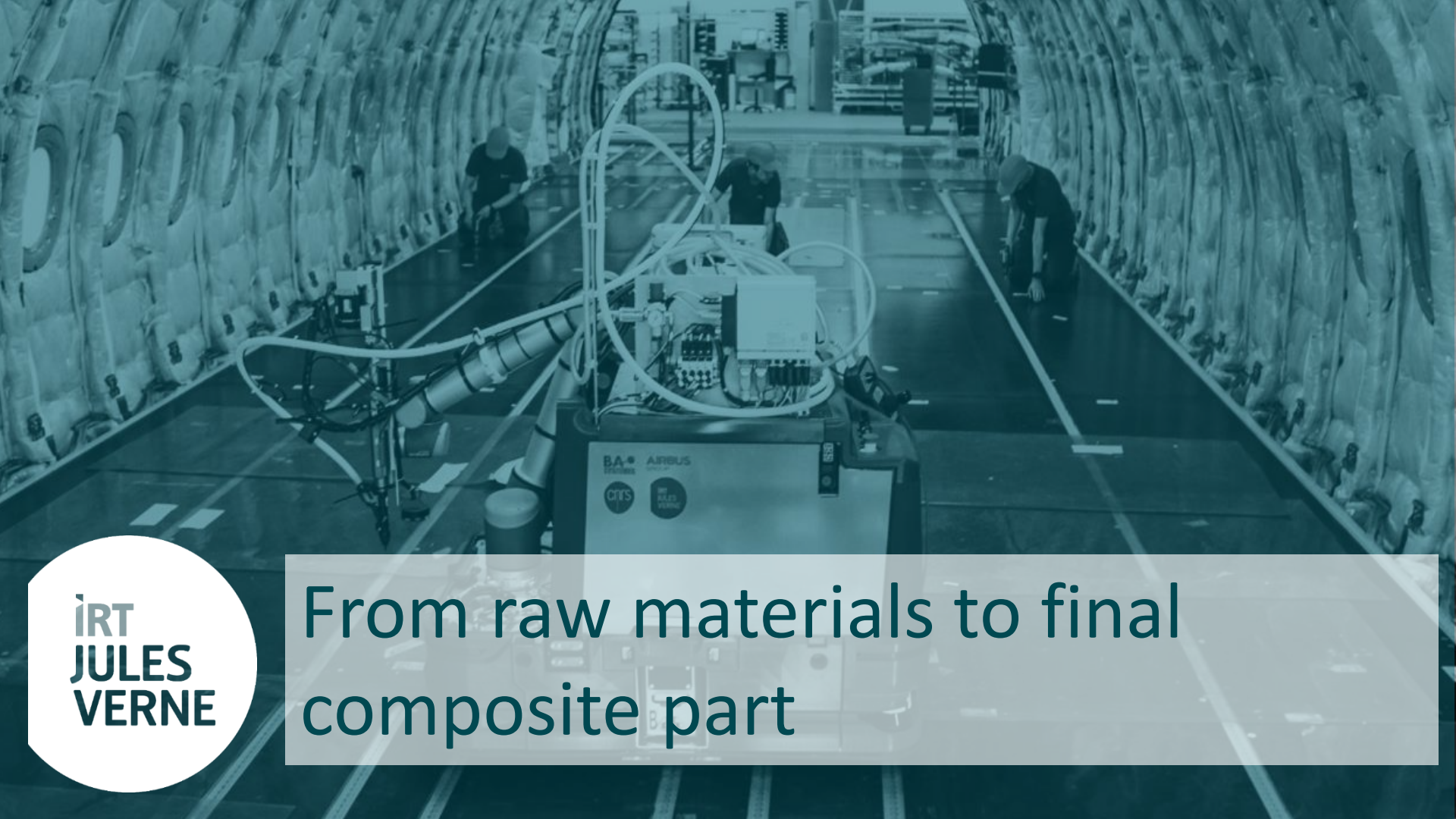
TECHNOLOGICAL EXPERTISE

- COMPOSITE PROCESSES
- METAL ADDITIVE MANUFACTURING
- ROBOTICS AND COBOTICS

- MODELLING AND SIMULATION
- CHARACTERISATION, CONTROL AND MONITORING

R&D THEMATICS

- FORMING AND PREFORMING PROCESSES
- ASSEMBLY
- ADDITIVE MANUFACTURING PROCESSES
- MOBILITY IN INDUSTRIAL ENVIRONMENT
- MANUFACTURING FLEXIBILITY



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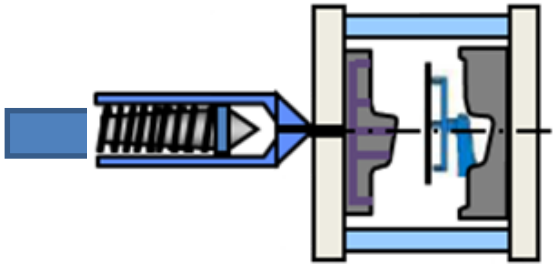
From raw materials to final composite part

How do we help to bring composite in industries ?

A few things we have to work on :



Raw Materials

- Cost ?
- New Materials ?

Process

- Cost ?
- Production rate?
- Net shape part ?
- New process ?

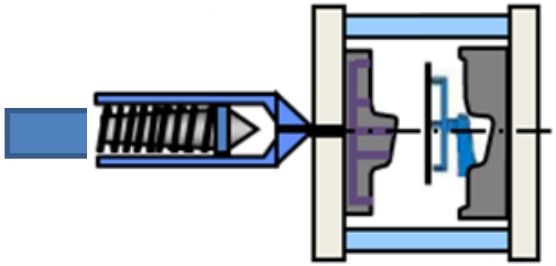
Assembly

- Assembly Time ?
- Composite/metal ?

Final composite part

How do we help to bring composite in industries ?

