femto-st SCIENCES & TECHNOLOGIES

CANAPAFORUM 2022

HEMP FIBRE EMPLOYMENT IN COMPOSITES

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FEMTO-ST – Department of Applied Mechanics

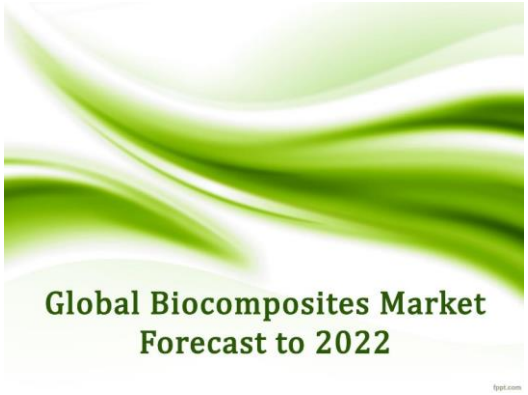
suchy DEVELOPING ADVANCED BIO-BASED COMPOSITES

cnrs UBFC UNIVERSITE BOURGOGNE FRANCHE-COMTE UNIVERSITÉ DE FRANCHE-COMTÉ ensmm École Nationale Supérieure de Mécanique et des Microtechniques utbm université de technologie Belfort-Montbéliard

Outline

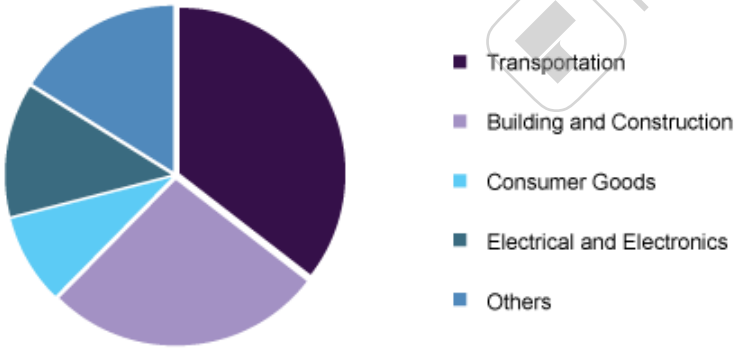
- Bio-based composites market
- SSUCHY project
- Hemp fibre reinforcements for composites
- Composite product demonstrators
- Conclusion

Bio-based composites market



- Biocomposites market:
  - valued at USD 16.46 Billion in 2016
  - projected to reach USD 36.76 Billion by 2022, at a compound annual growth rate of 14.44% from 2017 to 2022

Global biocomposites market share, by end use, 2016 (%)

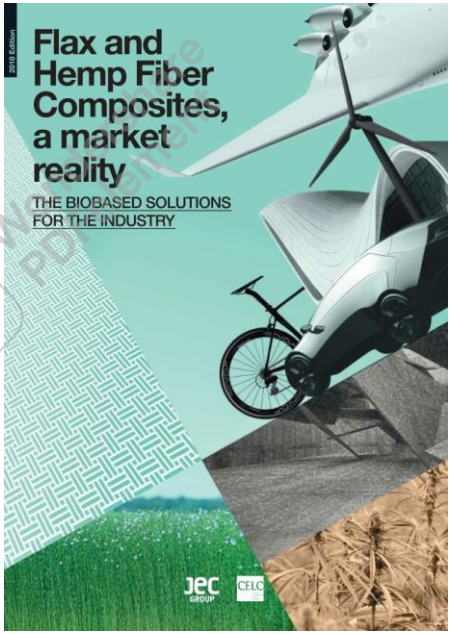


- The market is growing rapidly, in particular in well-established application sectors such as:
  - automotive and plastic industries,
  - building and construction,
  - emerging market of consumer goods and end-use industries.

BIOCOMPOSITES MARKET - GLOBAL FORECAST TO 2022 By Fiber (Wood Fiber and Non-Wood Fiber), Polymer (Synthetic and Natural), Product (Hybrid and Green), End-Use Industries (Building & Construction, Transportation and Consumer Goods) and Region. In: Markets&Markets, ditor.September 2017.

Bio-based composites market

- Natural fibres share in 2019 in the composites market
  - 9% in value
  - 11% in volume



Bio-based composites market

Automotive

Source CELC (Confédération Européenne Lin Chanvre)

Interior components such as door and instrumental panels

Construction

Bio-based composites market

Sport & leisure

Source CELC (Confédération Européenne Lin Chanvre)

Bio-based composites market

Design

Source CELC (Confédération Européenne Lin Chanvre)

