PRODUCT DATA SHEET

MC4

MULTI-LEVEL CIRCULAR PROCESS CHAIN
FOR CARBON AND GLASS FIBRE COMPOSITES

LEADING-EDGE RIB

LEVERAGING CALENDERING FOR A SCRAP-POWERED LIFT-OFF

Developed by FIDAMC for MC4, the Leading-Edge Rib Demo exemplifies how sustainability and high-performance engineering can coexist in aerospace composite production. By valorizing ATL scrap, it sets a precedent for scaling up circular manufacturing practices, ultimately enabling to reduce material waste and fostering innovation in the sector.

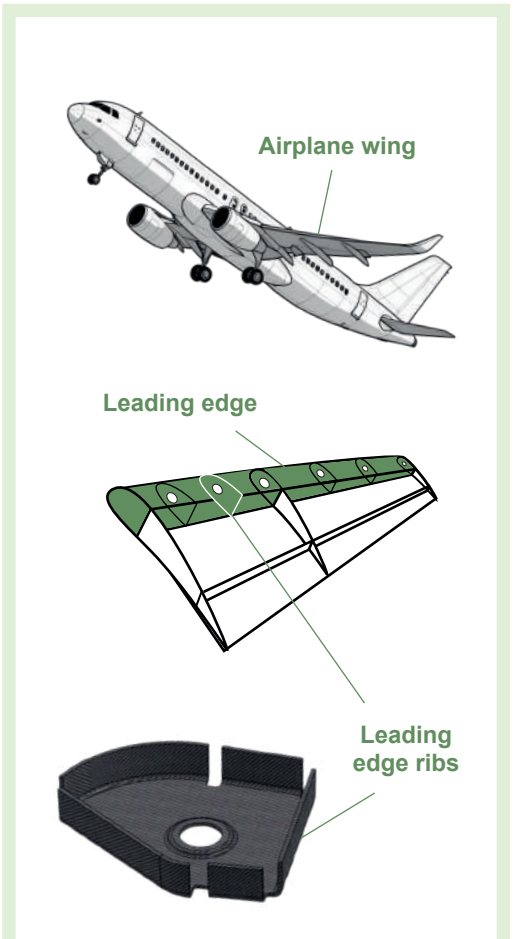
Embarking on a path of circularity for aircraft components

The leading edge of an aircraft is a critical structural component, designed to withstand aerodynamic forces, impacts, and environmental stress while ensuring optimal airflow. Traditionally made with high-performance materials, these parts require lightweight strength, damage resistance, and durability.

This demonstrator underlines that 100% reused carbon fibre multiaxial prepreg scraps, from Automatic Tape Layup (ATL) composite manufacture technique, can meet these demanding technical requirements. By refining and reprocessing multiaxial prepreg waste from ATL composite manufacturing, waste is transformed into value, creating a functional, high-performance aircraft part without compromising on strength or reliability.

Made from 100% reused material

Designed with sustainability in mind, this aircraft component transforms composite scraps into structural parts, thus minimizing end-of life waste by preventing landfill or incineration and enabling high-tech waste reuse, while cutting raw material production by enabling to reduce the need for virgin material.



Focus on the calendering process

1. **Preparing the scrap by sorting, classifying the prepreg scran and cutting to desired strip width**
2. **Feeding in the pre-heated calendering machine**
3. **Gradual thickness reduction from 2mm to about 1mm by applying controlled pressure with rollers**
4. **Ensuring fibres primarily oriented in the 0° direction to enhance material uniformity and mechanical properties**

After calendering, strips are bonded into a uniform panel, cut to fit the mold, and shaped using hot-press technology. The aluminum-steel tool ensures easy demolding by leveraging thermal expansion differences.

About the leading-edge rib demonstrator

- **100% calendered strips made from leftover material from the trimming of A380 stringers**
- Reused material created from strips of the carbon fibre prepreg scrap of 20mm of width and 1mm of thickness manufactured by calendering technology
- Dimensions 150mm x 175mm

Characterizing reused material properties

Recycling alters mechanical properties

Significant decrease in 0° tensile strength and stiffness, while 90° tensile and compression strength improve, indicating a transformation in material behavior.

