COMPOSITADOUR
COMPOSITES & ROBOTICS SOLUTIONS

IC3 - Arcachon

Automated Collaborative Process for Aerospace Omega Stiffeners Manufacturing

G.FOURAGE

June 5th, 2018

Framework

- **European funded project CleanSky 2 (part of Horizon2020 research programme)**
- **Airframe ITD Work Package B-3.6 : « New Materials and Manufacturing Technologies »**
- **Project name : COBOMEGA**
- **Topic Manager : Airbus DS, Cádiz, Spain**
- **Project leader : Compositadour**
- **12 months, ended December 31st, 2017**
- **120k€**

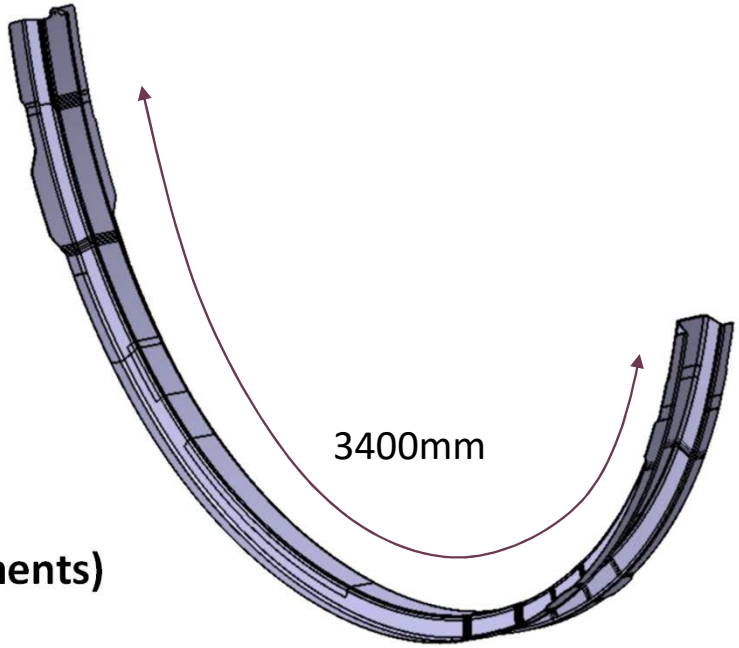
Objectives

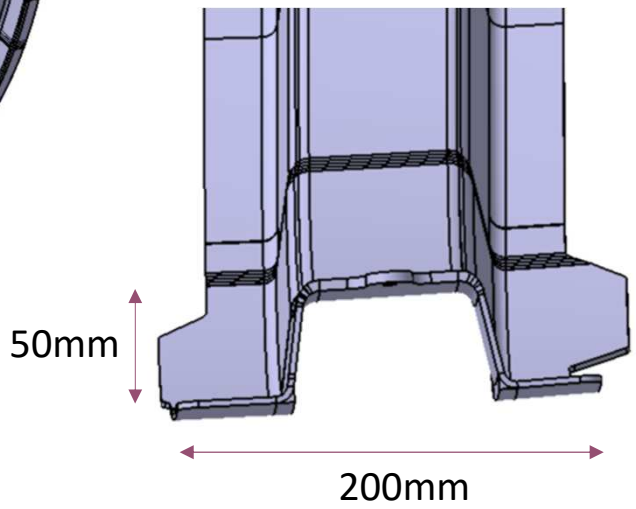
- ***"To set up technical specification for the implementation of advanced equipment to automate or assist the manufacturing process of hand lay-up of Carbon Fiber Composite stiffeners with omega section, and to realize the trials."***

  - **"Set up a concept for highly efficient industrial equipment able to manufacture Omega stiffeners with different curvatures"**
  - **"Evaluate various solutions considering ergonomic, cost and flexibility aspects"**
  - **"Design and test automated and/or assisted process for the layup operation"**

Stiffener specifications

- **Omega cross section**
- **Double curvature**
- **Prepreg UD & fabrics**
- **Hand lay up**
- **47 plies (3 main / 44 local reinforcements)**

