NOVOTECH SRL
AEROSPACE ADVANCED TECHNOLOGY

www.novotech.it

Design & Manufacturing of Aerospace Composites (R&I Projects)

Marco Barile, Ph.D.
Chief Technical Officer

SEMINARI INTERDISCIPLINARI DI CULTURA AERONAUTICA, Napoli – Maggio 2018

Clean Sky 2

ACCREDIA

Member of CISQ Federation
RINA
EN 9100
Certified Quality System

Contents

Composites (short overview)

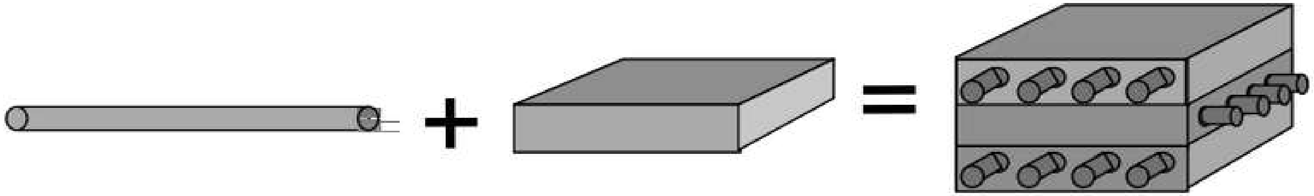
Composites (short overview)

Composites Vs Metals

Pls, see Audio «pigreco elEktroLiveCIrcus -rumori dallofficina. Mp3»

Composites (short overview)

A composite material can be defined as a combination of two or more materials that results in better properties than when the individual components are used alone.



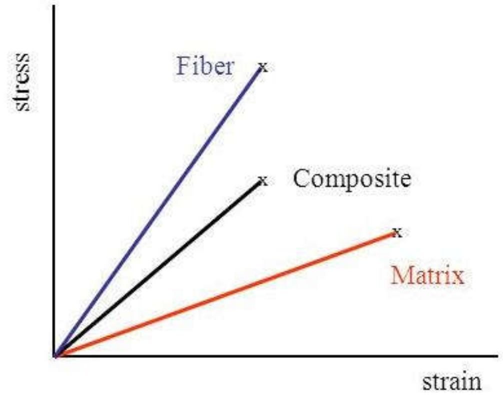
Fiber/Filament Reinforcement

- Provide strength and stiffness

Matrix

- Holds the fibers in their proper position
- Protects the fibers from abrasion
- Transfers loads between fibers
- Provides interlaminar shear strength

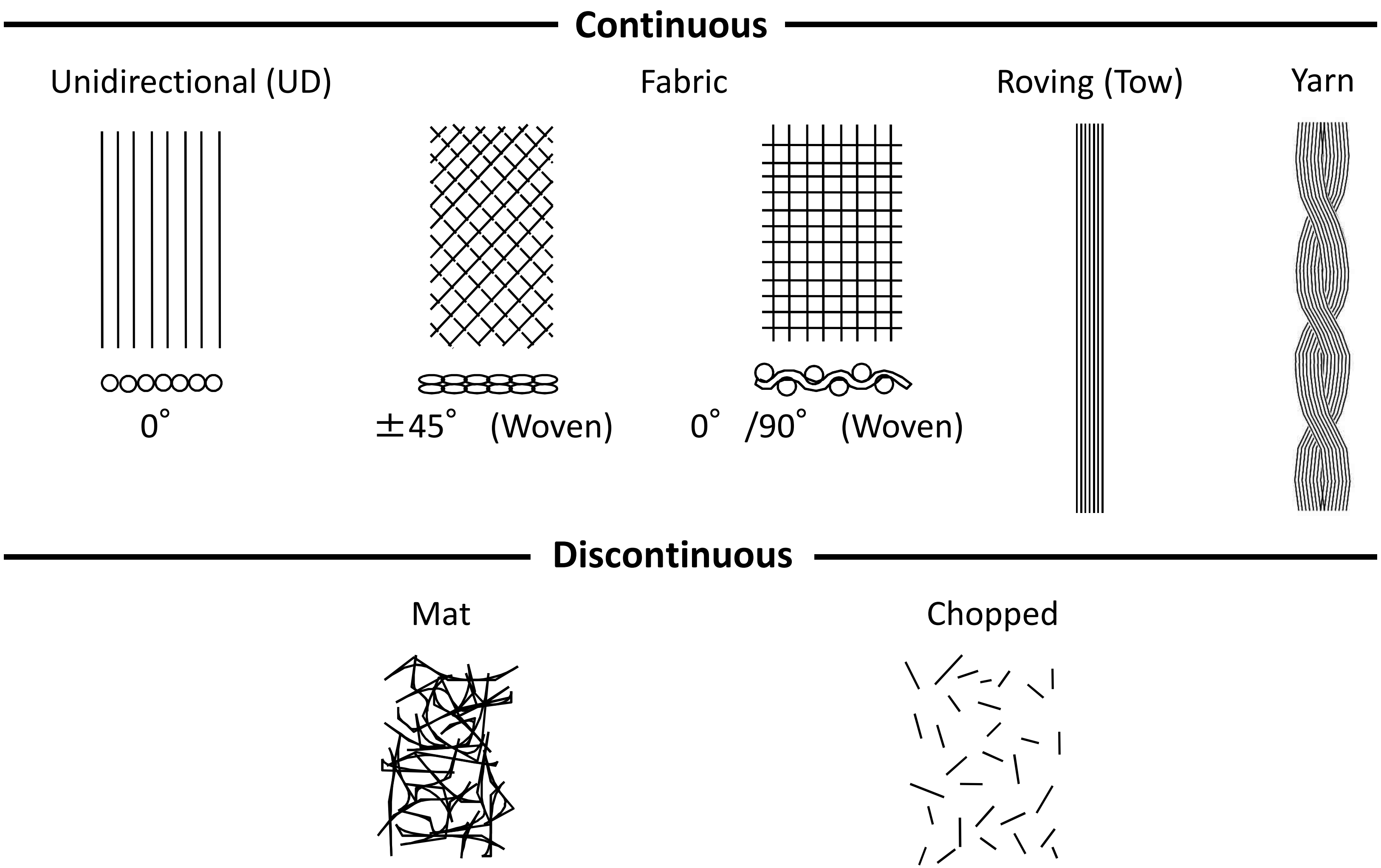
Composite



NOVOTECH SRL AEROSPACE ADVANCED TECHNOLOGY 25 years

Composites (short overview)

Reinforcement options (prepreg, dry)



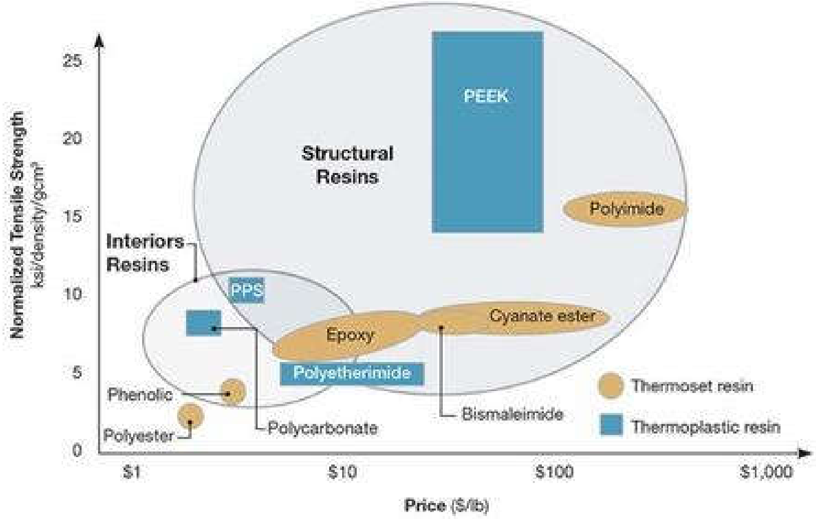
Composites (short overview)