Impact of FVF & porosity

Higher FVF and increased porosity influence mechanical behavior, with the material exceeding standard porosity levels for aerospace applications.

Transverse strength enhancement

Reused material shows better mechanical performance in the 90° direction, suggesting an improvement in transverse strength through the recycling process.

About FIDAMC

FIDAMC is a Research Center created in 2006 by the Spanish Ministry of Industry, the Regional Government of Madrid and the Airbus Group, focused on the research, development and potential uses of composite materials.

The entity is mainly addressed to aerospace activities but widely open to other sectors, having carried out projects in the railway, wind energy and automotive areas.

fidamc

About MC4

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SUN T-TOP

RECYCLED CARBON FIBRE & SOLAR-READY BOAT ROOF

The SUN T-Top is a sustainable alternative for boats, made from recycled carbon fiber with the aim of reducing waste and minimizing environmental impact in the nautical industry. Developed by AMURA within the European MC4 project, this roof represents a major step forward in the circularity of composite materials in the nautical industry.

Sailing towards a circular value chain

The maritime sector is responsible for 3% of global greenhouse gas emissions. Within the nautical industry, materials, particularly composites, account for up to 90% of the manufacturing footprint, highlighting the urgent need for more sustainable solutions.

Glass fiber has been widely used in the industry due to its balance between cost and mechanical properties. However, its recycling remains extremely limited, and the lack of viable reuse processes has led to an increasing accumulation of composite waste, contributing to significant environmental impact.

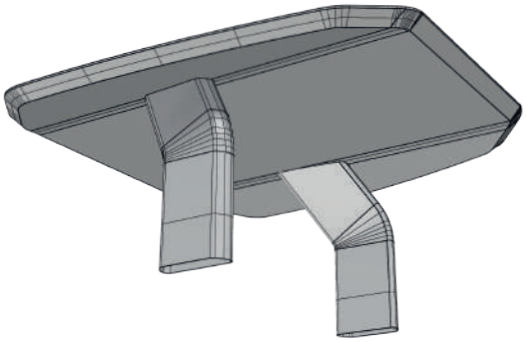
On the other hand, carbon fiber stands out for its rigidity and lightness, making it an attractive alternative for high-performance applications.
But its production requires high energy consumption and results in a larger carbon footprint.

Despite this, advancements in recycling have opened new opportunities for its reuse, positioning it as a key material in the transition toward a circular economy in the nautical sector.

As part of the MC4 project, Amura took on the challenge of integrating recycled materials into boat component manufacturing, driving the development of more sustainable solutions in the composites industry.

Reducing
glass fibre
production and waste

Reusing
carbon fibre
through recycling



Turning solar protection into energy

Its design allows for the seamless integration of solar panels without compromising functionality, transforming sun protection into a renewable energy source. In this way, it not only provides shade for the boat but also contributes to more sustainable navigation by generating clean energy during the journey.

The SUN T-Top at glance

Optimized design

Manufactured through vacuum infusion, its aerodynamic structure enables to reduce wind resistance and enhances vessel performance.

Easy installation

To be mounted with bolts and nuts on the boat's console.

Versatility

Designed to adapt to various boat models.

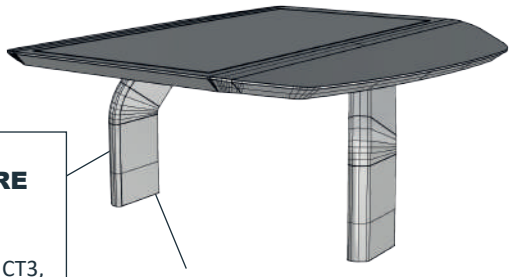
Sustainability

Recycled carbon fibre to reduce reliance on high-impact materials and minimize resource consumption.

Solar-panel compatibility

An optimized space adapted for solar panel integration.