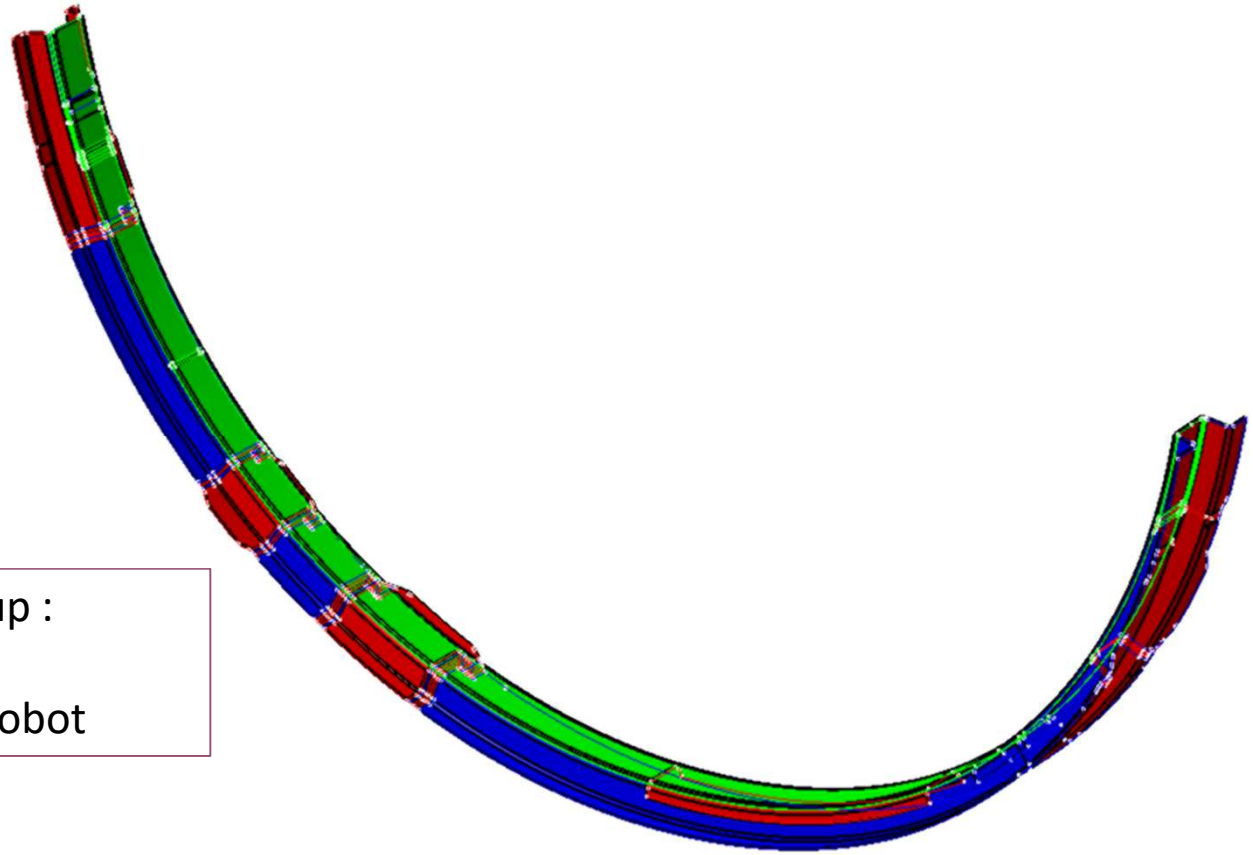




Stiffener specifications

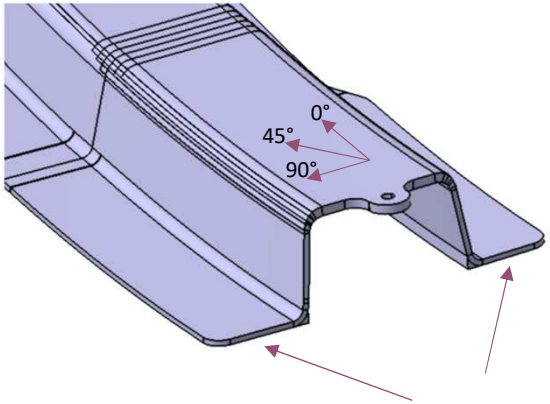
- **Main challenges for automation :**
  - High number of small plies
  - High variations in plies dimensions
  - Mix of UD/Fabrics
  - Curvature
  - Several stiffeners geometries