Resins: Thermoplastic Vs Thermoset

THERMO (heat)
PLASTIC (deform)

THERMO (heat)
SET (permanent)

Composites (short overview)



Thermoplastic Resin	Thermosetting Resin
▪ High MW solid	▪ Low MW liquid or solid
▪ Stable material	▪ Low-medium viscosity, requires cure
▪ Re-processable, recyclable	▪ Cross-linked, non-processable
▪ Amorphous or crystalline	▪ Liquid or solid
▪ Linear or branched polymer	▪ Low MW oligomers
▪ Liquid solvent resistance	▪ Excellent environmental/solvent resistance
▪ Short process cycle	▪ Long process cycle
▪ Neat up to 30% filler	▪ Long or short fiber reinforced
▪ Injection/Compression/Extrusion	▪ RTM/FW/SMC/Prepreg/Pultrusion
▪ Limited structural components	▪ Many structural components
▪ Neat resin + nanoparticles	▪ Neat or fiber reinforced + nanoparticles
▪ Commodity – high-performance areas for automotive, appliance housings, toys	▪ Commodity – advanced materials for construction, marine, aircraft, aerospace

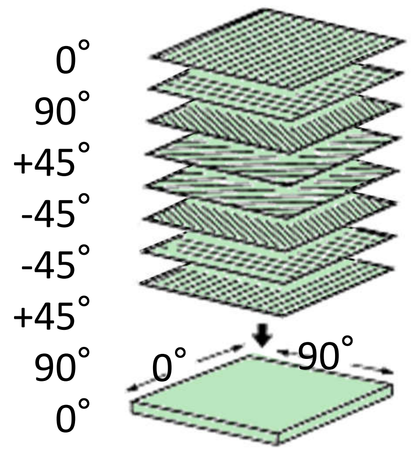
Composites (short overview)

Lamina and Laminate Lay-Ups

Fiber and Matrix Effects on Mechanical Properties

Mechanical Property	Dominating Composite Constituent: Fiber	Dominating Composite Constituent: Matrix
Lamina		
0° Tension	✓	
0° Compression	✓	✓
Shear		✓
90° Tension		✓
Laminate		
Tension	✓	
Compression	✓	✓
In-Plane Shear	✓	✓
Interlaminar Shear		✓

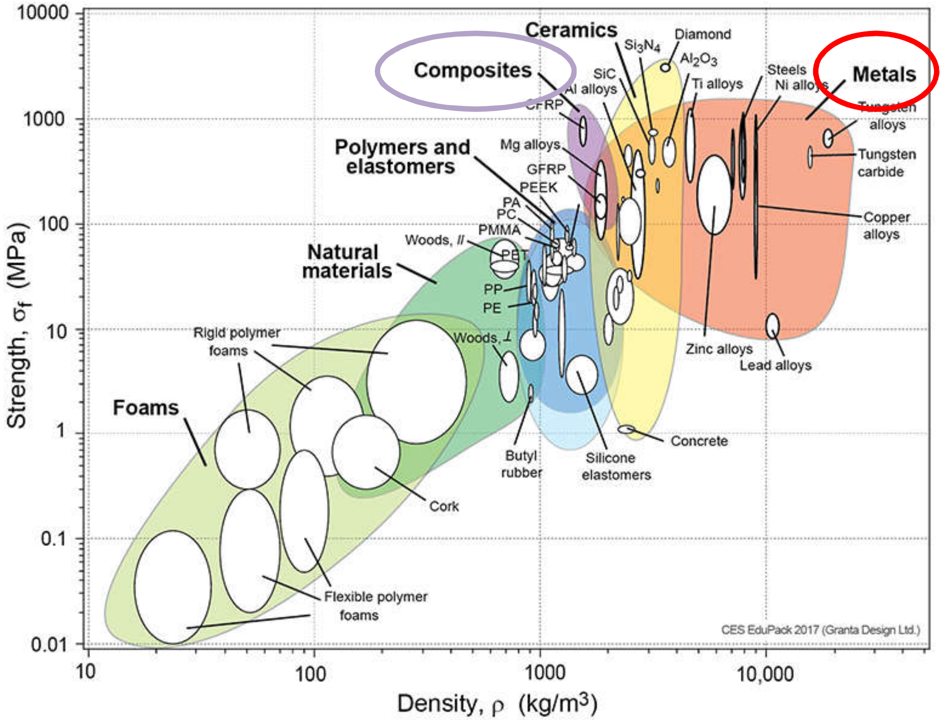
Note: 0° direction is the fiber direction in Lamina

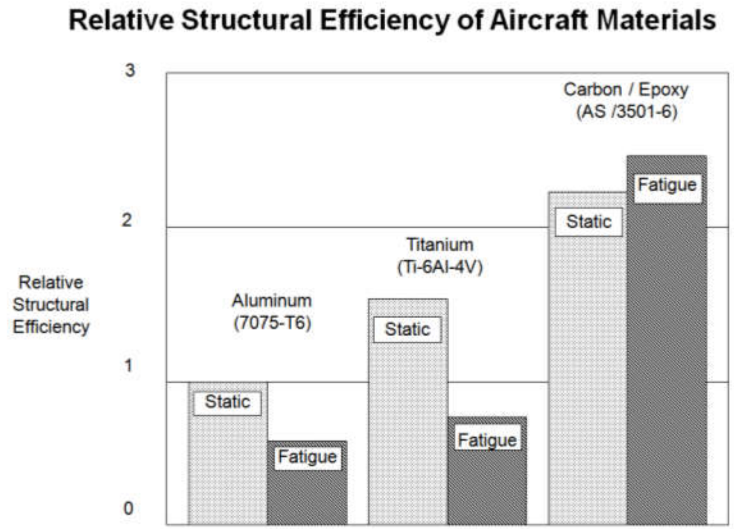


Quasi-Isotropic Lay-Up (Laminate)