Topics of our presentation:



Raw Materials

FORCE project

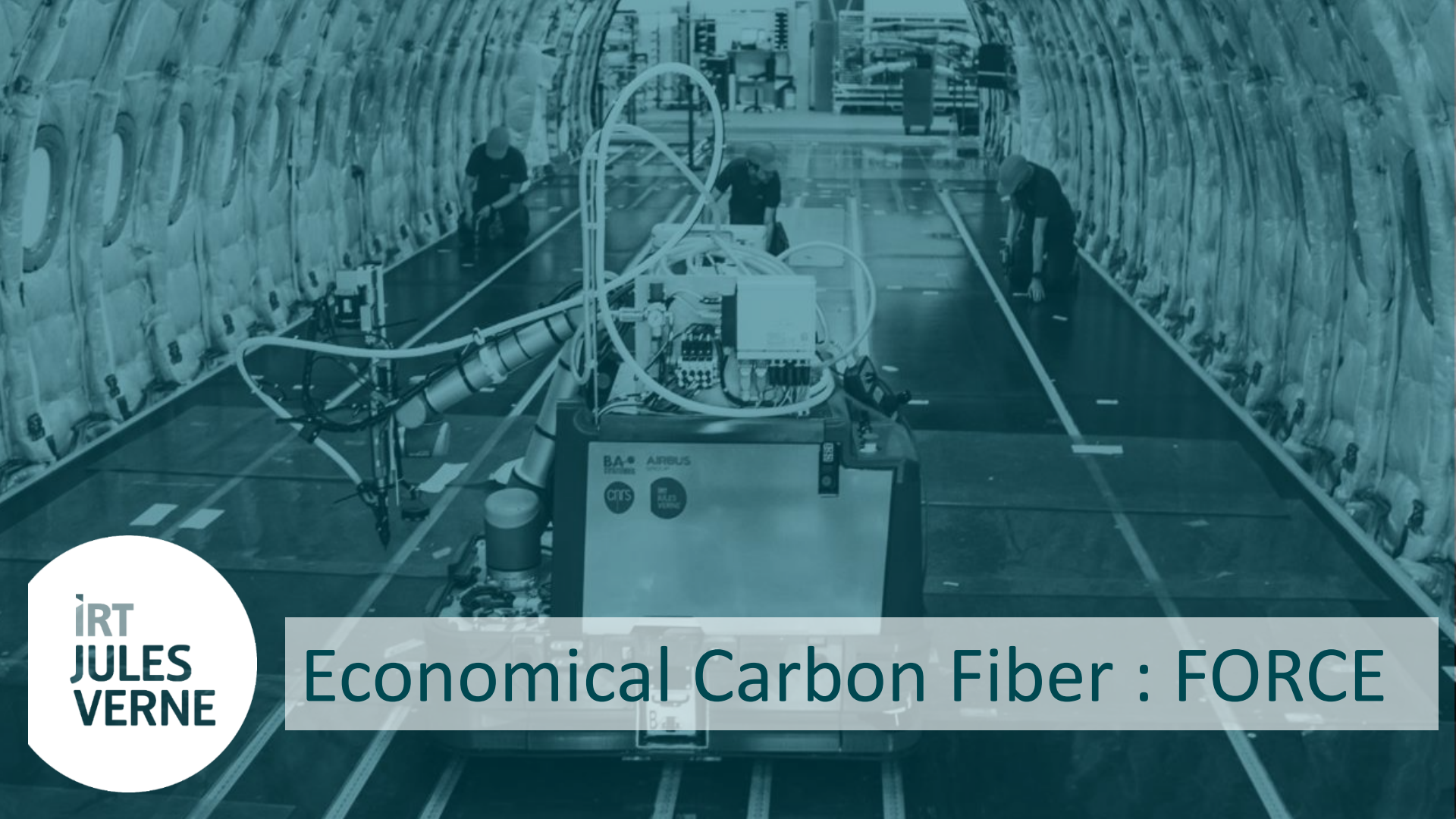
Process

COMPOSTAMP project

Assembly

LIMECO project

Final composite part



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Economical Carbon Fiber : FORCE

FORCE PROJECT : Economical Carbon Fiber

A consortium regrouping carbon fiber « users » and « producers »

Consortium includes players on the entire value chain

- Led by the “Institut Recherche Technologique” Jules Verne
- Benefit from CANOE technical platform expertise
- Audited by an independent Scientific Council (ex carbon manufacturer industrial director, Research director on carbon fiber…)
- With scientific collaboration of French universities, laboratories and CNRS (3 PhD and 4 post-doctoral positions)
- Sponsored by the “Plateforme de la Filière Automobile (PFA)”