Audio and musical instruments

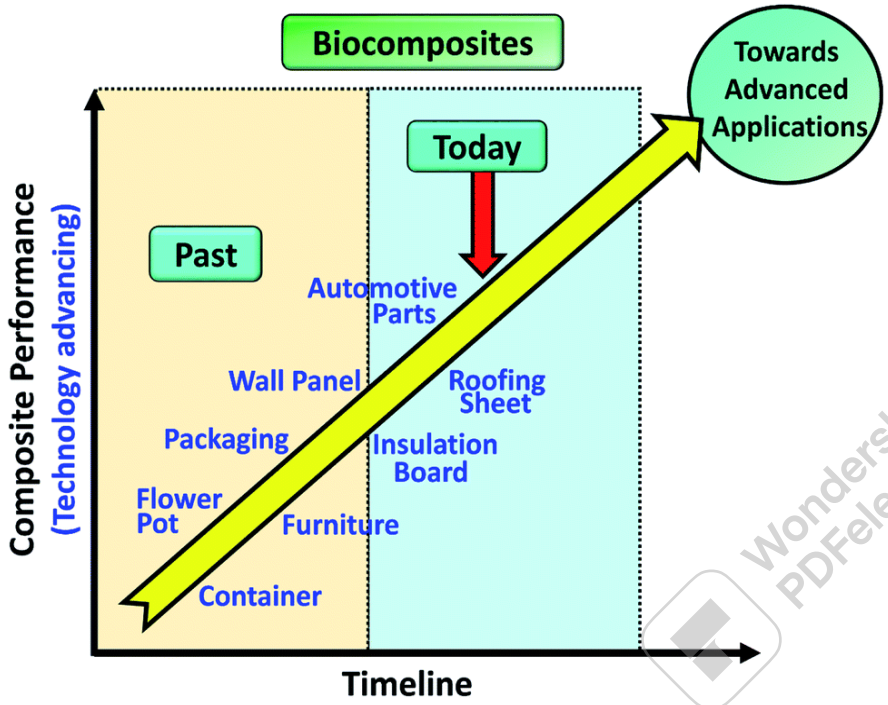
Personal and household goods

Bio-based composites market

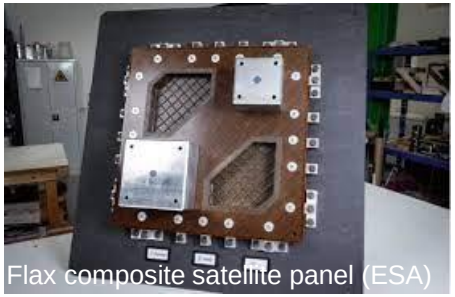
- In many of these applications, plant fibres are being employed primarily as:
  - + Light, Cheap, Renewable and recyclable
  - - Playing little or no structural role

- Next step: structural and functional applications
  - Using their:
    - + good specific mechanical properties
    - + damping capacity
    - + low thermal conductivity
  - Limiting or exploiting their:
    - -/+ sensitivity to humidity

Bio-based composites

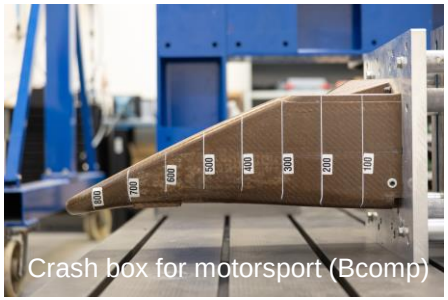


Chang et al. RSC Adv., 2020,**10**, 17955-17999


Flax composite satellite panel (ESA)


Smart Circular Bridge

Can hemp fibres be used for structural applications?


Crash box for motorsport (Bcomp)

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SSUCHY Project

- **Sustainable structural and multifunctional biocomposites from hybrid natural fibres and bio-based polymers**
- **BBI JU Project - Research & Innovation Action** – Value Chain 1: **Lignocellulose**
- **Topic BBI 2016.R7. Biopolymers with advanced functionalities for high performance applications**
- Project duration: **54 months** (September 2017 - February 2022)
- Total budget: **7.41 M€** including 4.45 M€ BBI JU contribution
- Consortium:

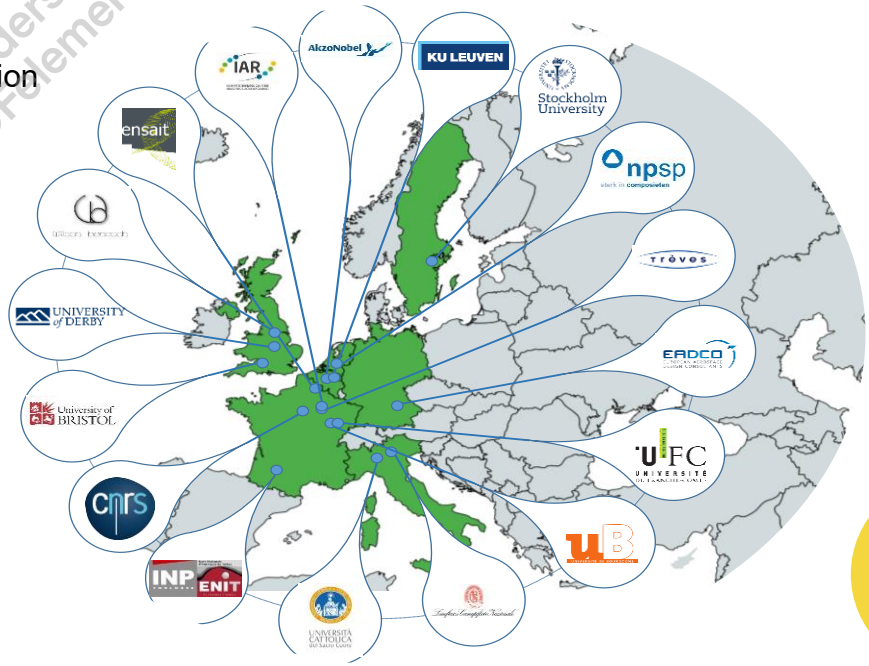
17 partners from 7 European countries

10 academic institutions

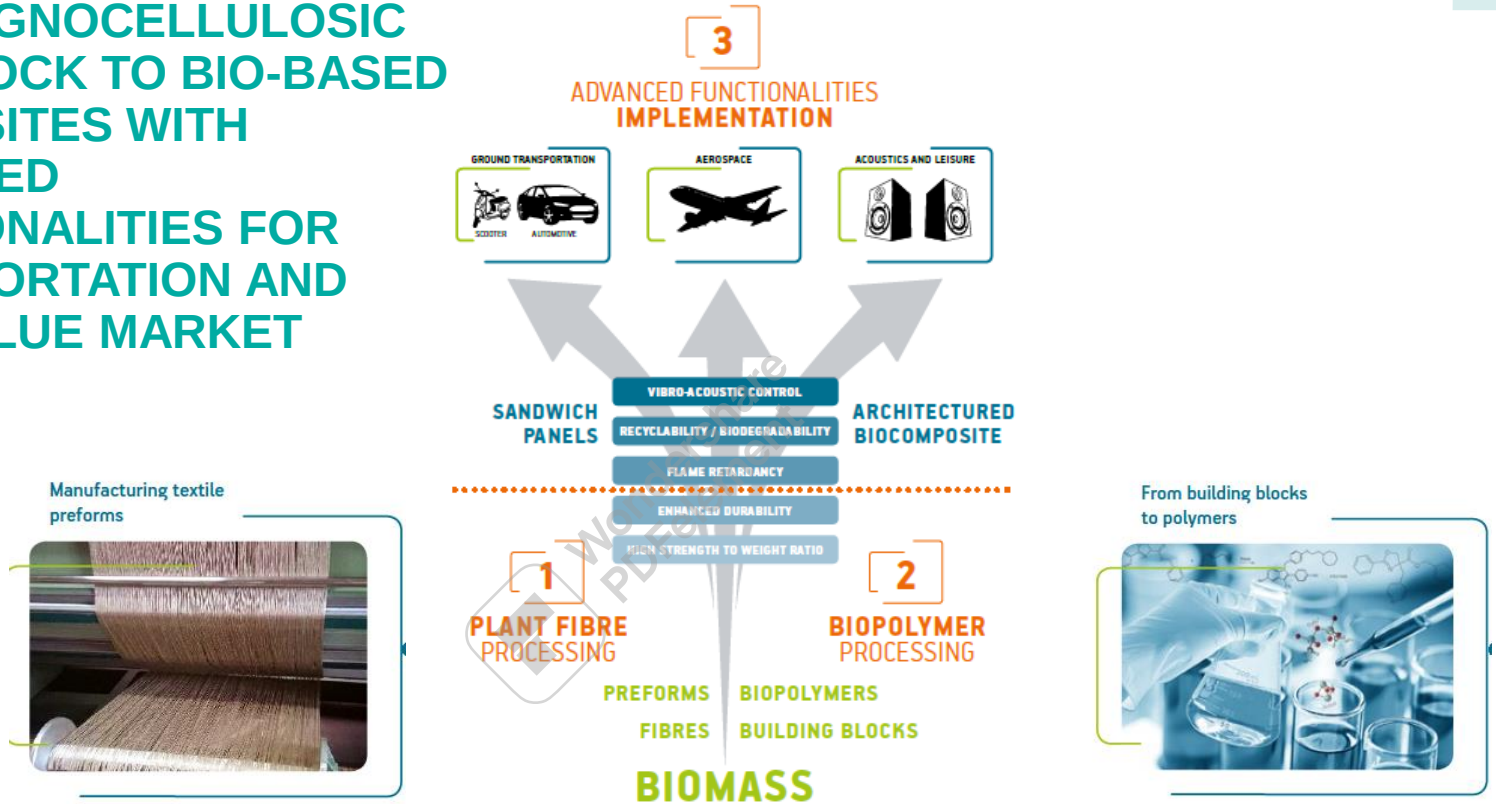
3 industries

3 SMEs

1 competitiveness cluster



FROM LIGNOCELLULOSIC FEEDSTOCK TO BIO-BASED COMPOSITES WITH ADVANCED FUNCTIONALITIES FOR TRANSPORTATION AND HIGH VALUE MARKET NICHES



SSUCHY is positioned on the development of composite constituents, based on a renewable resource (i.e. biopolymers and plant fibre reinforcements) for the development of multifunctional bio-based composites with advanced functionalities for applications in the transportation and audio sectors. It is dedicated to the development of specific concepts, technologies and materials to achieve a complete value chain and prove the principle at the scale of product demonstrators.