Material breakdown



CARBON FIBRE

82% recycled

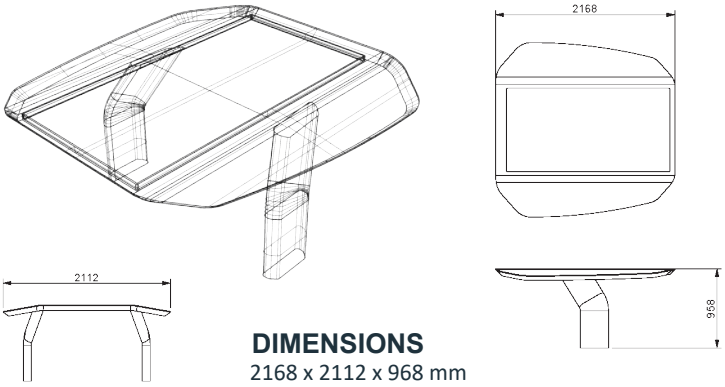
OCI1535, R BT300 CT3, 4 24K HS x 126cm

18% virgin

Biaxial 450 g/m² (for reinforcements)

RESIN

Noma Green & Noma Catalyst



DIMENSIONS

2168 x 2112 x 968 mm

From prototype to reality

Developed within the MC4 project, this prototype has demonstrated its feasibility and potential for application in the nautical industry. Its design is based on existing models already manufactured with virgin carbon and glass fiber, ensuring compatibility with current standards and integration into boat production.

Resilience in action: addressing recycled material integration challenges

As part of a circular economy research project, the SUN T-Top development required overcoming technical challenges for optimizing recycled materials. The use of recovered carbon fibre required adjustments in resin absorption and structural design, ultimately achieving a functional, sustainable solution applicable to future boat designs.

About AMURA

Amura, Astilleros y Servicios Náuticos, is a company specialized in boat manufacturing, maintenance, and repair. Our commitment to quality and effi ciency has positioned us as a key player in the industry. We have a dedicated R&D department, driving new solutions and participating in various innovation projects aimed at improving materials and processes in the nautical sector.

Partners Involved:
Chomarat - STFI - NOMA

Amura
ASTILLEROS Y SERVICIOS NÁUTICOS

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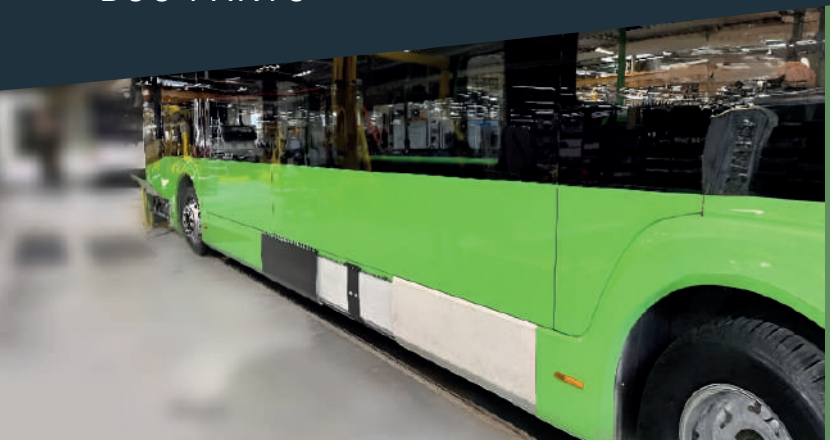
MC4

MULTI-LEVEL CIRCULAR PROCESS CHAIN
FOR CARBON AND GLASS FIBRE COMPOSITES

BUS SIDE SKIRT

FUELING CIRCULARITY FOR ENDURING BUS PARTS



Jointly developed by VDL and CRC as part of the MC4 project, the bus side skirt integrates recycled composite materials from production waste into a new, high-performance component. Designed for public transportation, this innovative part demonstrates the potential of circular manufacturing, combining sustainability, efficiency, and enhanced mechanical properties.

Leveraging a bus part at the forefront of protection and durability

Side skirts are protective panels attached to each side of the lower part of the vehicle. Acting as shock absorbers, they enable to reduce impact damage while also serving an aerodynamic function to enhance fuel efficiency.