PFA FILIÈRE AUTOMOBILE & MOBILITÉS

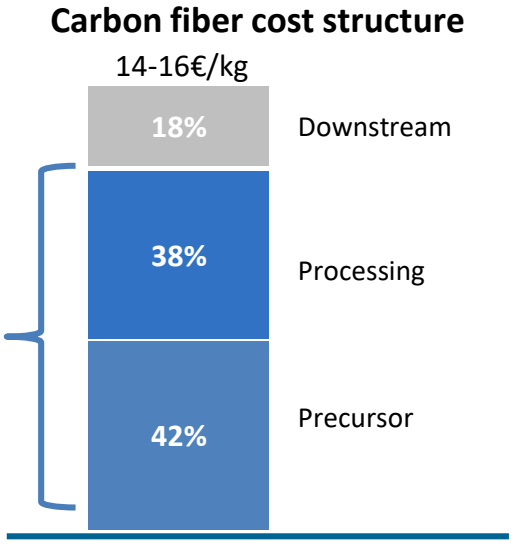
cnrs

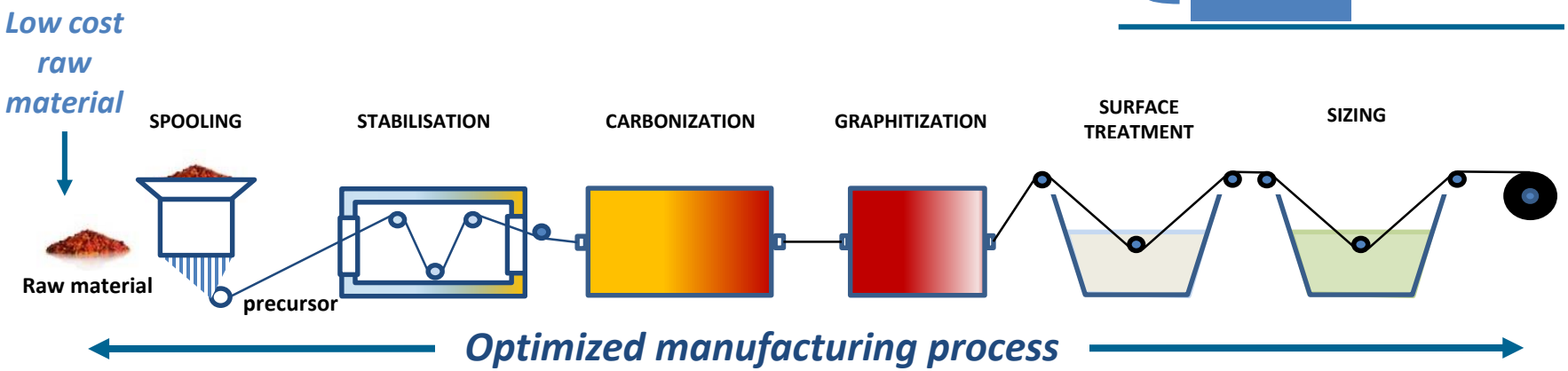
Chemicals/ Raw materials	Process	Users	Technical Centers
ARKEMA TOTAL tembec	MERSEN CHOMARAT	DECATHLON faurecia PLASTIC OMNIUM PSA GROUPE RENAULT La vie, avec passion STELIA COMPOSITES	canoe IRT JULES VERNE

A competitive Carbon Fiber ?

Development of a low cost carbon fiber at 8€/kg

- Today price>14€/kg
- Target automotive applications for structural elements
  - e.g. 250 GPa, 2500 Mpa
- Improving the raw material chemical structure
- Using alternative precursors (mainly bio based)
- Optimizing the whole manufacturing process





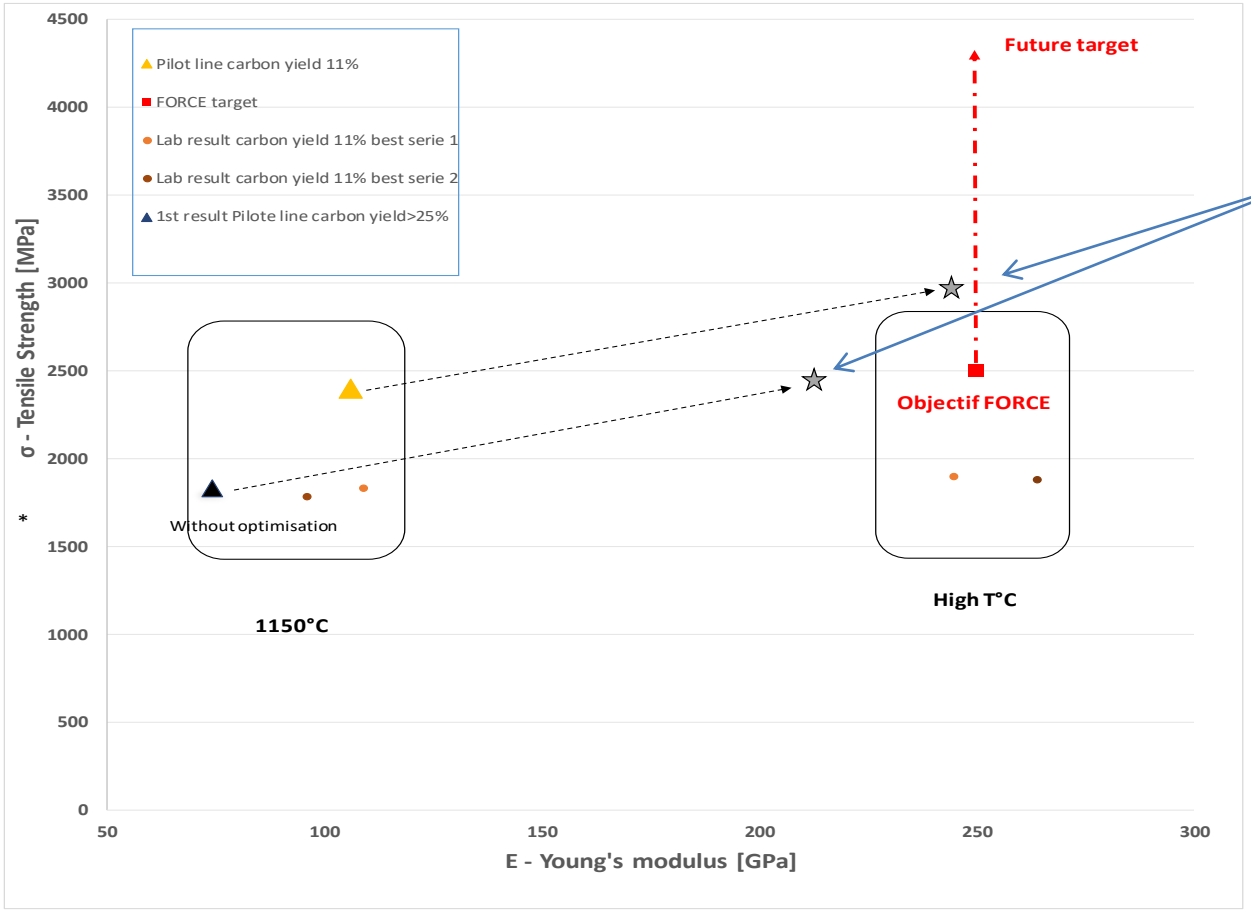
Carbon fibers from cellulose precursor

Polyvalent continuous carbonization pilot line able to :

