16 aprile 2016

Aula Scipione Bobbio
Scuola Politecnica e delle Scienze di Base
P.le Tecchio

DIPARTIMENTO DI
INGEGNERIA
INDUSTRIALE

PROCESSI DI PRODUZIONE AUTOMATIZZATA (AFP & RTM)

Leonardo Lecce

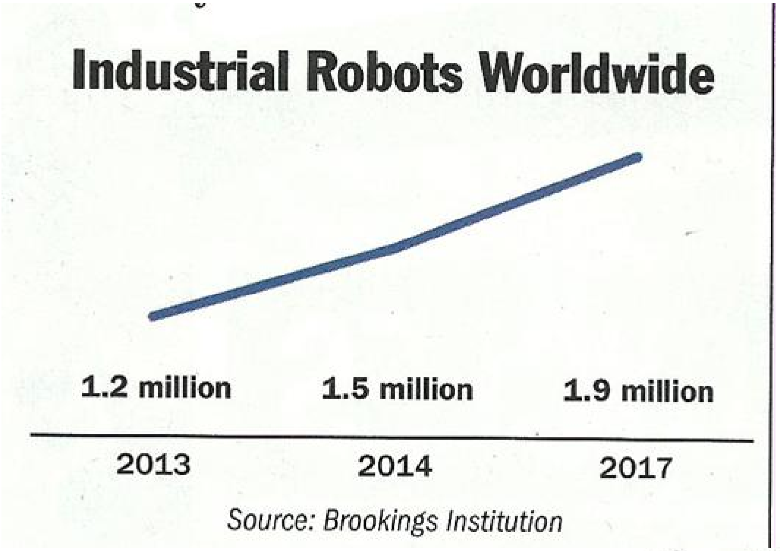
NOVOTECH
ADVANCED AEROSPACE TECHNOLOGY

Partner of CLEANSKY

CONTENUTO

1. INTRODUZIONE

AUTOMAZIONE…….QUALI INCOGNITE ?!



markets. Take Boeing's Black Diamond project. "The heart of this project is about automation," Allen says. "In both our defense and commercial businesses, when we automate we can radically change the cost proposition for building out our products."

tion think tank. Oxford University researchers Carl Frey and Michael Osborn studied 702 occupational groupings in 2013 and found "47% of U.S. workers have a high probability of seeing their jobs automated over the next 20 years."

1. INTRODUZIONE

TECNICA TRADIZIONALE : HAND-LAY-UP (HLU)

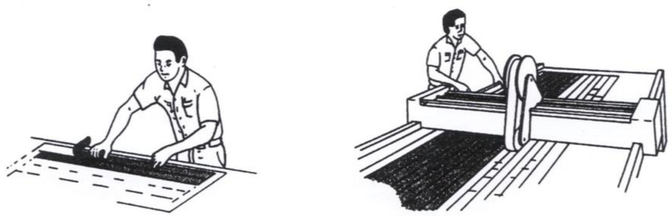
Advantages of the hand-lay-up method

1. Has been the workhorse for composites since the beginning –proven process.
2. Very flexible- Can handle part with complex configuration
3. Does not involve high capital investment in acquiring expensive machines
4. Can handle custom made parts well

Disadvantages of the hand-lay-up method

1. Rate of material deposition is slow.
2. Requires large amount of manual labor
3. Variability depending on the operator
4. Can not handle large parts
    1. Limit of out life of the prepregs
    2. Logistic issues
5. Introduces large amount of waste.
6. Lack of integration between manufacturing and design
7. Difficulty in making parts with no free edge (tubes)

Hand-lay-up.



Comparison between manufacturing of autos and aircrafts

Current aerospace composite part manufacture

Composites Clean Room

Current automobiles manufacture

MAIN AUTOMATED COMPOSITE MANUFACTURING TECHNOLOGIES

FILAMENT WINDING

ATL : AUTOMATIC TAPE LAY-UP : Wider tape (12 inch or more)

AFP: AUTOMATIC FIBER PLACEMENT: Narrower tape (0.125", 0.25", 0.5")
Multiple tapes (up to 32 or 64)
Fiber steering
Heating source for thermoplastic composites

CCM: CONTINUOS COMPRESSION MOULDING

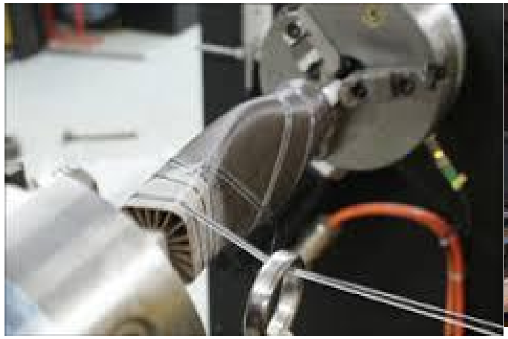
CM: COMPRESSION MOULDING

ARTM : AUTOMATED RESIN TRANSFER MOULDING

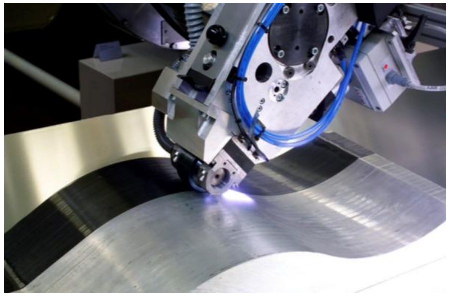
ESTRUSIONE, ETC

PANORAMICA TECNOLOGIE AUTOMATIZZATE

FILAMENT WINDING



ATL : AUTOMATIC TAPE LAY-UP



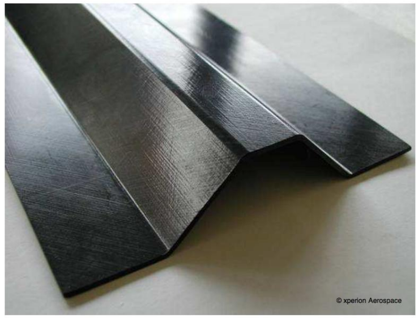
AFP: AUTOMATIC FIBER PLACEMENT

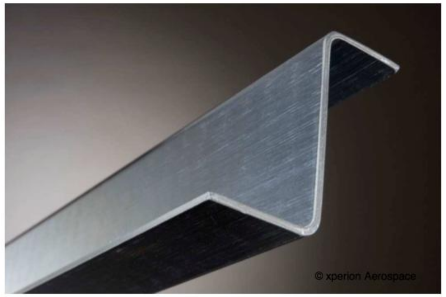
PANORAMICA TECNOLOGIE AUTOMATIZZATE

CCM: CONTINUOS COMPRESSION MOULDING (FINO A 80 m/h di profilati rettiliniei)

Continuous Compression Moulding Machines

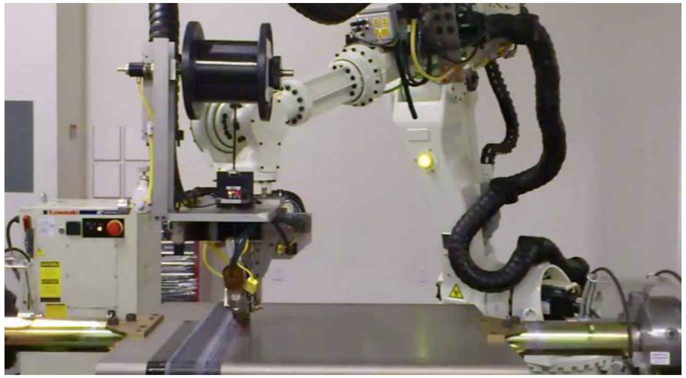
CCM Part hat shape





PANORAMICA TECNOLOGIE AUTOMATIZZATE
Tipologie diverse di AFP

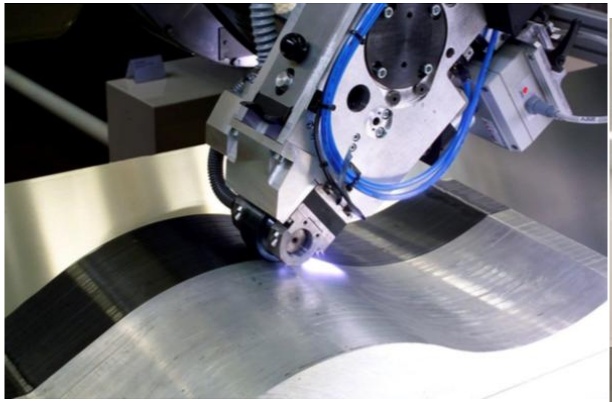
Automated Fiber Placement (AFP) machine at Concordia University



MAG IAS machine

MTorres machines

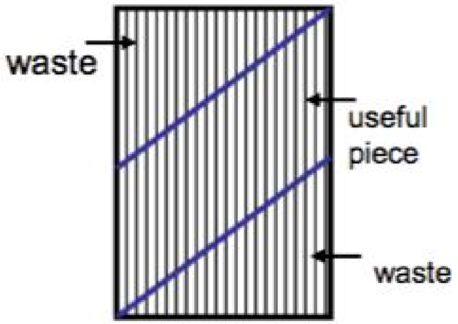
Ingersoll machines



Fraunhofer machine

CORIOLIS machine

Advantages of automated fiber placement (AFP)process



1. Fast speed of material deposition (> 10 lb/hr)
   (as compared to HLU- 2.5 lb/hr)
1. Does not depend on the operator
2. Less labor intensive
3. Less waste of materials (lower buy/fly ratio)
4. Repeatability of results
5. Seamless transition between manufacturing and design
6. Can handle large structures
7. Can produce unique structures
8. Steerable fibers

