ECO-COMPASS EU/CHINA PROJECT:
STATUS AND OUTLOOK ON ECOLOGICAL
IMPROVED COMPOSITES FOR AVIATION
INTERIOR AND SECONDARY STRUCTURES

Glasgow, September 2018
8th EASN-CEAS International
Workshop on Manufacturing for
Growth & Innovation
Jens Bachmann* (DLR)
Yi Xiaosu* (AVIC BIAM)
*) Coordinators of the ECO-COMPASS project

This project has received funding from:
- The European Union’s Horizon 2020 research and innovation programme under grant agreement No 690638
- The Ministry for Industry and Information of the People’s Republic of China under grant agreement No [2016]92
Content

- Background
- Aims
- Applications
- Involved partners from China & Europe
- Work Structure
- Challenges for eco-materials
- Status and chosen results
- Outlook
Background

- Aircraft configuration
- Propulsion / alternative fuels
- Aerodynamics
- Trajectory / flight path
- Energy management
- Lightweight design
  - Fibre Reinforced Composites
    - CFRP, GFRP, GLARE, ...
    → Synthetic / man-made materials
- Natural Fibres?
- Bio-based resins?
- Recycled materials?
- Function Integration?
ECO-COMPASS

Ecological and Multifunctional Composites for Application in Aircraft Interior and Secondary Structures

‣ Cooperation of Chinese and European partners
‣ 04/2016 – 03/2019

‣ Identification of applications for eco- and multifunctional composites
‣ Development, characterization and simulation of eco-materials to give a broad overview of the possibilities in aviation with leverage to other transport sectors like automotive and railway.
‣ Application / Demonstrators
‣ Life Cycle Assessment (LCA)
ECO-COMPASS Approach

Life Cycle Assessment (LCA)

Recycling Fibre (e.g. carbon)

Bio-Fibre (e.g. Ramie, Flax)

Eco-Reinforcement (e.g. hybrid non-woven)

Characterization, Modelling and Simulation

Eco-Composite Manufacturing

Use-Phase (e.g. secondary structure)

End of Life Recycling / Energy recovery

Material Protection Technologies (e.g. fire/moisture coatings)

Processability and Compatibility (e.g. nano cellulose, plasma treatment)

Multifunctionality (e.g. conductivity by interlayer or additives)

Bio-Resin (e.g. Epoxy)

Hybrid Sandwich Core
ECO-COMPASS

8
EUROPEAN PARTNERS
FROM 6 COUNTRIES

11
CHINESE PARTNERS

AIRBUS
CIMNE
DLR
inegi
UP
LEITAT
Manchester 1824
University of Patras
Laboratory of Technology
A Strength of Materials

CNITECH
AVIC HAIG
ECO-COMPASS Application

- Pylon Fairings and Nacelles
- Winglets
- Radome
- Spoilers / Flaps / Ailerons
- Horizontal Stabilizer Fairings
- Trailing Edge Upper and Lower Panels
- Main & Center Landing Gear Doors
- Face sheet
- Honeycomb core
- Ceiling panel
- Hat rack
- Side panel

September 2018
Natural Fibres: Challenges

- Fulfillment of demanding requirements in aviation
  - Mechanical properties
  - Fire properties
    - Heat Release
    - Flammability
    - Smoke Density & Toxicity
    - Flame penetration resistance (Cargo)
- Variable fibre properties
- Durability (Resistance to climate, UV, cleaning agents)
- Modifications and their effects on environmental impacts
- Prediction of material behaviour by modelling and simulation
EXAMPLES FROM THE WORK IN PROGRESS

EU & China
Reinforcements

Mechanical properties of modified sisal fibers

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Diameter (μm)</th>
<th>Tensile strength (MPa)</th>
<th>Young’s Modulus (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>173.3</td>
<td>529.9 (102)</td>
<td>13.6 (2.9)</td>
</tr>
<tr>
<td>Alkali-treated</td>
<td>142.6</td>
<td>692.8 (92)</td>
<td>18.8 (3.0)</td>
</tr>
<tr>
<td>Alkali-CNCs-EPD</td>
<td>156.4</td>
<td>614.9 (73)</td>
<td>22.0 (3.1)</td>
</tr>
<tr>
<td>Alkali-CNCs-ESA</td>
<td>150.2</td>
<td>716.6 (110)</td>
<td>21.0 (2.6)</td>
</tr>
</tbody>
</table>

Graphs showing tensile stress and cycles to debond for different treatments.
Reinforcements

E_{3PB}, Flexural Modulus (DIN EN ISO 14125)
0° test direction, 30% Fibre Volume Fraction

- 100% Flax
- 100% rCF
- 75% Flax + 25% rCF
- 75% Flax + 25% rCF (Gradient)

Plasma treatment?
Resins

- Epoxidized natural oils
- Rosin
- Saccharides
- Natural polyphenols
Characterization
Honeycomb
Demonstrators
Summary & Outlook

- Interior and Secondary Structures are possible application scenarios for eco-composites, e.g. fairings and linings.
- Demanding safety requirements (e.g. FST) have to be fulfilled without adverse effects on mechanical properties and weight.
- Bio-fibres (e.g. flax, ramie) offer promising specific properties. Modifications of fibres to enhance their properties are under investigation (plasma treatment, nano-cellulose, etc.).
- Hybrid composites based on bio-fibres and recycled carbon fibres could increase the mechanical properties and application range of eco-composites.
- Bio-based epoxy shows promising results comparable to petrol-based resins.
- Multifunctional aspects of high-performance composites like CFRP could lead to a better ecological footprint.
- Modelling & simulation helps to predict the behaviour of eco-composites in demanding applications like aviation.
- Life Cycle Assessment (LCA) to calculate the environmental impact from cradle to grave is important to compare „eco-composites“ with state of the art materials.
This project has received funding from:
- The European Union’s Horizon 2020 research and innovation programme under grant agreement No 690638
- The Ministry for Industry and Information of the People’s Republic of China under grant agreement No [2016]92

THANK YOU FOR YOUR ATTENTION.
Multifunction

- Functionalized Interlayer Technology (FIT)

A micron-sized toughening network, improving:

- $G_{IC}$ (J/m$^2$)
  - Control: 306
  - FIT sample: 667

- $G_{IC}$ (J/m$^2$)
  - Control: 718
  - FIT sample: 2345

A nano-sized conductive network, improving:

- $\sigma_x$ (S/cm): 0.21
  - Control: 25.6
  - FIT sample: 1.39
- $\sigma_z$ (S/cm): 0.12

* $y$: perpendicular to the fiber direction
  $z$: through-thickness direction