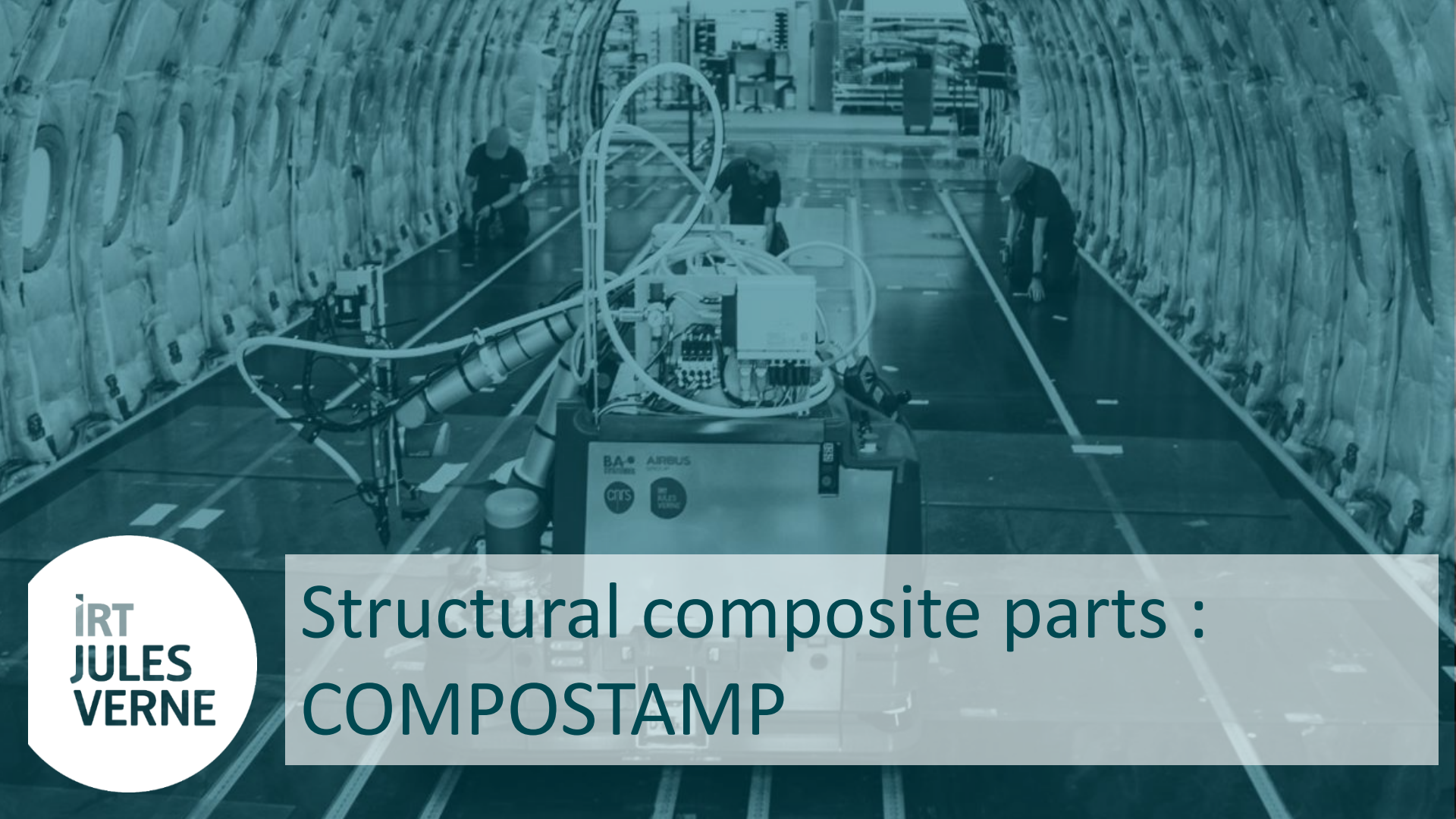
- Produce enough carbon fibers for realization of composite demonstrators
- Carbonize different kinds of precursors : cellulose, lignin, PE, others…
- Demonstrate the feasibility for further industrialization

10 tows in parallel
> 1100°C for now
carbonization of fabrics
1 to 4 tons / year

Performance: where we are



Tests and verification on going@ high T°C



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Structural composite parts : COMPOSTAMP

Composite parts by stamping and overmolding

Manufacturing net shape/one shot composite part by stamping and overmolding proccesses for aeronautic and automotive industries.

Targets :

- Economical performance
- Technical Performance
- Production rate
- Repetability process

	AERONAUTIC	AUTOMOTIVE
Production rate	1 part/5 minutes cycle time	1 part/minute cycle time
Materials	Carbon fibers with PEKK resin	Glass fibers with PA66 resin
Size part	Small part (0,1m²)	Medium part (1m²)
Batch production	30 parts	300 parts
TRL level	From 2 to 4	From 4 to 6

Patners :

DEDIENNE MULTIPLASTURGY GROUP

CEMCAT

PSA GROUPE

faurecia

cetim Centre technique des industries mécaniques

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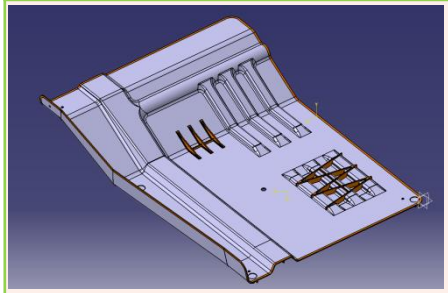
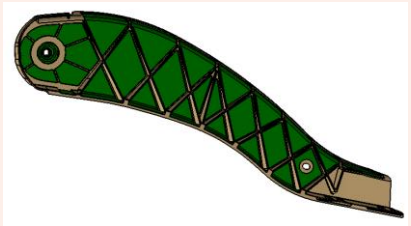
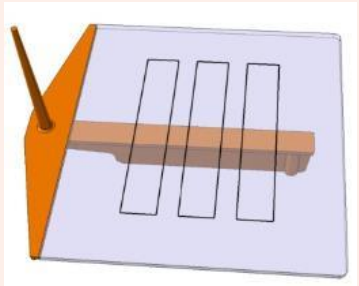
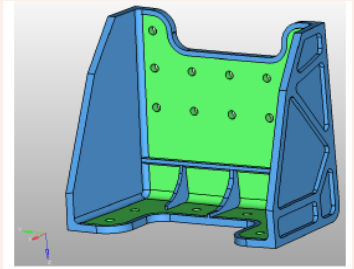
AIRBUS