Hemp value chain

Hemp a good candidate to expand purpose-grown biomass

Main assets are:

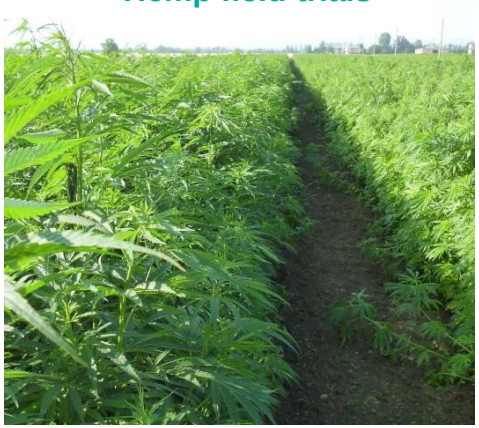
- a **sustainable high yielding crop**, very adaptable, **growing worldwide** (for northern latitudes to tropical climates), well adapted to most European conditions,
- a **multipurpose crop** (seed/oil, shives, metabolites and fibres),
- a **rapidly growing plant** that tolerates high planting density (substantial consumer of CO2, approximately 1.4 kg of CO2 is stored per kg of hemp fibres).
- a **vigorous growth**, shading capacity and disease resistance, that allow a growth **without the use of herbicide, pesticide or fungicide**. Suitable for organic agriculture.
- a **low energy cost for its production** (low fertilizer inputs, limited interventions and manpower requirements for farming).

Take advantage of availability, technical and environmental-friendly characteristics and moderate cost of hemp fibres to market a high performance plant fibre reinforcement for composite application with competitive price

SSUCHY Project

Hemp value chain

Hemp field trials



UNIVERSITÀ CATTOLICA del Sacro Cuore

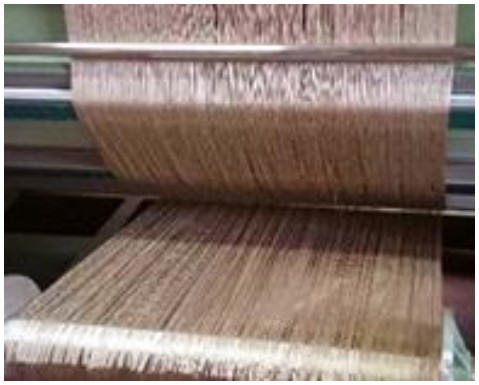
Stefano Amaducci's group

Hemp harvesting and retting

INP TOULOUSE ENIT ÉCOLE NATIONALE D'INGÉNIEURS DE TARBES

Pierre Ouagne's group

Hemp reinforcements



ensait ROUBAIX ECOLE D'INGENIEURS TEXTILE

Damien Soulat's group

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SSUCHY hemp reinforcements

Production of low-twisted rovings - Processing routes

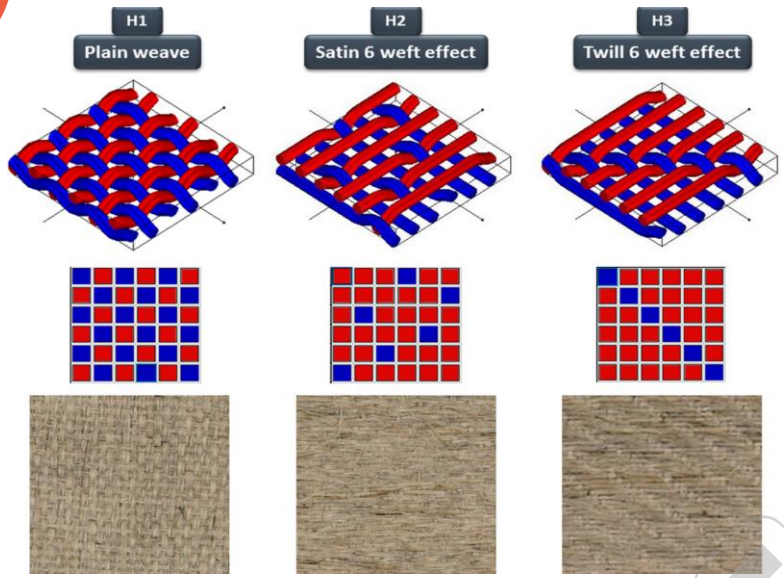
Development of **hemp low-twisted rovings optimised** for **composite applications**

1. Long-aligned hemp fibres for high-performance composite applications (use of the **flax machinery**, adaptation and simplification of the “textile method“ – **aligned straws**)

2. Medium length carded fibres for mid-range composite performance and moderate cost (disordered straws)

SSUCHY hemp reinforcements

Secondary processing – production of woven fabrics



Quasi-unidirectional

Weaving from the low-twisted rovings (suppression of the time-, money- and energy-consuming spinning step)