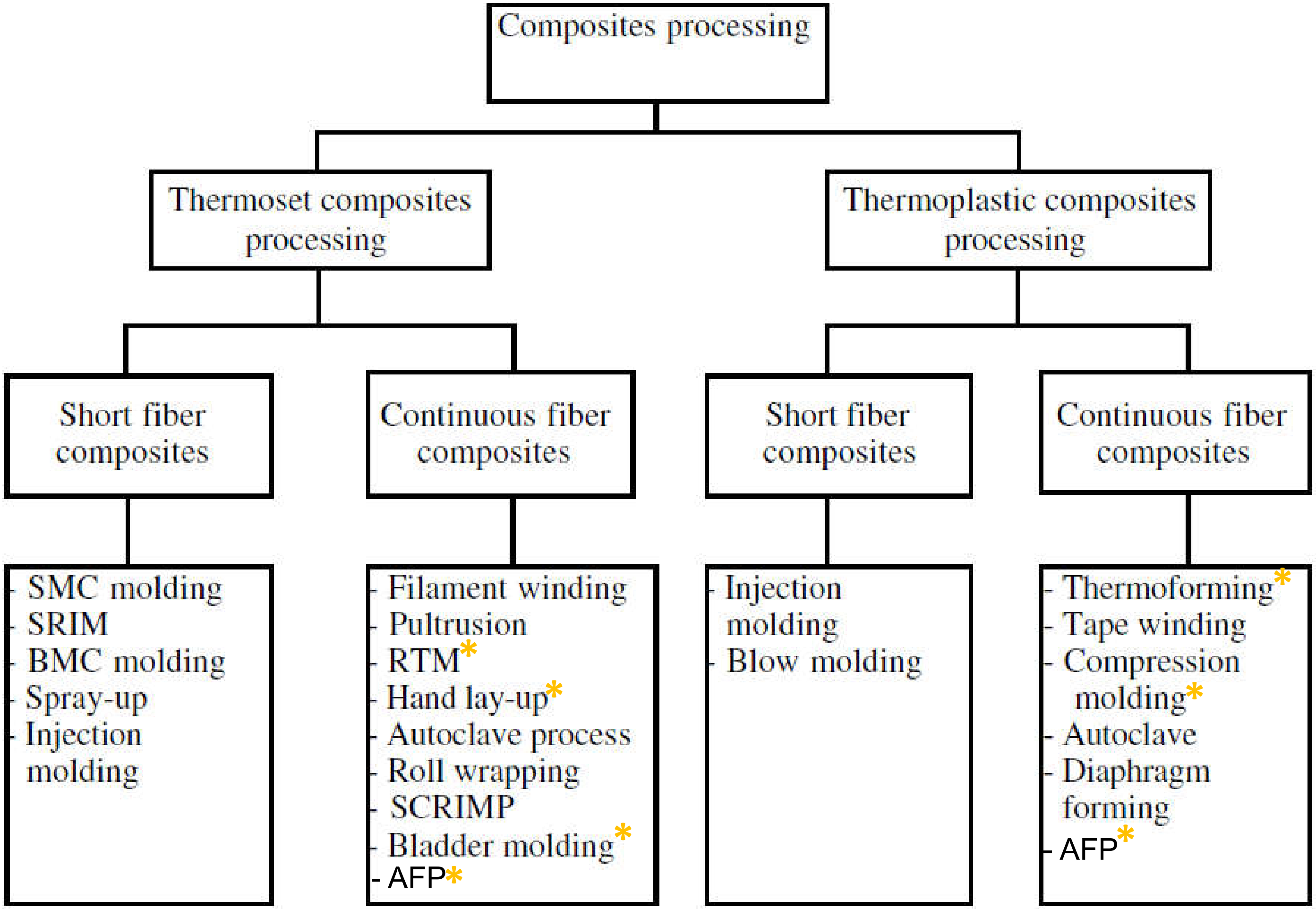
Design & Manufacturing of Aerospace Composites (R&I Projects)

Composites (short overview)





Composites (short overview)



***Composites Production processes available at Novotech**

Composites (short overview)

Manufacturing Process Selection Criteria

Process	Production Speed	Cost	Strength	Size	Shape	Raw Material
Filament winding	Slow to fast	Low to high	High	Small to large	Cylindrical and axisymmetric	Continuous fibers with epoxy and polyester resins
Pultrusion	Fast	Low to medium	High (along longitudinal direction)	No restriction on length; small to medium size cross-section	Constant cross-section	Continuous fibers, usually with polyester and vinylester resins
Hand lay-up	Slow	High	High	Small to large	Simple to complex	Prepreg and fabric with epoxy resin
Wet lay-up	Slow	Medium	Medium to high	Medium to large	Simple to complex	Fabric/mat with polyester and epoxy resins
Spray-up	Medium to fast	Low	Low	Small to medium	Simple to complex	Short fiber with catalyzed resin
RTM	Medium	Low to medium	Medium	Small to medium	Simple to complex	Preform and fabric with vinylester and epoxy
SRIM	Fast	Low	Medium	Small to medium	Simple to complex	Fabric or preform with polyisocyanurate resin
Compression molding	Fast	Low	Medium	Small to medium	Simple to complex	Molded compound (e.g., SMC, BMC)
Stamping	Fast	Medium	Medium	Medium	Simple to contoured	Fabric impregnated with thermoplastic (tape)
Injection molding	Fast	Low	Low to medium	Small	Complex	Pallets (short fiber with thermoplastic)
Roll wrapping	Medium to fast	Low to medium	High	Small to medium	Tubular	Prepregs

Composites (short overview)

Advantages of composites are many including:

- Lighter **weight**
- The ability to **tailor** the lay-up for optimum strength and stiffness
- Improved **fatigue** life
- **Corrosion** resistance
- Reduced **assembly** costs due to fewer detail parts and fasteners

Composites (short overview)

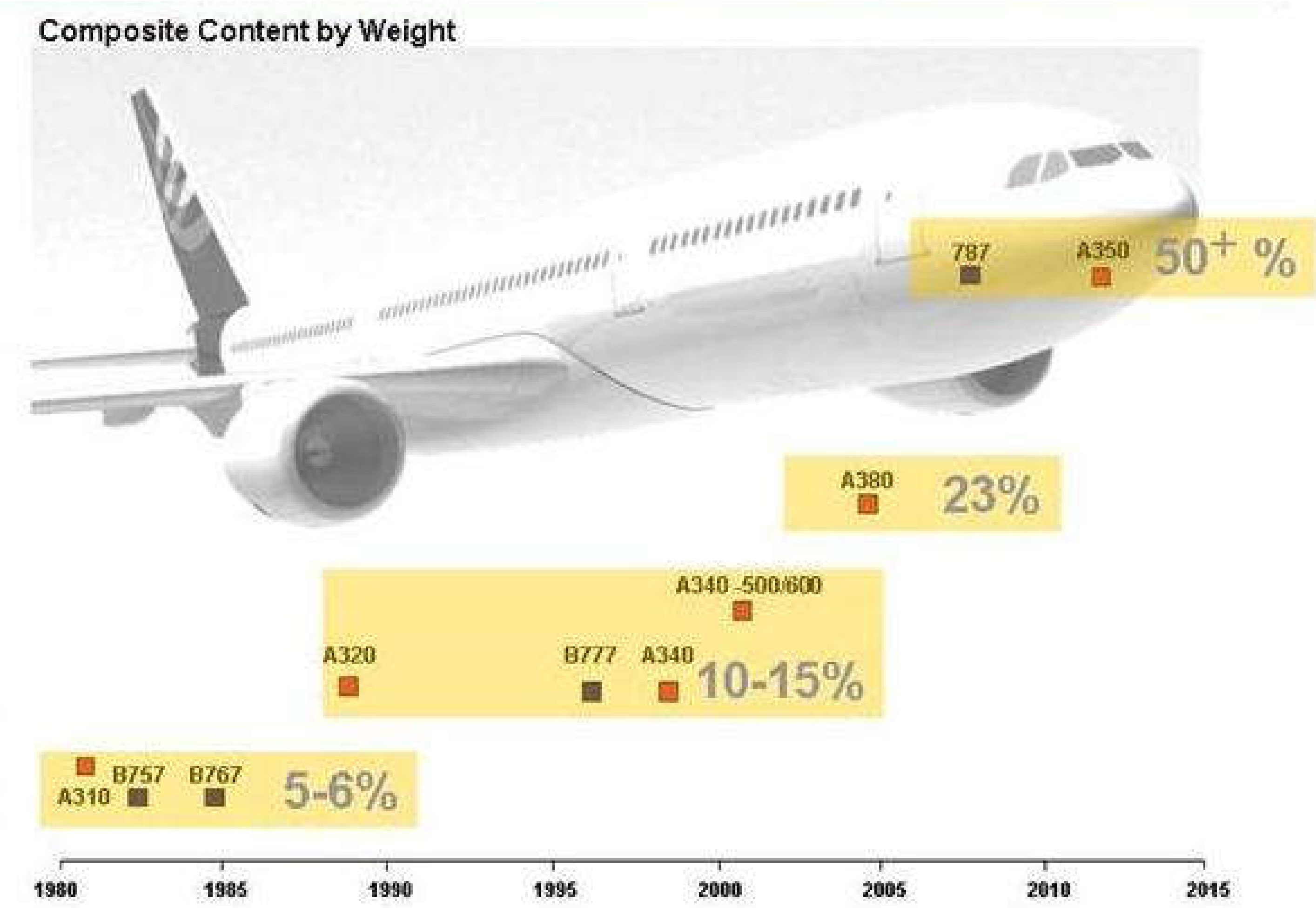
Disadvantages of composites include:

- High raw **material costs** and usually high fabrication and assembly costs.
- Composites are adversely affected by both **temperature** and **moisture**.
- Composites are weak in the **out-of-plane** direction where the matrix carries the primary load and should not be used where load paths are complex (e.g., lugs and fittings).
- Composites are susceptible to **impact damage** and delaminations or ply separations can occur.
- Composites are more difficult to **repair** than metallic structure.