Challenges for automated fiber placement (AFP)process

1. High capital cost
2. New technology
3. Thermoset composites still need second operation (autoclave or oven)
4. Laps and gaps issues
5. Distortion in thermoplastic composite processing

PANORAMICA TECNOLOGIE AUTOMATIZZATE
Diffusione macchine AFP-ATL

GRUPPI INDUSTRIALI

1. Boeing
2. Spirit
3. Airbus
4. Bell Helicopter TexTron
5. Bombardier (Coriolis)
6. ATK
7. COMAC
8. SUPERJET
9. FINMECCANICA - AA (Grottaglie-Foggia)
10. FINMECCANICA –AW (Brindisi)

UNIVERSITA' E CENTRI DI RICERCA

1. Sheffield university (UK)
2. Manchester Institute of Technology (UK)
3. Bristol University (UK)
4. Fraunhofer Institute (Germany)
5. NLR (Netherlands)
6. Univ. of Missouri (USA)
7. Union College (USA)
8. Australia
9. Japan
10. Concordia University (Canada)
11. National Research Council Canada (Canada)
12. TUM Munich (Germany)
13. COMPODITATOUR (France)

NOVOTECH SrL – Avetrana (TA)

AFP – VISTA DA UN COSTRUTTORE CORIOLIS COMOSITES

COMPANY PROFILE

Founded in 2001
- By 3 « young » engineers

110 employes
- Mostly engineers
- Highly skilled in robotics, composites & software

Turnover 15M€
- More than 20M€ expected in 2015

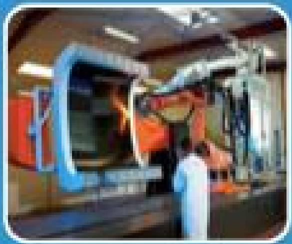
French independant company
- Founder owned

Patented technology
- 15 families of patent
- 150 titles

References
- Airbus Group (D&S, Aero) A350, Ariane 6, A320 NEO
- Safran (Aircelle),
- Dassault Aviation, Bombardier, Aerocomposit

CONGRES SFIP SIA IRT JV JUNE 11&12 2014 NANTES

AFP – VISTA DA UN COSTRUTTORE
CORIOLIS COMOSITES



Robotic cells

- TP, dry/binder tow, Thermoset
- 8 to 32 tows

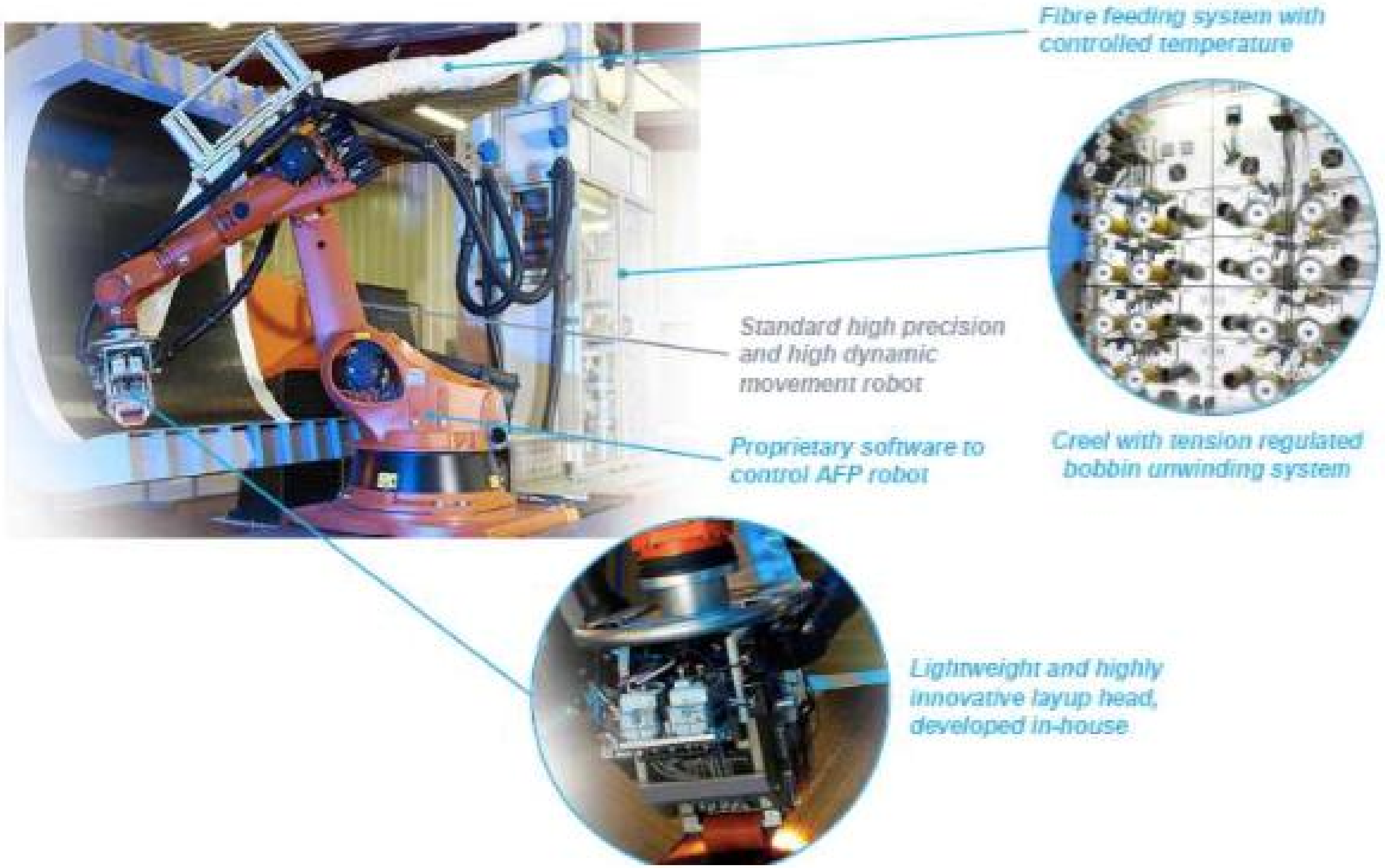
Software

- Integrated in CATIA V5/V6 or standalone
- Composites design, simulation and programing

Collaborative R&T

- Skilled engineer team
- Worldwide

AFP – VISTA DA UN COSTRUTTORE CORIOLIS COMOSITES



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AFP – VISTA DA UN COSTRUTTORE CORIOLIS COMOSITES

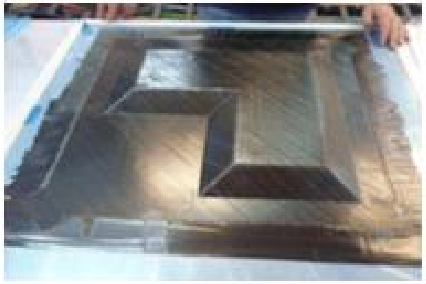
- Head for 8/16/32 x ¼'' or 8 x 1/8''
- Materials: thermoset, thermoplastic, dry binder yarn
- Heating: IR & Laser
- Independent Cut & Feed on the fly, v_{max} = 1 m/s

CONGRES SFIP SIA IRT JV JUNE 11&12 2014 NANTES

AFP – VISTA DA UN COSTRUTTORE CORIOLIS COMOSITES

Partner of CLEANSKY

CURRENT ROBOTIC FIBER PLACEMENT


Inserts and variable thickness


No scrap when cut-outs


Steering

- No scrap
- High mechanical properties
- Variable thickness capability
- Control of compaction and consolidation
- Full simulation and off-line programming

CONGRES SFIP SIA IRT JV JUNE 11&12 2014 NANTES

AFP – VISTA DA CORIOLIS COMOSITES

AEROSPACE & AUTOMOTIVE

ADVANCED MANUFACTURING

Faster Carbon

Europe's aircraft industry seeks to pave way for high-rate production of carbon-fiber structures

Graham Warwick Paris

Auto to Aero

Can aircraft manufacturers use low-cost, high-rate composite technologies from the car industry?

Graham Warwick Paris

AFP – VISTA DA CORIOLIS COMOSITES

AEROSPACE & AUTOMOTIVE

Initially, carbon fiber was used only in high-performance but low-volume supercars where material cost and manufacturing cycle times are less critical. Then in 2009, BMW announced it would build a small all-electric car using carbon-fiber composites. Deliveries of the i3 began late in 2013, but at 100 cars a day, it is at the lower end of the high-volume spectrum. Now automakers like PSA Peugeot Citroen are looking at composites, but for rates exceeding 900 cars a day.