Linificio e Canapificio Nazionale

SSUCHY hemp reinforcements

Secondary processing – production of braids

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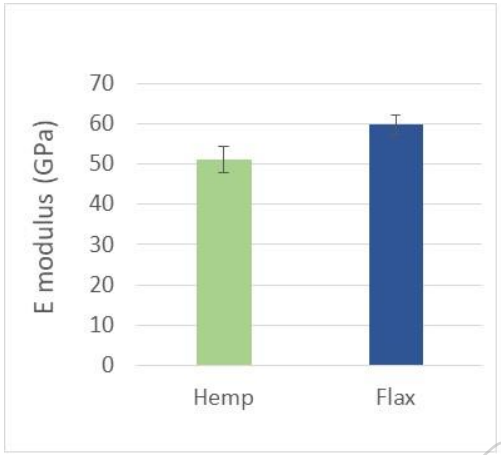
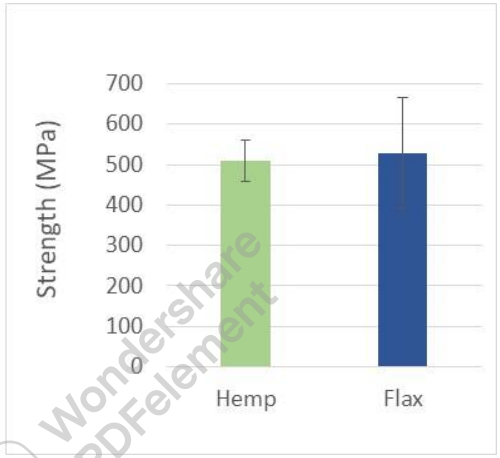
ROUBAIX
ECOLE D'INGENIEURS TEXTILE

SSUCHY hemp reinforcements

Merchanical performance of hemp fibres and reinforcements

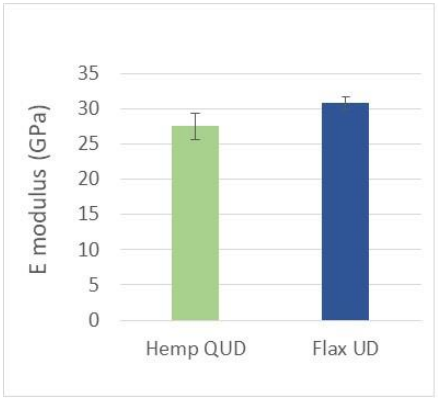
- Long aligned fibres (evaluated from Impregnated Fibre Bundle Test)

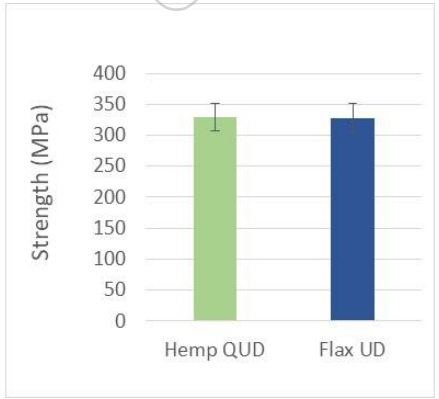


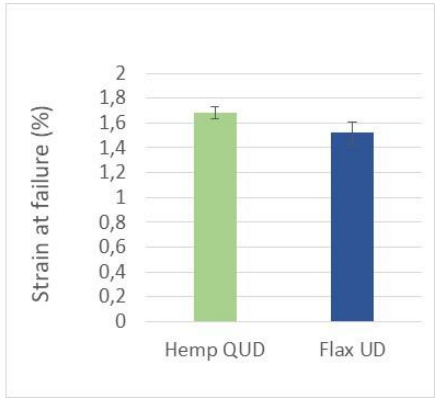


Reference flax:
Bensadoun F, Verpoest I, Baets J, et al. Impregnated fibre bundle test for natural fibres used in composites. Journal of Reinforced Plastics and Composites. 2017;36(13):942-957. doi:10.1177/0731684417695461

- Composite made of woven hemp fabrics (GreenPoxy matrix, Vf=48%)







Benchmark flax materials:
Flaxtape 110 Lineo-Ecotechnilin
AmpliTex BComp

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DEMONSTRATORS

- High performance green loudspeaker system

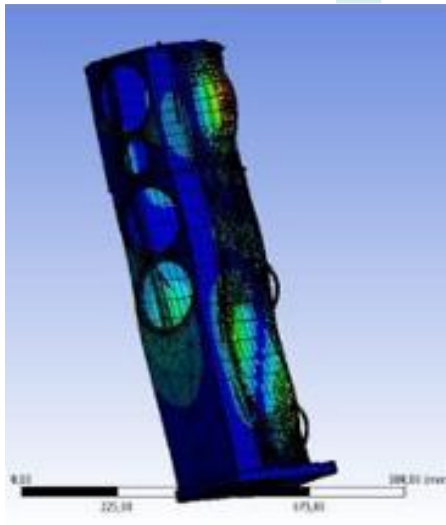
- Bio-based monocoque structure for electric scooter