Composites in Aerospace (examples)

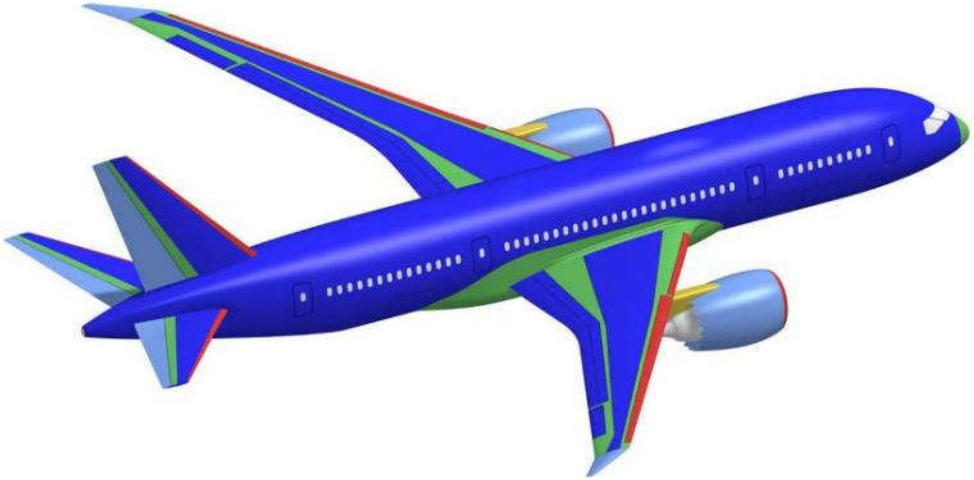
Composites in Aerospace

Commercial Aerospace - Composites Penetration



Composites in Aerospace

BOEING 787 Dreamliner



50% Composite Structure

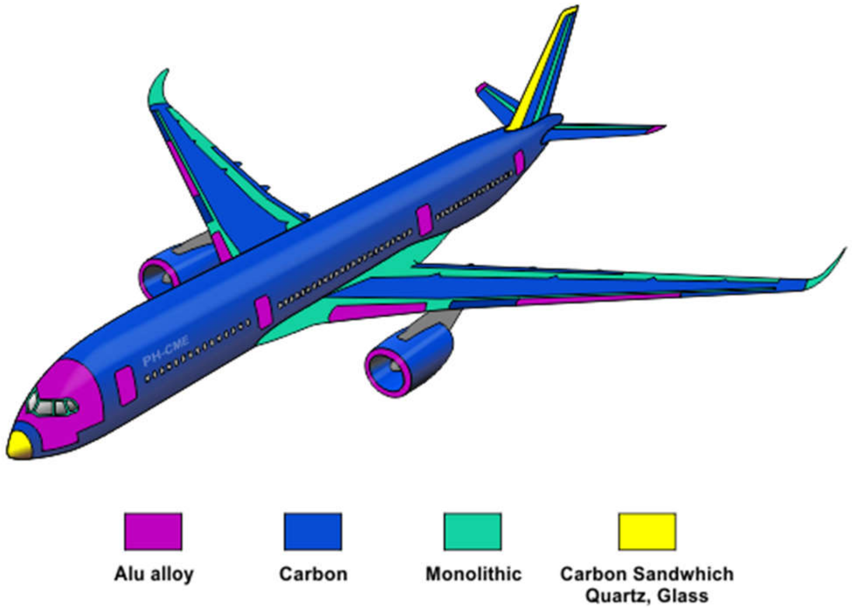
Carbon Laminate | Carbon Sandwich | Fiberglass

