IMASUS

Imageneering Sustainability

Zero Waste Design

IMASUS Training Module

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About

IMASUS (Imagineering Sustainability) is a pioneering initiative dedicated to transforming the fashion industry towards sustainability and addressing climate change challenges and led by the partnership of the Institute of Nanoscience and Materials of Aragon, Lottozero textile laboratories, Munkun creative strategy & learning studio and the European Creative Hubs Network.

Fashion, while influential, is one of the largest contributors to environmental degradation. IMASUS seeks to catalyze a shift in industry practices by promoting sustainable methods, such as using organic materials, recycling, and adopting circular design principles. Our goal is to inspire a widespread change in behaviors and practices, fostering a sustainable, ethical, and creative future for fashion.

The project integrates academic research, industry expertise, and practical learning experiences to equip fashion professionals with the necessary skills and tools for the sustainable fashion sector. Through workshops, digital tools, and collaborative approaches, we are building a community focused on innovation and real-world solutions for the fashion industry.

Part 1 – The Training Module

1. Introduction to Zero Waste Fashion Design

Zero waste fashion design addresses one of the most immediate and measurable forms of inefficiency in the apparel industry: material loss during garment production. By shifting attention to the cutting and patternmaking stages, this approach challenges conventional manufacturing logic and reframes waste as a design problem rather than a production inevitability.

1.1 Learning Objectives

By the end of this module, learners should be able to:

- Define zero waste design as a pattern-making and systems-based approach
- Explain the environmental significance of pre-consumer textile waste
- Identify construction and layout strategies that eliminate or reduce cutting waste
- Analyse the relationship between material efficiency, form, and aesthetics
- Evaluate the practical and industrial limitations of zero waste implementation
- Develop a garment concept using zero waste design principles

1.2 Definition and Scope

Zero waste fashion design refers to a design approach in which garments are conceived, patterned, and constructed with the explicit goal of preventing textile waste during the cutting and sewing stages (Rissanen & McQuillan, 2016). In conventional fashion systems, textile waste occurs predominantly at two points in the product lifecycle: pre-consumer and post-consumer phases. Pre-consumer waste includes offcuts, flawed fabrics, and surplus materials generated during manufacturing before a garment reaches the wearer. Post-consumer waste refers to discarded clothing at the end of its useful life.

Pre-consumer waste is particularly significant. Approximately 25% of resources are lost at the production stage, much of it due to traditional pattern-cutting techniques that leave 15–30% of the fabric unused (Blum, p. 15). These offcuts are typically downcycled, incinerated, or landfilled. Downcycling reduces fiber value because mechanical recycling shortens fiber length: for example, when wool garments are shredded and repurposed as cushion filling. Because these processes downgrade rather than preserve material quality, preventing waste at the design stage is far more sustainable than recycling after the fact.

1.3 Environmental Context and Industry Impact

This challenge is magnified by the environmental impact of the fashion and textile industry, one of the largest waste-producing and resource-intensive sectors globally. Enormous quantities of water, energy, and chemicals are consumed during fiber cultivation and textile production. Cotton, although natural and biodegradable, requires substantial water and pesticide use, and can release methane and chemical residues as it decomposes. Polyester—currently the world's most widely produced fiber—is valued for its durability, but it is derived from fossil fuels, sheds microplastics, and can take centuries to break down. The combination of increasing global fiber production and declining material value intensifies the urgency for textile efficiency at the design stage.

1.4 Zero Waste as Design Intervention

Against this backdrop, zero-waste fashion design represents a critical intervention. It differs from general "waste reduction" because it aims not to minimize waste but to eliminate it entirely. Zero-waste designers incorporate waste-avoidance strategies beginning at the earliest moment of the design process. Waste is not treated as an afterthought to be managed at the end of production; instead, it becomes a foundational design parameter that shapes silhouette, pattern geometry, garment structure, and material selection.

Zero-waste patternmaking often requires arranging pattern pieces like a puzzle within the fabric's width and length, using every centimeter of material. This process demands close attention to fabric dimensions, grain direction, and construction logic. As a result, zero-waste design becomes not only a technical method but also a creative and aesthetic approach—one that treats the garment, pattern, and fabric as an integrated whole. It is simultaneously a mindset, a methodology, and a design philosophy that challenges traditional notions of fashion production and encourages designers to consider material responsibility from the start.

2. Historical & Cultural Roots

Zero-waste design is often presented as a contemporary sustainability strategy, yet its principles predate industrial fashion by centuries. Many historical clothing traditions emerged from material scarcity, labour intensity, and cultural values that prioritised care and preservation.

2.1 Pre-Industrial Material Logic

Before industrialisation, clothing production was labour-intensive and highly skilled. Spinning, weaving, and sewing were done by hand, often within households, and textiles were valuable commodities (Waddell, 2004). As a result, garments were carefully made and rarely discarded. Many traditions developed techniques that avoided waste by necessity. These practices demonstrate that zero-waste design is not new, but rooted in long-standing material awareness.

2.2 Whole-Cloth Garments and Draped Construction

Across many regions, garments were created from whole pieces of fabric requiring little or no cutting. In ancient Greece, the himation, chiton, and peplos consisted of rectangular cloth wrapped or folded around the body. Similarly, the sari in India is a continuous length of fabric shaped entirely through draping. In these traditions, fabric itself defines the silhouette, with minimal alteration.