AFP – VISTA DA CORIOLIS COMOSITES

AEROSPACE & AUTOMOTIVE

INDUSTRY NEEDS REGARDING AFP

Industry	Aerospace	Industry
Materials	Thermoset Binder Yarn Thermoplastics 50 to 100 €/kg	Dry fiber Thermoplastics Thermoset 5 to 15€/kg
Typical parts	Fuselage + Door Tail cone Fairings	Chassis Body structure Spars
Dimensions **Parts/Year**	1 – 25 m 100 - > 2.000	0.1 – 2.5 m 1.000 - > 200.000
Features	Double curved High quality Complex contour Sandwich	Complex 3D Variable thickness Local reinforcements

Flexible machine
Precision

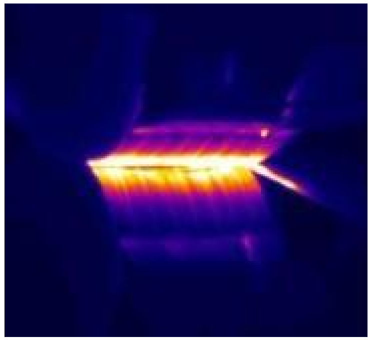
⇨

Highly automated
High productivity
Low material costs

CONTENUTO

NOUS

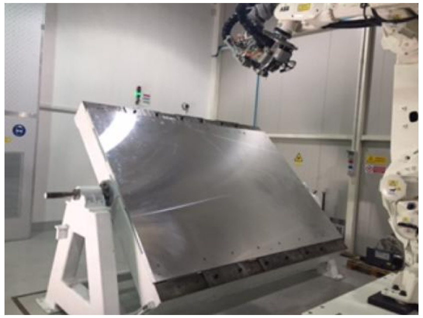
Composites Research Hub



Overview on our Solutions in Composites Manufacturing

Relevant Equipment and SW

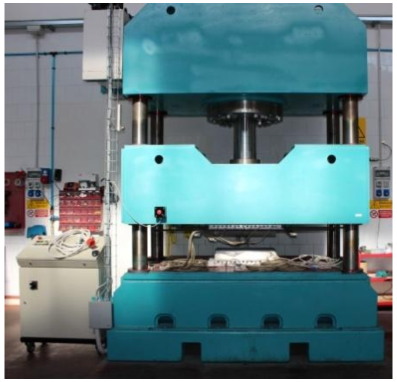
Manufacturing, Curing, Machining and Repair of Composites



AFP Machine
ABB IRB-6640/205/2.75 standard robot 8-fibre placement head, developed by Coriolis Composites s.a.s. (France), mounted on a linear axis with a working length of 3m. Material heating can be performed by a 3kW laser or IR lamp.

Infuser Servo *injector for HP-RTM/VARTM molds, up to 4000cc per shot*

Hypaject MKIII *injection system thermostatted up to 10bar injection pressure for RTM.*



Hot Press for RTM and CM
with plates of [m] 1.2 x 1.8, 400° C Insulated Plates.

Vertical Machine Center
MV 214 P 12B from Quaser.

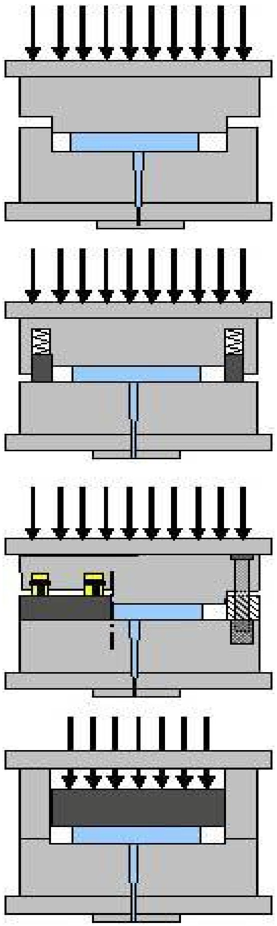
Composite Curing Oven
400° +/-2° C uniformity temperature, size [m] 1.0 x 1.0 x 1.2 with Vacuum Line.

ACR3 Dual Zone Hot Bonder
with SR Blanket kit from BriskHeat Corporation

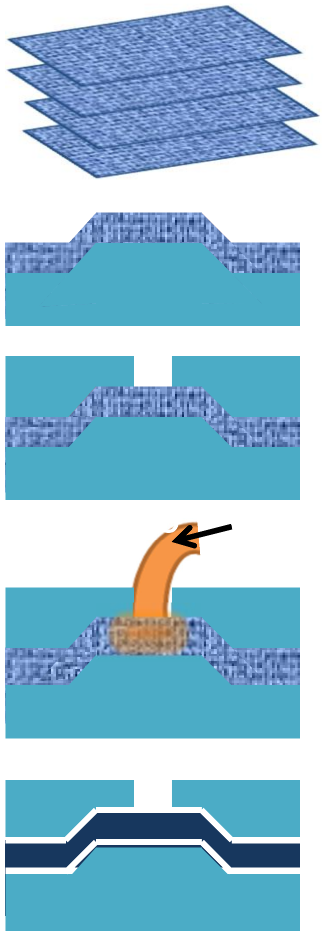
Virtual Product Development

MSC Software DS CATIA CORIOLIS software

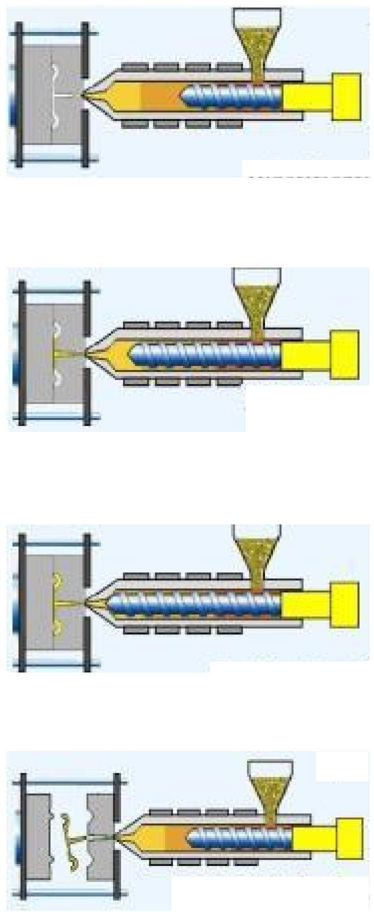
Technology - Targeted Innovation



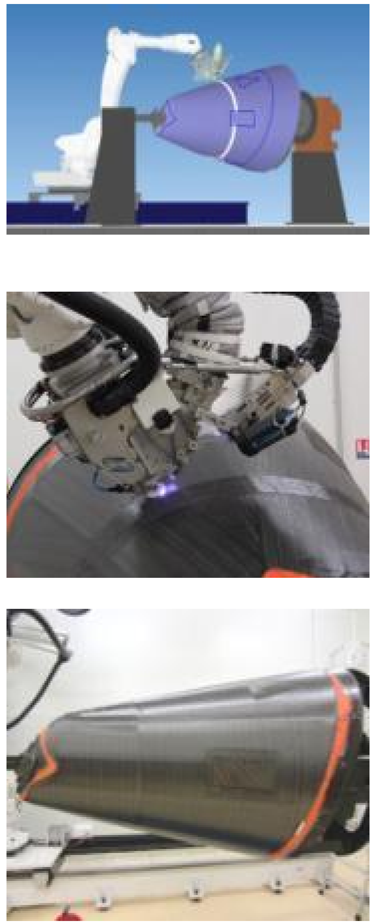
Compression Moulding Process



Resin Transfer Moulding Process



Injection Moulding Process

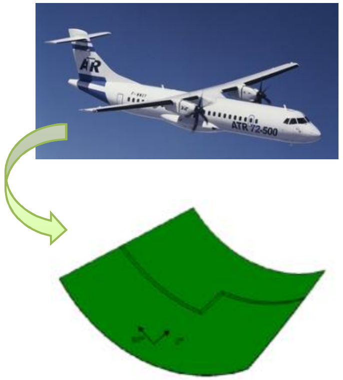


Automated Fiber Placement Process

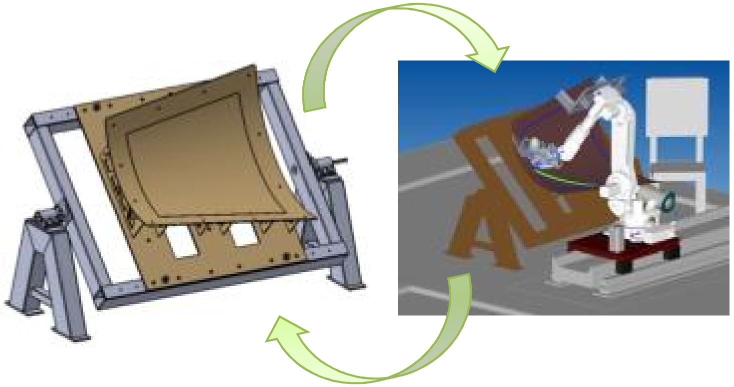
Design & Manufacturing of Composite Layups by AFP Process - LAMITECH Project

DEVELOPMENT OF A REGIONAL A/C TAIL CONE PORTION (1/4)