Aluminum | Aluminum/Steel/Titanium Pylons

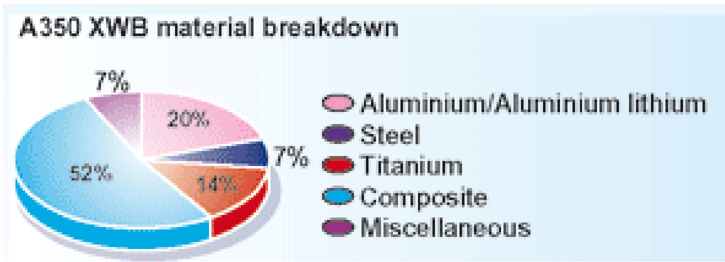
787 Composite Fuselage Portion

Composites in Aerospace

AIRBUS A350



A350 XWB 32m by 6m lower wing cover



Composites in Aerospace

ATR 72

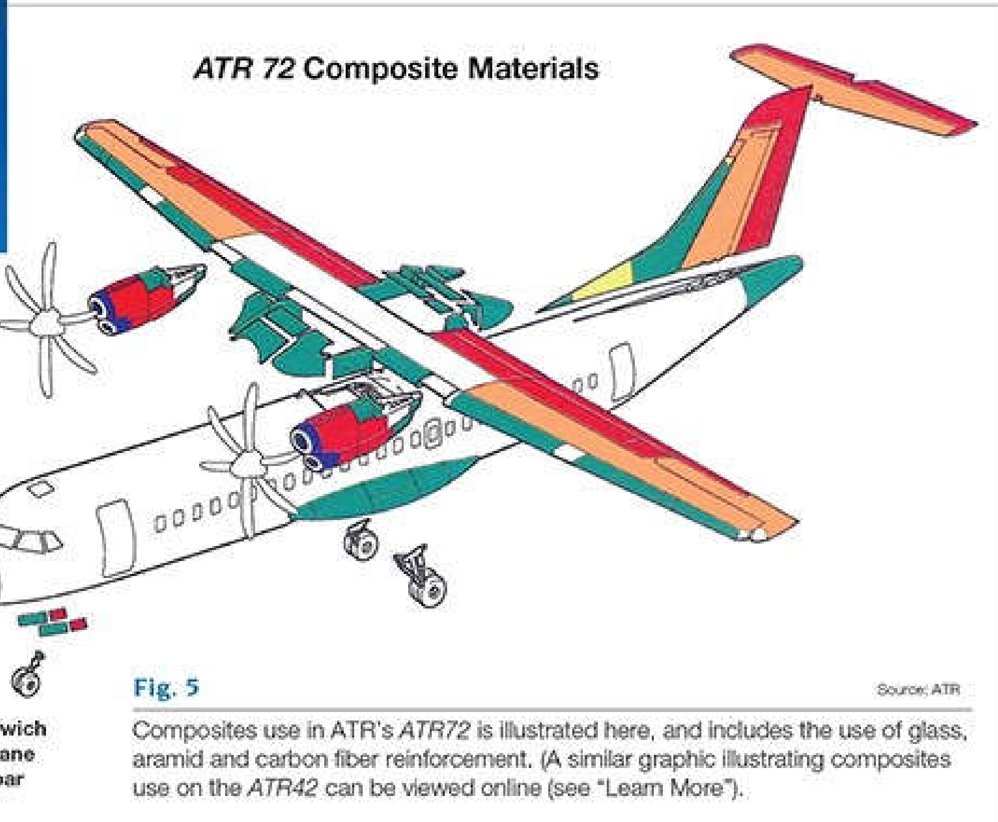


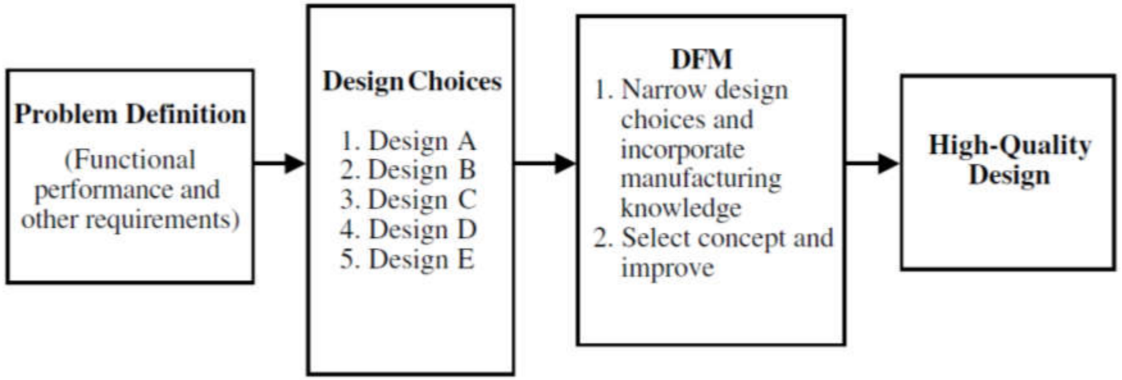
Fig. 5

Composites use in ATR's *ATR72* is illustrated here, and includes the use of glass, aramid and carbon fiber reinforcement. (A similar graphic illustrating composites use on the *ATR42* can be viewed online (see "Learn More").

Design and Manufacturing of Composite Aerostructures

Design and Manufacturing of Composite Aerostructures

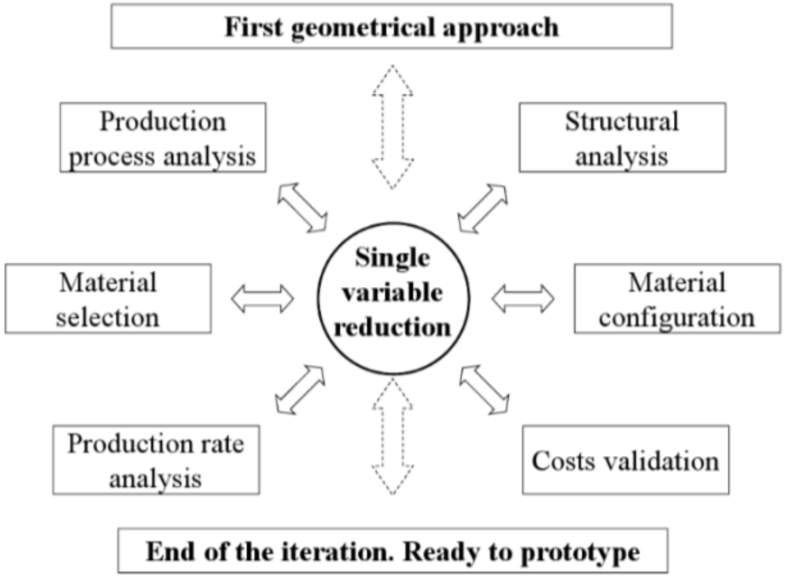
DESIGN FOR MANUFACTURING (DFM)



The purpose of DfM is to:

- **Narrow design choices** to optimum design
- Perform **generation of concepts**, down-selection and improvement
- Minimize product development **cycle time and cost**
- Achieve high product quality and reliability
- **Simplify production** methods (reduce nr. of parts and assembly time)
- Have a **quick and smooth transition** from the design phase to the production phase
- Eliminate, simplify and **standardize** whenever possible

Design and Manufacturing of Composite Aerostructures



Time and resource limitations

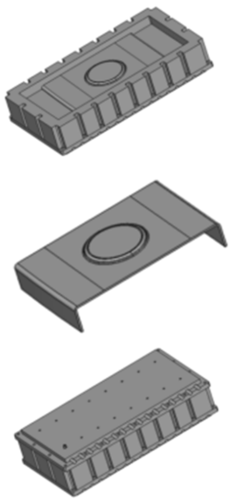
Lessons learned

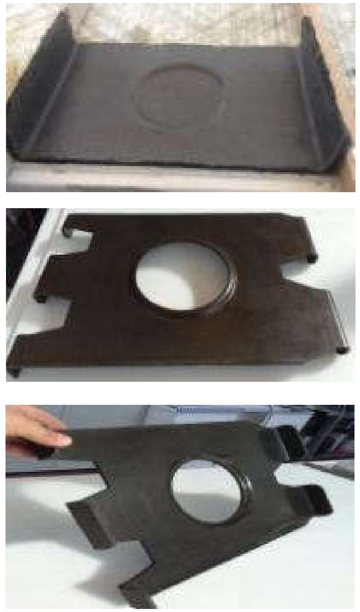
Virtual design and manufacturing tools

R&I projects

R&I Projects: Design & Manufacturing of Composite Aerostructures by RTM Process - Clean Sky 1 as subco (closed)

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

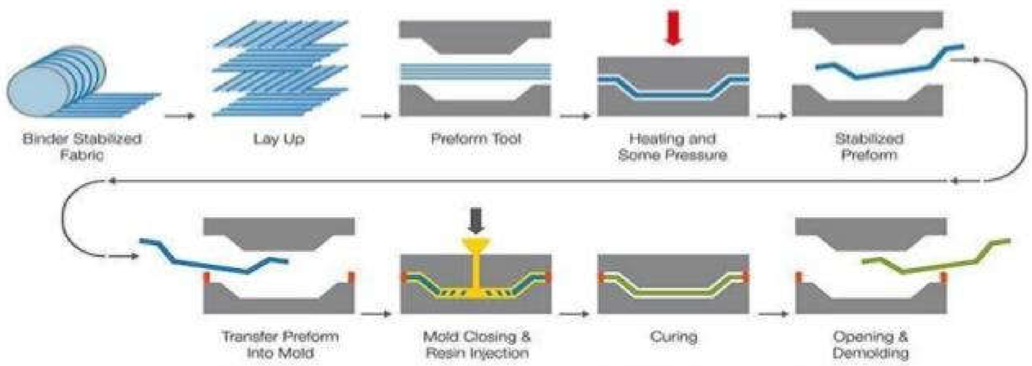


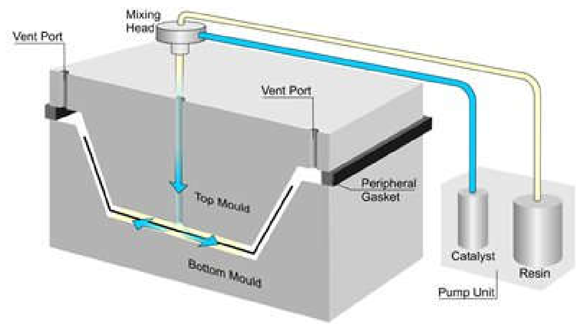


R&I Projects: Design & Manufacturing of Composite Aerostructures by RTM Process - Clean Sky 1 as subco (closed)

RESIN TRANSFER MOLDING PROCESS

Resin Transfer Moulding (RTM) fits into the broad fabrication category of closed moulding processes, where composite manufacturing is conducted within an enclosed cavity.





- If automated it is capable of rapid production cycle times, that means it can be suitable for **medium to high volume** production, producing relatively low cost parts.

- Higher production rates can be achieved by heating the moulds, using preform reinforcements and **resins with short gel and cure times**.

- RTM involves a **capital investment** in tooling and infrastructure that is higher than vacuum infusion but lower than compression moulding.