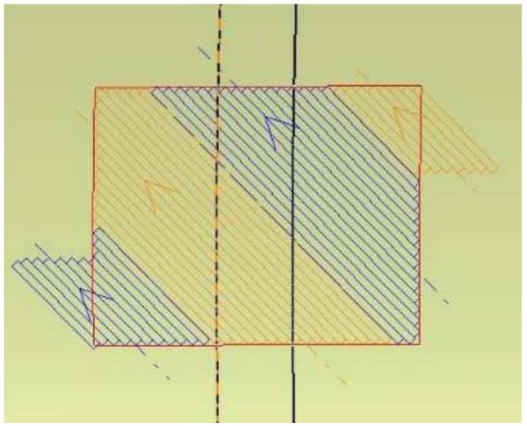
Two solutions investigated for lay up :
Automation with AFP
Assisted process with collaborative robot



Automation with AFP

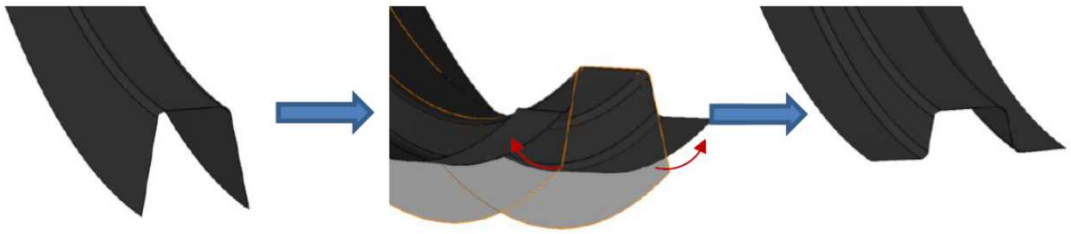
- **AFP constraints**
  - **Limited lay up geometry => U-shape or flat cross section only**
  - **UD material only => high increase of plies quantity !**
  - **Minimal fiber length => overlength required for 45°/135° is problematic for plies inside EOP contour**





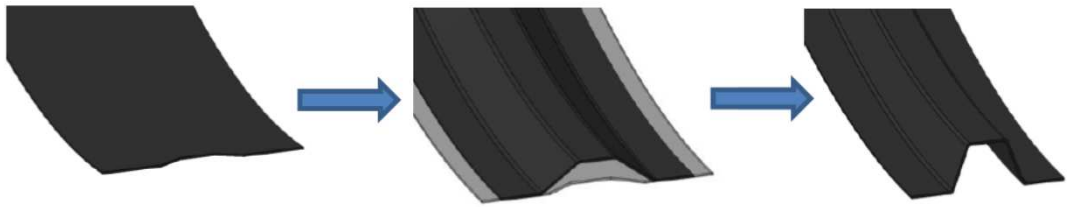
Automation with AFP

- **Lay up strategies : AFP + Hot forming**



OPTION 1 : U-Shape cross section preform

- **Compression applied to 0° fibers on flanges during forming => high risk of wrinkles**
- **Reduced lay up speed due to corner pass**
- **Still need a forming step for flanges**



OPTION 2 : Curved preform with flat cross section

- **Tension applied to 0° fibers during flange and web forming**
- **Fast lay up speed**

Avoid 0° fibers on flanges
Flat preform enhance lay up speed without influence on forming time
OPTION N°2 selected due to process time/manufacturing

Automation with AFP

- **Direct conversion of stacking from fabrics to UD leads to increase of plies number / preform thickness, with impact on lay up time and local stiffness**
- **Downsize FAW leads to use of non qualified materials**