Due to their exposed position, side skirts, usually six per bus, are prone to frequent impacts and wear, requiring regular replacement. A non-negligible volume of these parts must therefore frequently be discarded, traditionally incinerated or landfilled, adding to composite waste and material costs.

Given their inherent high replacement rate and the part they play it the vehicle durability, side skirts are a prime candidate for circular innovation: offering a sustainable and cost-effective alternative with recycled composite materials, without compromising on performance.

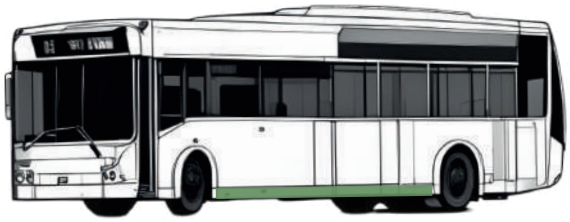
From waste to high-performance

45%
recycled glass fibre content

Superior
mechanical performance

Lighter weight
for energy efficiency

Reduced costs
through material optimisation



Enhancing bus lifespan for the future of urban mobility

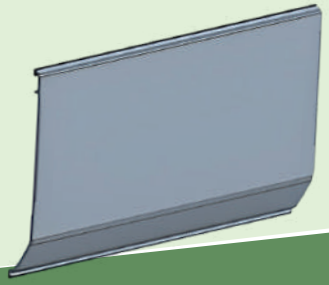
As one of the lowest carbon-footprint transport modes, buses are central to public policies for sustainable mobility. The progressive transition from thermic to electric energy already enabled great progress in terms of energy-related impact, even more so when powered by renewable energy.
Manufacturing, however, still accounts for up to 30% of the carbon footprint for an average 12-year lifespan in buses, highlighting the importance of studying material reincoporation perspectives.

Supporting circular manufacturing in the transportation industry

This new side skirt has been developed using **45% recycled composite materials**, proving that waste can be transformed into high-value components.

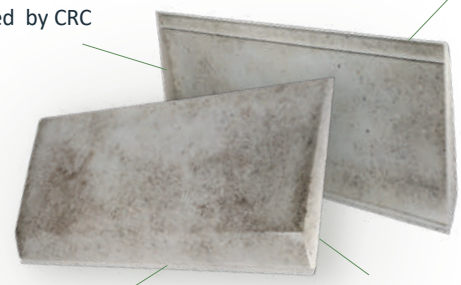
This innovative approach not only reduces environmental impact, by lowering the composite waste currently sent to landfills or incinerated, but also enhances performance with greater stiffness and tensile strength compared to conventional parts. Further more, reducing virgin material usage enables to lower production costs.

Its lightweight design makes it ideal for electric buses, which require durable and lightweight parts as weight directly impacts energy consumption.



Material breakdown

Recycled glass fibre waste
Processed by CRC
45%



Foaming epoxy resin
Lightweight and cost-effective
45%

Virgin UD fibres
Cut-offs from bus wall production
10%

Interface material
Metal or plastic, depending on cost and strength requirements.

Dimensions

1.4m x 0.45m x 0.05m
Custom dimensions available to fit various bus models.

Manufacturing Process

1. Glass fibre waste is shredded, sorted and cleaned by CRC
2. Material is pressed with foaming epoxy resin in a 2-sided mold
3. Final finishing is completed to ensure durability and easy attachment to the bus
4. Recycled fibres are combined with virgin fibre cut-offs for added strength

About VDL Fibertech

VDL Fibertech Industries BV is a leading supplier of fiber-reinforced composite parts, specializing in thermoset sandwiches. These composites are primarily used in applications requiring high stiffness and low weight, such as in the medical sector and transport industry. With a modern production facility in Hapert, Netherlands, VDL Fibertech Industries offers customized solutions for both small and large series. Their expertise includes materials like carbon fibers and glass fibers, and production methods such as (VA-) RTM, hot pressing, and RIM. The company strives for collaboration and innovation, as evidenced by their involvement in projects like the MC4 project.

Through their technical knowledge and high-quality production processes, they can deliver cost-effective and high-quality parts that meet the strictest requirements of their customers.

