MUltiscale Modelling and SImulation of Complex materials
for production of Sustainable composites - MUSICS

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The **MUSICS** project focuses on the advanced modeling, design, and development of next-generation **sustainable composite materials**, particularly **natural fibre composites (NFCs)** and **recycled fibre composites (RFCs)**. These materials aim to replace petroleum-based products with **eco-friendly, biodegradable, and recyclable alternatives** for industrial applications in automotive, aerospace, marine, green mobility, and wind energy sectors. At its core, the project addresses the **multiscale and multiphysics behavior** of complex materials, which exhibit intricate internal structures and interactions between mechanical, thermal, and environmental effects. The project proposes the use of **non-classical continuum models**, including micromorphic and non-local formulations, to effectively describe materials with substructures across nano, micro, meso, and macro scales.

Key goals include the:

- **Development of new theoretical and computational multiscale models** for thermo-mechanical characterisation.
- **Design and optimization of green composites** using natural fibres (e.g., flax, hemp, cotton) and recycled carbon fibres, combined with bio-based resins.
- **Implementation of advanced numerical tools** (e.g., XFEM, peridynamics, VEM) for structural analysis and crack modelling.
- **Experimental validation** through testing campaigns, including mechanical, thermal, and durability assessments.
- **Industrial process optimization** using techniques like the Taguchi method to enhance material quality and reduce manufacturing time.
- **Market analysis and validation** to ensure the industrial viability and environmental impact of the proposed solutions.

The project is structured into seven Work Packages (WPs), encompassing theoretical modeling (WP1), computational tools (WP2), experimental campaigns (WP3), material design (WP4 & WP5), industrial scaling (WP6), and market integration (WP7). The final aim is to produce and validate prototypes suitable for real-world use, supporting the transition to **low-impact, circular economy-based materials**.

Synopsis of the Work Packages (WPs):

- **WP0: Project coordination and management**.
- **WP1: Non-classical/non-local continuous constitutive models for "complex materials".**
- **WP2: Advanced computational tools for structural analysis and optimisation of new materials.**

- **WP3: Experimental campaign for properties characterisation and model validation**
- **WP4: Design and development of next-generation natural fibre composite materials and prototypes.**
- **WP5: Design and development of next generation recycled composite materials and prototypes.**
- **WP6: Industrial process flow set-up for next-generation recycled and bio- based composite products.**
- **WP7: Market validation.**

The research project is industrial oriented with **Sapienza University of Rome** as Reaserch Organization (RO) and Affiliation Institution (AI) and **Carbon Dream SpA** as Host Institution (HI) and other 3 associated industrial partners.