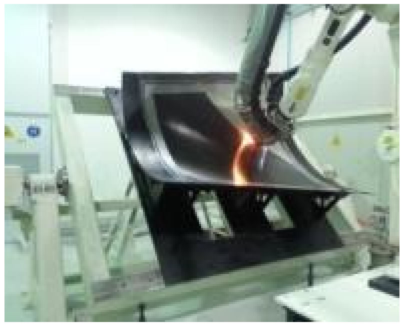
DOUBLE CURVATURE COMPOSITE PANEL WITH RAMP



CONCEPT, DESIGN AND FEASIBILITY STUDY

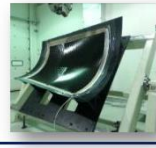


MANUFACTURING

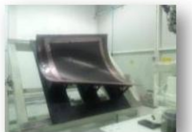


Double Curvature panel (rmin=850, rmax=1150 mm) with a ramp - Thermoset Prepreg (977-2-35-12KHTS from Cytec)

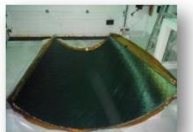
Double Curvature panel (rmin=850, rmax=1150 mm) with a ramp layered on Copper foil - Thermoset Prepreg (977-2-35-12KHTS from Cytec)



Double Curvature panel (rmin=850, rmax=1150 mm) with a ramp - Dry Fiber material (Prism TX1100 IMS-65 from Cytec)



Double Curvature panel (rmin=850, rmax=1150 mm) with a ramp - Thermoplastic Prepreg (APC2-34-AS4 from Cytec)

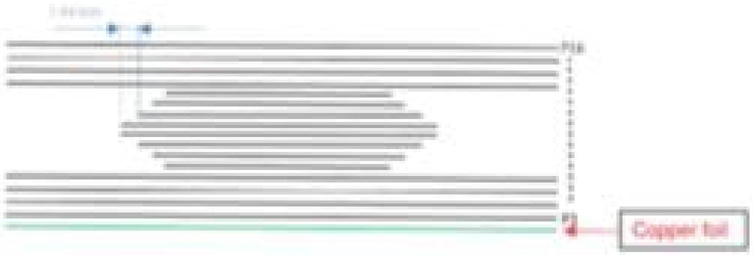


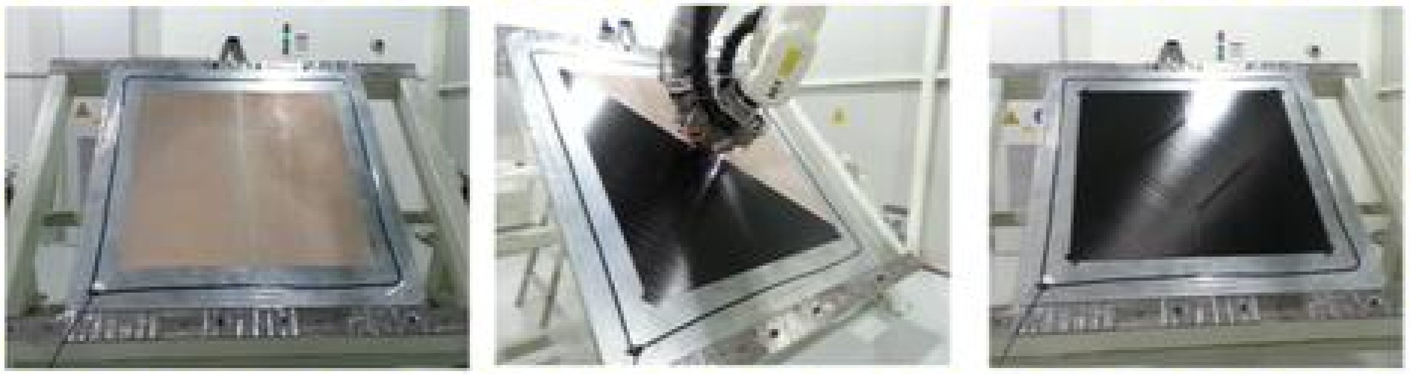
The 2nd International Symposium on *Automated Composites Manufacturing*
April 23-24, 2015 Montreal, Canada

NOVOTECH
ADVANCED AEROSPACE TECHNOLOGY

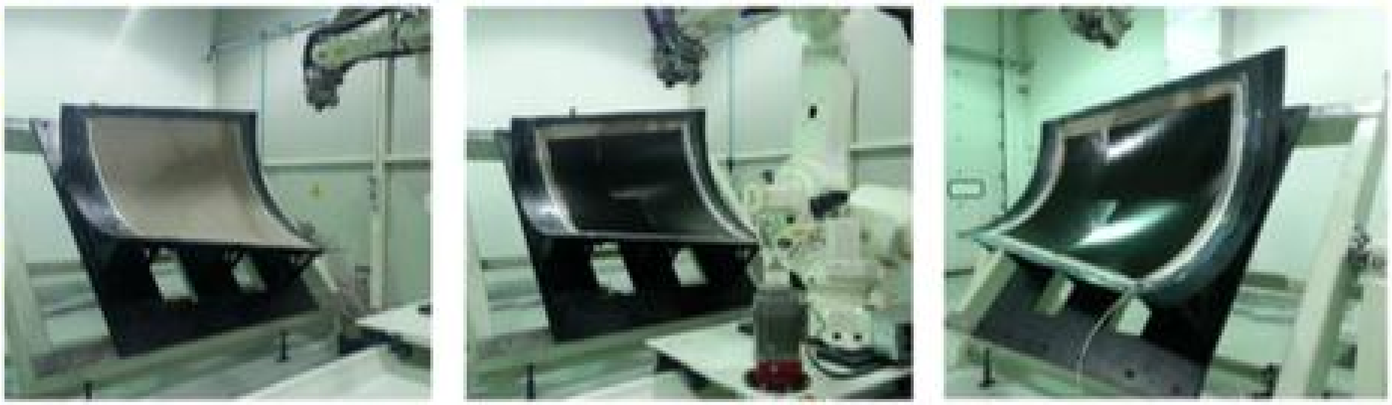
Alenia Aermacchi
A Finmeccanica Company

Manufacturing of test trials with Lightning strike protection





Test Trial #1



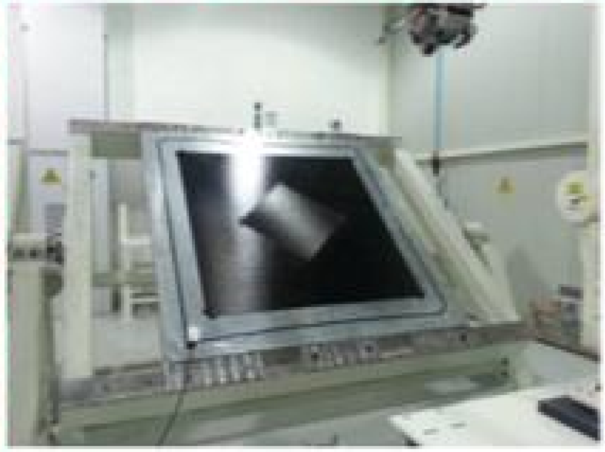
Test Trial #2

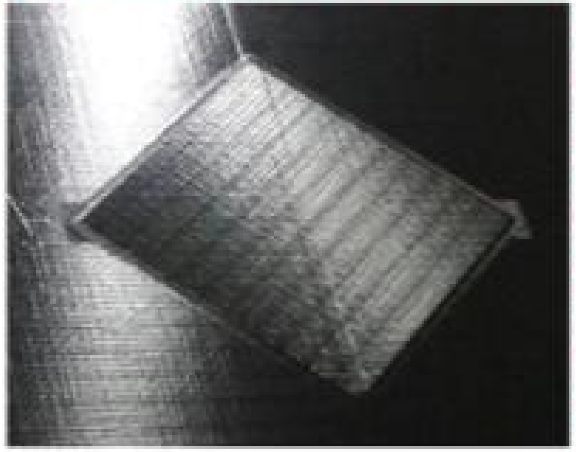
NOVOTECH
ADVANCED AEROSPACE TECHNOLOGY

Manufacturing of a test trial with Acoustic Damping ability

Alenia Aermacchi
A Finmeccanica Company

Mid-plane views of the panel during (left) and after (right) the placement of the acoustic damping layer.

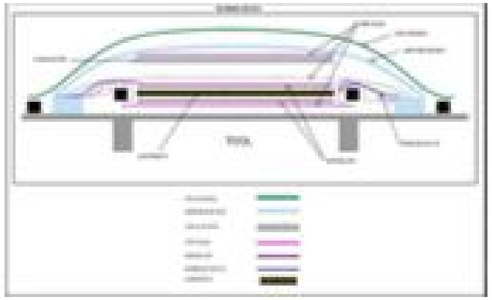


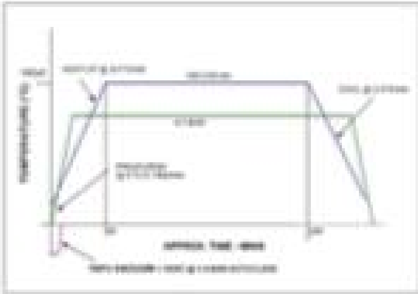


Test Trial #3

The 2nd International Symposium on *Automated Composites Manufacturing*
April 23-24, 2015 Montreal, Canada

Manufacturing of a test trial with Acoustic Damping ability





Datasheet recommendations for the bagging scheme and curing cycle of the test trial

Side A

Side B

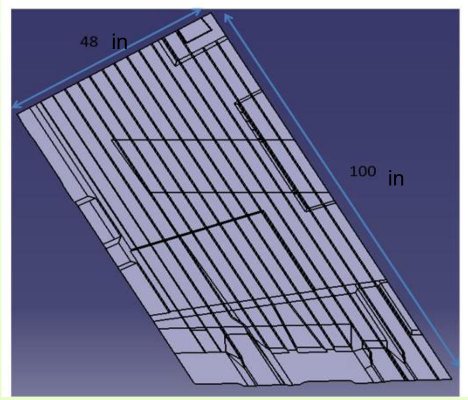
NDI of the test trial. C-Scan on both sides was performed.