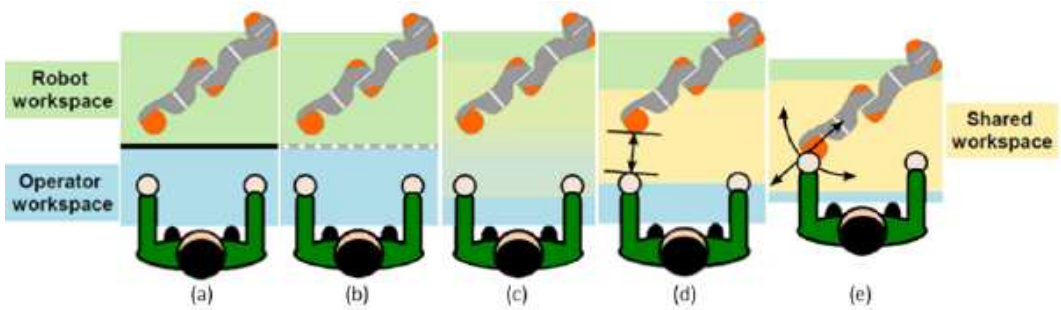
	Orientation (°)	CPT (mm)
RH1-P001A,B,C,D	+/-45	0,28
RH1-P010A,B,C,D	0/90	0,28
RH1-P047A,B,C,D	+/-45	0,28
TOTAL		**0,840**

	Orientation (°)	CPT (mm)
RH1-P001A,B,C,D	45	0,184
RH1-P001A,B,C,D	-45	0,184
RH1-P010A,B,C,D	0	0,184
RH1-P010A,B,C,D	90	0,184
RH1-P010A,B,C,D	*90*	*0,184*
RH1-P010A,B,C,D	*0*	*0,184*
RH1-P047A,B,C,D	-45	0,184
RH1-P047A,B,C,D	45	0,184
TOTAL		**1,472**

Downsize FAW
Modify stacking to reach acceptable thickness and respect RSDP rules

Collaborative process

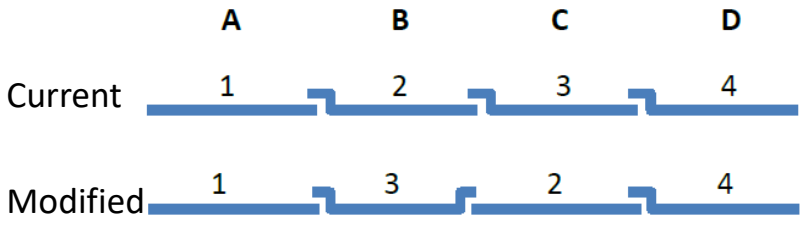
- **Cobot and human in shared workspace with possible contact**
- **End effector must comply with various plies sizes & stiffener geometries**
- **Release film removal after lay up is difficult to robotized**
- **Automation of compaction at web-flange transition remains complex due to stiffener curvature**

