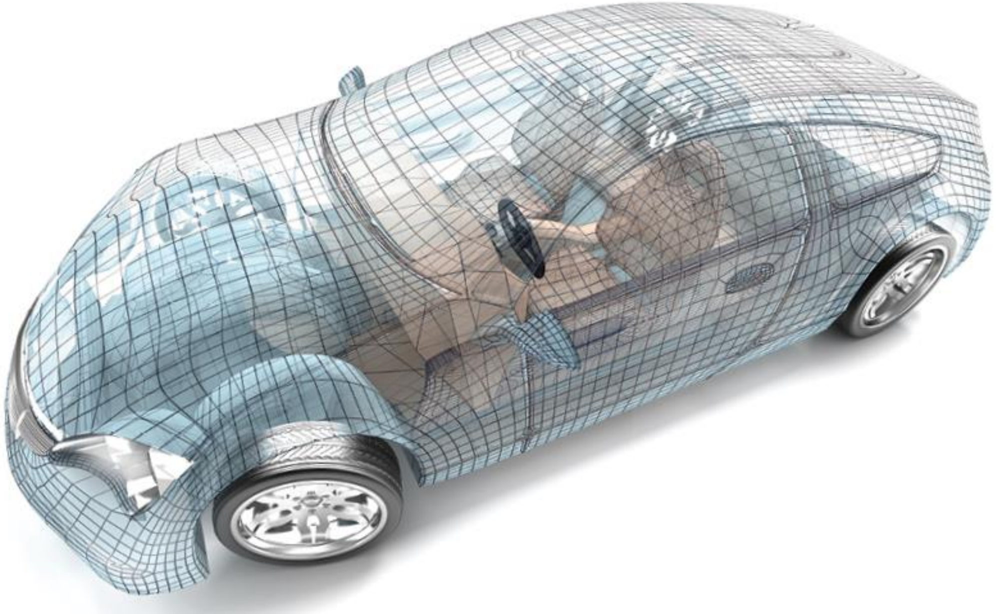
TCC 2020
THERMOPLASTIC COMPOSITES CONFERENCE

A VIRTUAL EVENT
APRIL 29 – MAY 1, 2020



AFP of Double-Curved Thermoplastic Composite Aerostructure Skin.

Presented By: Dan Ursenbach
Associate Director, Research and Technology
Collins Aerospace – Aerostructures Division

Acknowledgments

Justin Merotte, Coriolis Composites, Queven, France

Noushin Bahramshahi, Collins Aerospace

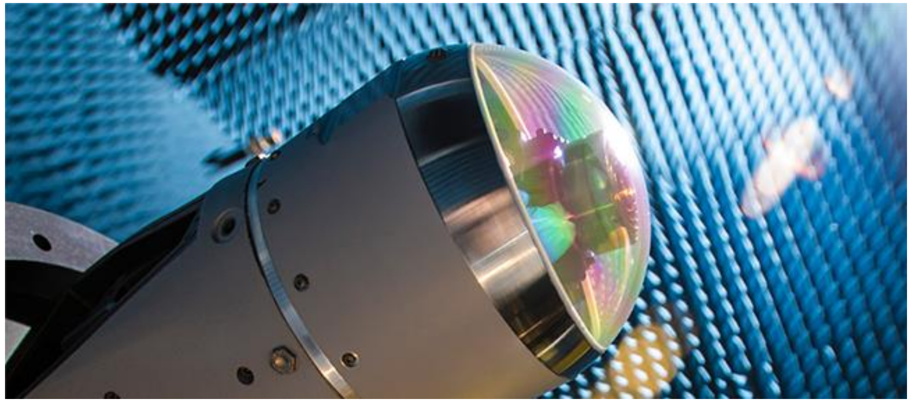
Raytheon Technologies

Collins Aerospace

Pratt & Whitney

Raytheon Intelligence & Space

Raytheon Missiles & Defense



Collins Aerospace

Formed to meet customer needs and represent the best in innovation, technology and expertise.

Aerostructures

Avionics

Interiors

Mechanical Systems

Mission Systems

Power & Controls

Collins Aerospace

By the numbers

GLOBAL PRESENCE

78,000+
employees

16,000+
engineers

300+
sites globally

ANNUAL REVENUE

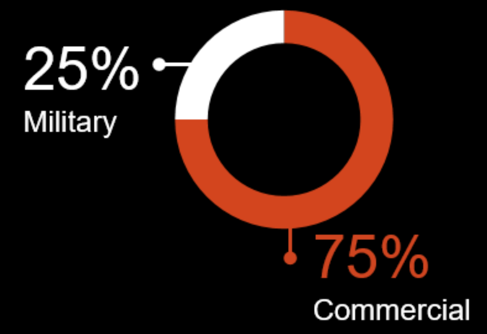
$26 billion
net sales

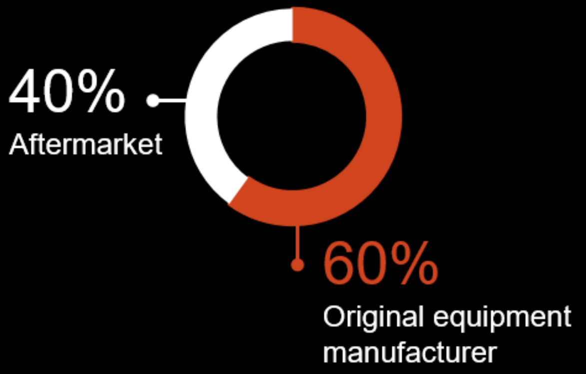
INVESTED IN INNOVATION

$3.7 billion
research and development investment*

* * 2019, company- and customer-funded

BROAD AVIATION AND MILITARY PORTFOLIO





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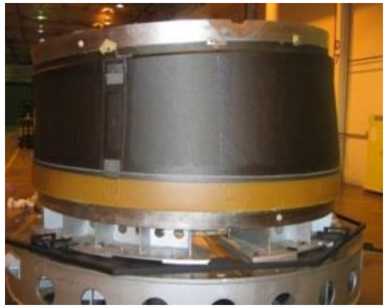
Aerostructures Division Composites Legacy

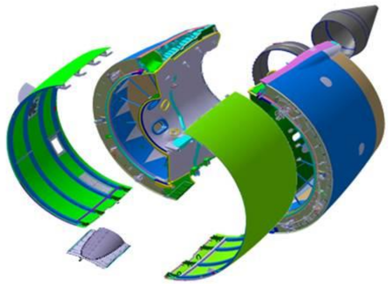
MD-80
Composite Lower Cowl Door

NASA X-33
BMI Panels

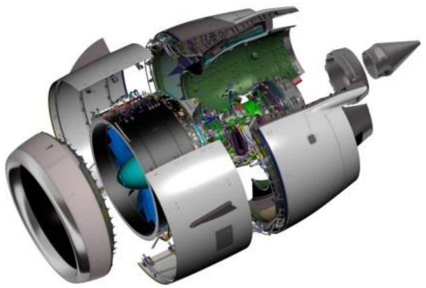
787
1-Piece Inner Barrel



A350XWB Nacelle



A320neo Nacelle



40% composite by weight

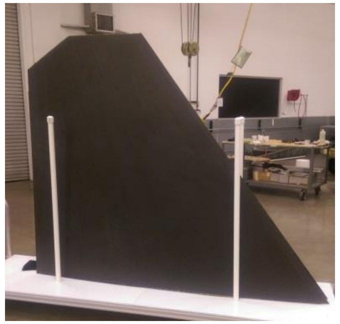
1980	1985	1990	1995	2000	2005	2010	2015	2020