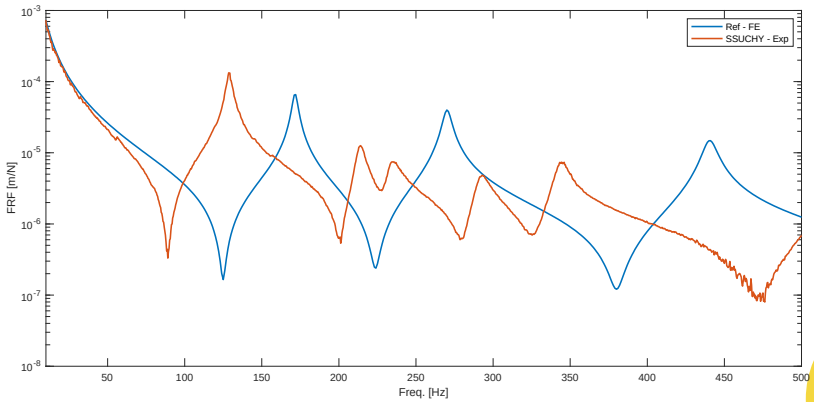
- Bio-based panel for electric aircraft interior

- Bio-based floor and trim panel structures for automotive applications

DEMONSTRATORS

➢ GREEN LOUDSPEAKER





Damping doubled when compared to existing solutio

DEMONSTRATORS

➢ GREEN LOUDSPEAKER

Wilson benesch

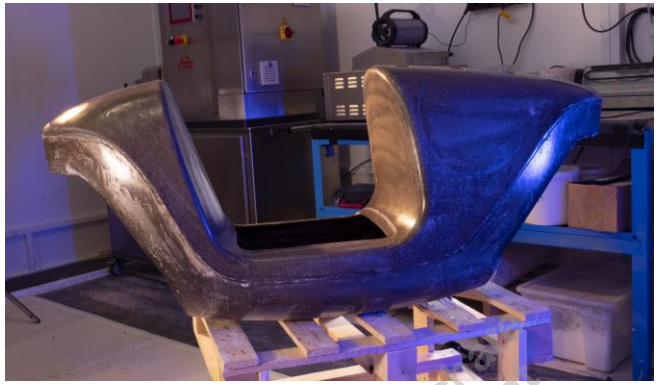
DEMONSTRATORS

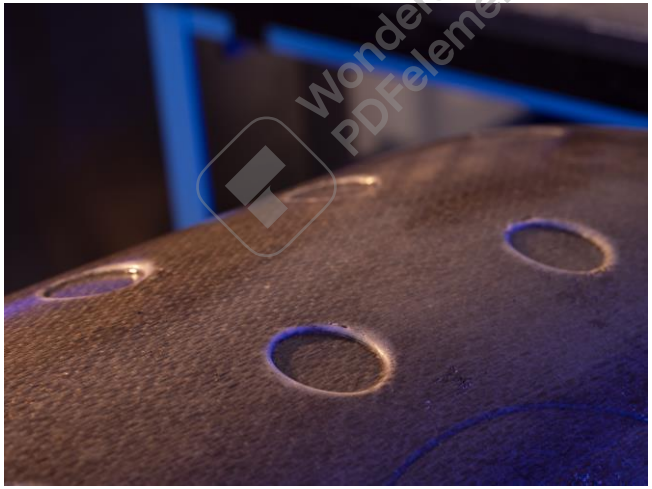