Images 1-3: kimono, sari, ancient Greek robe. Images retrieved from freepik.

2.3 The Kimono as Structured Zero-Waste System

The Japanese kimono is one of the most frequently cited examples of zero-waste construction. It is composed of straight, uniform panels cut from narrow-width fabric; shaping is achieved through folding and seam placement rather than curved cutting. Because pattern pieces derive directly from the width of the woven bolt, irregular offcuts are avoided and nearly all fabric is used (Rissanen, 2013; Rissanen, 2022). In this system, textile dimensions determine garment dimensions, illustrating how material constraints guide design decisions.

2.4 Repair, Reuse, and Patchwork Traditions

Not all traditions eliminated waste through pattern planning alone. Many cultures extended textile life through repair, patchwork, and reconfiguration. Japan's *boro* textiles—garments repeatedly mended with layered patches and sashiko stitching—reflect both necessity and values of care and resourcefulness. In parts of Africa, textile traditions incorporate patchwork assemblies of repurposed cloth. In the United States, quilting developed as a method of salvaging small fabric remnants and recombining them into larger patterned forms. These examples show how labour investment and cultural meaning encouraged preservation rather than disposal.

2.5 Industrial Disruption and the Normalisation of Waste

Industrialisation transformed textile production. Mechanisation increased speed, lowered costs, and shifted perceptions of textiles from scarce to abundant. As ready-made clothing became accessible, fashion cycles accelerated and garments lost long-term value. Efficiency in volume replaced careful cloth utilisation. Pattern cutting became detached from textile dimensions, and offcuts were accepted as unavoidable by-products of mass production.

2.6 Twentieth-Century Revivals and Design Experimentation

Zero-waste principles resurfaced in the 20th century through experimental design. Ernesto Thayaht's 1920s "Tuta" jumpsuit was cut from a single piece of fabric. Mid-century designers such as Claire McCardell and Bernardo Rudofsky explored simplified construction and reduced cutting. In the 1970s, Zandra Rhodes created garments shaped directly by textile prints. In the 1980s, Yeohlee Teng treated fabric dimensions as primary design constraints—an approach later documented in *Yield: Making Fashion Without Waste* (McQuillan & Rissanen, 2011).

These historical examples show that zero-waste design is both traditional and evolving. A consistent theme emerges: when textiles are valued, design methods maximise material use. Contemporary zero-waste fashion builds on these principles, combining historical knowledge with modern patternmaking, digital tools, and systems thinking to address today's environmental challenges.

3. Redefining The Fashion Hierarchy for Zero-Waste Design

Historically, the fashion system has operated through a vertical hierarchy in which each stage of garment creation—design, patternmaking, grading, cutting, sewing, and production management—is separated into distinct roles. Since the early twentieth century, industrialisation has reinforced this division of labour in pursuit of efficiency (Rissanen, 2022). While this model improved speed and scalability, it also created rigid boundaries between creative and technical stages, producing a linear flow of decision-making from concept to production.

At the top sits the creative director, who defines artistic vision and brand direction but is typically removed from technical execution. The fashion designer translates this vision into garments, selecting materials, silhouettes, and details. The patternmaker converts sketches into two-dimensional structures, determining fit and proportion through specialised knowledge of the body and fabric behaviour. The grader expands patterns across size ranges; the cutter transfers them to fabric; the sewer assembles the garment. After rounds of sampling and refinement, production moves to industrial scale under the supervision of a production manager.

In this conventional structure, each role depends on prior decisions, with limited feedback across stages. Because garments are rarely designed with the cutting layout (marker) in mind, fabric waste is largely determined by early design choices—the number and shape of pattern pieces, size range requirements, and marker efficiency (Rissanen, 2022). This separation of design and cutting logic directly contributes to material waste.

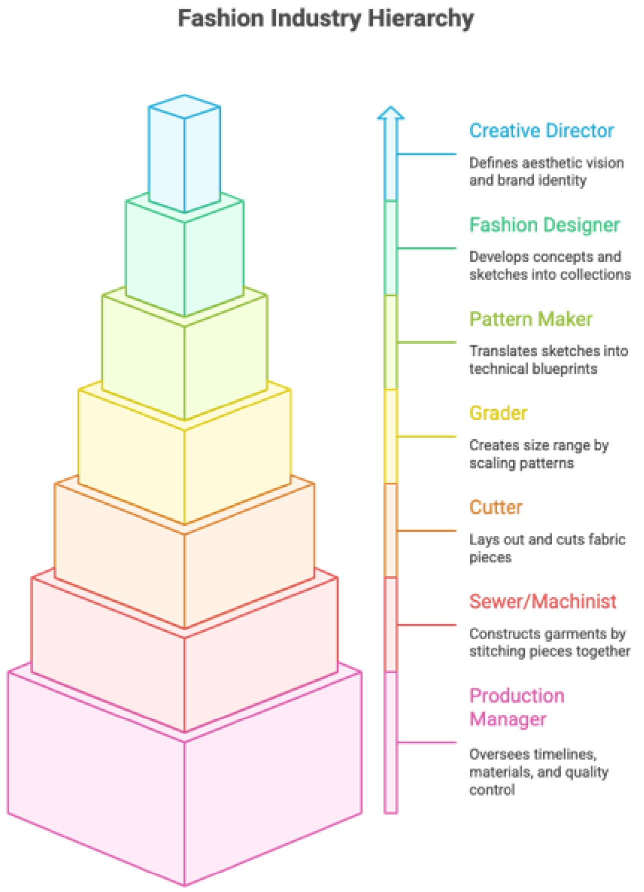

Figure 1: Illustration representing the division of roles in the fashion hierarchy. Illustration created by the author using Napkin.