CF6-80C2 Fan Cowl
Filament winding

CF6-80C2 Fan Cowl
Fully co-cured

787 IFS
Automated Fiber Placement

A320neo Fan Cowl
Resin Film Infusion



F-16 Stabilator
Out of Autoclave RPM

40+ years of composites legacy

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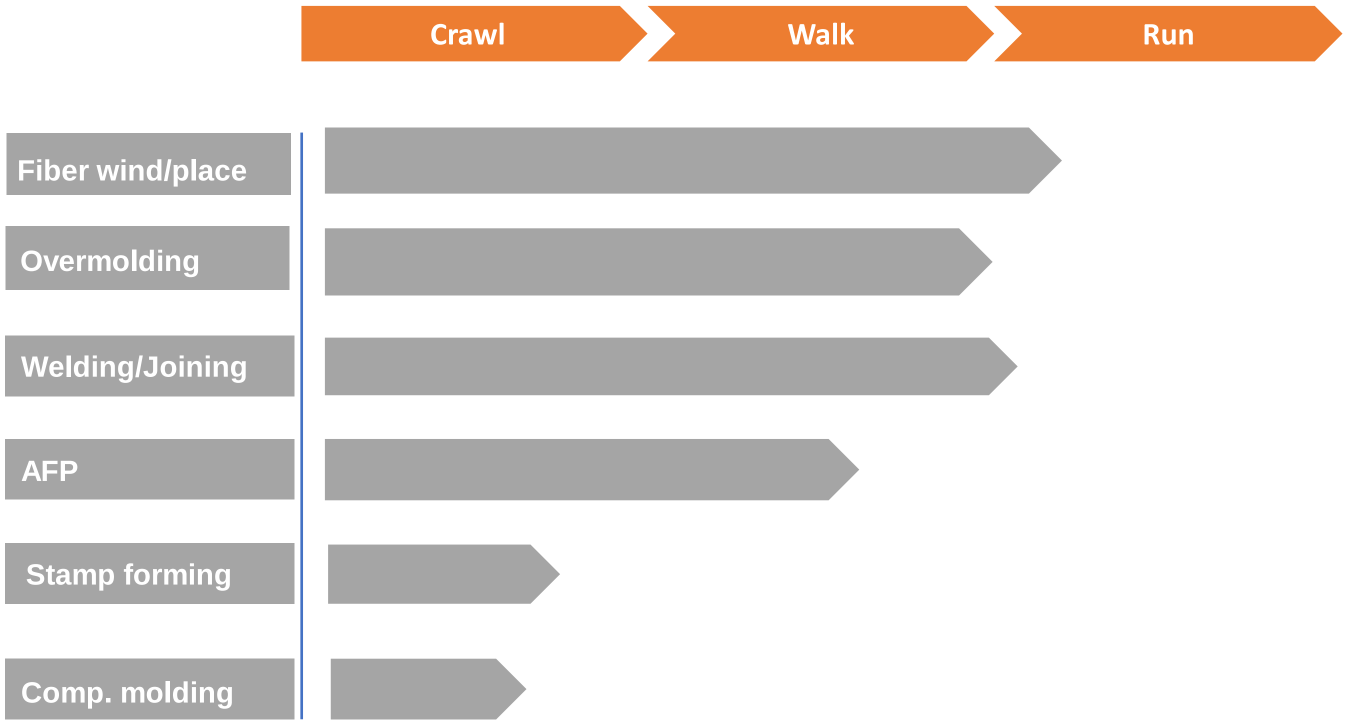
Thermoplastic Roadmap



Building block approach to full service capability

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Thermoplastics Pilot Line – Riverside, California

