



Gen
Phoenix



CirculAir *playbook*

The practical, actionable resource that supports the aviation industry in embedding circular design and recyclability into aircraft seat cover design.

The industry challenge

Currently, over **1 million seat dress covers are discarded annually**, most ending up in landfills or being incinerated.* Airlines are actively seeking solutions that support Environmental, Social, and Governance (ESG) targets without compromising regulatory compliance, cost, product performance, or passenger experience.

While there are materials that claim to be sustainable or 'circular', no cabin dress cover solution (to date) delivers true circularity: combining renewable input, durability, recyclability, and the infrastructure for return and reuse of a material at its highest value.

In addition, the aviation interiors ecosystem is not currently set up to enable recovery of aircraft interior materials. Even when sustainable materials are used, aircraft seat covers typically become unrecoverable because of how they are designed and constructed. Laminated materials that are difficult, time-consuming and costly to separate from a foam backing are effectively forced into landfill or incineration at end-of-life.

*Source: Aircraft Interiors International



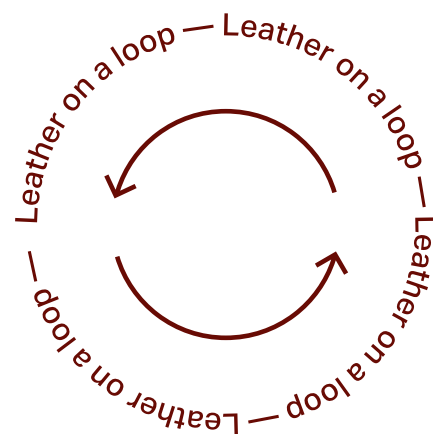
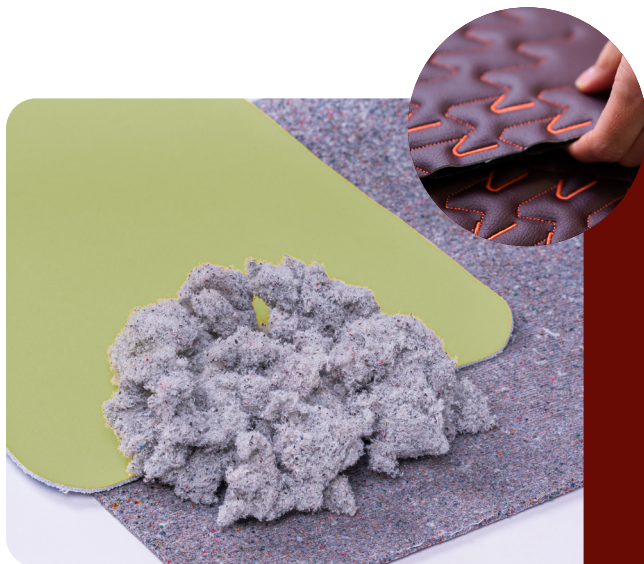
Circularity is an industry wide challenge and can only be addressed by collaboration across the entire ecosystem.





Gen Phoenix has been diverting leather waste from landfill for nearly two decades, but we believe this is only the beginning of the journey towards closed-loop circularity. Our proprietary recycling technology goes beyond wet blue leather waste, enabling us to process finished material—including both trimming waste from seat cover production and end-of-life seat covers—back into new high-performance aviation products.

The technology is ready. What comes next is a shift in mindset across the industry, transforming not only how seat covers are designed and constructed, but how materials are valued, enabled for recovery, and kept in circulation at the end of their useful life.



This playbook is designed to offer a **practical, actionable** resource for seat dress cover design, and supports the industry in embedding circularity and recyclability into cabin design from the outset. By translating sustainability ambitions into clear steps and real-world guidance, it aims to help the full aviation supply chain, including designers, OEMs and aviation seating-related suppliers to make measurable progress toward a more sustainable cabin ecosystem.



Designing for *circularity*

Decisions made at the design and specification stage directly affect whether materials can be recovered *decades* later.



Today, dress covers are traditionally built as complex multi-layer laminates, with leather (or other upholstery) permanently bonded to foam for comfort, aesthetics and performance. While effective in service, these constructions are extremely difficult to recycle because the materials cannot be easily or economically separated. By contrast, specifying alternative materials that can be milled to fibre, or easily separable stack-ups, allows high-value materials to be **recovered** and **reprocessed** at end-of-life.



Specifying an alternative to foam, such as 3Mesh[®] spacer fabric by Müller Textil, offers benefits to airline operators and their passengers, while also removing the obstacle of recycling traditional foams.

What goes around, comes around. What goes around, comes around. What goes around, comes around.