3.1 Shifting from Hierarchy to Systems Thinking

Zero-waste fashion design challenges this linear model. Rather than treating design and production as separate steps, it frames them as interconnected processes in which designers, pattern cutters, graders, and manufacturers hold equal importance. This requires moving away from sequential decision-making toward a systems-based approach where silhouette, textile choice, pattern geometry, and production feasibility are considered simultaneously.

As Rissanen and McQuillan argue, the designer's role expands beyond stylist or sketch author to systems thinker—someone who understands how material use, manufacturing processes, commerce, wearer behaviour, and end-of-life outcomes intersect (McQuillan & Rissanen, 2011; Rissanen, 2022). In zero-waste practice, thinking, designing, and making cannot be separated.

Adopting this mindset is a key point of intervention. A systems-oriented approach reframes fashion's role in society by encouraging responsible relationships between designers, producers, and users.

Figure 2: Representation of a zero-waste fashion system. Illustration created by the author using Napkin.

3.2 Critical Making as a Design Approach

Fashion education often prioritises sketching as the starting point of design. Zero-waste design, however, aligns more closely with critical making—a practice that connects conceptual exploration with hands-on experimentation (Ratto, 2011; McQuillan, Rissanen & Roberts, 2013). Critical making values iterative prototyping and reflection, recognising that knowledge emerges through the act of making rather than from a predetermined final image.

This approach reframes garment development as a dialogue between designer, textile, and form. Unexpected results—misalignments, structural tensions, unconventional shapes—can become creative opportunities. As Roberts notes in subtraction cutting, “carefulness and precision are no guarantee of successful outcomes”; it is often when a garment “goes wrong” that new possibilities emerge (Roberts, 2021).

By emphasising process rather than fixed aesthetics, zero-waste design reveals elements usually hidden in fashion production: textile structure, pattern logic, and the designer’s intervention. Nothing is removed; instead, as McQuillan and Rissanen suggest, it is “an absence of absence” (2011).

3.3 Zero-Waste Fashion Design Practices

Zero-waste practices are grounded in the principle that fabric and form are inseparable. The primary constraint in zero-waste patternmaking is the requirement to use 100% of the fabric width, whether within a single garment or across multiple pieces (McQuillan, 2020). This shifts pattern cutting from a technical afterthought to a central component of concept development (Sinha, in ElShishtawy et al., 2022).

Because adjustments to one pattern piece affect all others, zero-waste patternmaking requires integrated knowledge of draping, construction, and textile behaviour. Outcomes are not fully predictable, and iterative experimentation becomes essential.

This exploratory process often produces forms that differ from conventional sketch-led designs. Pattern cutting becomes generative: the cut initiates design rather than merely executing it.

3.4 The Zero Waste Fashion Design Process

Zero-waste design is supported by a systems-based framework that considers interrelated constraints: brand identity, sustainability goals, resource use, production capacity, labour skills, grading requirements, and yield efficiency (McQuillan, 2019). These factors shape which zero-waste strategies are appropriate in a given context.

Five essential criteria must be balanced for a zero-waste garment to succeed (Rissanen, 2022):

- Appearance: The garment must remain visually compelling; aesthetics cannot be sacrificed for waste reduction alone.
- Fit: Comfort, movement, and body–garment relationships must function properly.
- Cost: Strategies must support realistic pricing and avoid unnecessary increases.
- Sustainability: Fibre selection, durability, and potential future transformations must align with environmental goals.
- Manufacturability: The garment must be feasible to produce; zero-waste design has limited value if it cannot be constructed effectively.

Together, these criteria ensure that zero-waste design is not a purely technical exercise but an integrated strategy balancing form, function, and material responsibility.

4. Zero Waste Fashion Design Methods

Zero-waste fashion design can be developed through several garment construction systems. Rissanen (2022) categorises fashion creation into three broad areas: garments constructed from fabric (cut-and-sew systems, including zero-waste patternmaking); garments constructed from yarn (fully fashioned and seamless knitting); and garments constructed directly from fibre (such as felted or moulded forms). These systems are not mutually exclusive, and hybrid approaches are increasingly common. In this module, zero waste refers specifically to cut-and-sew garments made from fabric, where the main objective is eliminating waste during the cutting stage.