Automated Fiber Placement

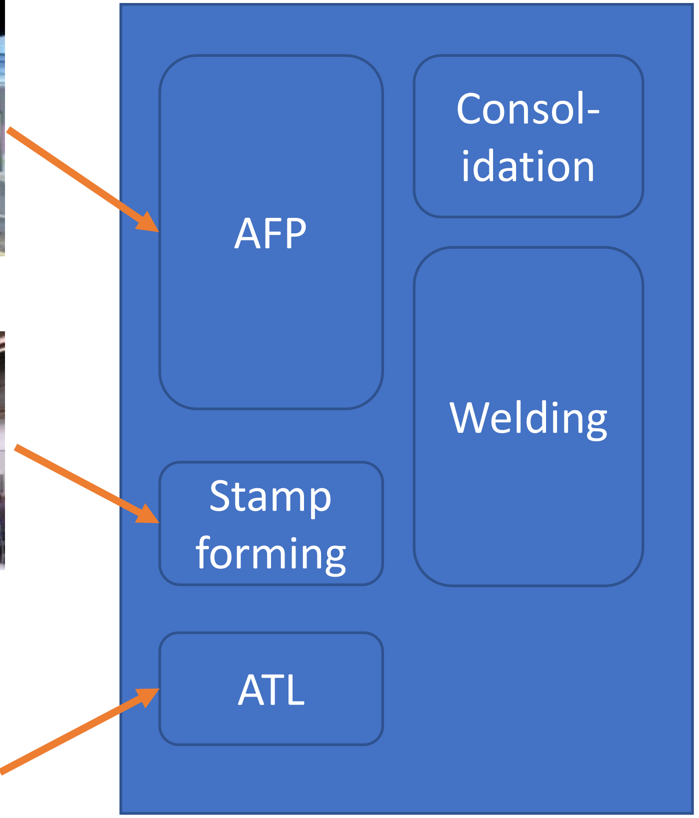
Image courtesy of Coriolis

Stamp Forming

Image courtesy of Pinette

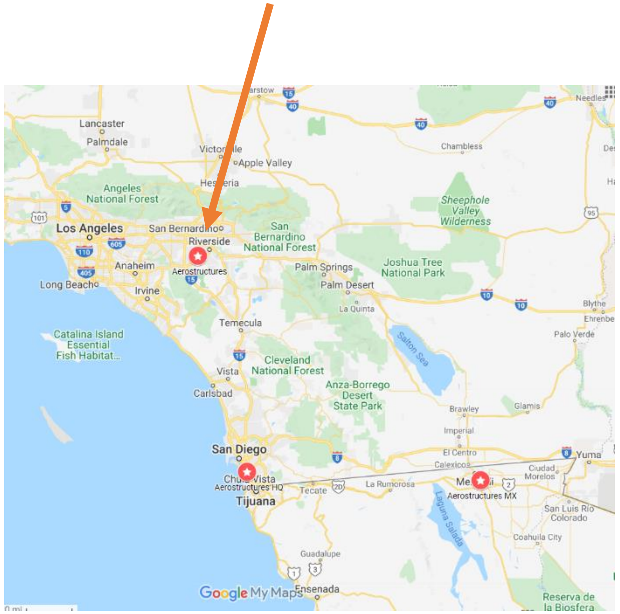
Automatic Tape Laying

Image courtesy of Boikon



Investment for in house thermoplastics pilot line

3rd- 4th Qtr 2020 Implementation in Collins-Aerostructures Riverside



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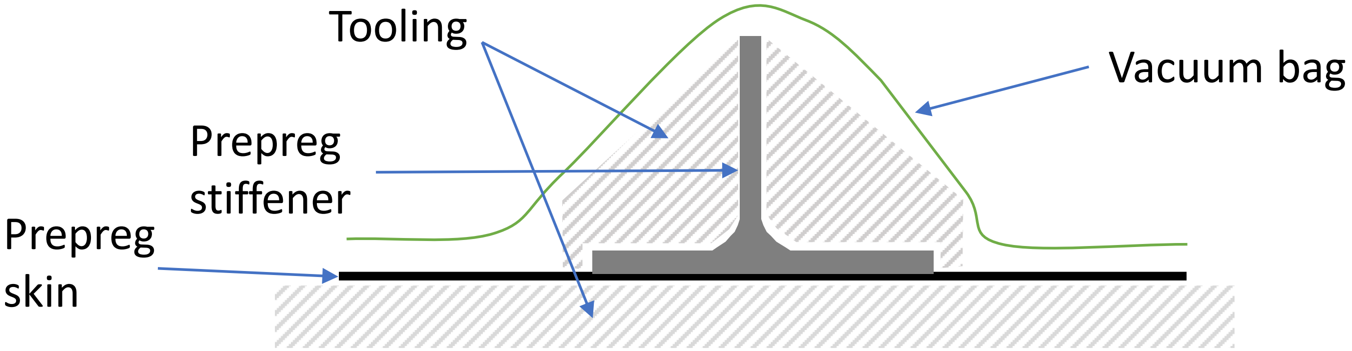
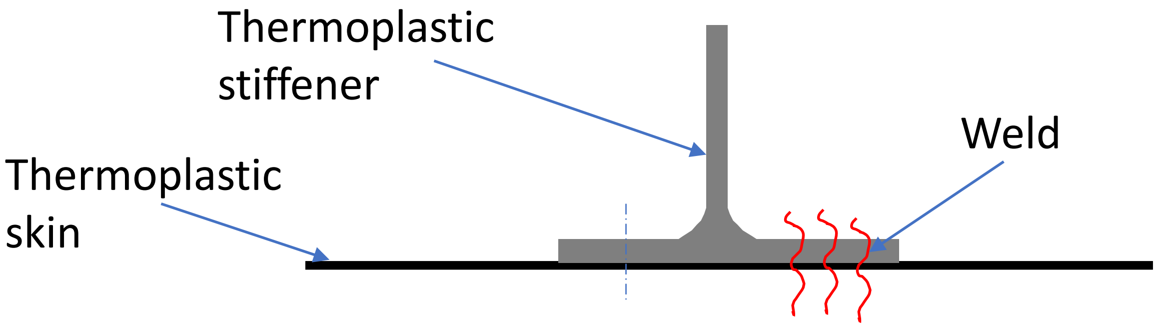
Stiffened skin structure for aerospace

Wide Body Fan Cowl



Thermoset consolidation & cure process



Thermoplastic joining process

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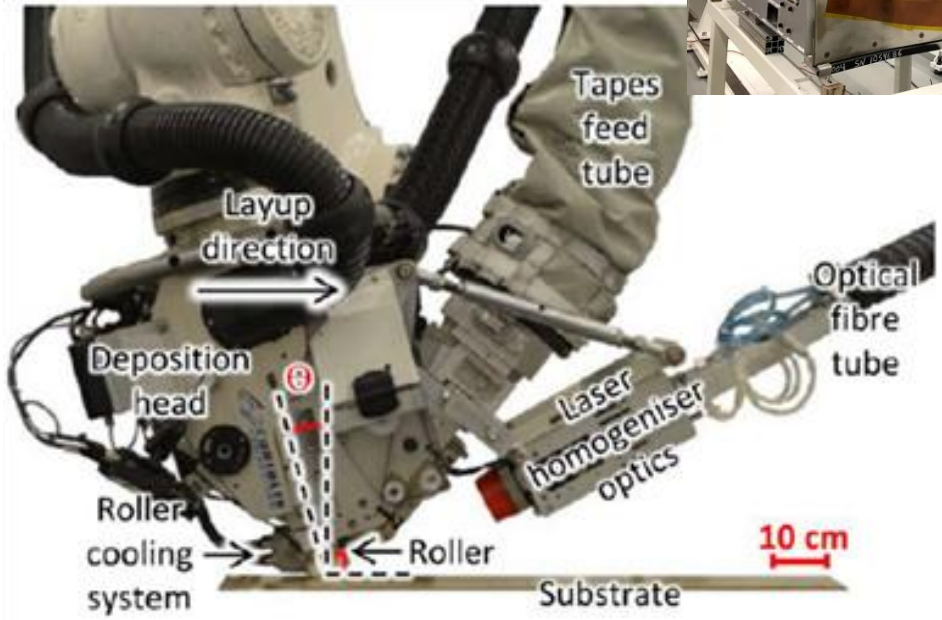
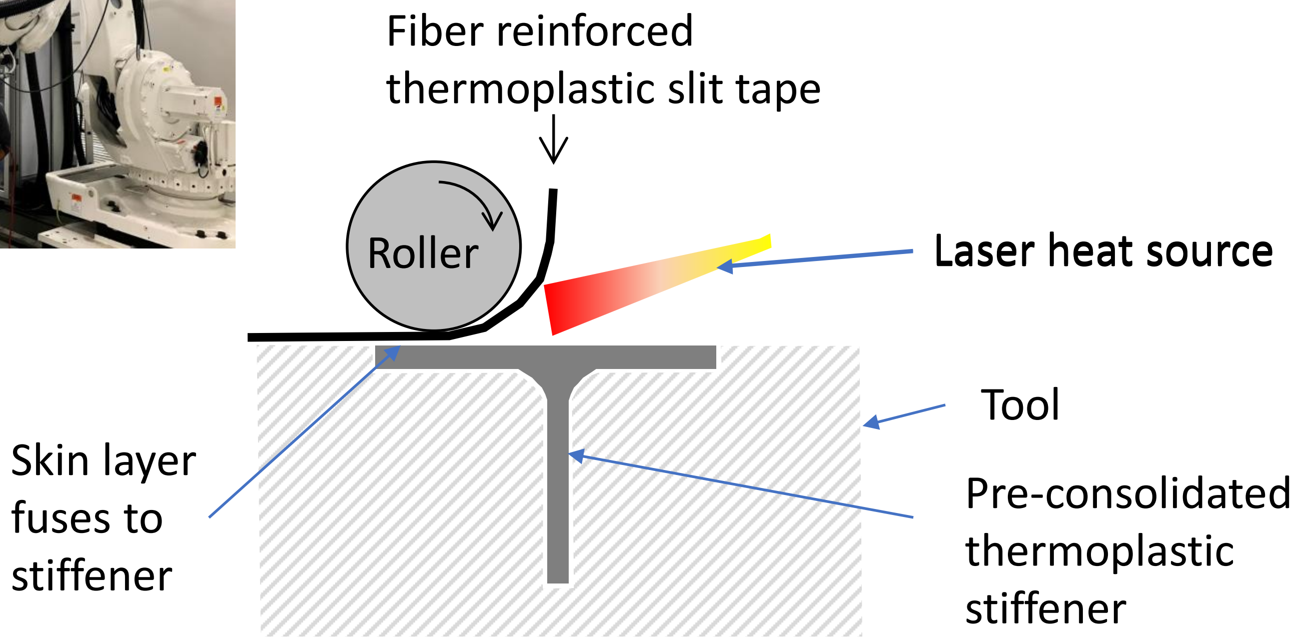
Laser assisted thermoplastic fiber placement