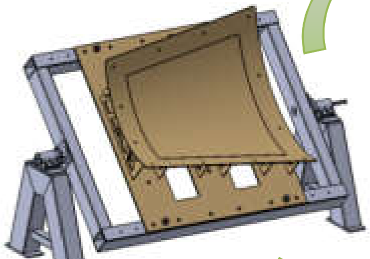
- RTM uses two matched moulds brought together thus producing parts with **two finished surfaces.**

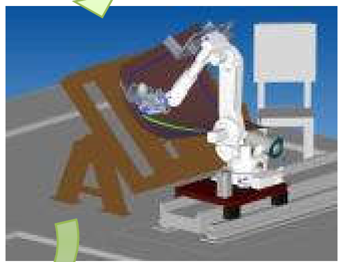
R&I Projects: LAMITECH (closed)

DESIGN & MANUFACTURING OF A REGIONAL A/C TAIL CONE PORTION (1/4) BY AUTOMATED TECHNOLOGY

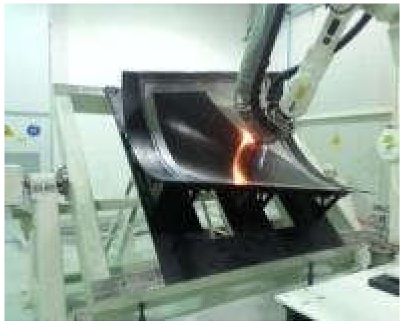
DOUBLE CURVATURE COMPOSITE PANEL WITH RAMP

CONCEPT, DESIGN AND FEASIBILITY STUDY



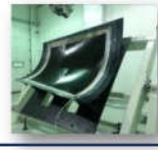


MANUFACTURING



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)

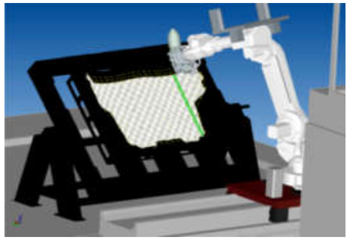
Double Curvature panel (rmin=850, rmax=1150 mm) with a ramp - Thermoplastic Prepreg (APC2-34-AS4 from Cytec)

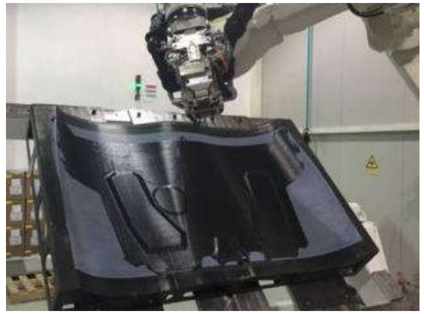
Design & Manufacturing of Aerospace Composites (R&I Projects)

R&I Projects: SPIA (closed)

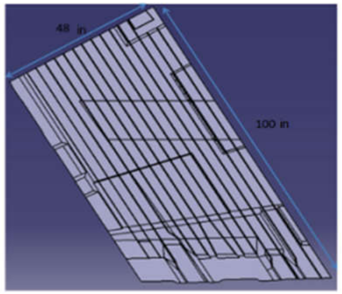
MANUFACTURING OF COMPLEX COMPOSITE DEMONSTRATORS BY AUTOMATED TECHNOLOGY

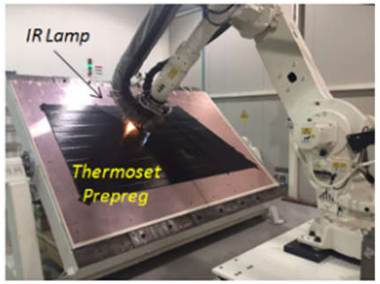
M-346 FUSELAGE PORTION (scale 1:1)

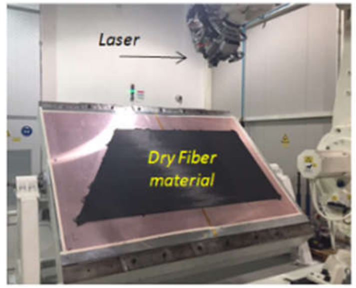





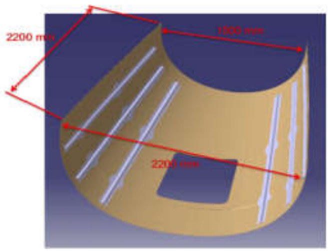
NGTP VERTICAL FIN PORTION (2.5mtx1.5mt)





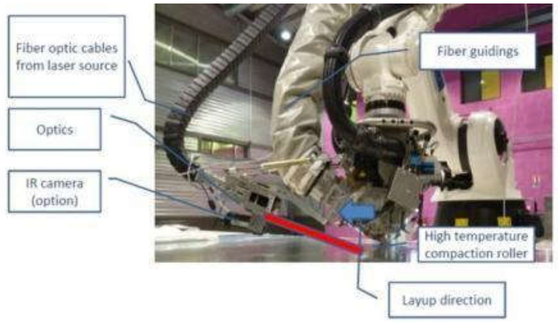


A/C TAIL CONE PORTION (1/2 & 1/4) including stringers laydown by AFP process

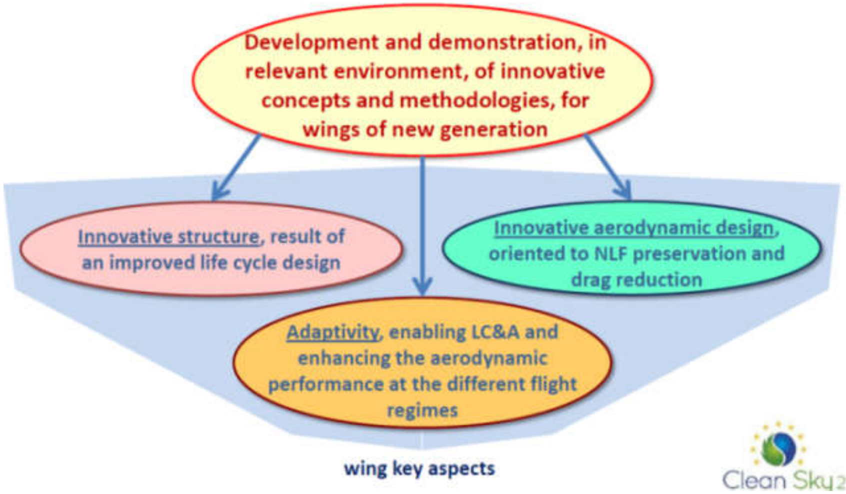



R&I Projects: AIRGREEN 2 (ongoing)

Novotech s.r.l. is part of **H2020 / Clean Sky JU**, with **AIRGREEN 2** Consortium, 16 partners for a 7-years research program (Call identifier: H2020-CS2-CPW01-2014-01/ Topic: JTI-CS2-CPW-REG-01-02).