DAHER

RENAULT Passion for life

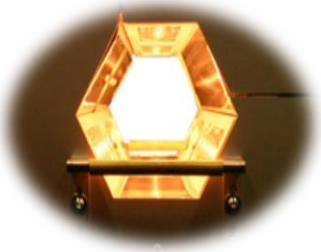
compose tooling expert

COMPOSTAMP composites parts

Automotive technical part	Automotive technical part	Aeronautic simple part	Aeronautic technical part
Dimensions 800x600 mm Thickness 2 mm	Dimensions 500x150 mm Thickness 2 mm	Dimensions 225x200 mm Thickness 4 mm	Dimensions 160x140 mm Thickness 4 mm
Vertical Press	Horizontal Press	Horizontal Press	Horizontal Press
Where : CETIM	Where : IPC	Where : DEDIENNE	Where : DEDIENNE
			

Stamping and overmolding process

Heating
(IR oven)



Transfer

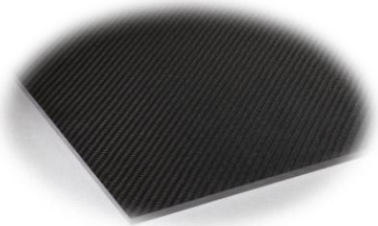
stamping

TP Injection

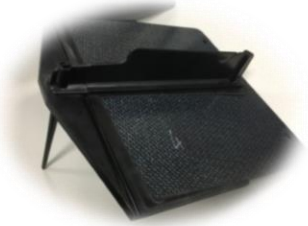
Transfer

1 to 5 minute cycle time

Transfer



Laminates



Net-shape/one shot composite part

Aeronautic technical analysis

What do we need to develop to make industrial overmolded parts fly?

- Design to manufacture with overmolding process
- Design specifics for hybrid parts mixing continuous fibres with short fibres

Stamping and injection of high performance materials

- Injection of PEKK or PAEK resins is not a baseline for manufacturers. Process window has to be determined, tooling has to be adapted

Overmolded products characterization

- Mechanical resistance, physico-chemical characterization, adhesion between injected part on substrate, conductivity

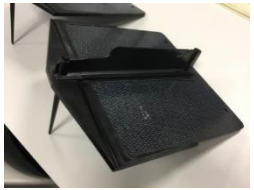
Industrial assessment

- Quality, repeatability, capability, cost assessment

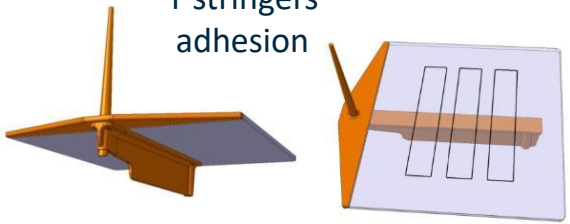
COMPOSTAMP project purpose

Conception and Design of characterization samples

Design of characterization samples: result of a concession between characterization needs and process limitations

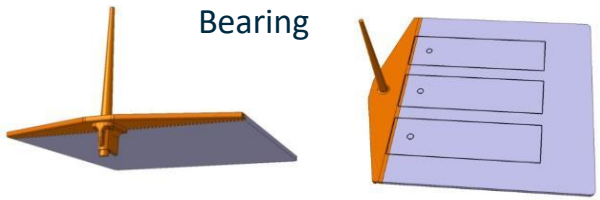


T stringers adhesion



Objective = Adhesion between injected part and composite part
➔ Sizing approach = Break has to be in the injected part and not at the interface

Bearing



Objective = characterize the edge sealing and evaluate the knock down factor
➔ Sizing approach = Edge sealing has a mechanical contribution to the part sizing

Single Lap Shear

Objective = Adhesion between injected part and composite laminate (peeling & shear strain)
➔ Sizing approach = Break takes part in the injected area and shear strain above 30 MPa

Mechanical test objectives: understanding of the impact of overmolding on composite parts made of continuous fibers

Aeronautic example : from metal to composite

Develop and evaluate the stamping overmoulding industrial performances, with an application to fuselage clips

AS IS
3 assembled parts
+ edge sealing

New design

TO BE
One shot
overmoulded part

- Develop stamping – over moulding process full automated line
- Clip/cleat redesign with “One Shot” + “Net shape” functions integration
- Carbon/PEKK UD & Fabrics substrates / PEKK resin over moulded

Industrial objectives :

- **Reduce lead time**
- **Reduce recurrent costs**
- **Increase rate**

Fuselage clips manufacturing (AS IS)