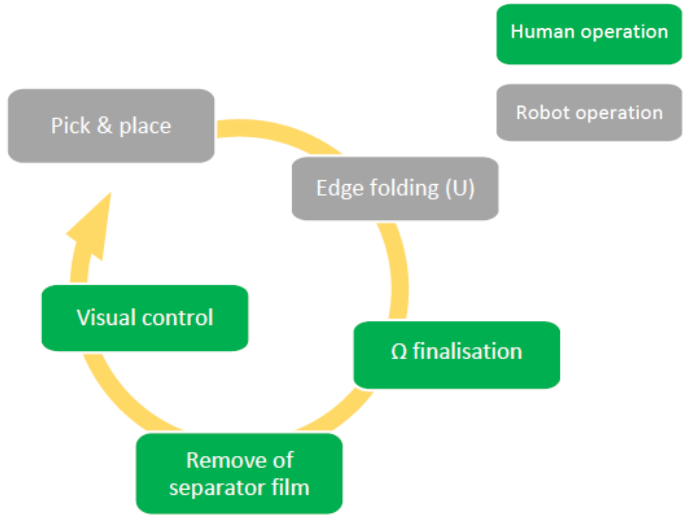


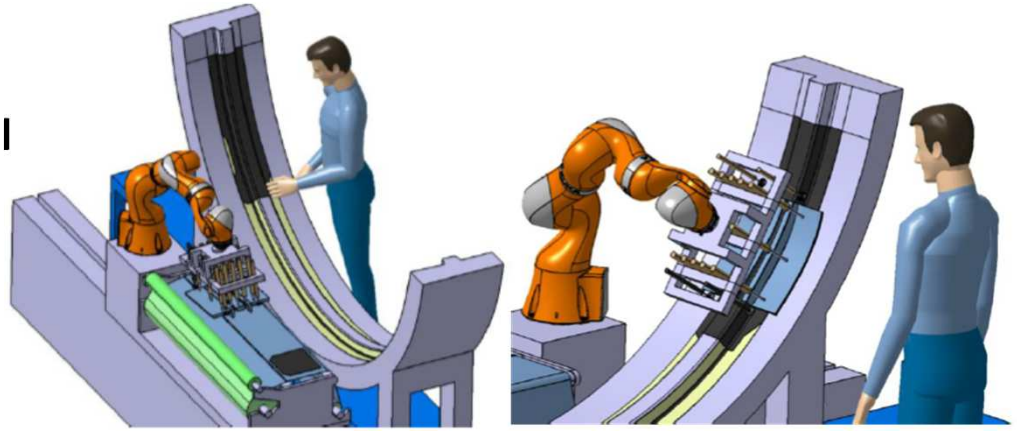
Task repartition is a key factor for process efficiency
Specific end effector development needed

Collaborative process

- **Tasks repartition Cobot/human**
  - Pick & Place + compaction => COBOT
  - Corner compaction, release film removal and control => HUMAN
- **No stacking changes required**
- **Adaptation of plies lay up order for release film removal**







Comparison between AFP and Cobot

- **Equivalent process time AFP + hot forming / Pick & Place**

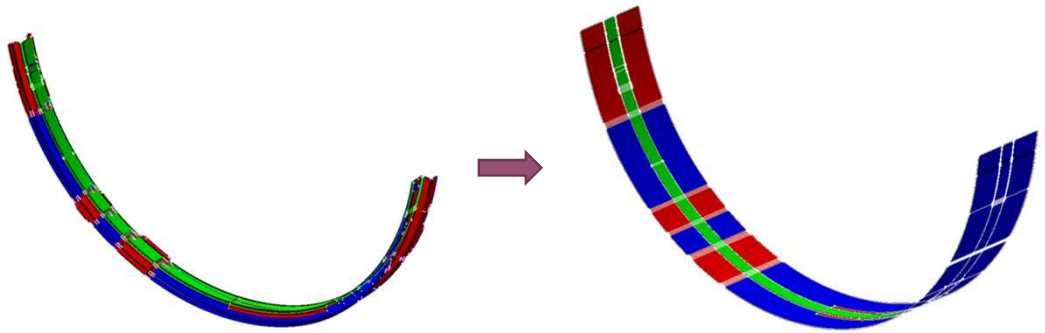
- **AFP**
  - Faster material preparation
  - High efficiency on full plies, UD and large size reinforcements
  - Low efficiency on small reinforcements
  - High manufacturing readiness level
  - Need hot forming step
  - Need stacking modifications

- **Pick & Place**
  - Time consuming Cutting/Kitting
  - Low efficiency on full plies, UD and large size reinforcements
  - High efficiency on small reinforcements
  - Low manufacturing readiness level (end effector)
  - No additional forming required
  - Identical part design