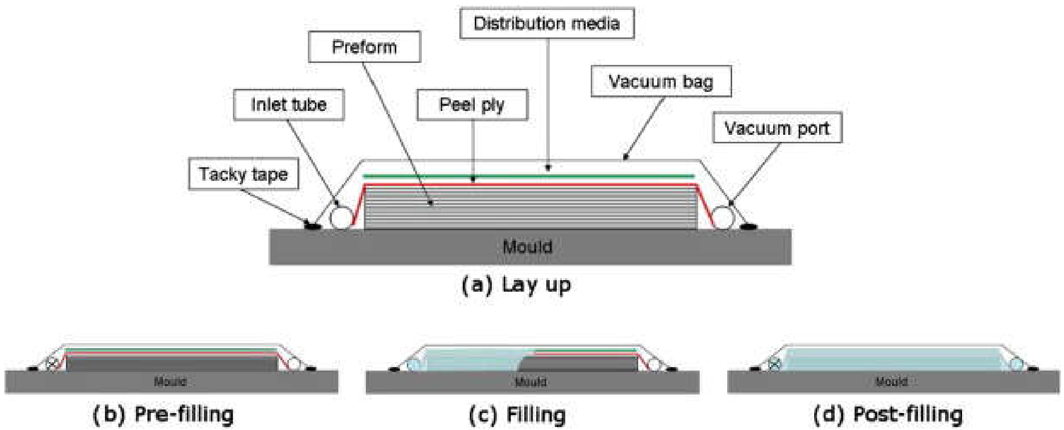
TOPIC : Advanced wing for regional A/C - Technologies Development, Design and Manufacturing for FTB#1



Composite demonstrator produced by AFP followed by LRI in one-shot

R&I Projects: AIRGREEN 2 (ongoing)

LIQUID RESIN INFUSION PROCESS



Composite demonstrator produced by AFP followed by LRI in one-shot

Normally, a **single-sided mould** is also used here which is sealed with a vacuum bag.
Use atmospheric pressure to suck air from under vacuum bag, to compact composite layers down and make a high quality laminate.

Composite curing oven for LRI process

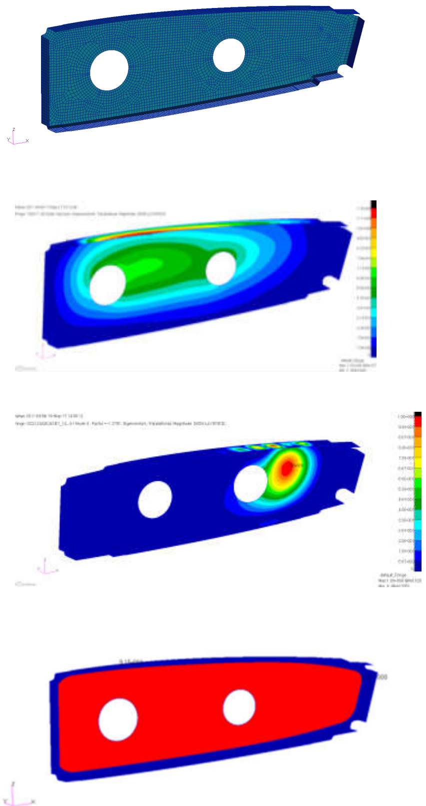
R&I Projects: COGEA (ongoing)

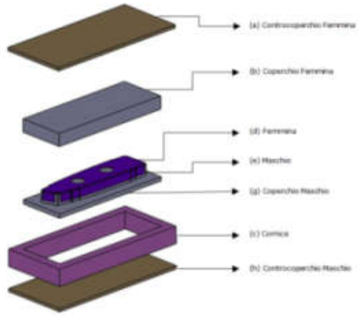
COmposite Certification in GEneral Aviation

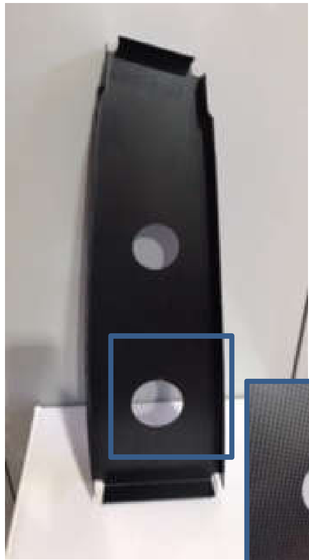
Research deals with the investigation of innovative solutions, in terms of materials and processes, to apply on manufacturing of primary aerostructures for general aviation A/Cs.

Novotech is involved in the design and manufacturing of Ribs and Ailerons:

- **Ribs** will be produced by dry HLU preforming and LRI process;
- Part of **Ailerons** will be produced by dry AFPM rapid preforming and LRI process.







from Design to Manufacturing

R&I Projects: NHYTE (ongoing)

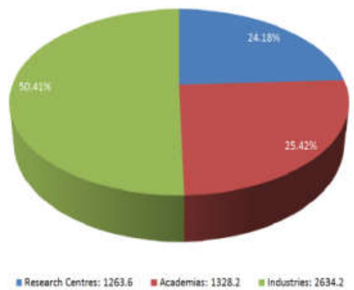
__N__ew __HY__brid __THE__rmoplastic composite aerostructures manufactured by out of autoclave continuous automated technologies

Topic : MG-1.1-2016 Reducing energy consumption and environmental impact of aviation

✓ **8 Partners from 6 different EU countries** granting the strength of the European aerospace supply chain competitiveness coupled with strong cooperation on RTD;

✓ more than the **25%** of the EDCs will be **outsourced to EU** countries.

FUNDING Distribution per Organization k€



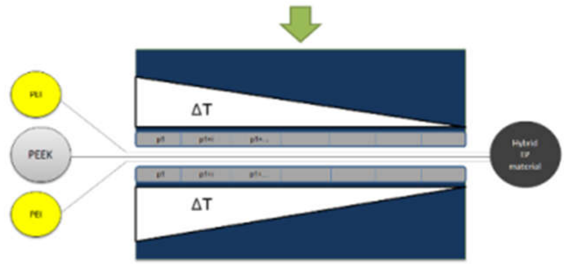
www.nhyte-h2020.eu

R&I Projects: NHYTE (ongoing)

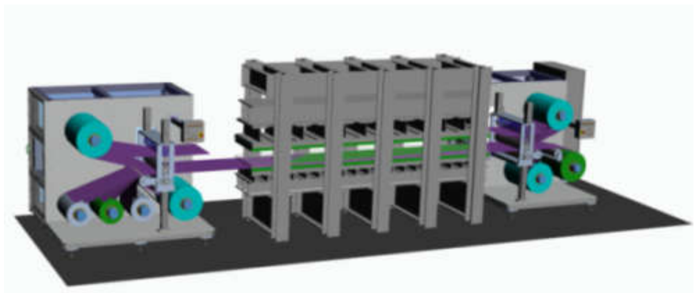
NHYTE project is developing concepts and methodologies enabling the realization of innovative and green integrated aero-structures made by a new recyclable hybrid thermoplastic composite material with multifunctional capabilities (induction welding).

Such new material, fabricated by an innovative machine implementing continuous automated production processes, returns functions of **toughness improvement** (multilayer material) and process simplification, since it **does not require autoclave consolidation** (**improved cycle times** and lower energy consumptions, **greener production**).