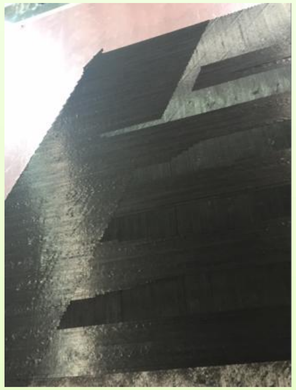
No defect revealed.

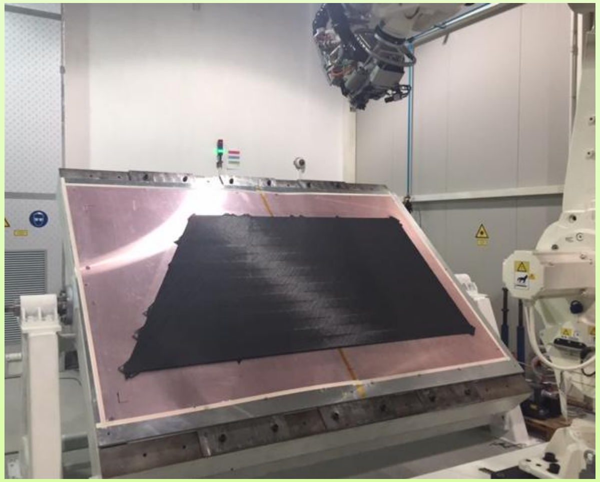
Design & Manufacturing of composite demonstrators by AFP Process - SPIA Project (ongoing)

DEVELOPMENT OF COMPLEX COMPOSITE DEMONSTRATORS

NGTP VERTICAL FIN PORTION

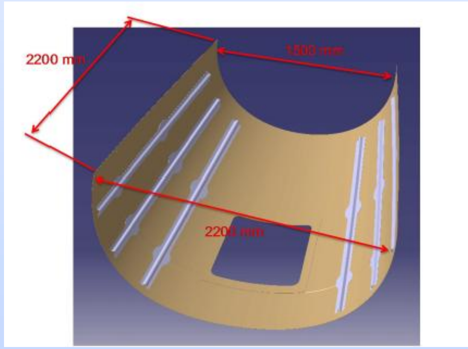




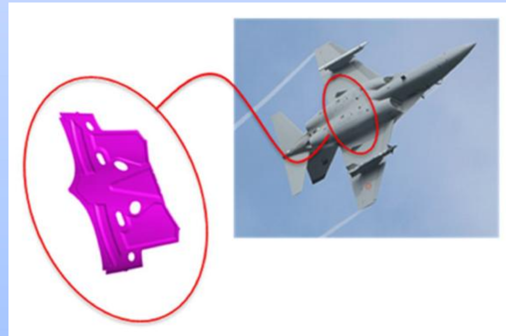


..in progress

A/C TAIL CONE PORTION (1/2)

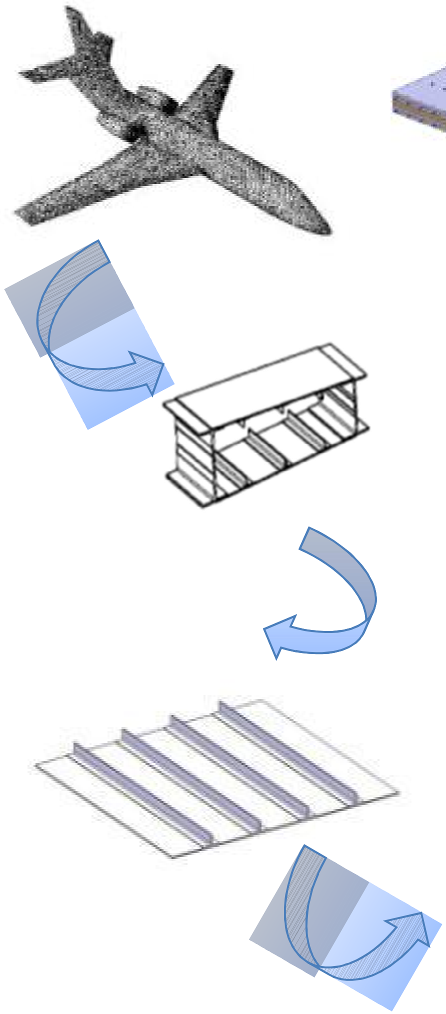


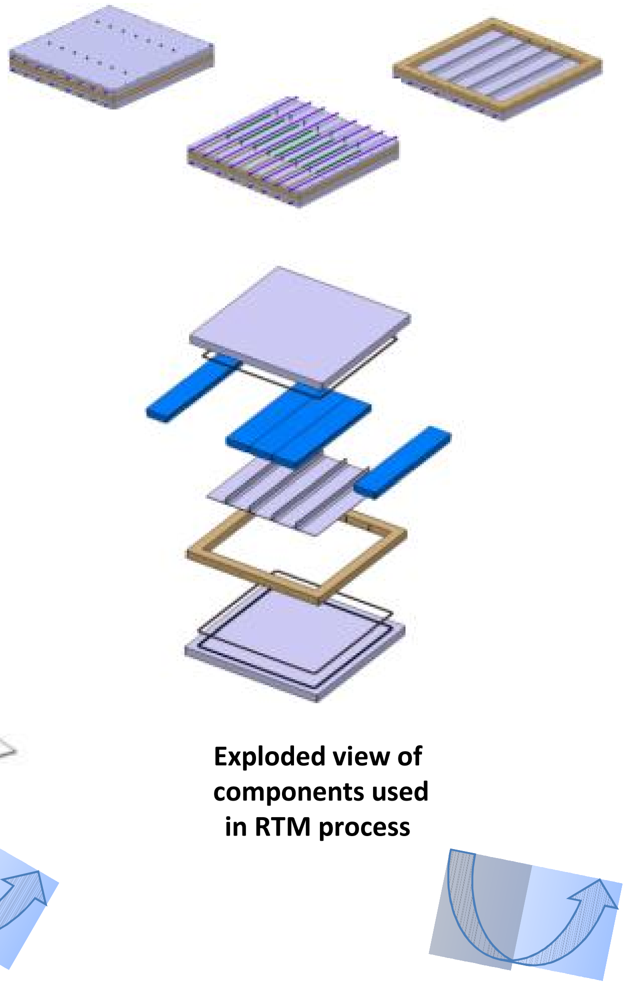
M346 FUSELAGE PORTION



Design & Manufacturing of Composite Layups by RTM process

This method offers high precision moulded parts and enables integrated solutions offering high quality and repeatability beyond a reduction of weight, costs and assembly time.





Exploded view of components used in RTM process

Equipment used in the RTM process

View as built of Composite Stiffened Panels (TS) samples manufactured by RTM process for an International R&T Project with University of Naples “Federico II”

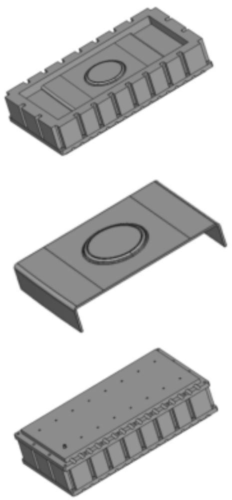
Overview on our Solutions in Composites Manufacturing

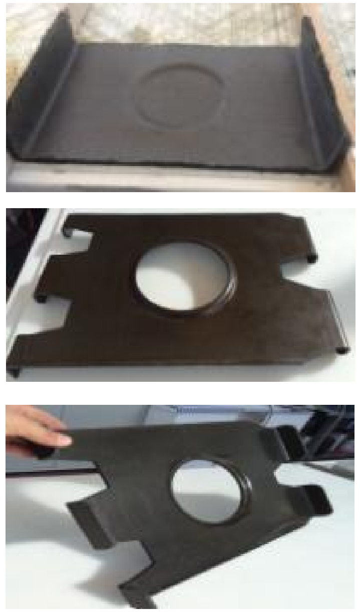
Design & Manufacturing of Composite Layups by RTM process

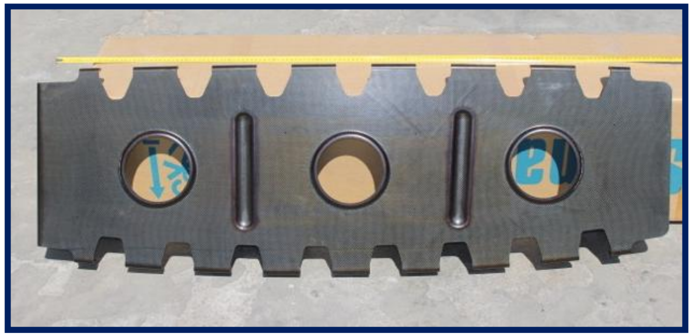
Compositi Avanzati s.r.l.