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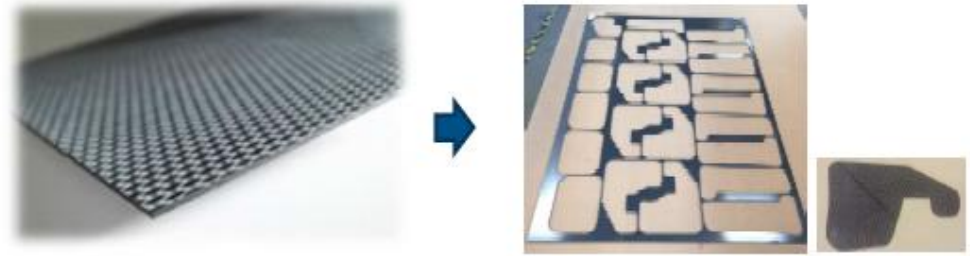
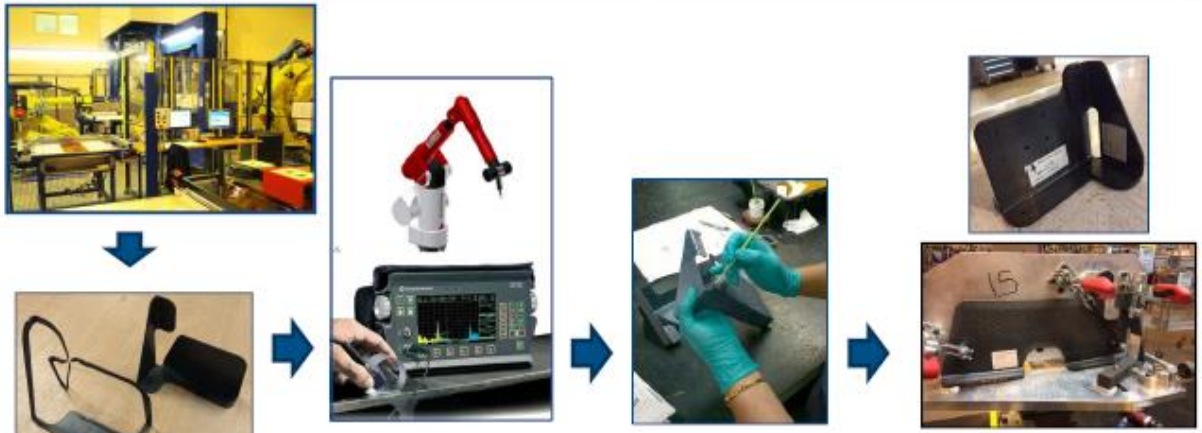
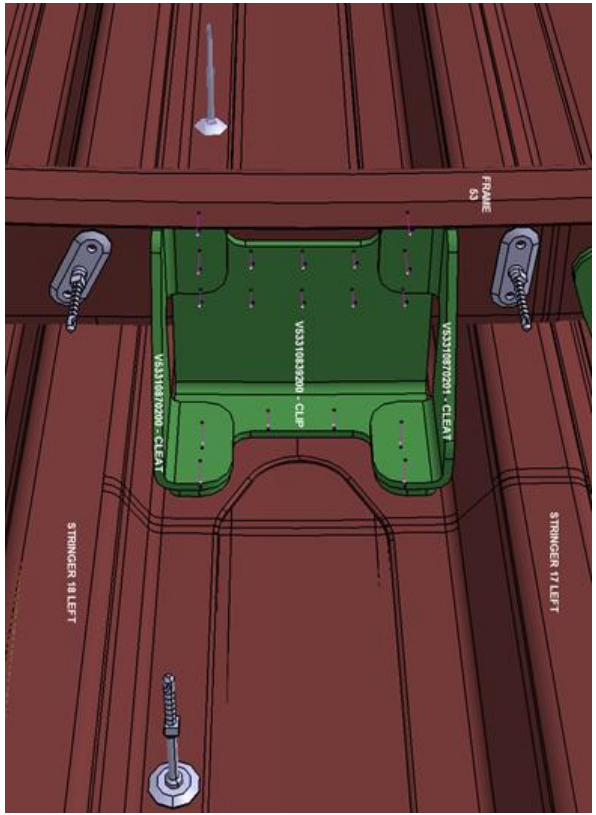
Blank preparation



Forming

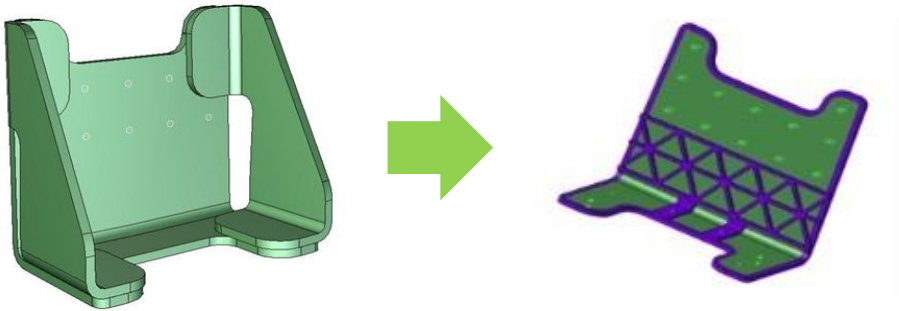


→ 7 production steps



Clip evolution and design

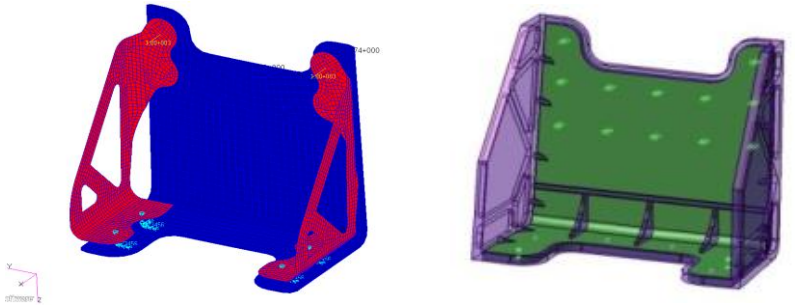
Base line: A350 fuselage clip



- First evolution: injection design to reach the same stress requirements
  - Injection cross junctions (mechanical properties)
  - Edge sealing with TP injection
  - Cross junction not possible due to technologies and mold limitation.

-> Partial injection

New design adapted to stamp forming and overmolding

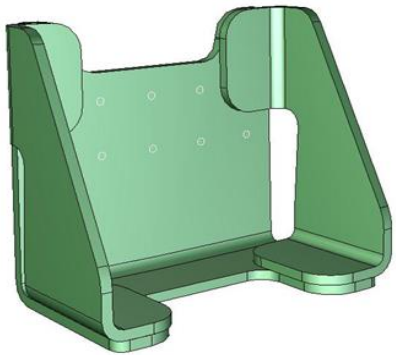


- Second evolution: Study of injection design reaching the same stress requirements.
  - Hollow cleat injection
  - Cleats injection not possible due to technologies and mold limitation.