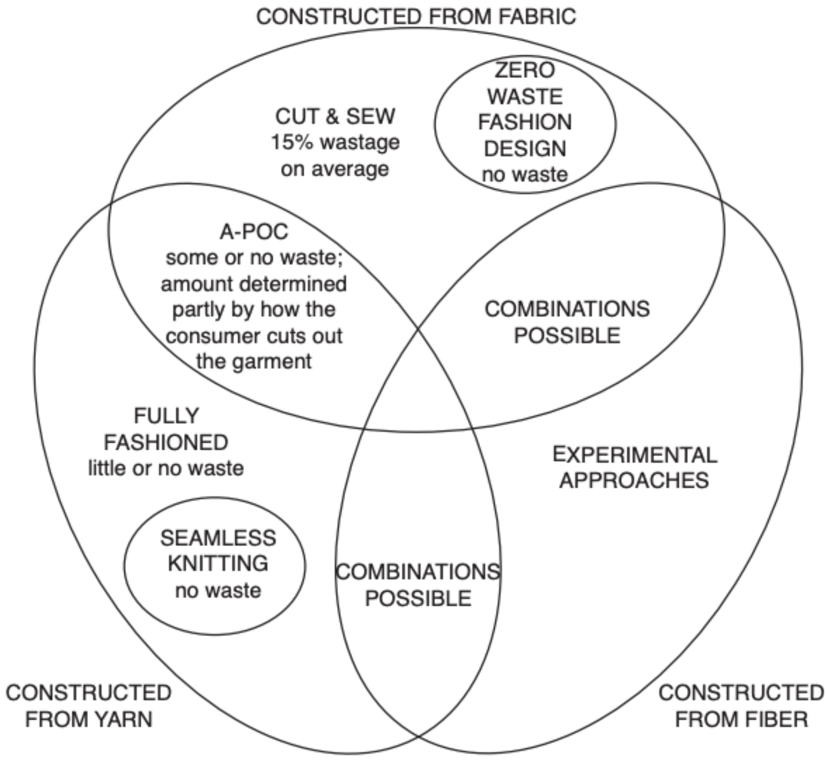

Figure 3. Illustration by Timo Rissanen depicting fashion creation methods from a fabric waste perspective. Three broad fashion creation approaches exist, but combinations of these are also possible (Rissanen, 2022).

4.1 Design Approaches in Zero-Waste Fashion (Rissanen's Nine Approaches)

Rissanen (2013) identifies nine common design sequences that show how garments can begin from different entry points—sketching, draping, textile print layout, conceptual ideas, existing garments, or photographs. These sequences demonstrate that zero-waste design is not tied to a single linear process. Designers may move between 2D and 3D stages multiple times, refining ideas in response to material constraints.

1. Sketch → Pattern → Toile → (Design alteration) → Pattern alteration → Sample garment
2. Pattern → Toile → (Design alteration) → Pattern alteration → Sample garment
3. Sketch → Draping → Pattern → Toile → (Design alteration) → Pattern alteration → Sample garment
4. Draping → Pattern → Toile → (Design alteration) → Pattern alteration → Sample garment
5. Conceptual idea → Pattern → Toile → (Design alteration) → Pattern alteration → Sample garment
6. Textile print on paper → Draping paper on body → (Sketch) → Pattern → Toile → (Design alteration) → Pattern alteration → Sample garment
7. Existing garment → Sketch → Pattern → Toile → (Design alteration) → Pattern alteration → Sample garment
8. Existing garment → Pattern → Toile → (Design alteration) → Pattern alteration → Sample garment
9. Photograph of garment → Pattern → Toile → (Design alteration) → Pattern alteration → Sample garment

The importance of these sequences lies in recognising patternmaking as a flexible design tool rather than a purely technical step. Zero-waste practice often moves back and forth between flat pattern and three-dimensional form. Fabric width, geometry, and layout logic are considered early in development. The process is iterative, with multiple possible pathways leading to a final garment.

4.2 Constructed from Fabric: Patternmaking Methods

Zero-waste patternmaking integrates pattern development into the earliest stages of design. Instead of sketching first and drafting later, designers work simultaneously with silhouette, fabric width, and geometry (McQuillan, Rissanen & Roberts, 2013). Fabric width becomes a defining constraint that shapes the garment (Rissanen, 2022). Pattern pieces are arranged to eliminate negative space on the marker, often using geometric forms—rectangles, squares, and straight lines aligned with the woven structure.

Because each pattern piece affects the others, adjustments often require changes across the entire layout. This demands spatial awareness and flexibility. Designers may adapt conventional blocks—bodices, sleeves, skirts, trousers—but ensure each piece includes seam allowance and fits within a waste-free configuration. As Almond (2010) notes, this approach requires both technical precision and conceptual openness. Patternmaking becomes a generative stage of design rather than a secondary one.

4.3 Zero Waste Pattern Making Techniques

4.3.1 Subtractive and Additive Cutting

Subtractive cutting, developed by Julian Roberts, focuses on creating internal voids through which the body moves rather than defining the outer silhouette. Large panels are cut with openings that fold and drape around the body (McQuillan, Rissanen & Roberts, 2013). Because much of the cloth remains intact and removed shapes are reused, waste is minimal.

The technique accepts unpredictability. Designers guide the process by adjusting openings and seam relationships rather than fully controlling the final form. Roberts's "plug" method—where any shape can fill any opening if seam lengths match—demonstrates the system's flexibility. Although often sculptural, subtractive cutting shows how zero-waste design can produce complex forms without conventional cut-and-sew logic.

Image 4: *The Pluto Dress*, by Julian Roberts created in collaboration with Mari Bendeliani, exhibited and later dissected live to reveal a painting concealed inside. The performance took place during the practitioner talk at the *Speed of Thought* exhibition, Newington Gallery, The Art Academy London, UK, November 2019. (Julian Roberts's Portfolio)

4.3.2 Minimum-Cut, Minimum-Seam, Origami, and Geometric Cutting Methods

Minimum-cut methods aim to reduce the number of cuts and seams, relying instead on folding, layering, and geometric shaping. Designers often use large rectangular panels, forming garments through tucks, pleats, slashes, and drawstring channels (Rissanen, 2022). This preserves more fabric and leverages natural drape and grain direction.