➢ ELECTRIC SCOOTER FRAME

npsp

DEMONSTRATORS

➢ ELECTRIC SCOOTER FRAME





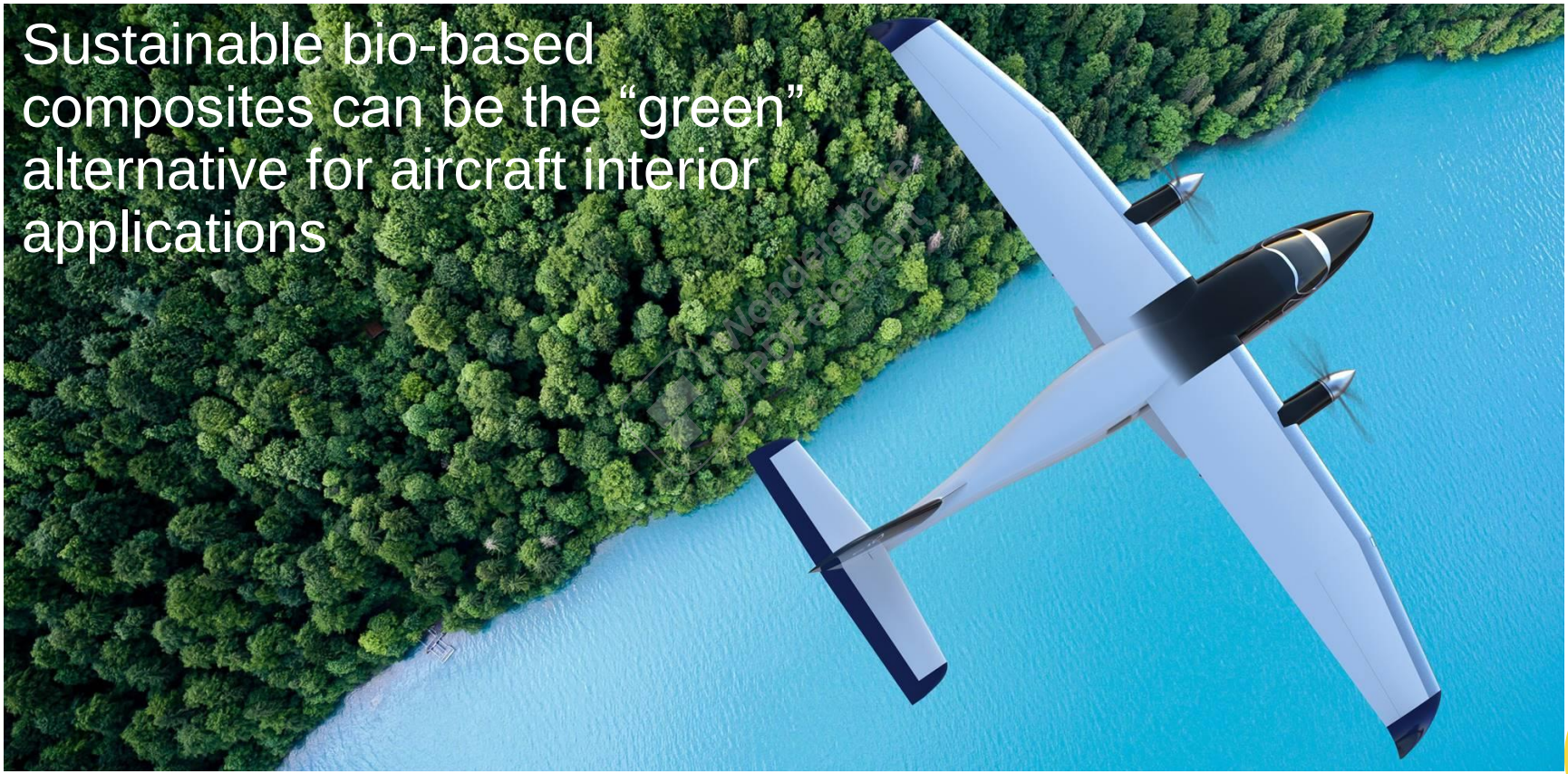
Electric Scooter –N5010

- Lower weight -> 13 kg (-56%)
- Higher biobased content -> 65% (was 30%)
- Lower costs by saving on labor time -> -50% (price -40%)

DEMONSTRATORS

- **ELECTRIC AIRCRAFT COKPIT PANEL**

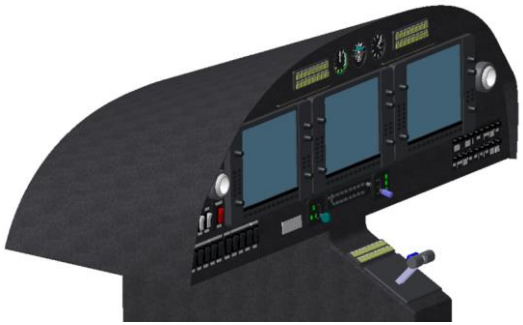
EADCO
EUROPEAN AEROSPACE DESIGN CONSULTANTS