-> Weld line

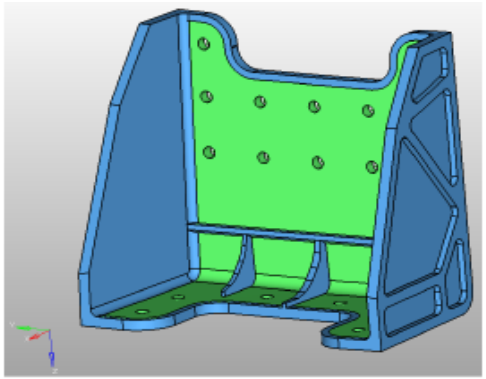
Clip final evolution and design

Base line: A350 fuselage clip



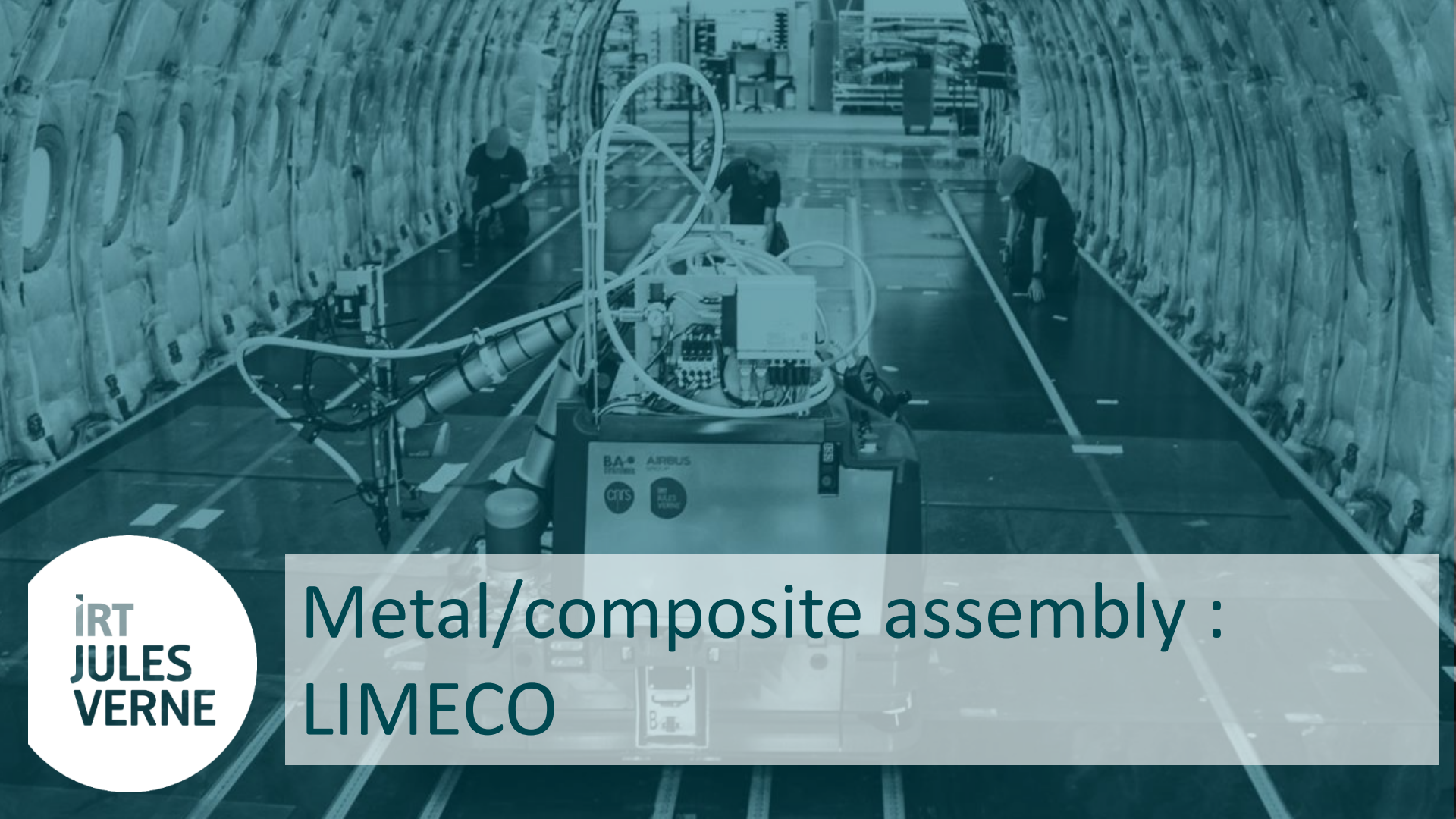
Re-design

New design adapted to stamp forming and overmolding



Third evolution: taking into account mold and technologies limitations

- Composites area simplification + drilling zone taken into account
- Cleats injectable
- Injection modelling improvement
- Tooling injection optimization



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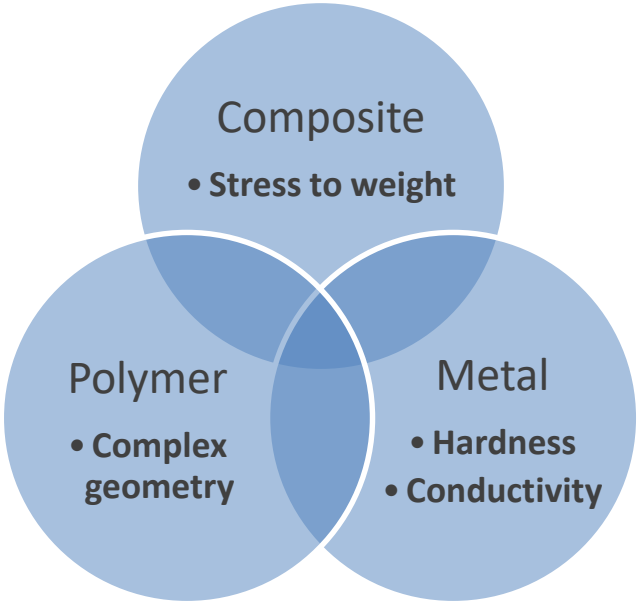
Metal/composite assembly : LIMECO

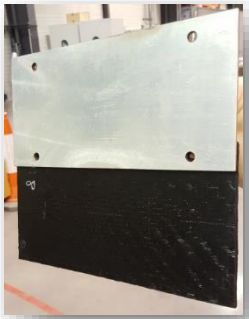
Why hybriding Composite, Polymer and Metal

Using the best of each « world »