Combined process

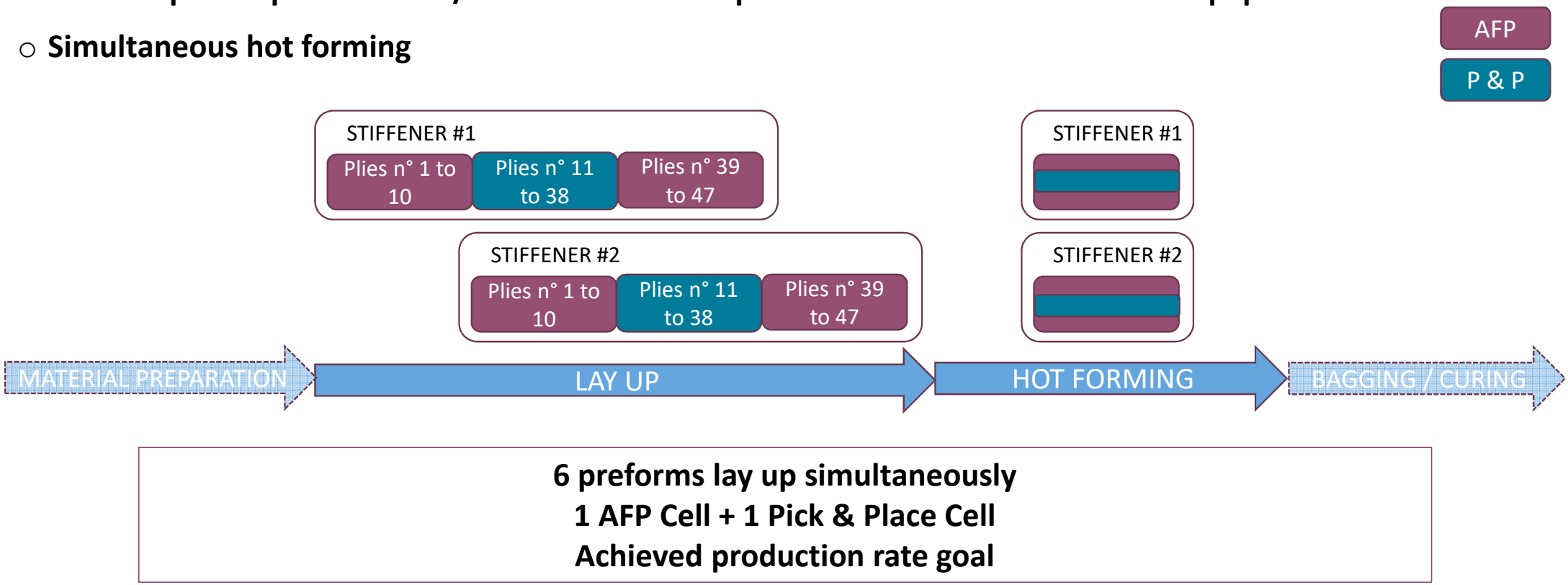
Solution => Combined process AFP/Pick & Place + Hot forming

- **Modified stacking to avoid 0° on flanges**
- **Same materials as original part**
- **Full plies, UD and large plies = AFP**
- **Small plies = Pick & Place**
- **Flat preform cross section simplify end effector design**