Clean Sky

MANUFACTURING OF RIBS FOR REGIONAL A/Cs : FROM SUB-COMPONENT TO A FULL-SCALE DEMONSTRATOR

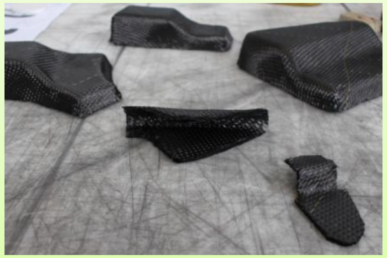
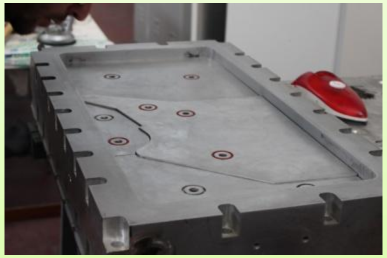






Design & Manufacturing of Demonstrators by RTM process

HELICOPTER DASHBOARD SUPPORT

AIRCRAFT WING SPAR


HANDLE FOR HELICOPTERS

CONTENUTO

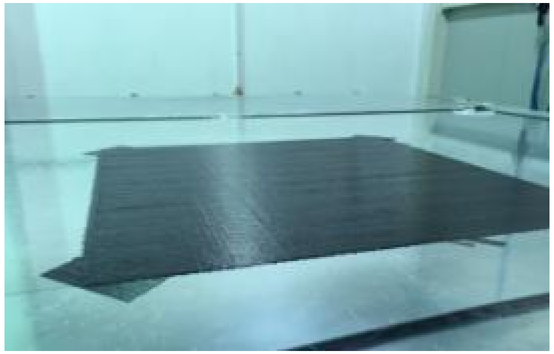
1. *INTRODUZIONE*
2. *PANORAMICA TECNOLOGIE AUTOMATIZZATE*
3. *AFP – VISTA DA UN COSTRUTTORE (CORIOLIS COMOSITES)*
4. *ESPERIENZE DI SVILUPPO DI TECNOLOGIE AUTOMATIZZATE (NOVOTECH & COMPOSITI AVANZATI)*
5. *TEMATICHE DI SVILUPPO E RICERCA DI NOVOTECH*
6. *CONCLUSIONI*

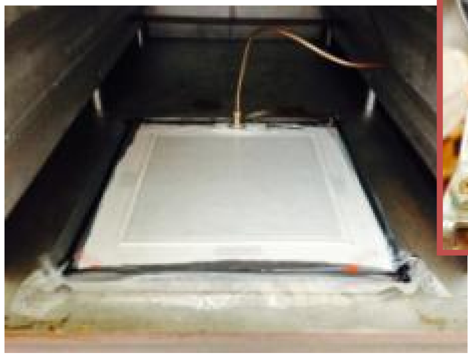
Partners:

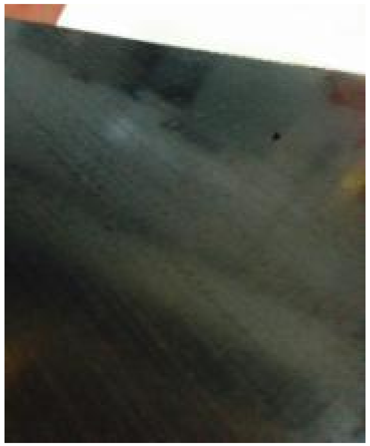
Alenia Aermacchi
A Finmeccanica Company

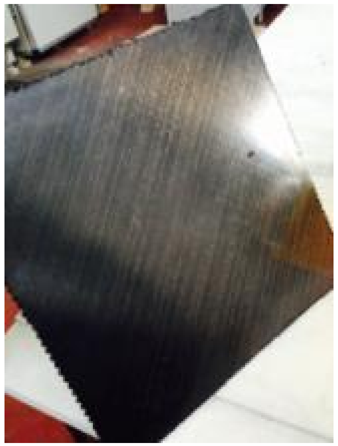
CYTEC

Out of Autoclave Panels (CYCOM 5320-1) using AFPM

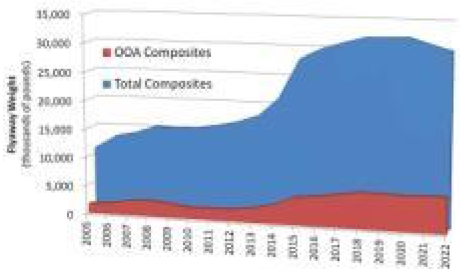








ESTIMATED 2013-2022 MARKET FOR TOTAL AEROSPACE COMPOSITE STRUCTURES VS. OOA COMPOSITES.



Source CFC (Jan 2014)

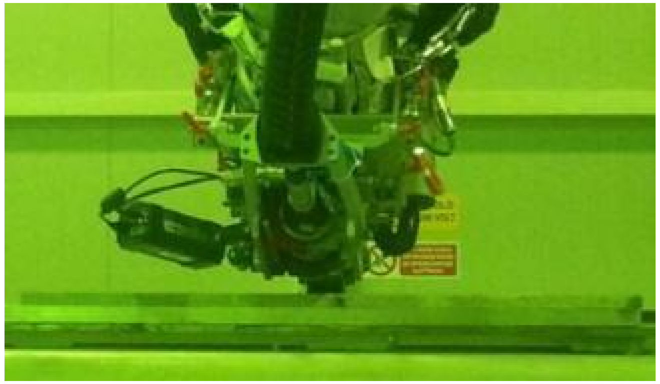
Partners:

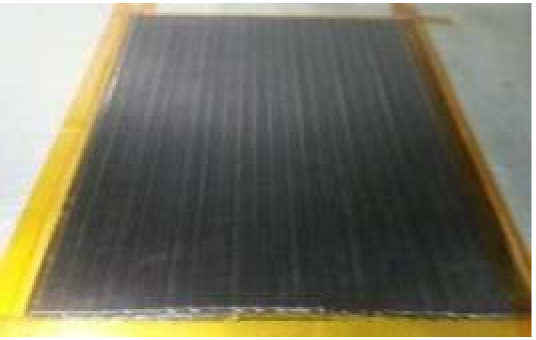
Alenia Aermacchi
A Finmeccanica Company

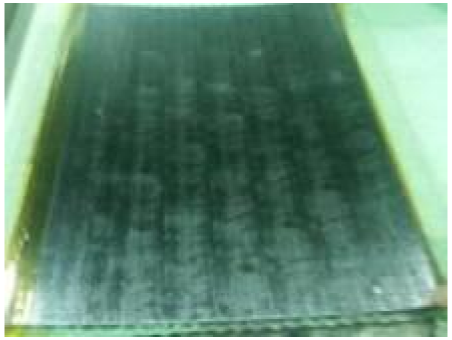
CYTEC

TP In-Situ Consolidation using AFPM (in progress)

- *Layup performed by NVT*
- *Materials provided by AAAEM*
- *NDI and Mechanical Tests will be performed by Cytec*