In-situ melt consolidation process

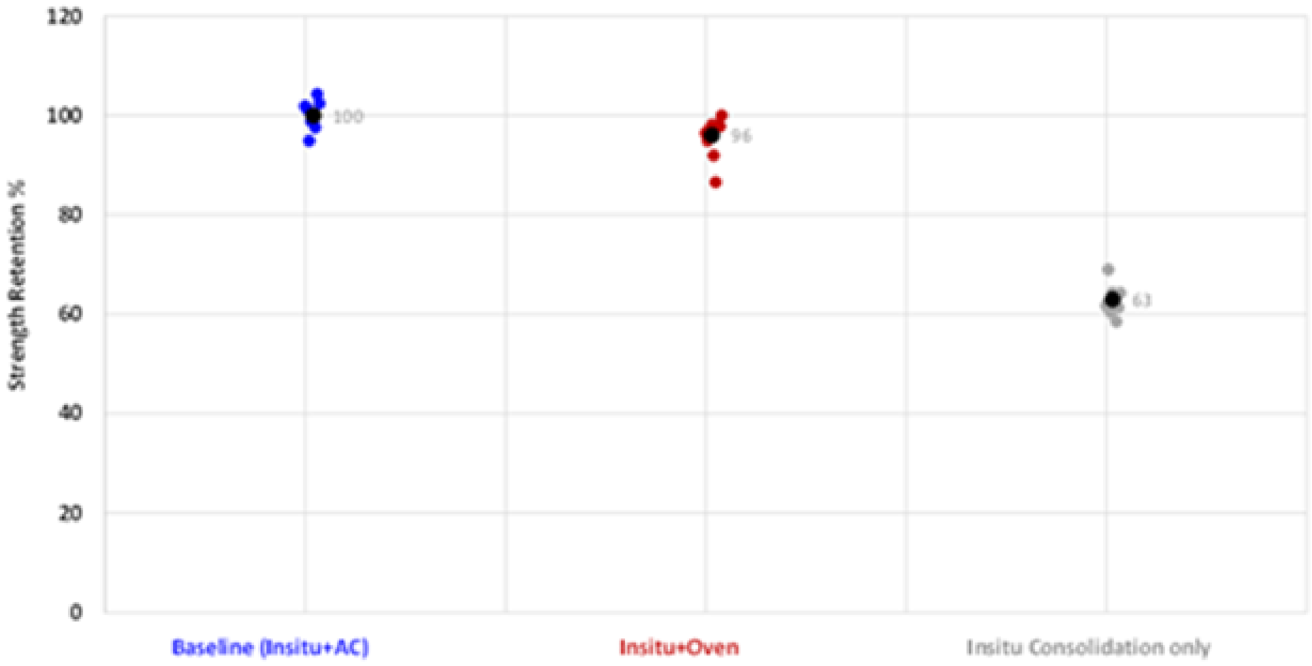
In-situ fiber placement only

Pros

Eliminate secondary consolidation step & tooling
Eliminate secondary joining/bonding

Cons

Mechanical property knockdown
Slow speed to attain low void content
Residual stress buildup
Culmination of geometric variation on aero surface



Percent Compression Strength Retention of PEEK LAFP Specimens manufactured using different processes (ISC+AC, ISC+OOA, ISC)

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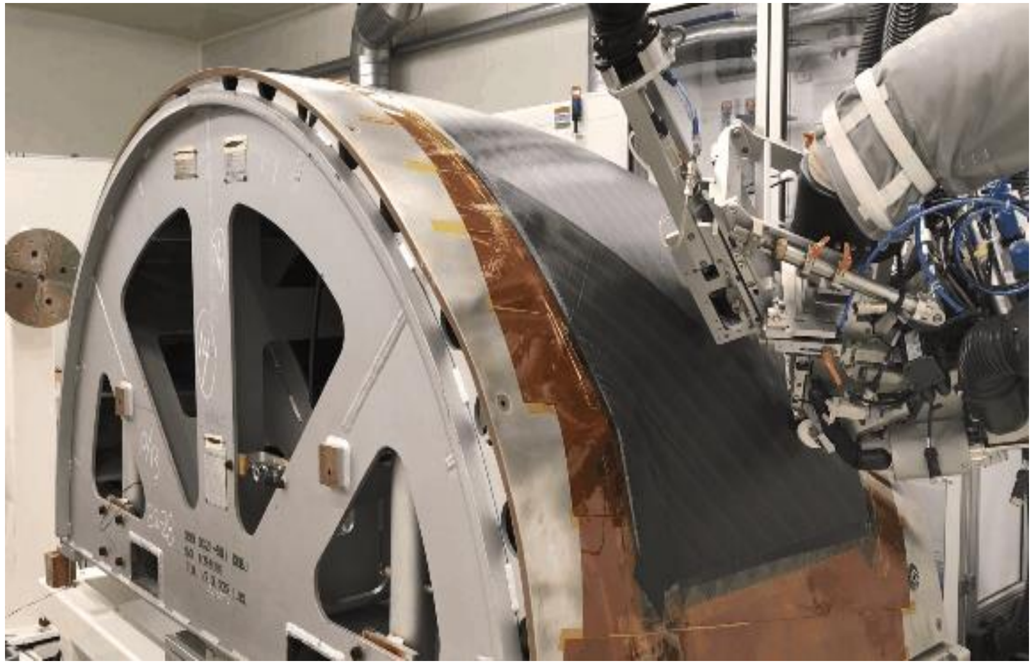
Double curved barrel demonstrator

Approximately 80” diameter
Work performed by Coriolis in Queven, France
Both concave and convex trials