Structured silhouettes can still be achieved. Designers such as David Telfer demonstrate how selective seam placement and geometric logic produce refined forms (McQuillan & Rissanen, 2011). Interlocking gores, gussets, and folded edges can replace curved seams and darts. These systems show how constraint can drive innovation while reducing offcuts.

Image 5: Minimum seam duffle coat, work shirt and trousers, along with the zero waste pattern designed to create them, created by David Telfar in 2010 and shown in the Yield exhibition (McQuillan& Rissanen, 2011).

4.3.3 Transformational Reconstruction

Transformational Reconstruction (TR), developed by Shingo Sato, merges patternmaking and three-dimensional design. Starting with a basic block on a dress form, designers draw new style lines directly onto the toile (El-Dosuky, 2023). These lines are cut, flattened, and reassembled to integrate shaping into seam lines (ElShishtawy, Sinha & Bennell, 2022).

While not inherently zero-waste, TR aligns with its principles because it reshapes rather than removes material. Pattern pieces can be engineered to interlock efficiently. TR allows sculptural and expressive forms while maintaining structural control, making it a useful complement to zero-waste layout strategies.

Sato developed several TR techniques:

- Dart TR: Relocates darts by redrawing shaping lines and integrating them into new seams.
- Vortex TR: Creates swirling volumes by radiating lines around a cone-like structure.

- **Balloon TR:** Produces rounded forms by duplicating and spreading curved pieces.
- **Architectural TR:** Incorporates geometric modules into the garment structure.
- **Accordion TR:** Duplicates and spreads elements to create layered, fan-like effects.

These techniques allow varied silhouettes to emerge from a single block through manipulation rather than removal.

Image 6: Transformation reconstruction pattern development retrieved from https://www.muellerundsohn.com/app/uploads/2018/08/Shingo-Sato-Wellenjacke-naehen_MuellerundSohn_Step1.jpg

Image 7: Transformation reconstruction techniques used to make a bodice and a sleeve, retrieved from https://asiastage.mx/el-transformational-reconstruction-de-shingo-sato/

4.3.4 Jigsaw Method

The jigsaw method uses interlocking pattern shapes that fill the entire fabric area without gaps (Binde & Freimane, 2022). Unlike tessellation, it does not rely on repeating identical units; varied shapes are allowed, offering greater flexibility.

This method requires strong spatial reasoning. A curve in one piece must correspond to its neighbouring piece, and changes to one shape affect the entire layout (Sinha, in ElShishtawy et al., 2022). Jigsaw logic can be built from scratch or integrated into conventional patterns, making it adaptable to both experimental and commercial contexts.

4.3.5 Tessellation

Tessellation, developed by Holly McQuillan, uses a single repeating shape that tiles the fabric without gaps (McQuillan, 2019). Multiple layers are cut from this repeating unit, creating modular components that can be assembled in various configurations.

The modular structure allows transformability and part replacement (Pingki, Hasnine & Rahman, 2019). However, the shape must tile precisely to the selvage; otherwise, waste occurs (Sinha, in ElShishtawy et al., 2022). Tessellation is powerful conceptually but may be more suited to experimental or limited-production contexts.

Image 8: Zero-waste tessellation top by Holly McQuillan. White shapes indicate garment body components; blue shapes indicate decorative edging (McQuillan, n.d.).

4.3.6 Creative Cut

Creative Cut transforms typographic forms—letters or words—into pattern pieces. Designers cut apart a word and reassemble its fragments into garment shapes. Because all pieces are incorporated, layouts can achieve zero waste.

This method encourages experimentation and direct testing on the body or dress form (Roberts Portfolio, 2019). It challenges conventional assumptions about shape and reinforces the principle that every cut piece has value.

Image 9: Typographic cutting demonstration by Julian Roberts for the Body Language masterclass, showing how the word “LOVE” is transformed into a set of pattern shapes explored on the designer’s body (Roberts Portfolio, 2019).

4.4 Integration with Technology

Digital tools support zero-waste design by allowing layouts to be tested before physical cutting. Software such as CLO3D, Browzwear, and Optitex visualises the relationship between 2D patterns and 3D form (McQuillan, 2020). This reduces physical sampling, which can waste significant fabric during development (Waddell, 2004).

Digital fabric simulation helps designers anticipate drape and behaviour in complex layouts. While not yet perfect, emerging AI-assisted modelling improves prediction accuracy. These tools strengthen the connection between pattern logic, material performance, and garment construction.