3 examples of how spacer fabric can offer optimum versatility and functionality:



Thicknesses

Spacer fabric comes in a variety of thickness from 1mm - 40mm. Consider the different parts of a dress cover and where you can impact passenger comfort. For example, the seat base cushion and side bolsters could take a thicker product for added comfort and a more luxurious seat feel without significantly increasing weight—a technique typical in the automotive seating industry.



Density

Similar to the thickness, spacer fabric is available in soft and firm variations to give ultimate flexibility in elasticity. Try the firm products in areas like the headrest and footrest/ottoman in premium or business class seats where durability and support is key, and select softer options for areas of the seat where you want to enhance comfort.

Seat builders and cut and sews can try combinations or even stacking different spacers. For example a firm support with a soft top layer could be a great option for lumbar support.



It's all in the weave

The way spacer fabric is manufactured creates a natural spring-like support through a three-dimensional, warp-knit. In the middle, monofilament yarns are expertly knit into individual channels that facilitate airflow and provide uniform pressure distribution under load. Even under rigorous Herman Squirms testing, dress covers made with 3Mesh® maintain their dimensional stability without degradation.

It's no secret that spacer fabric has been the product of choice in the automotive industry for decades. **But why?**



DESIGN

Passenger experience often comes from aesthetics and overall perception of a cabin interior look and feel, and the seat is where they have the closest personal connection. Gen Phoenix's Essence in combination with spacer fabric offers multiple finishes and design possibilities for crafting beautiful dress cover trim with secondary processes, such as deboss and stitch patterns.



RECYCLABLE/CIRCULAR

Knit from 100% PET, 3Mesh® is complementary to Gen Phoenix's Essence recycled leather upholstery, together enabling a simple yet transformative solution for recycling seat covers at end-of-life.



COMFORT

The key to introducing a new innovation to any well-established industry is 'no compromise'. Passenger experience and perception of comfort is critical to an airline's brand loyalty. With variation in firmness, thickness and innovative weight distribution, the dress cover can be optimised to get the perfect balance across the entire seat.



DURABLE

Due to pressure distribution and the way spacer fabric springs back, always returning to its original shape after being compressed, the seat cushion retains its form for years with no degradation. When combined with Gen Phoenix's Essence, this offers airlines a superior performance in service, where the entire stack up is built to last.



LIGHTWEIGHT

Selecting Essence with spacer fabric as an alternative to graphite foam offers airlines the option to enhance comfort without compromising weight. As shown in the examples below, even at a 50% increase in thickness over graphite foam, spacer fabric still offers weight savings with no compromise.

Examples:

Essence 480gsm + 6.5mm spacer 530gsm = 1010gsm

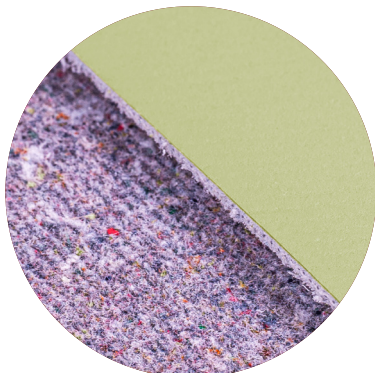
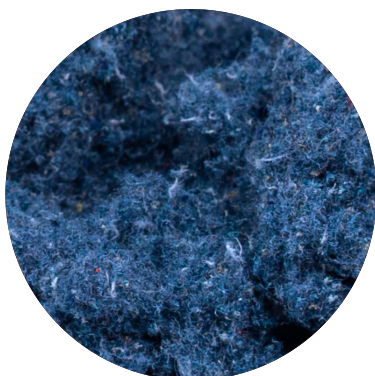
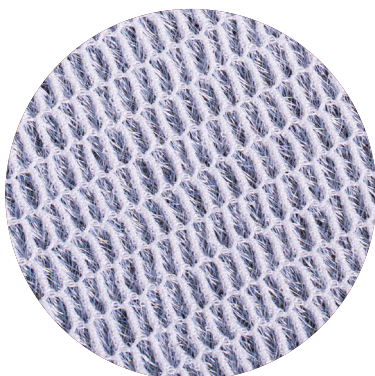
Essence 480gsm + 7.5mm spacer 535gsm = 1015gsm

Essence 480gsm + 5mm graphite foam
(industry standard) 560gsm = 1040gsm



Enhanced comfort. More durability. More beauty. More innovation.
All in a package that weighs less and is circular in nature.

Working with an *alternative* material

**NOTE**

Lamination with spacer follows the same process as foam, however, certain parameters may need adjustment to achieve best results.