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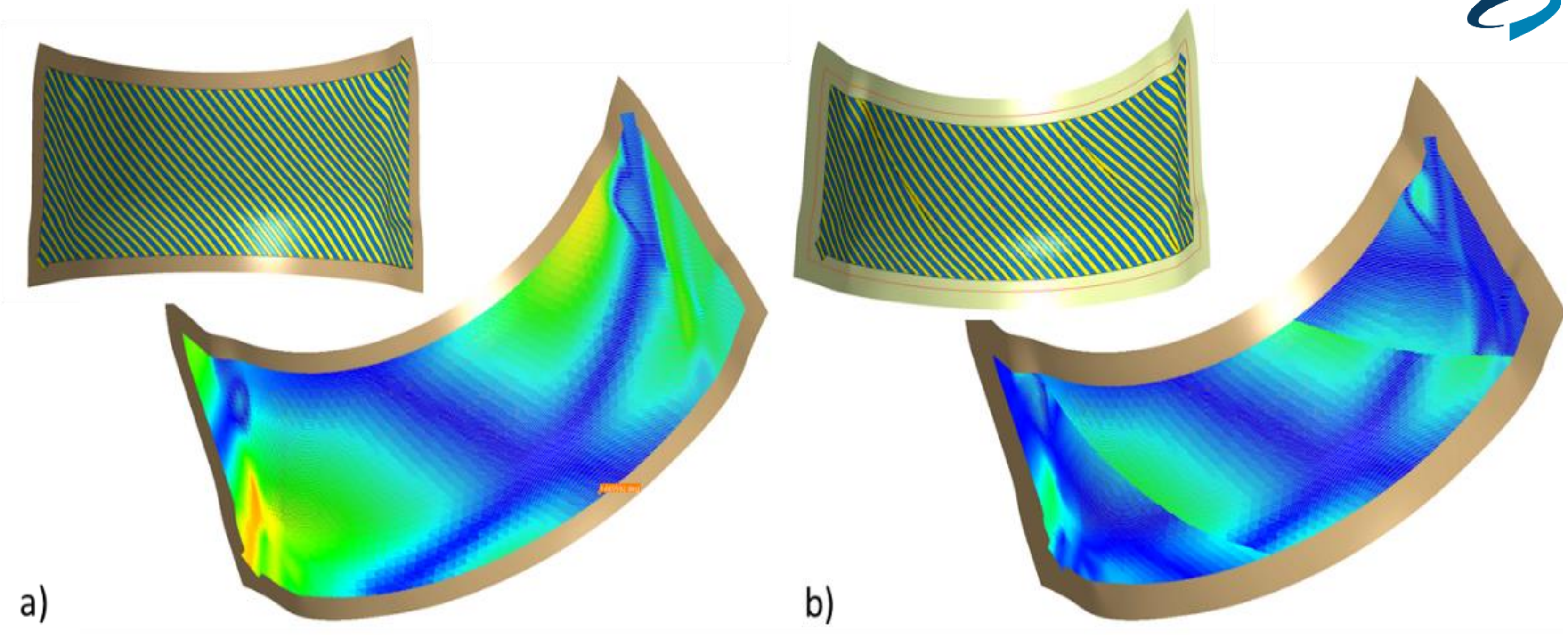
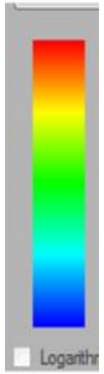
Fiber curvature strategy

CORIOLIS CADFiber®





Max fiber angle deviation

Single sector

Three separate sectors

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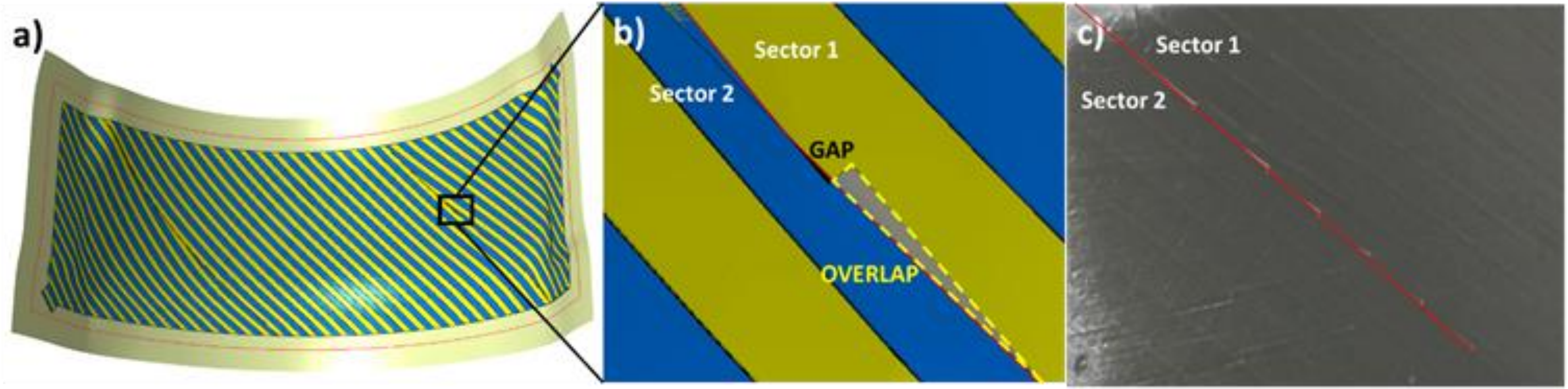
CORIOLIS CADFiber®