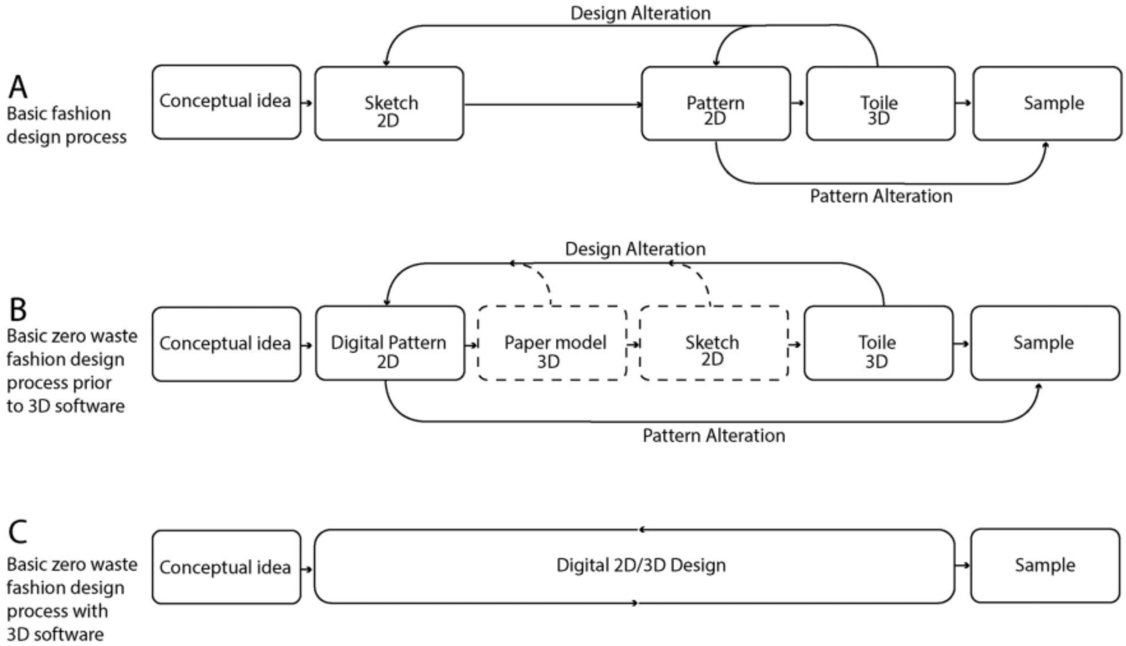

Figure 4. Diagrams created by Holly McQuillian (2020) showing (A) the basic fashion design, (B) a basic zero-waste design process without 3D tools and (C) a basic zero-waste design process using 3D tools.

4.5 Manufacturing Methods

Integrating zero-waste design into mass production requires coordination between design and manufacturing. In conventional systems, marker makers optimise layouts for cost (Rissanen, 2022). In zero-waste practice, optimisation must begin at the design stage.

Grading presents challenges, as interlocking shapes may not scale evenly across sizes. This demands close collaboration between designers, patternmakers, and production teams.

Digital marker-making, laser cutting, and algorithmic layout tools support efficient configurations. Research indicates that integrated digital systems can achieve fabric utilisation above 98% (Ramkalaon & Sayem, 2020). As optimisation technologies advance, zero-waste layouts are becoming increasingly compatible with industrial production. At the same time, their geometric and modular aesthetics are now recognised as intentional design languages rather than constraints.

Image 10: Marker layout example (Bennell & Oliveira, 2008)

5. Challenges & Critiques

Zero-waste fashion design faces several barriers to wider industry adoption. One of the main challenges is unpredictability. Because zero-waste patternmaking requires constant adjustments across interconnected pieces, the final three-dimensional form can be difficult to anticipate. When translating a 2D layout into a wearable garment, designers may encounter inconsistencies in fit, proportion, or silhouette (ElShishtawy, Sinha & Bennell, 2022). While this openness can lead to innovation, it complicates replication and standardisation.

The shift from design to production also presents difficulties. Zero-waste methods depend on flexibility and collaboration, yet most fashion systems operate through linear workflows where design, grading, marker making, and production are separated. These rigid structures limit integration (Rissanen, 2022). In mass production, interlocking or tessellated layouts may not scale evenly across sizes, and complex pattern configurations can slow production, increasing costs and conflicting with priorities such as speed and volume.

Economic constraints further restrict adoption. Zero-waste design often involves experimentation and iteration, making outcomes less predictable and harder to standardise at scale (McQuillan, Rissanen & Roberts, 2013). This uncertainty contrasts with the efficiency-driven models that dominate much of the industry. Consumer expectations may also pose challenges, as unconventional seam placement or sculptural silhouettes may not align with mainstream preferences.

Finally, zero-waste patternmaking addresses material waste at the cutting stage but does not resolve broader structural issues such as overproduction, fibre impacts, consumption habits, or end-of-life disposal. There is also a risk of superficial application, where limited zero-waste elements are presented as comprehensive sustainability solutions. Without systemic change, such claims can contribute to greenwashing rather than meaningful transformation.

6. Future Directions in Zero Waste Fashion

Despite these challenges, several developments point toward promising future directions. Advances in digital patternmaking and 3D prototyping allow designers to simulate drape, structure, and fit with greater accuracy, reducing reliance on physical sampling (McQuillan, 2020). The integration of artificial intelligence into simulation and marker-making systems may further improve precision and material efficiency.

Regulatory frameworks are also evolving. Policies such as extended producer responsibility (EPR) and EU circular textile regulations encourage waste reduction and material preservation, creating structural incentives for zero-waste strategies. At the same time, material innovation supports new possibilities, including mono-material textiles, bio-based fibres, regenerative materials, and fabrics engineered to align with efficient pattern layouts.