www.nhyte-h2020.eu



Automated Machine for hybrid material production : Concept



Development

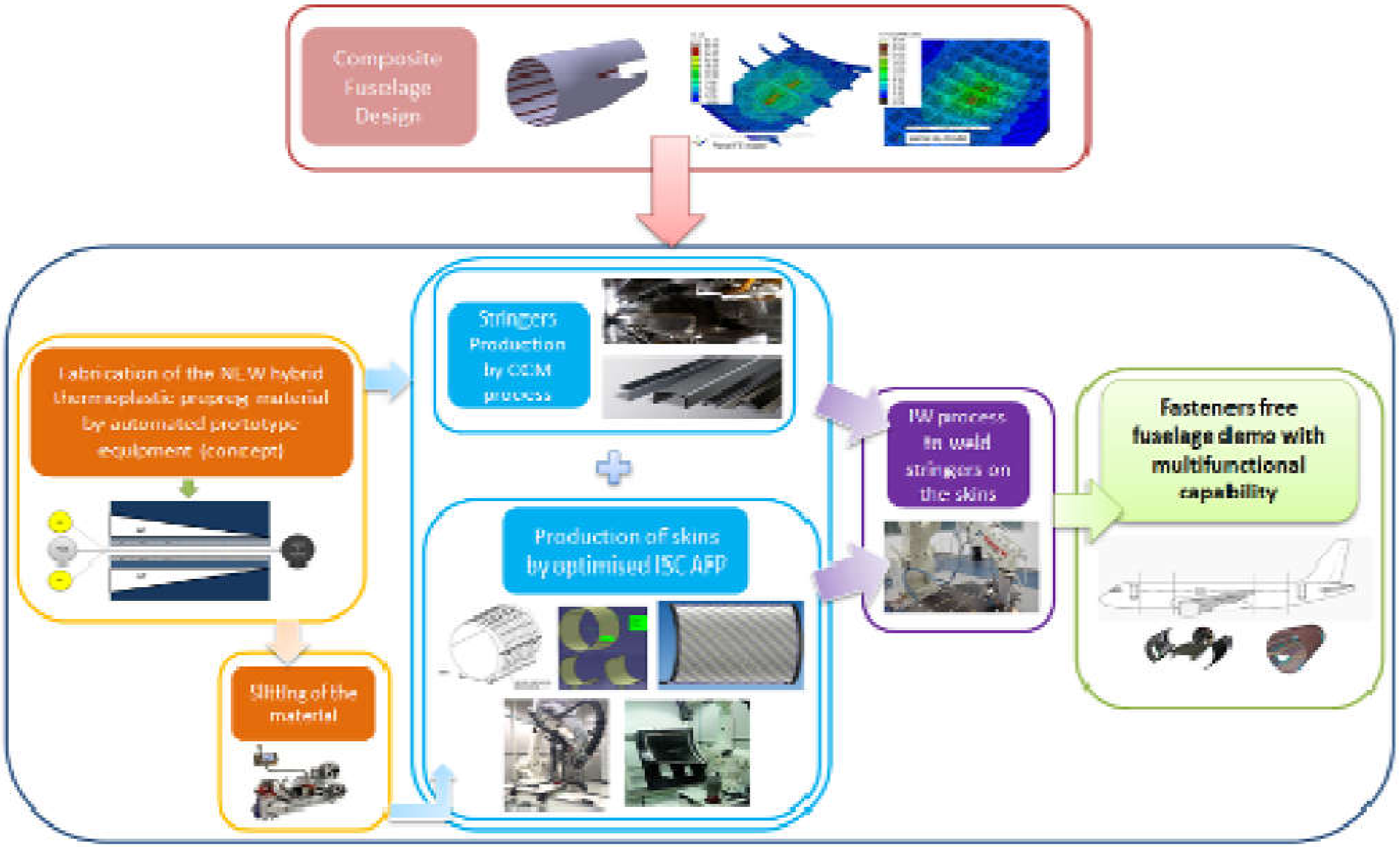
The new equipment for material fabrication installed on March 2018

Design & Manufacturing of Aerospace Composites (R&I Projects)

R&I Projects: NHYTE (ongoing)

Proof of concept :

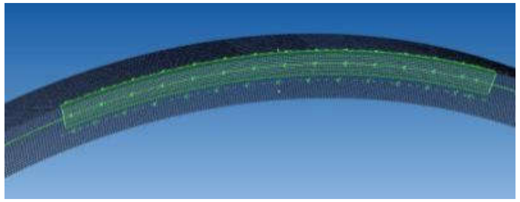
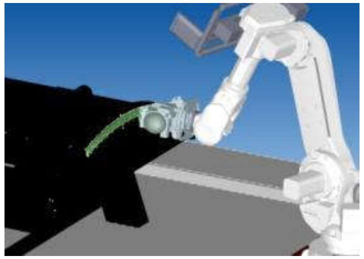
Manufacturing of a Fuselage portion Demo that will be fatigue and static tested

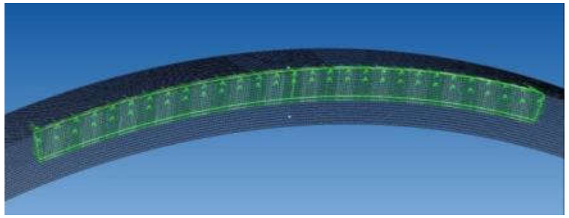
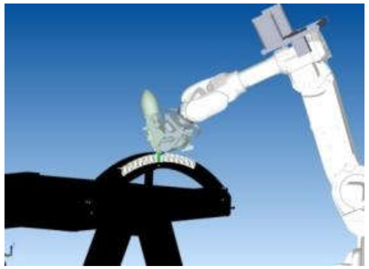


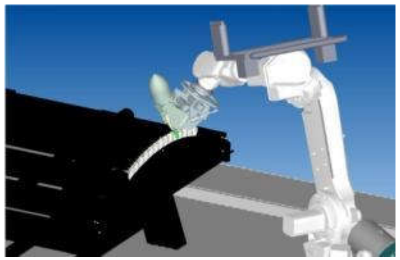
www.nhyte-h2020.eu

R&I Projects: Z-Frame Trials (ongoing)

MANUFACTURING OF Z-FRAMES DEMONSTRATORS FOR REGIONAL A/C BY AUTOMATED TECHNOLOGY

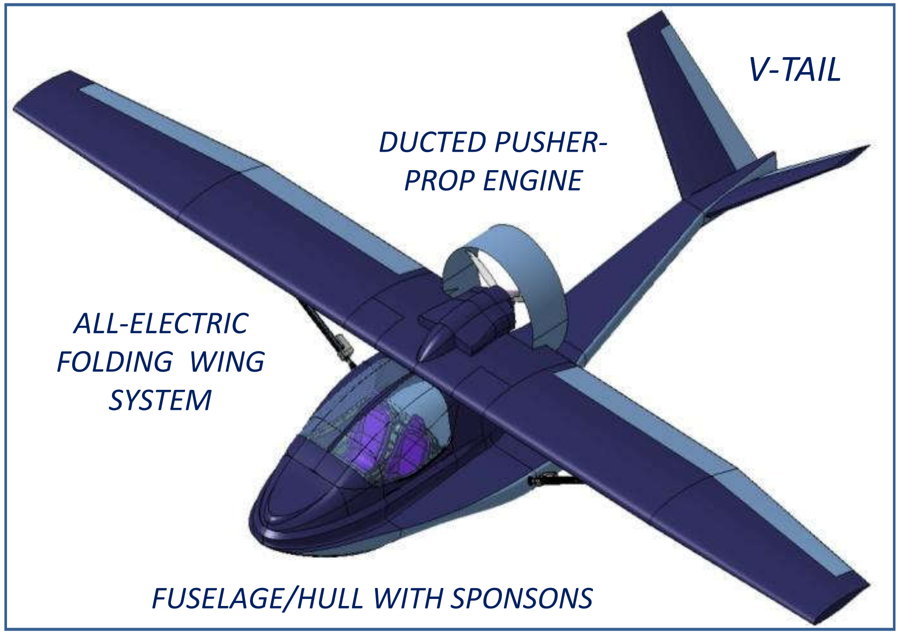




SEAGULL - The Marin-Air Vehicle for the Millennial Generation

*The SEAGULL is a **breakthrough** with respect to the current transportation systems, a high performing **ultralight amphibian aircraft**, **easy** and **economical**, operating from any infrastructure in complete **autonomy**.*

SEAGULL Main Characteristics

- *Full composite amphibious*
- *Braced wing (through linear actuators)*
- *Automated Folding wing allowing the usage:*
    - *as classical UL aircraft (no folded)*
    - *as sail boat (folded at 90°)*
    - *as ship or for ground transport and storage (fully folded aft)*
- *Single engine pusher configuration*
- *Ducted fan to ensure safety in water navigation*
- *Hybrid propulsion system (alternative)*
- *Retractable landing gear*



*Project partially **funded** by **MISE** - Italian Ministry of the Economic Development (Law 808/85)*

Start date: *January 2018*
End date: *December 2020*

*Financing of **1.3M€** of which 55% to be returned*

Thank you

for your attention

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