Sector Convergence



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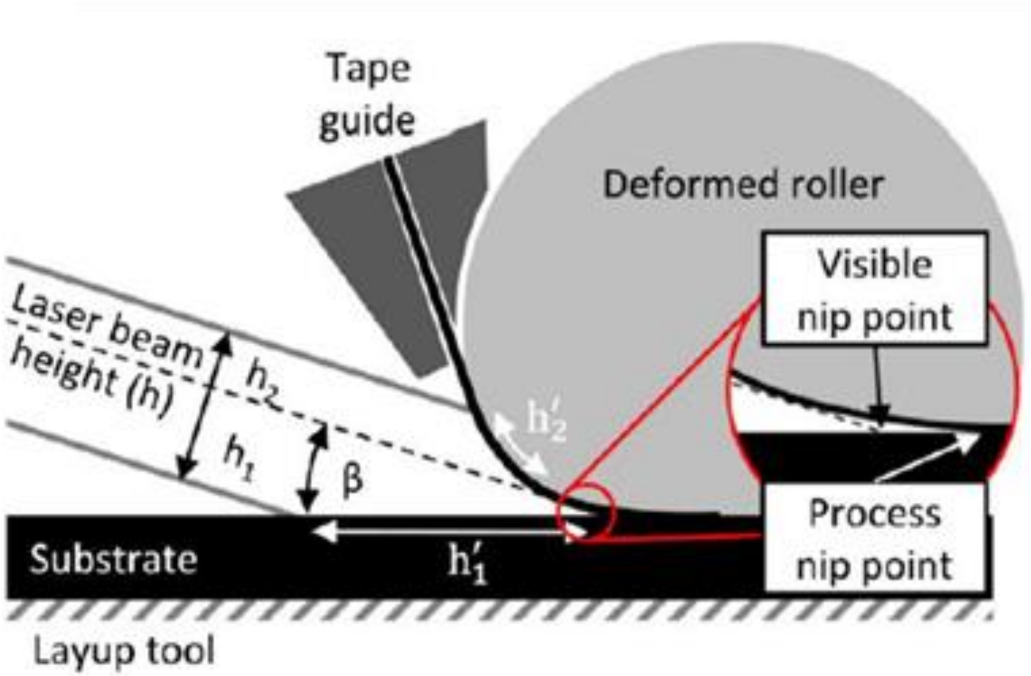
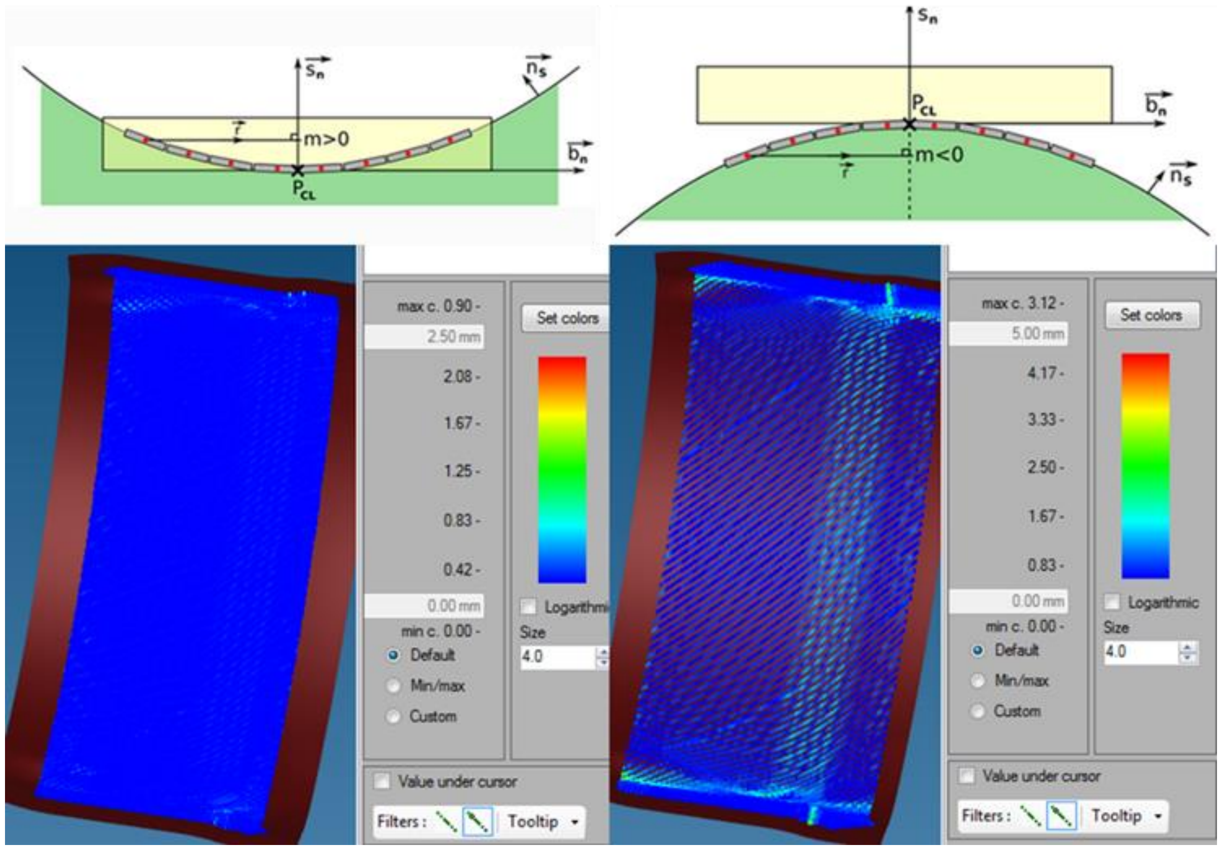
Roller deformation and surface contact