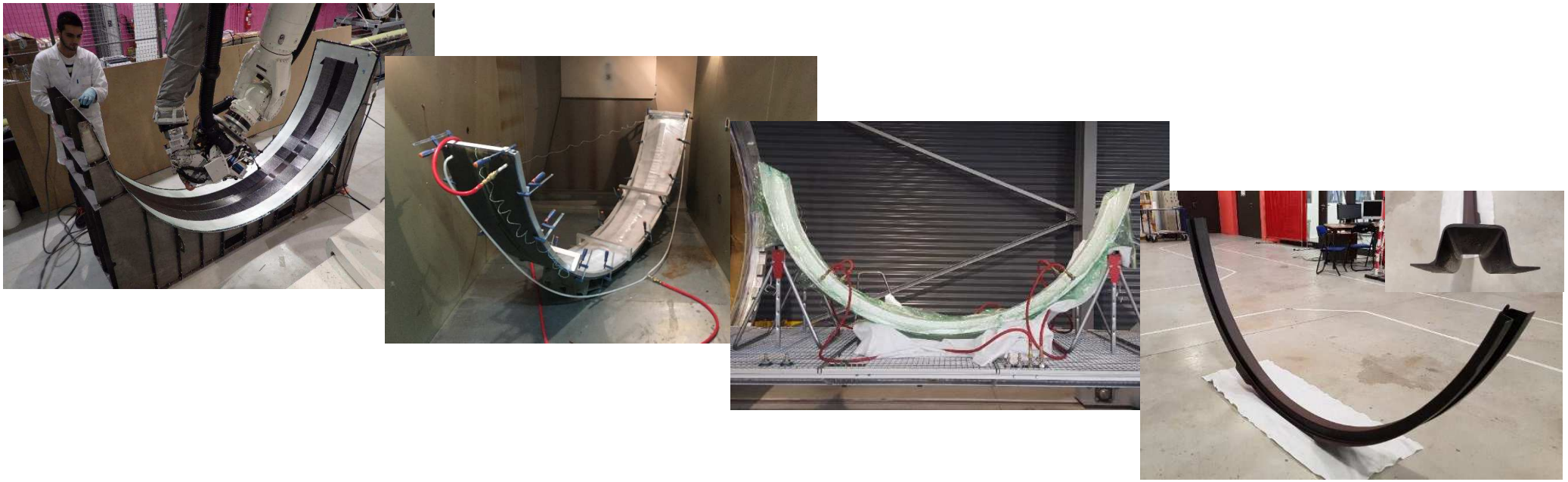
Combined process

- **Efficient plies repartition AFP/Cobot => balanced process time for each industrial equipment**
- **Simultaneous hot forming**



6 preforms lay up simultaneously
1 AFP Cell + 1 Pick & Place Cell
Achieved production rate goal

Prototypes manufacturing

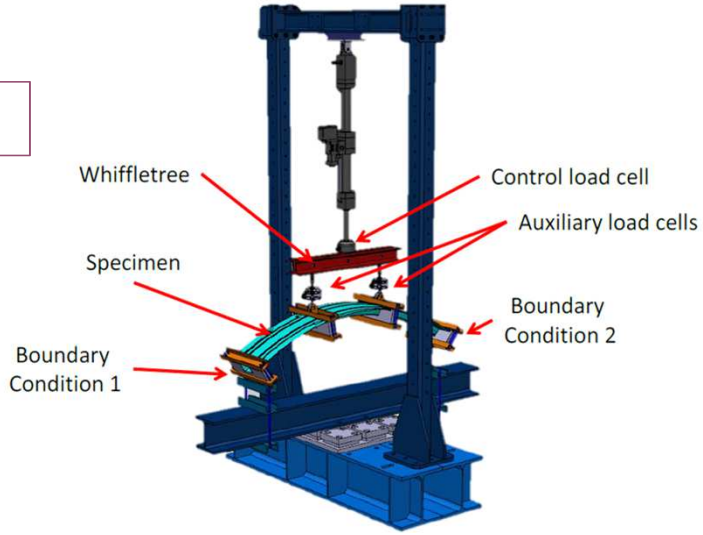


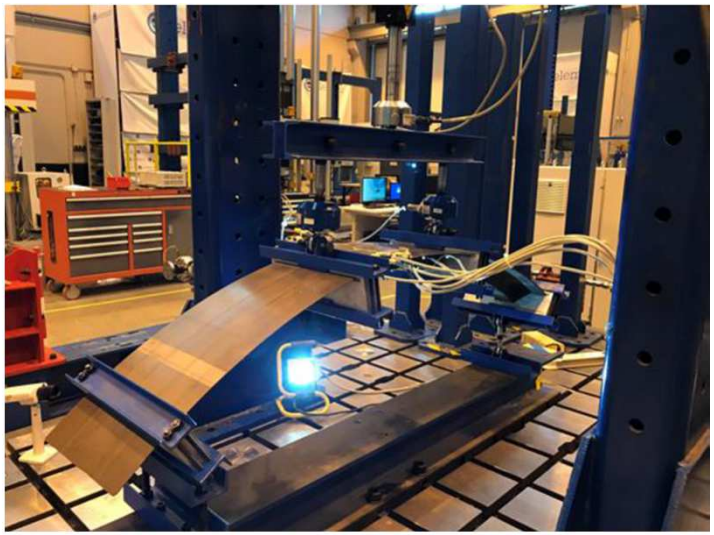
Caul plate and curing tool made in house
Four stiffeners prototypes manufactured

Prototypes testing

- **Four points bending test done on stiffener prototype**

Bending strength improved by 15%





Test done under GAIN project scope

Conclusion

- ***Combined AFP/Pick & Place process offers flexibility, lay up accuracy and high production rate***
- ***Flat preform section simplify end effector design and compliance with several stiffener curvature***
- ***Slight adaptations still required to improve manufacturing (stacking)***

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