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ADVANCING CIRCULAR COMPOSITES

HIGH-PERFORMANCE INTERMEDIATES FOR SUSTAINABLE MANUFACTURING

MC4

MULTI-LEVEL CIRCULAR PROCESS CHAIN
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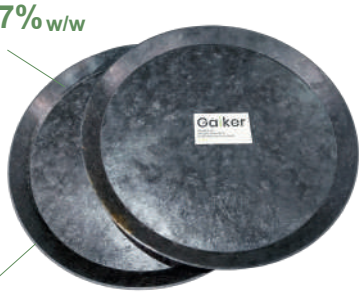
In the course of MC4, Gaiker has developed and validated two innovative intermediate materials to be processed into final parts, demonstrating how recycled carbon fiber can be effectively reintegrated into high-performance composites. The project both explored the manufacturing of prepreg with carbon fibre waste and the valorisation of prepreg scrap for a Bulk Moulding Compound (BMC) for various applications.
These developments offer viable alternatives to virgin materials, supporting a more circular composite industry by optimizing material formulations and processing conditions.

1 Bulk Moulding Compound from uncured aeronautical sector prepreg scrap

This Bulk Moulding Compound (BMC) is made from uncured carbon prepreg scrap from the aeronautical sector. By repurposing this material, it reduces hazardous waste while eliminating the need for virgin carbon fiber. The resulting BMC demonstrates comparable mechanical performance to commercial alternatives for applications in automobile, industry or leisure, with optimized processing and storage properties.

Characteristics

Uncured prepreg scrap
67% w/w



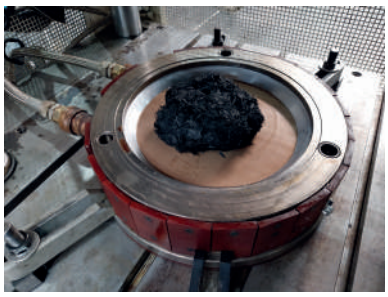
Recycled carbon fibre
50% w/w
100% of the reinforcement

33% w/w
Virgin resin formulation - vinyl ester

Fibre length tested
10-25mm

Tested for high performance and low-impact

- Mechanical properties tested for various % of added prepreg scrap fibre lentgh, degree of curing progress and storage conditions
- Proven mechanical performance compared to commercial BMC
- Optimized for short curing cycles and long storage stability (up to 6°C)
- Enables to reduce hazardous waste and eliminates need for virgin carbon fibre



2 Vacuum pressed prepreg material from mechanically recycled carbon fibre

Assessing prepreg integration suitability to both simple and complex components

This prepreg intermediate material was developed with nonwoven fabric made from recycled carbon fibre waste, and tested for two type of parts with different levels of complexity: simple (back seat cover) and complex (pedestal base).

This approach contributes to demonstrate the suitability of using this type of nonwoven material for two purposes: first, in the manufacturing of prepregs, and second, in moulding parts for the transportation sector, including marine and automotive applications.

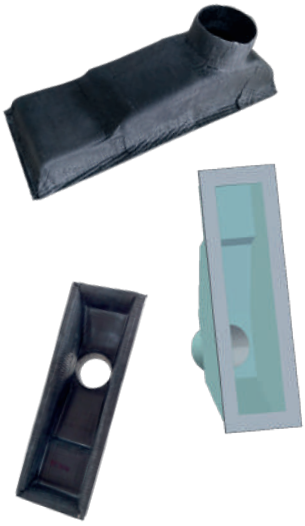
Involving project partners GAIKER, STFI and CHOMARAT, this project underscores the potential of recycled materials in high-performance applications while addressing the limitations that need to be overcome for more intricate designs.

1. Back seat cover

Cover on the backrest of the seat, to be upholstered

2. Pedestal base

Pillar-securing base or support for folding roofs on sailing vessels, e.g. bimini or canopy



About the prepreg

Composition

20% recycled carbon fibre
Reinforcement: nonwoven 300g/m2 C-fibre (OCI1535, R BT300 CT3, 4 24K HS x 126cm)
Number of layers of prepreg in final parts: 2
Added resin: vinyl ester

Additional features

1500g/m2 prepreg, short curing cycles, long stability at room temperature

Key contributions

While the backseat cover showcases the feasibility of using recycled carbon fibre to reduce the weight and environmental impact of the part, the pedestal base highlights the challenges of using nonwoven material for more complex shapes.