CORIOLIS CADFiber®

Roller crush analysis



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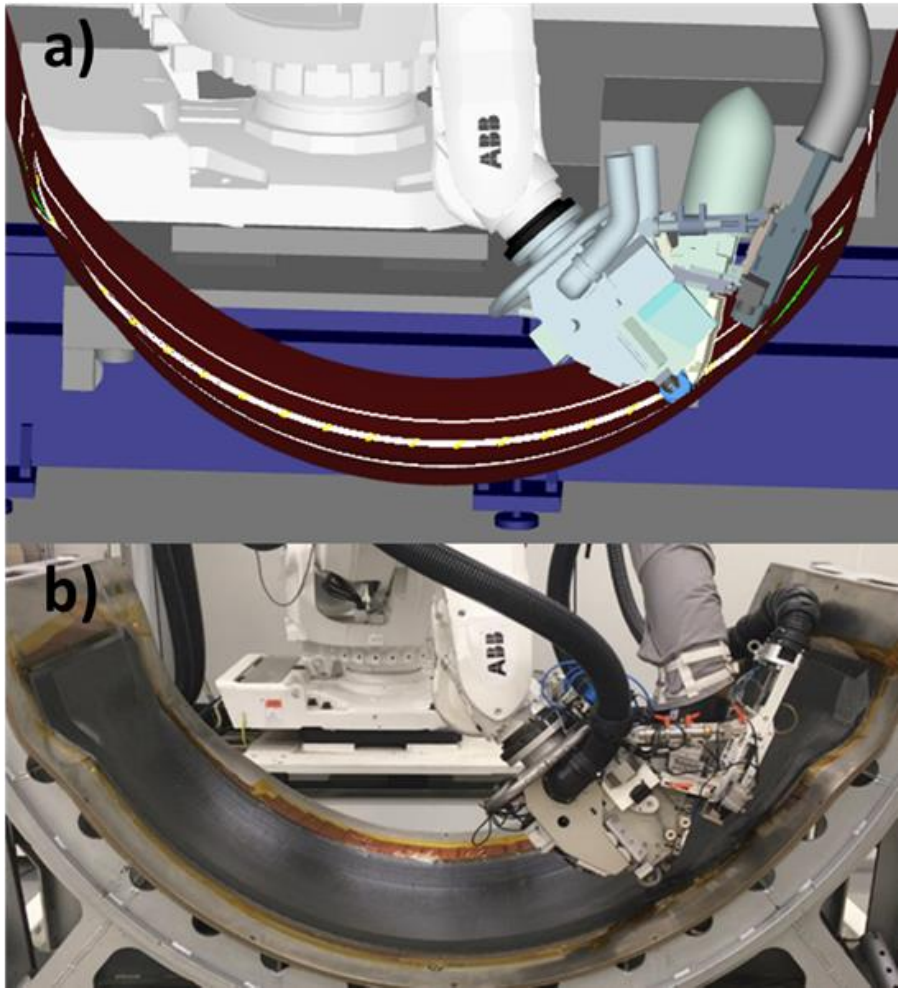
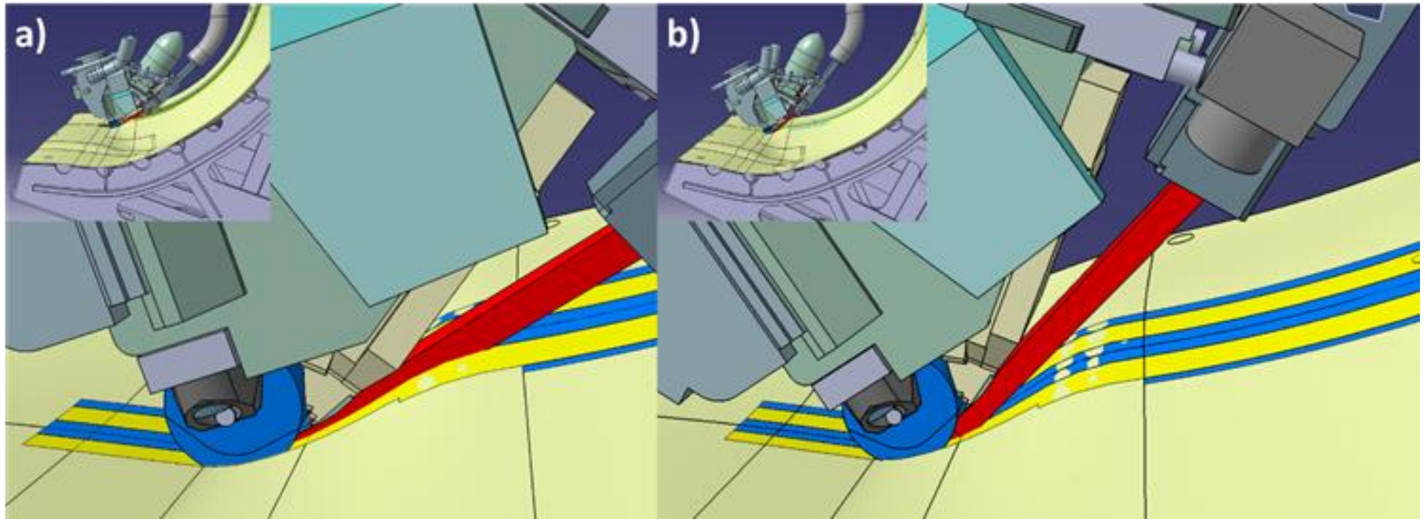
CORIOLIS CATFiber®

Head Movement Simulation





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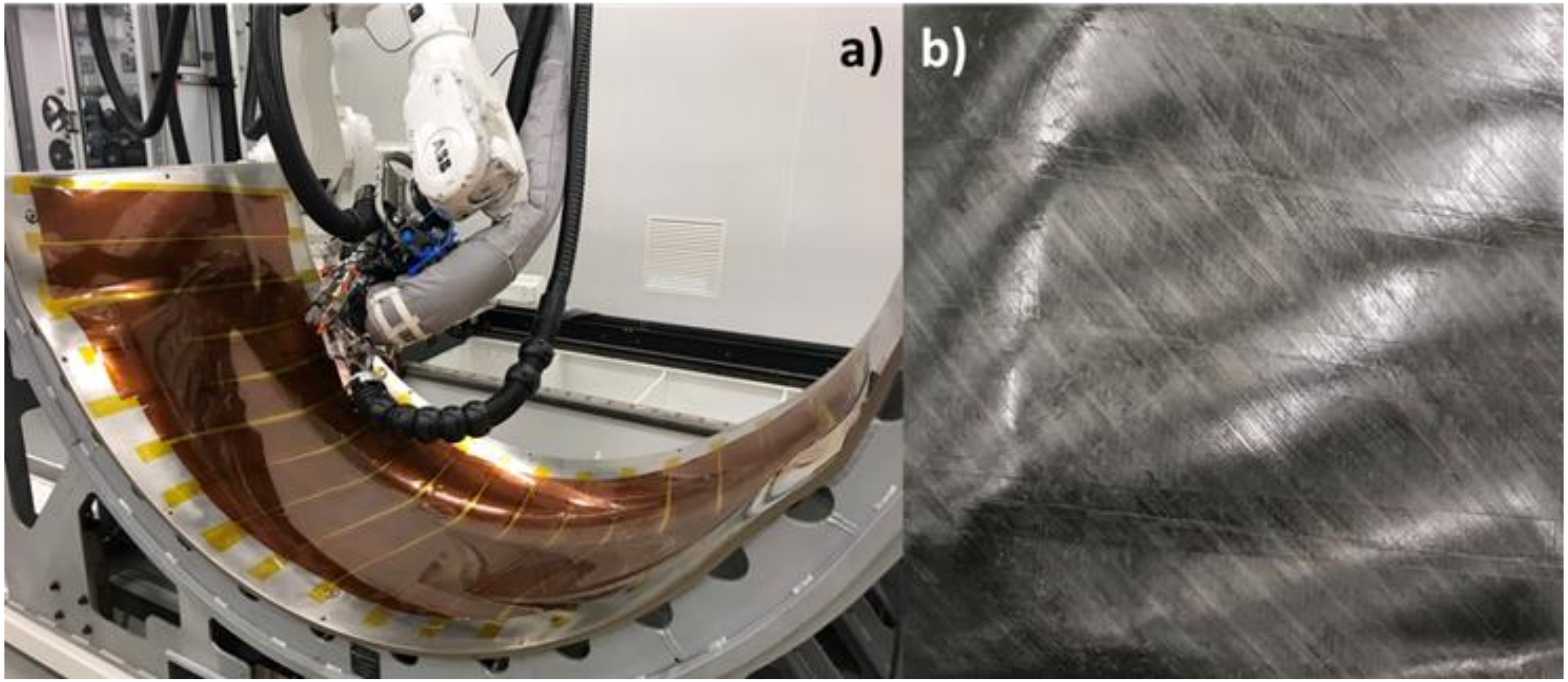
Surface release ply