KEY LEARNINGS

Collaborative development with multiple industry partners has built strong expertise in spacer lamination processes. Trials have demonstrated the advantages of web adhesive systems in controlling adhesive distribution, limiting penetration into the substrate, and supporting improved material softness and consistency. Web adhesives are the most common form of lamination across the automotive industry, which has years of experience using this type of seating construction.

CRITICAL PROCESS PARAMETERS

Successful lamination depends on carefully balancing several interacting variables, including adhesive chemistry and structure, heat transfer through the laminate stack, pressure application, spacer fabric construction, equipment configuration, and production line speed.

PROCESS CONTROL REQUIREMENTS

Once optimal conditions are established, consistent production requires tight control of both material inputs and processing conditions. Key factors include spacer fabric characteristics, adhesive properties, and manufacturing parameters such as line speed, thermal exposure, and material handling throughout the lamination process.

IS IT CERTIFIABLE?

Gen Phoenix has taken the concept a step further by demonstrating that a typical dress cover constructed using 3Mesh® spacer fabric by Müller Textil laminated to Gen Phoenix's Essence material can meet the requirements of FAR 25.853. Depending on the specific application, an additional flame-retardant scrim may be required.



In seating, 3Mesh® by Müller Textil has a scrim-like A-side for easy lamination, and an open and flexible B-side that works with the A-side to allow Gen Phoenix's recycled leather materials to comfortably move under load; reducing risk of creasing and wrinkling in service.

CASE STUDY



Circularity by Design, Not by Compromise

The Circular Dress Cover Innovation Engine (CDCIE) represents a collaboration of industry leaders making a transformative leap toward circular, sustainable aviation interiors. This multi-partner initiative, powered by Boeing, Teague, Elevate Aircraft Seating, Aerofoam Industries, Müller Textil and Gen Phoenix, fuses the capabilities of product engineering, design, manufacturing and material science to create a fully circular dress cover solution.

The initiative offers a compelling model for how bold collaboration can redefine the future of seating materials and industry standards.

At the heart of the Innovation Engine is a simple but revolutionary concept: designing aircraft seating dress covers that are not just recyclable at end-of-life, but circular in origin and destination.



Supported and backed by Boeing, contributing scalability guidance and end-user integration.

The results

- A recycled leather upholstery, developed by Gen Phoenix, both made of waste and engineered to be recovered and regenerated into new material.
- Developing a reverse logistics solution, enabling recovery of cutting waste and material reprocessing—a big step for commercial aircraft interiors.
- FAA/EASA certification-ready material and stack up, lab testing in accordance with 14 CFR Part 25.853 for flammability standards.
- A modular seat cover construction pioneered by Elevate Aircraft Seating, Aerofoam Industries and Müller Textil, allows for a material stack up that can be recycled in its entirety without complex disassembly or deconstruction.

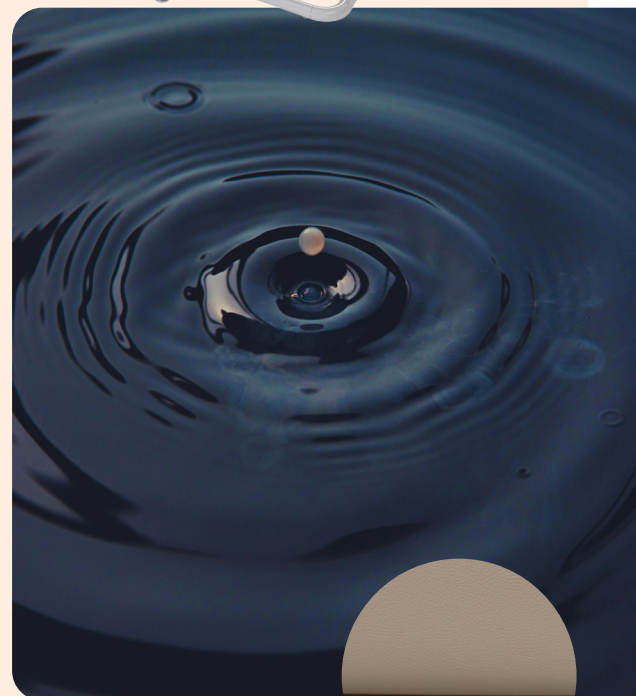


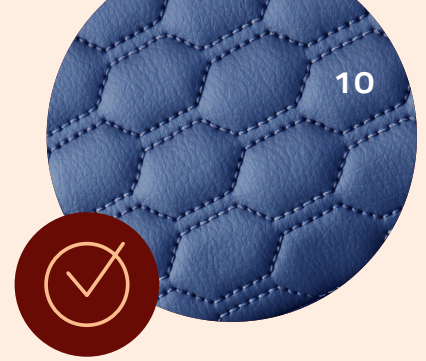
An innovative design language by **TEAGUE**



At Teague, we set out to shape more than a design direction—we aimed to spark a shift in thinking. Rooted in the principles of sustainability and circularity, the circular seating project gave rise to 'Ripple Effect,' a concept inspired by a single droplet sending ever-expanding waves across a body of water. It's a metaphor for how one intentional innovation—like a recyclable seat cover—can radiate outward, influencing systems, partners, and ultimately an entire industry."