About GAIKER

GAIKER Technological Centre, located in the Technological Park of Bizkaia (Spain), is devoted to the development of new technologies and knowledge in Biotechnology, Recycling, and Plastics and Composites. Since 1985, GAIKER has carried out close to 1500 R&D projects with industries and academia collaborations. In the field of recycling GAIKER has a wide experience in recycling processes for post-consumer waste from different streams (WEEE, C&DW, ELV, etc.). Additionally, GAIKER analyses the recyclability of composites by offering more sustainable solutions by incorporating resins from renewable natural sources, recyclable resins, natural fibres or recycled fibres. Finally, GAIKER recovers composites at the end of their life cycle in new semi-finished and final products.

Gaiker
MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

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MULTI-LEVEL CIRCULAR PROCESS CHAIN
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JOINING COLLET

PIPELINE BONDS FOR A CIRCULAR FUTURE

NOMA Resins sp. z o.o., as part of the MC4 project, has developed an innovative joining collet for civil engineering applications. This pioneering solution introduces the first composite joining collet incorporating recycled material fractions, specifically engineered for the mining and fuel transportation industries. This innovation enables the construction of fully secure pipelines that meet stringent industry standards while ensuring intuitive, cost-effective, and user-friendly installation.

Advancing pipeline infrastructure with composite innovation

The growing demand for pipeline infrastructure in gas, liquid fuels, and mining industries presents a significant opportunity to overcome the limitations of traditional joining collets. Typically made from steel or reinforced concrete, conventional collets are heavy, prone to corrosion, and challenging to install.

By providing mechanically and chemically resistant components, composite-based materials can address the growing market need while answering a necessity for increased sustainability. This demonstrator underlines their capacity to withstand sophisticated conditions with the integration of materials achieved from recycling.

Engineered for sustainability

Reduced material footprint

Composite elements account for only about 10% of the weight of a comparable reinforced concrete structure, 20% for a steel structure, and 25% of a malleable cast iron structure.

Lighter weight

Significantly reduced need for heavy equipment, as used for laying pipelines or transporting prefabricated elements, thereby also lowering investment costs.

Extended product lifecycle

Incorporating recycled GFRP to enhance the circularity in material use

Technical specifications

Objective
Replace heavy, corrosion-prone joining collets with a sustainable alternative.

Material Composition
50 wt.% shredded GFRP + NOMA epoxy resin

Advantages

- Corrosion-resistant for long-term operational use
- Lightweight structure for improved handling
- Increased durability and mechanical performance

Dimensions

Ø 285 mm | Thickness: 35 mm

Ø 445 mm | Thickness: 36 mm

Ø 545 mm | Thickness: 40 mm

Manufacturing process

1. Mixing shredded GFPR with NOMA resin
2. Preparation of mould
3. Filling with composite composition
4. Compression moudling processing
5. Demoulding

About NOMA resins

NOMA, Polish specialist of composites and resins production, in particular epoxy resins, also provides auxiliary materials necessary in the technological process of composite production, as well as fabricate composite components, e.g. for transportation sector. Among other prepregs, NOMA produces in the form of textiles and tapes as well as SMC/BMC materials (also with recyclate) and composite elements. Taking advantage that NOMA produces their own formulation, the SME has the ability to personalize products and improve them in cooperation with the clients and according to their needs.

NOMA RESINS

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KAYAK & PADDLE

ROWING BEYOND COMPOSITE WASTE

Developed by Managing Composites with contributions from CIDETEC and Chomarat, the MC4 Kayak demonstrates the potential of recyclable composites in sporting goods. Built using glass fiber and CIDETEC's 3R epoxy resin, it combines durability with circularity. At end-of-life, key components can be reshaped into new paddles, closing the loop on composite waste.