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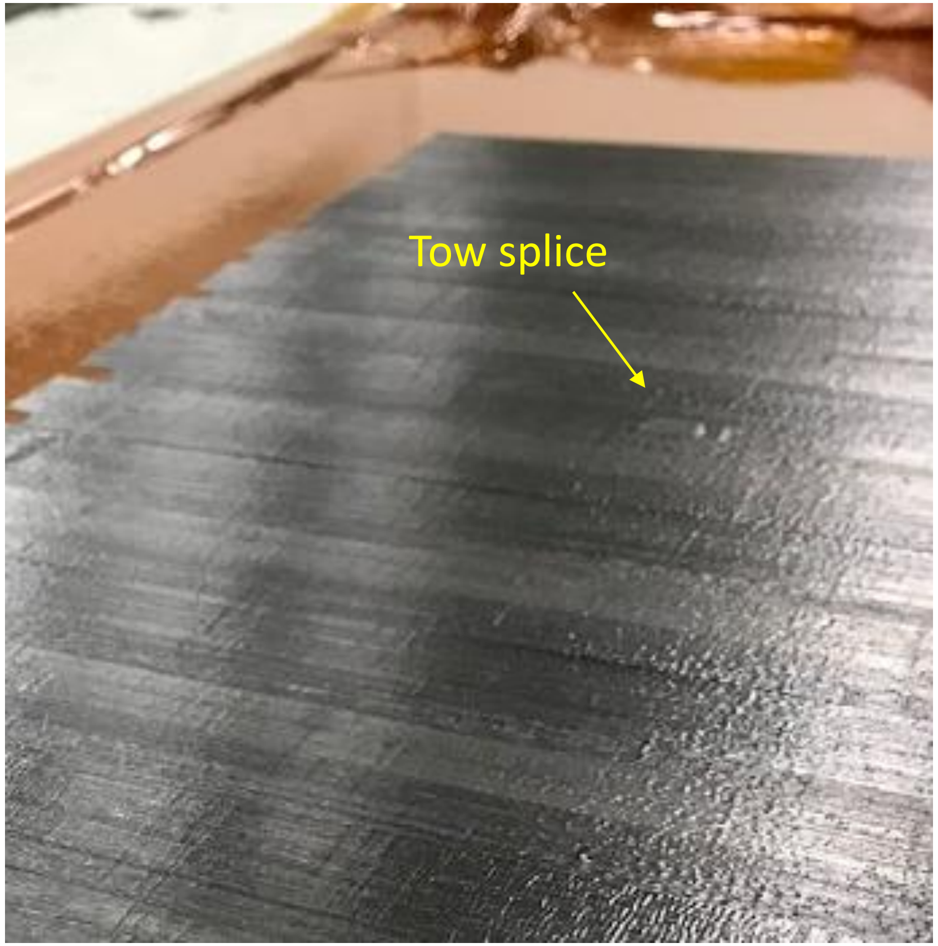
Material consistency



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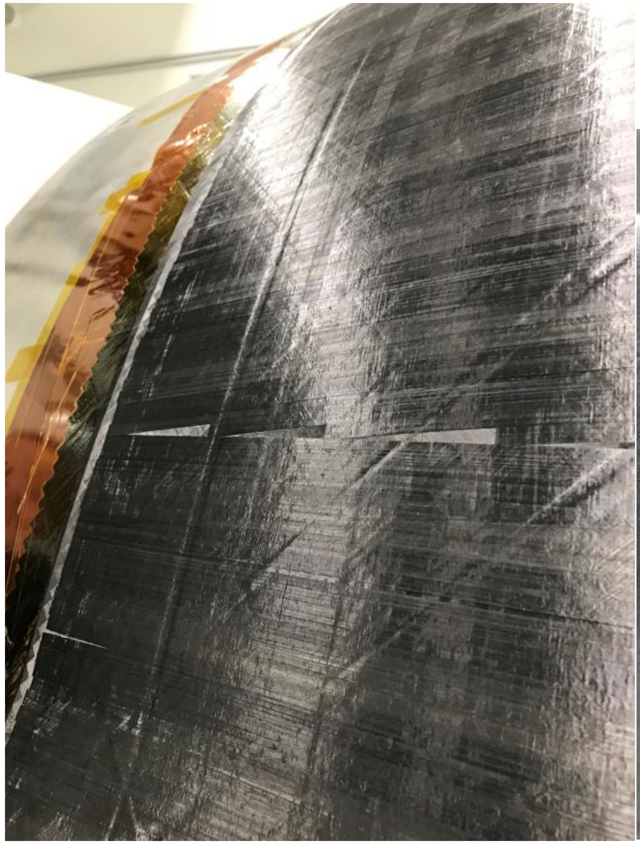
Convergence zones – print through



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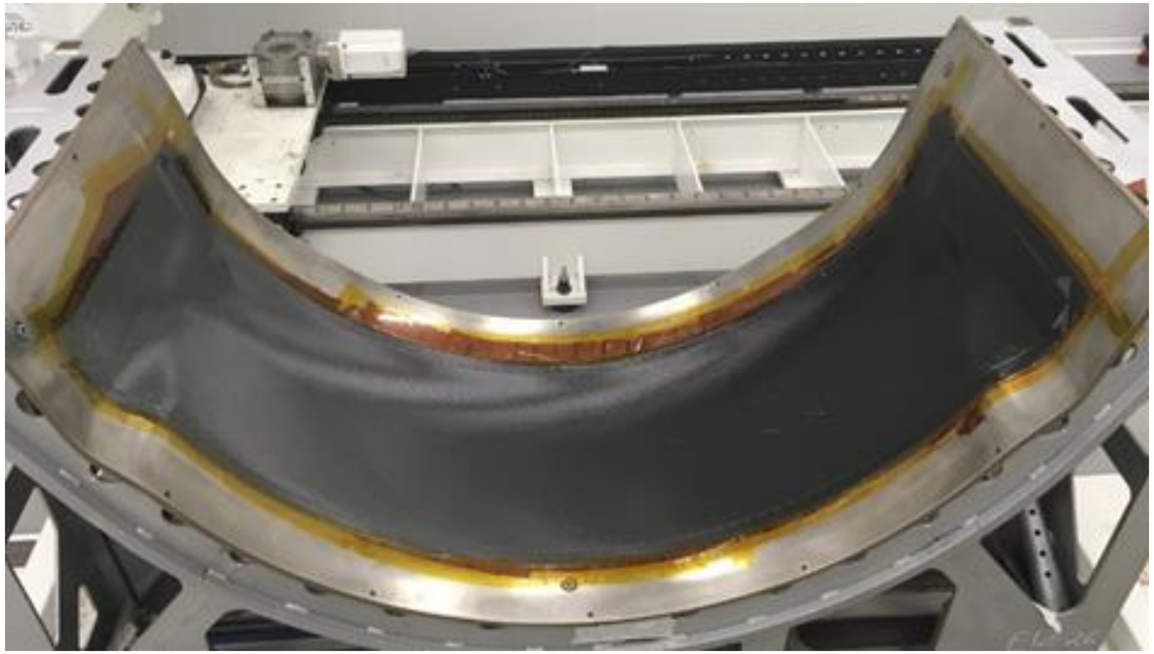
Concave lay-up & bonded stiffener



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Conclusions

For in-situ to work:
Improved lay-up speed
Improved mechanical properties
Stiffener flange-to-tool transitions (temp & geometry)
(Residual stress prediction)

In general:
Tool surface / 1st ply strategies
Acceptable gaps & overlaps
Tow splices
Material consistency