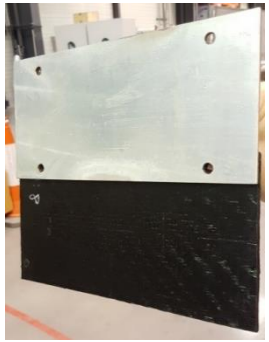
How to assemble metals with composites

- Fastening
- Bonding
- Overmolding
- Direct adhesion



Designing Polymer/Metal assemblies

Assembly method: Direct adhesion



Mechanical strength of the assembly

- Properties of the bond line
- Stress calculation methodology

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DEDIENNE MULTIPLASTURGY GROUP

cetim

faurecia

SAFRAN AEROSPACE · DEFENCE · SECURITY

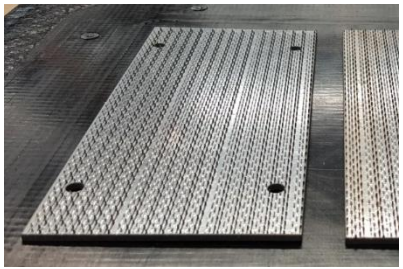
Properties of the bond line

Objective: Achieve equivalent properties to adhesive bonding → SLS

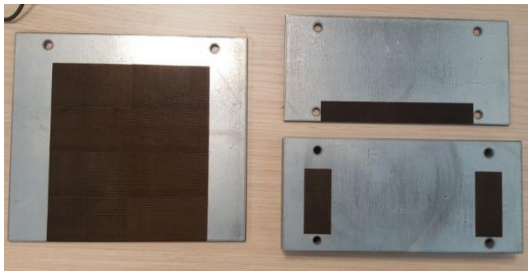
- Process optimisation




- Surface preparation selection


Mechanical bonding


Interface materials


Laser treatments

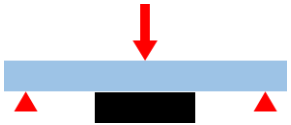
10MPa

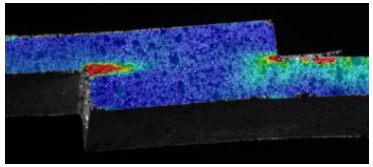
20MPa

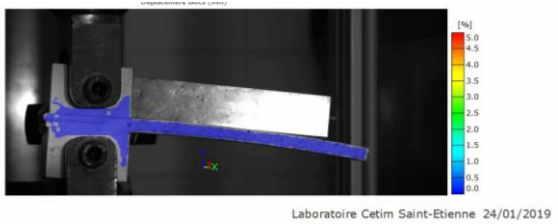
30MPa

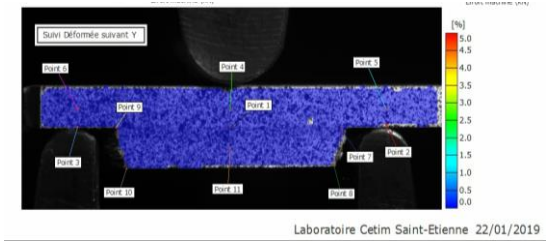
Stress calculation methodologies

Elementary properties characterization

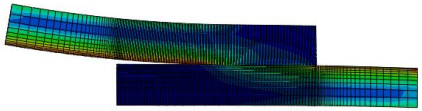


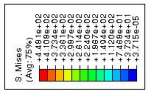


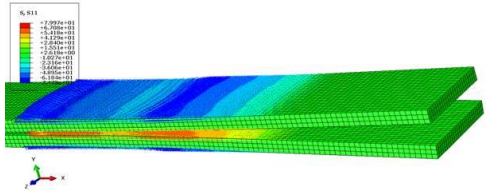


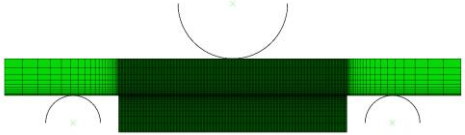


Modelling

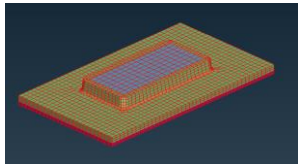


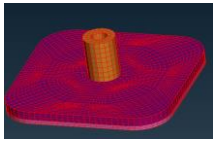


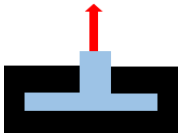




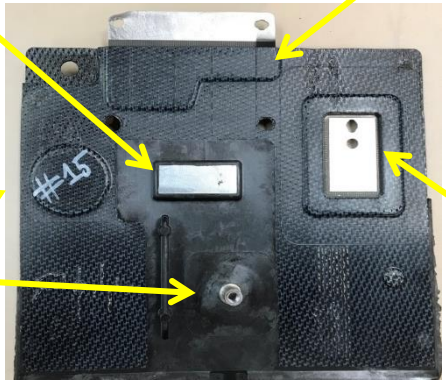
Application to representative inserts

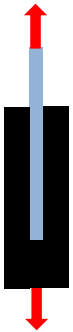


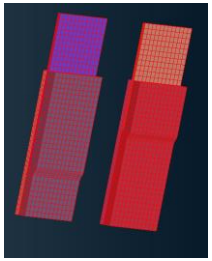


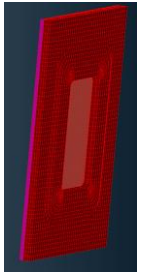


RESULTS UNDER EXPLOITATION









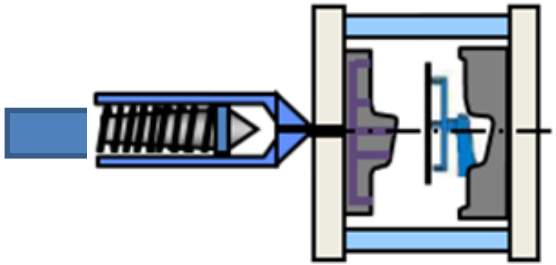
Mechanical results close to results obtain with adhesive bonding

General Conclusion

Some of our works on composite materials

Process

- Net-shape composite part by stamping and overmolding



Raw Materials

- Low cast carbon fiber

Assembly

- Test of bonding technologies

Final composite part

Questions