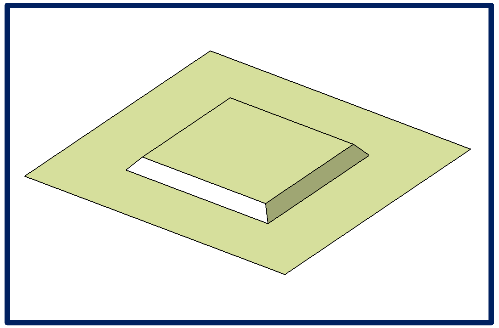


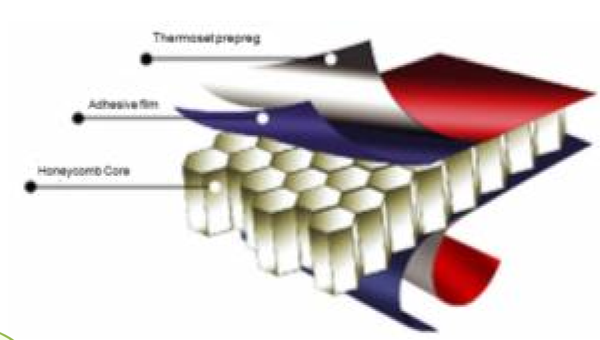
(a)
Layup at T≈250° C

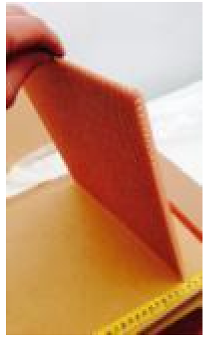
(b)
Layup at T ≈ 400° C

(c)
Layup at T ≈ 400° C on a thermal insulation plate

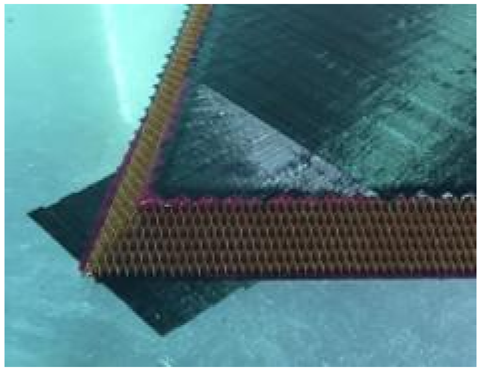
Sandwich Panels using AFPM

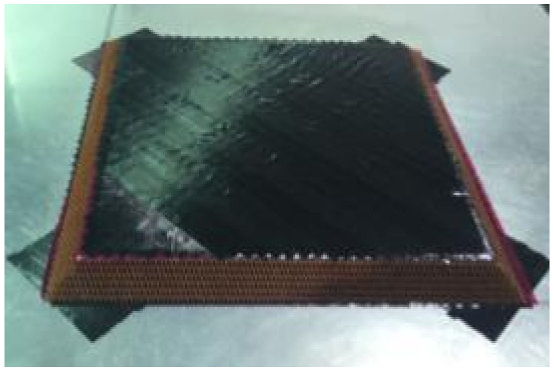




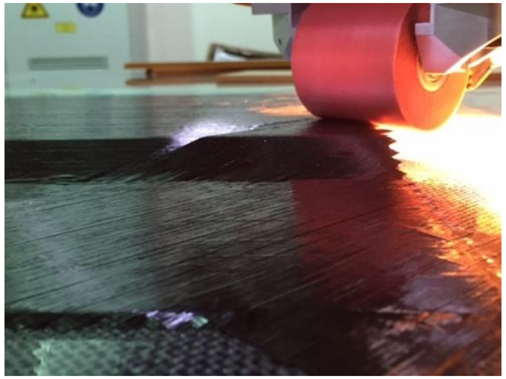
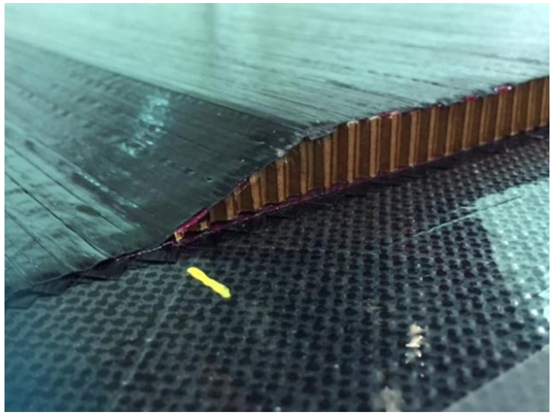
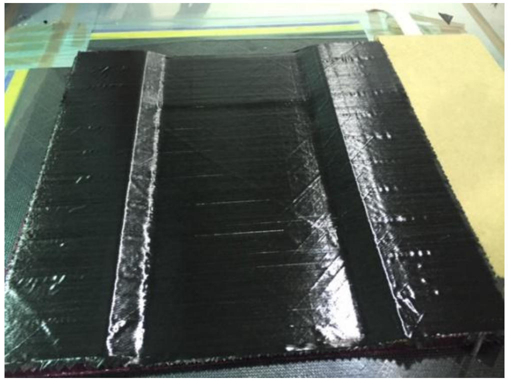
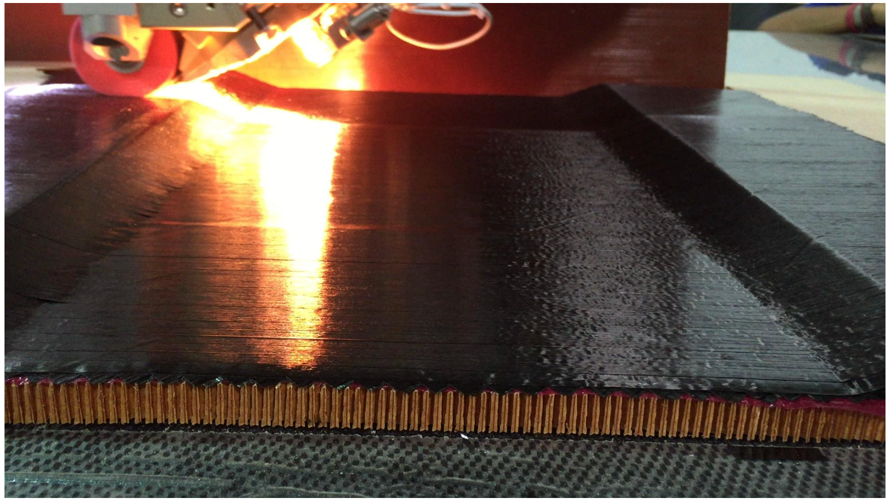
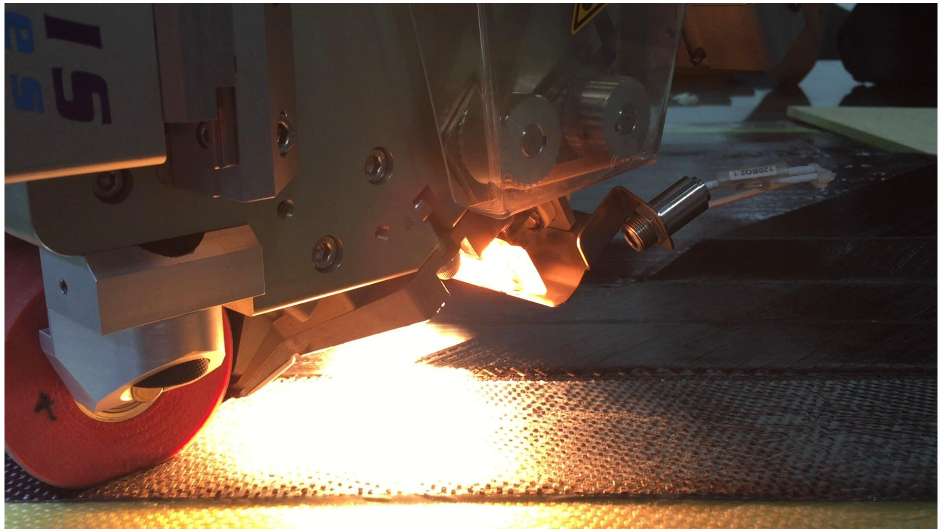


Test trial



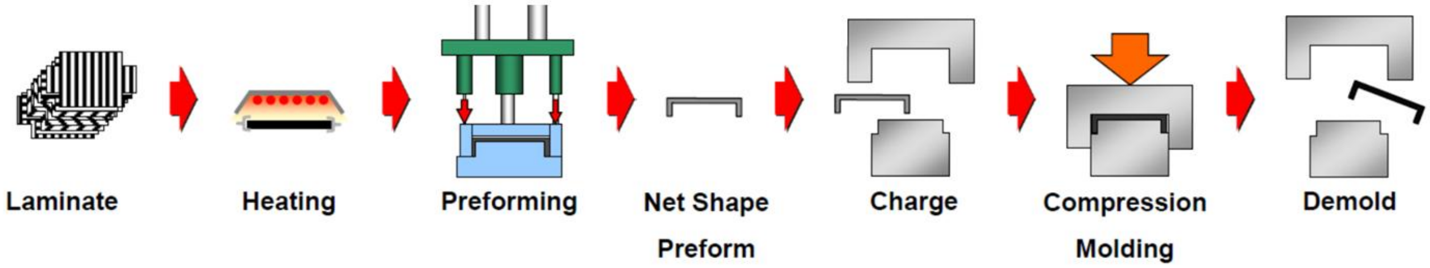


-45°	Thermoset 977-2 (Cytec)
45°	
90°	
0°	
Adhesive	3M™ Scotch-Weld™ Structural AF 163-2
Component	Honeycomb
Adhesive	3M™ Scotch-Weld™ Structural AF 163-2
0°	Thermoset 977-2 (Cytec)
90°	
45°	
-45°	

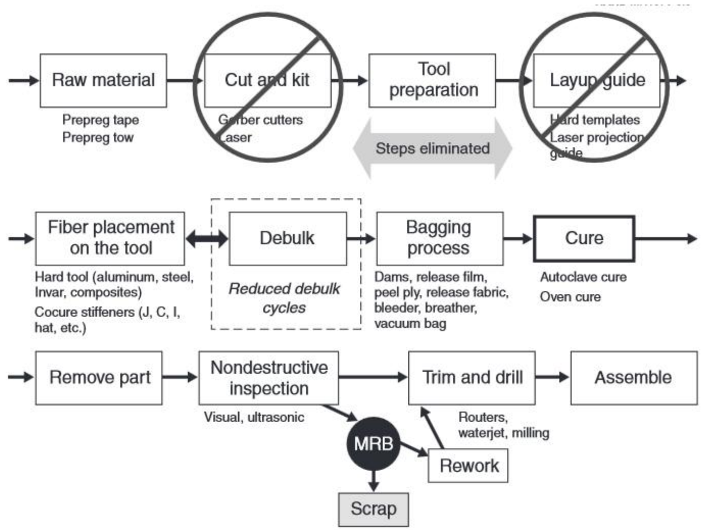






Rapid Preforming process using AFPM

- *Preforming of Prepreg for PCM or Dry Fiber material for Infusion process*
- *High Surface Quality*
- *OOA process (Hot Press or Oven depending on the part)*