Through hand-in-hand collaboration, the team wove together vision, material innovation, and real-world feasibility. **The result: a meaningful step toward a more sustainable aircraft cabin and a future of commercial flight shaped by thoughtful, collective progress.**





Lamination and cut and sew expertise from Aerofoam Industries

At the core of the innovation is Aerofoam's extensive lamination expertise. By precisely controlling lamination temperatures, specialty adhesive application, and process parameters, Aerofoam ensures optimal material bonding without compromising recyclability or long-term durability. This disciplined approach preserves material integrity while enabling separation at end of life—an essential requirement for true circularity.

Comfort engineering plays an equally critical role. Leveraging deep ergonomics and manufacturing expertise, Aerofoam strategically tunes lamination thicknesses across defined seating zones. This targeted application of advanced spacer fabrics creates sculpted visual depth, enhanced breathability, and ergonomic support where it matters most.

The result is comfort that is intentionally engineered, not incidental.

The finished product delivers a refined luxury appearance, a soft and inviting tactile experience, and a system-level approach to sustainability designed specifically for next-generation aviation interiors.

As airlines and OEMs accelerate their sustainability commitments, Aerofoam Industries continues to lead with solutions that balance operational performance, premium passenger experience, and responsible material strategies.

This cross-sector coalition streamlined decision-making, co-developed rapid prototypes, and executed parallel paths of validation in under a year—a timeline virtually unheard of in aviation.

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“This program demonstrates what is possible when design intent, advanced materials, and precision manufacturing align. The future of aircraft seating must deliver performance, passenger experience, and environmental responsibility simultaneously. We believe this concept proves that those goals are not mutually exclusive.”

Aerofoam Industries



Industry Call to Action

Enabling circularity is the first step, but following through at end-of-life is the key to truly closing the loop. The good news is that the seating supply chain is already close to achieving this ambition. However, a few critical challenges remain.



Certification Complexity

Meeting FAA/EASA standards for new materials is rigorous. Close collaboration with Boeing's regulatory teams helped pre-empt and address issues early.



Material Scaling

Gen Phoenix's reclaimed material had to meet both performance and scalability demands. Through intensive iteration and pre-certification testing, a viable solution was achieved.



Mindset Shift

Circularity requires a rethinking of value—away from a linear, single-product cycle toward a circular model. Educating and communicating this value across the supply chain is key to industry-wide buy-in.



Supply Chain Disruption

Introducing non-linear reverse logistics requires airline buy-in and operational redesign. While the market shows strong interest, there is still industry-wide caution in being the first adopter. By working as a coalition, we hope the speed with which this was developed, and having multiple parties supporting these efforts, proves not only the urgency but signals to the wider aviation industry the in-market viability of this innovation to accelerate adoption. Making real impact today takes a village and the entire supply chain must collaborate transparently in order to succeed.



"Achieving true circularity in aviation requires looking across the entire cabin ecosystem, including components that are often overlooked. The **CirculAir Playbook** demonstrates that high-performance, lightweight circular cabin interiors are no longer a future ambition, but an operational reality the industry can deliver today.

It reflects one of the four pillars of the **Aviation Circularity Consortium's 2050 roadmap, *Design for Circularity***, which calls for integrating end-of-life considerations into materials and product design so they can be effectively recovered and reprocessed within aviation supply chains. While the solutions are scalable and ready, as highlighted in the Playbook, doing so requires industry-wide collaboration to address challenges such as certification, material scaling, and reverse logistics."

Karina Cady, CEO and Co-Founder, Nandina REM
Aviation Circularity Consortium Founding Member

The work that has been completed with the CDCIE collaboration has proven that covers can be designed in a way that enables circularity without compromising performance. Gen Phoenix's proprietary manufacturing process ensures that those covers can be recycled at end-of-life.



Without the need for
complex disassembly



Without compromise
to durability or comfort



Without compromise
to cost or complexity

However, **recovery**, **storage** and **reverse logistics** require further thought and industry collaboration. We understand the huge complexity of aviation supply chains and that there won't be a one-size-fits-all solution, but we are ready to work with airlines who are serious about closing the loop.

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