Unlocking composite recyclability with a sustainable epoxy

The **3R resin** is an environmentally friendly epoxy vitrimeric system developed by CIDETEC in recent years. Containing reversible bonds, this system exhibits stress relaxation at high temperatures (vitrimeric behavior), enabling composites to be reshaped, repaired, and ultimately recycled into new products rather than being landfilled or incinerated, a systemic challenge faced by composite materials.

This system enables to re-use composite parts without separating the fiber from the matrix, thus offering the possibility to recycle through a re-shaping process to create new components for different applications.

With this demonstrator, Managing Composites, with support from CIDETEC and Chomarat, explores the recycling GFRC with the 3R resin to highlight how reprocessable composites are able to maintain the high level of performance properties required in demanding applications while reducing waste.

About the 3R resin

Recyclable

Reprocessable

Repairable

The kayak: an ideal demonstrator

A strong case for circularity

A product to reconnect with nature and outdoors yet demonstrating a relatively short lifespan and difficult conventional recyclability.

High potential for recovery

An elongated shape and large surface facilitating an efficient reuse, enabling sections to be repurposed into new components, such as paddles.

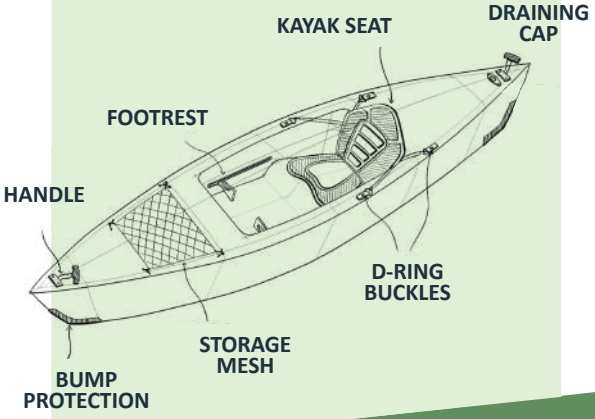
A demanding yet 3D-ready test

A requirement for high mechanical performance, balancing rigidity, durability and lightness, while aligning with 3R resin compatible manufacturing process (infusion).

A versatile, convenient and functional product

Hybrid between a recreational sit-on-top and a touring kayak, this model is stable, easy to use and fun while also comfortable and useful in many different settings such as longer-distance traveling. It is meant to be used by a single person, and it has several added features to make it fully functional.

Features include: a storage mesh, two handles to carry the kayak; a seat to improve ergonomics and comfort with two adjustable footrests to allow the use by people of different sizes (mounted on specifically designed composite brackets), and lastly, a draining cap to account for any water that could be leaked inside the structure.



Composition

KAYAK

40wt%

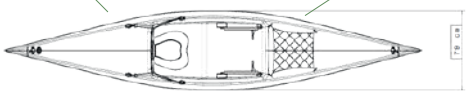
3R Resin

made of 3 different components

60wt%

Glass fibre

Biaxial squared twill of 360gsm, developed by Chomarat, used as reinforcement fibre



PADDLE

BLADES

Recycled glass fibre composite

Blades cut-outs from a discarded kayak and reshaped through thermoforming with the 3R resin

FIXING INTERFACE

Block of glass fibre and epoxy composite

To fix blades to rod and reinforce weak areas, machined and adhered between

ROD

Carbon fiber

2m long as a connection between the blades, due to its lightness and excellent mechanical properties

Manufacturing process

1

Development of a new resin in compliance with specifications of envisioned manufacturing process (infusion)

2

Selection of most adequate fibre sizing to be used in combination with 3R resin (with Chomarat and 3B Fibreglass)

3

Manufacturing by combination of 3R resin and glass fibre fabrics for mechanical characterization and demonstrators' designs validation

4

Thermoforming trials on 3R composite laminates to explore process limitations and define processing window for recycling of kayak parts into paddles

About Managing Composites

Managing Composites is an engineering company specialized in the development of composite materials from early-stage prototype design to small series production. Its main activity focuses on automotive, aerospace, marine and sport and leisure industry. Managing Composites also have a strong R&D activity, tending to develop and spread the intensive use of sustainable materials for a greener industry.