Education plays a central role in long-term adoption. Zero-waste design requires integrated knowledge of patternmaking, material behaviour, manufacturing systems, and digital tools. Moving beyond strictly linear, sketch-first design processes toward exploratory and iterative methods can help embed zero-waste thinking more deeply in design practice.

Collaborative and open-source cultures further support diffusion. Practitioners such as McQuillan and Roberts have shared patterns, digital files, and process documentation, challenging the tradition of secrecy in fashion production. This openness encourages collective experimentation and knowledge exchange. As designers increasingly adopt non-linear creative approaches, zero-waste design may shift from a niche technique to a foundational component of a more responsible fashion system.

Key Insights

- Zero-waste fashion design eliminates pre-consumer textile waste by integrating patternmaking into the earliest stages of design.
- Historical garment traditions demonstrate that material efficiency is deeply rooted in global clothing cultures.
- Zero-waste practice challenges the traditional fashion hierarchy by promoting systems thinking and collaboration between design and production stages.
- Patternmaking becomes a generative design tool rather than a technical afterthought.
- Techniques such as subtractive cutting, tessellation, jigsaw layouts, and transformational reconstruction offer multiple pathways to achieve zero waste.
- Digital tools and AI-assisted marker-making systems are expanding the feasibility of zero-waste production at scale.
- Zero-waste design reduces material waste but must be integrated within broader circular strategies to address overproduction and consumption patterns.

Summary

Zero-waste fashion design should not be understood as a constraint, but as a catalyst for innovation. By requiring designers to work within the limits of fabric dimensions and material efficiency, it reframes constraint as a creative driver. Silhouette, pattern geometry, and textile behaviour become interconnected elements of a unified system rather than isolated stages of development.

At its core, zero-waste design is both technical and conceptual. Technically, it eliminates waste at the cutting stage through integrated patternmaking and spatial reasoning. Conceptually, it challenges hierarchical and linear fashion workflows, encouraging systems thinking, collaboration, and iterative experimentation.

Zero-waste practice also reconnects contemporary design to historical garment traditions in which cloth was valued and fully utilised. By combining these principles with digital tools, material innovation, and evolving regulatory frameworks, zero-waste design becomes increasingly viable within modern production systems.

However, zero waste alone does not resolve the structural challenges of the fashion industry. Its greatest potential emerges when integrated with durability, recyclability, responsible material selection, and shifts in consumption culture.

Ultimately, zero-waste fashion invites designers to engage deeply with fabric, rethink established processes, and contribute to a more resource-aware and regenerative fashion system. Rather than limiting creativity, it expands it—demonstrating that material responsibility can generate new aesthetic, technical, and cultural possibilities.

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Part 2 – Case Study

Holly McQuillan: Designing the Future of Zero Waste Fashion

1. Introduction and Context

Holly McQuillan is a fashion designer, researcher and educator from New Zealand. A lecturer in the Fashion Design programme at Massey University's Faculty of Creative Arts in Wellington, McQuillan combines design creativity with academic research and technological innovation in her practice.

Throughout her academic career, she has contributed significantly to the development of critical thinking on sustainable fashion. Together with Timo Rissanen, she co-authored Zero Waste Fashion Design (Bloomsbury, 2016), now considered a reference text in the field.

McQuillan's vision goes beyond simply reducing waste. For her, fashion must be an open and inclusive system, capable of connecting technology with creativity, craftsmanship with materials science, and sustainability with aesthetics. Her work offers a concrete alternative to the linear 'produce-consume-throw away' model, moving instead towards circular design, where every element of the process has value and can be regenerated.

Image 1: Zero waste garment developed by Holly McQuillan retrieved from https://hollymcquillan.com/portfolio/wolf-sheep-2009/

1.1 Defining zero waste in McQuillan's work

The concept of zero waste is not just a strategy to reduce environmental impact, but a genuine design methodology. Zero-waste design means eliminating waste from the conception stage, imagining garments in which every part of the fabric is used intentionally. For McQuillan, this condition is not a limitation, but a creative constraint: fertile ground for experimentation.

Zero waste design not only serves to avoid waste, but also becomes the generator of form itself, a device capable of transforming material limitations into aesthetic opportunities. McQuillan consciously accepts risk as an essential part of his method: he lets constraints, the width and length of the fabric, the structure of a typeface or even the silhouette of an animal guide the creation of the pattern and the final form. This experimental attitude makes his approach an example of how sustainability can become a driver of innovation, demonstrating that 'zero waste' does not mean sacrifice, but possibility.

2. Methods, Innovations, and Practice-Based Research

2.1 Zero-waste modelling techniques

Among Holly McQuillan's most emblematic projects, 'Make/Use', developed between 2015 and 2016, represents a real revolution in the way we conceive clothing and the role of the user. Created in collaboration with other designers and academic institutions, the project is based on the idea that consumers can become an active part of the creation process.

The 'Make/Use' system provides open source patterns that anyone can download, print and create: an approach that embodies the principle of 'design for participation', where the creative process does not end with production but continues at the moment of use.

The garments are designed to completely eliminate fabric waste, but also to be modifiable and adaptable: people can change the shape, length or details according to their needs.

From a technical point of view, each model is constructed as a modular system: a single piece of fabric is folded, cut and sewn strategically to achieve complex three-dimensional shapes. In this way, McQuillan extends the narrative and durability of the garment, transforming the act of dressing into a collaborative gesture.