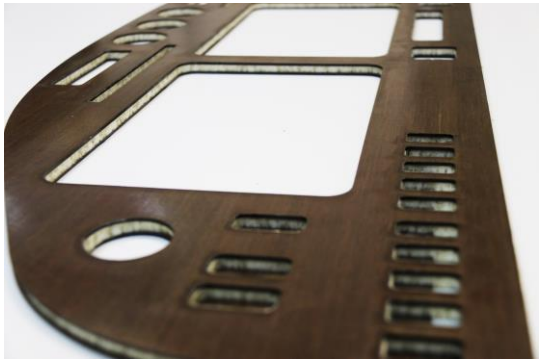


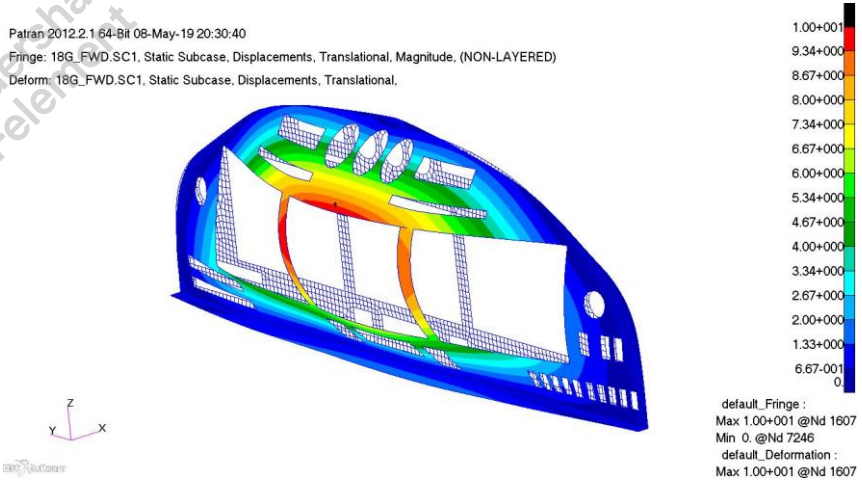
DEMONSTRATORS

➢ ELECTRIC AIRCRAFT COKPIT PANEL

EADCO EUROPEAN AEROSPACE DESIGN CONSULTANTS



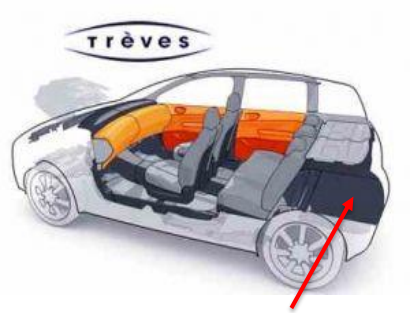


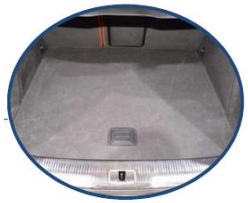


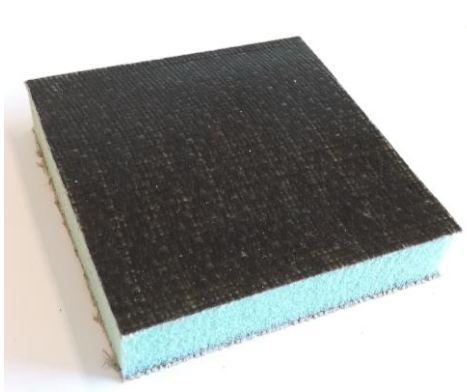
- **Increased vibration damping**
- **Reduction of the GWP** (Global Warming Potential, kg CO2 eq.) **by 76%** when compared to the existing solution made with carbon fibres

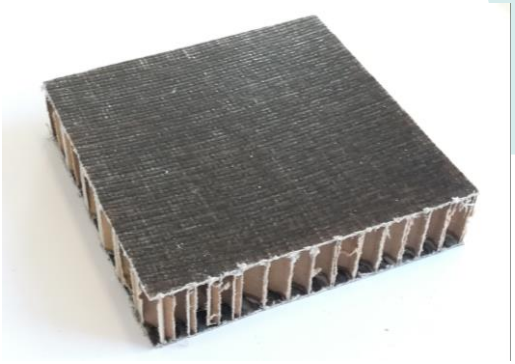
DEMONSTRATORS

➢ AUTOMOTIVE INTERIORS

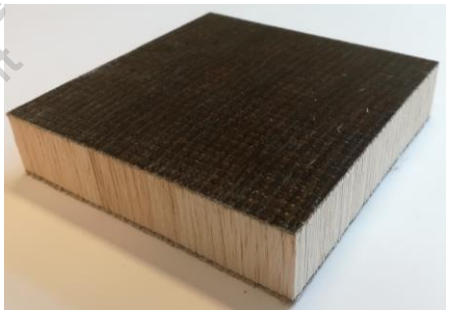




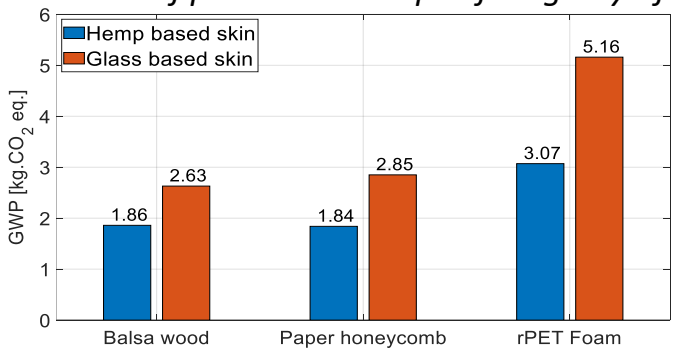




Loadfloor structure



GWP production of panels with a specific rigidity of 1 kN.m².kg^{-1}.



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Conclusions

- **Demonstration of the feasibility of processing hemp** for the production of **continuous reinforcements** suitable for **composite applications**
- **Mechanical performance of hemp fibers and associated composites comparable to those of flax**
- **Specifications for advanced composite applications (structural & multifunctional) can be met using hemp fibres**

SSUCHY, to learn more…

https://www.ssuchy.eu/wp-content/uploads/2022/04/SSUCHY-Del-11.12-Book-Of-Final-Results.pdf

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