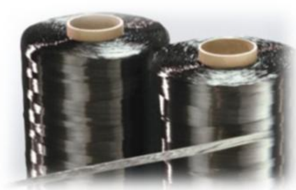


Automated Fiber Placement steps compared to Hand Layup



Advanced preforming process :

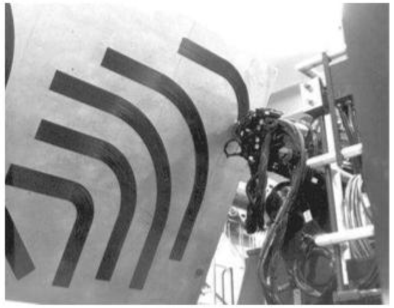
- Fast
- Consistent
- Less manual labor
- Automated

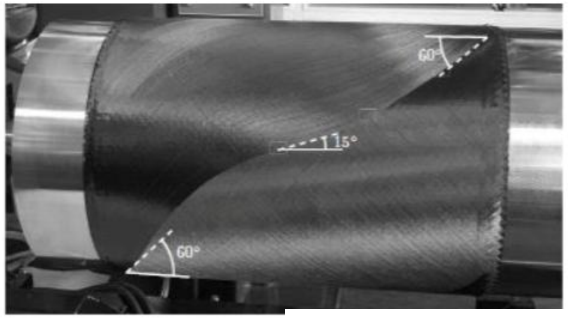


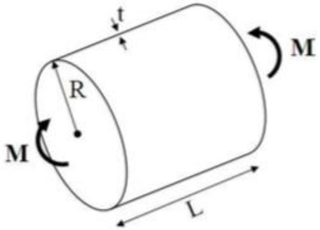
NOVOTECH ADVANCED AEROSPACE TECHNOLOGY

Fiber steering and buckling optimization

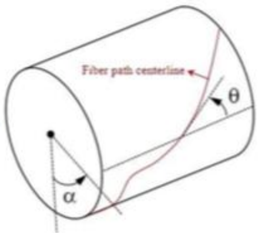
Partner of CLEANSKY

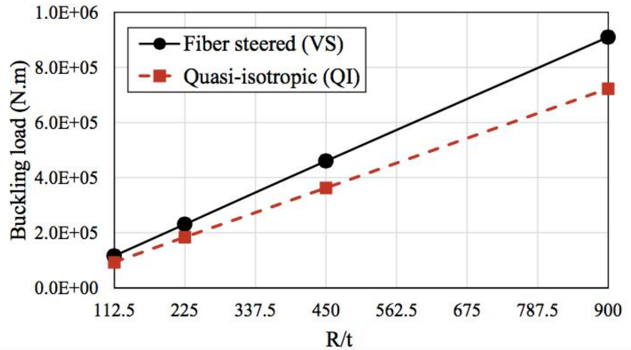


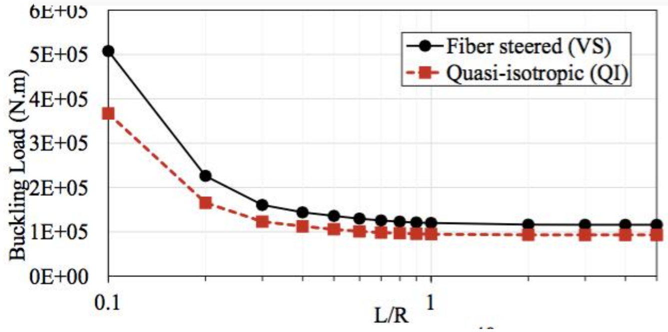




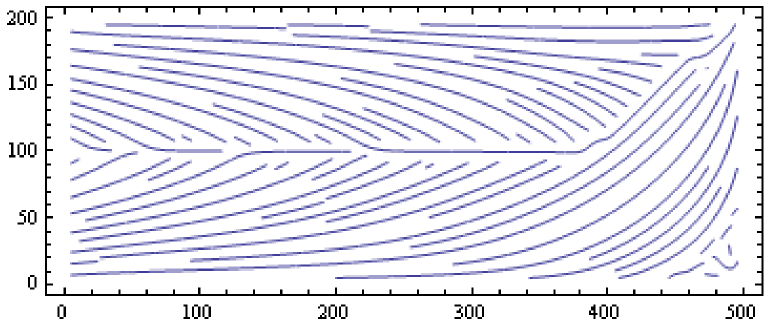
What is the optimum path (θ) to have maximum buckling load?

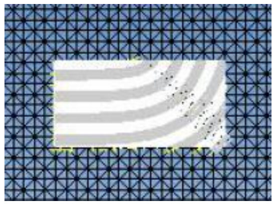


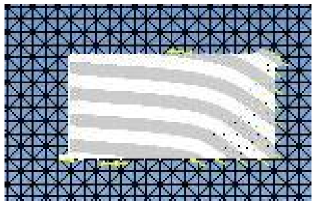


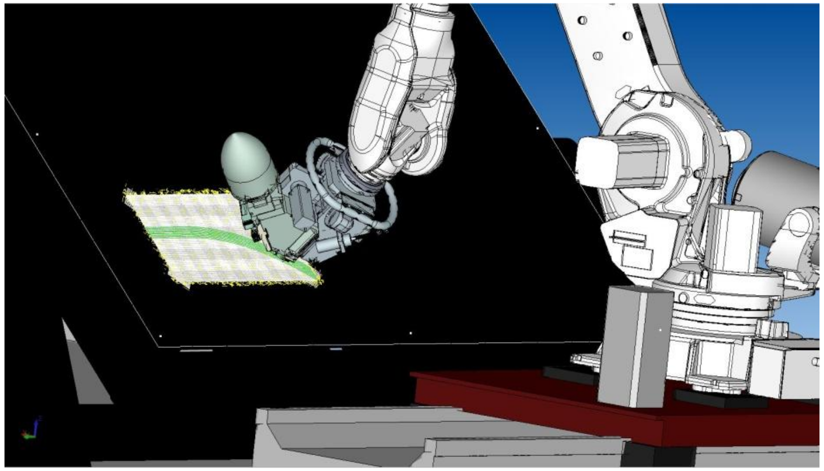


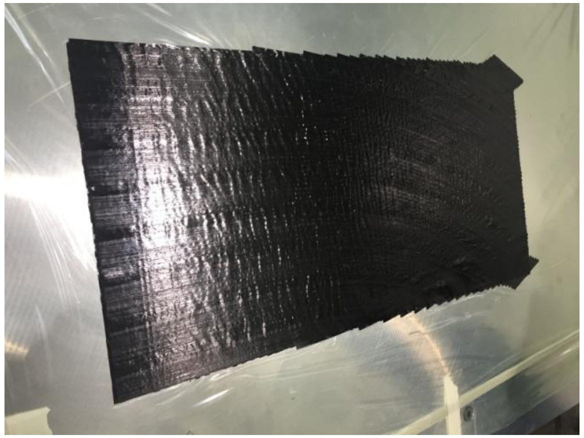
Optimized stratification strategy

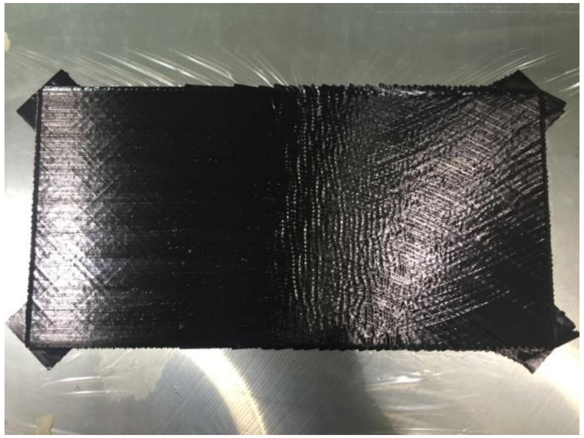


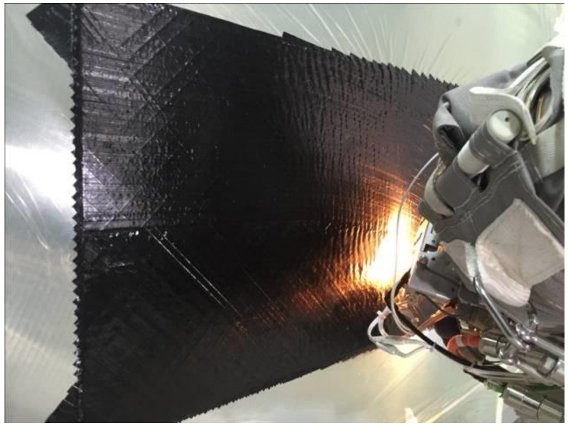












Thank you

for your attention

If You Want To Go Fast, Go Alone.
If You Want To Go Far, Go Together.

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Compositi Avanzati s.r.l.