MANAGING COMPOSITES

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SOUL BENCH

URBAN SEATING FOR THE FUTURE

Developed in Milan by LAB23, partner of the project MC4, the Soul Bench aims to reincorporate recycled composite material from end-of-life urban furniture, into a new, elevated product who blends design, functionality and sustainability.

Bringing soul back to urban spaces

The name “Soul” reflects the bench’s dual purpose: a soulful approach to sustainability and a unifying space for community gatherings.

More than just a piece of furniture; the Soul Bench is a functional work of art that transforms public spaces into welcoming and stimulating environments. Its design invites social interaction, encouraging community connection.

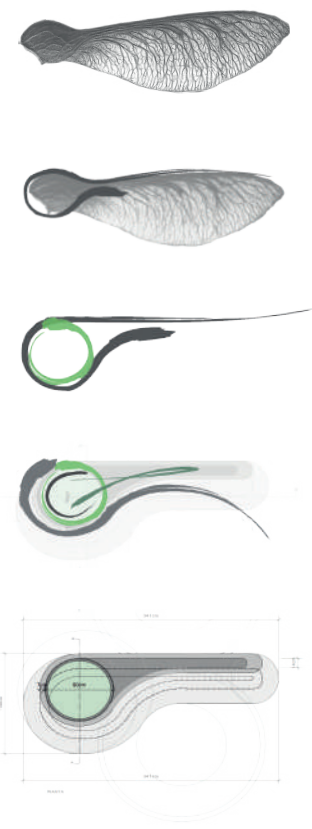
By nature, for nature

Sustainability-driven

Incorporating recycled material from end-of-life urban seating, fully recyclable and eco-friendly production processes the Soul Bench represents a step toward achieving circular material loops, giving new life to end-of-life urban furniture.

Bio-inspired

Inspired by the gentle form of a sycamore seed, the Soul Bench blends nature-inspired design with sustainable innovation. Created in collaboration with Studio AG&P, its soft, fluid lines adapt effortlessly to both urban and natural settings.



Where functionality meets sustainable innovation

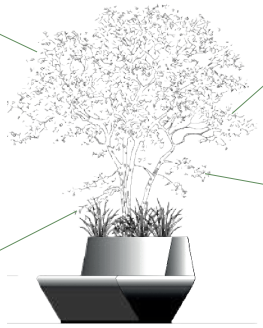
Composition

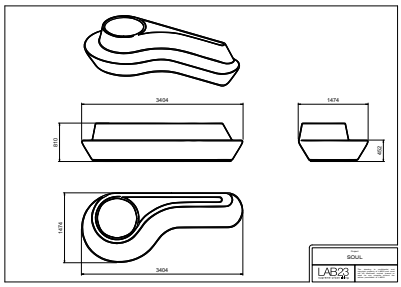
The Soul Bench uses a high-performance composite material developed by LAB23.

Composed of **at least 50% recycled content** and **100% recyclable**, it offers durability, weather resistance, and long-term outdoor performance.

This advanced material reflects LAB23's commitment to sustainability and circularity, reducing environmental impact while ensuring strength and reliability.

Material breakdown





Dimensions

Height.....1.4m
Width.....3.2m
Weight.....205kg

Features

INTEGRATED ARMRESTS

USB & WIRELESS CHARGING

ENVIRONMENTAL SENSORS

BLUETOOTH SPEAKERS

About LAB23

LAB23 offers a varied range of products – benches, bus or car canopies, bins, bollards, planters, bike racks, tree grates – for a total of about 200 products meant for both public and private clients. All products are characterized by a contemporary design combining rigid, essential shapes with soft and sinuous ones and high-quality, high-resistant materials that require very little maintenance costs. To achieve this, LAB23 chooses materials like galvanized steel, stainless steel, corten steel, hardwood, and HPRC (composite material).

LAB23
supreme urban living

About MC4

MC4 (Multi-level Circular Process Chain for Carbon and Glass Fibre Composites) is a European partnership aiming to establish circular approaches for carbon and glass fibre composites. After a 3 years implementation, MC4 will make the European carbon and glass fibre value chains more circular, independent and competitive.

MORE INFORMATION

mc4-project.eu

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