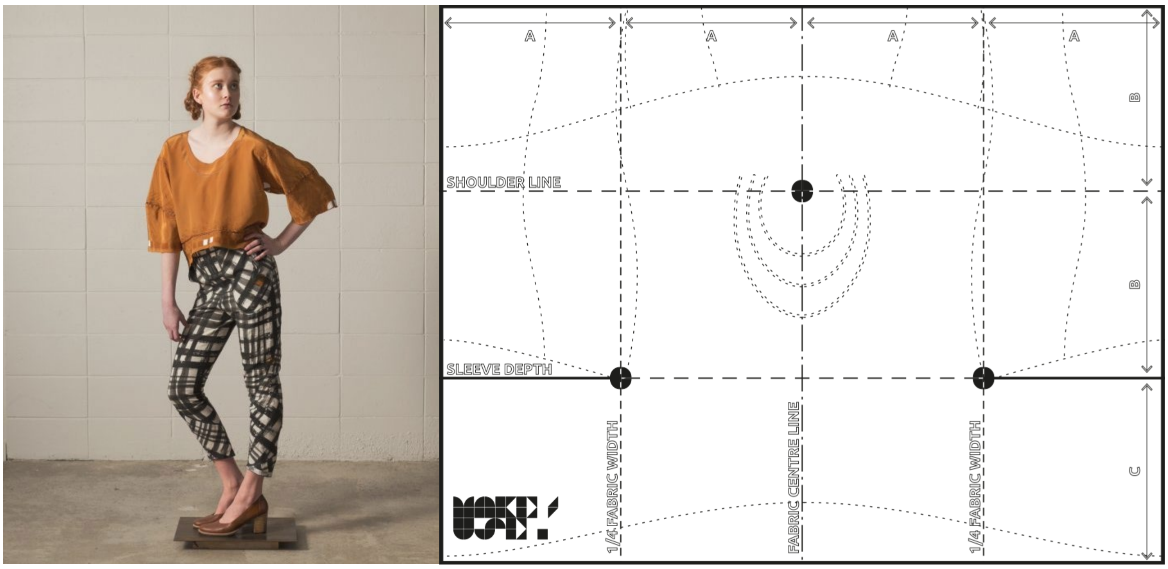

Image 2: Zero waste garment and pattern by Holly McQuillan retrieved from https://makeuse.nz/make/crop-t-shirt/

2.2 Flat to Form

The Make/Use project introduces a radically different approach to traditional clothing manufacturing processes. This method involves a change of perspective in the way the designer interprets the transition from flat pattern to body volume. Although it may seem complex, this paradigm shift is based on very simple principles.

One of the fundamentals of the system is the generation of volume through the connection of two edges of the fabric, which form a 'tube', a space through which the body can move. All the garments in the Make/Use project are derived from this logic: some, such as the skirt or tube dress, are based on a single tube, while others, such as T-shirts, coats or trousers, are created through the interaction of two or more tubes.

To fully understand these principles, it can be helpful to experiment with paper models, a practice reminiscent of the art of origami. This approach mirrors the working methods of Holly McQuillan, who uses paper models to quickly explore and develop new zero-waste design solutions.

2.3 Integration of digital and textile innovation

McQuillan integrates advanced use of digital prototyping tools, such as CLO3D, laser cutting and parametric design, into her zero-waste fashion design approach to simulate and optimise garments before physical production, minimising fabric waste and sampling stages. Her research experiments with the use of one-piece fabrics and shaped fabrics, designed to completely eliminate cutting waste through a design that is based on the logic of full surface utilisation. McQuillan also collaborates with textile technologists to develop materials designed in synergy with the construction of the garment: fabrics whose woven structures and geometric compositions follow the lines of the model, merging textile design and garment design into a single integrated and sustainable process.

2.4 Aesthetic and conceptual results

McQuillan's work openly challenges the assumption that zero-waste design results in garments with rigid or inelegant silhouettes. Through in-depth research into pattern construction methods and the integral use of fabric, McQuillan demonstrates that sustainability can become a true aesthetic language. Her garments, often modular, sculptural and visually complex, not only eliminate material waste but reinterpret the very concept of form and volume in fashion.

3. Impact, Challenges, and Lessons for Designers

3.1 Impact on education and industry

The Make/Use initiative bridges the gap between academic research and public engagement, transforming fashion design into a participatory and shared process. This approach has influenced fashion curricula globally, inspiring courses in sustainable patternmaking and digital fashion. The dissemination of open source resources, including patterns, guides, and CLO3D simulations, allows designers, students, and enthusiasts to explore the possibilities of zero waste fashion design in a practical way, promoting a collaborative and responsible design culture.

3.2 Critical reflection and synthesis of best practices

McQuillan demonstrates that zero-waste design can be both aesthetic and sustainable, combining formal experimentation with environmental responsibility.

Her best practices are based on:

- model-based innovation, where the construction of the garment and its shape are based on a geometric logic that eliminates waste;
- digital integration that allows complex processes to be simulated, optimised and shared;
- awareness of materials, which guides every design choice towards a more intelligent and regenerative use of resources;
- open source collaboration, which opens up design to a collective dimension, transforming knowledge into a shared asset.

However, challenges remain, such as the difficulty of adopting these methods on a large industrial scale and the need for a more profound cultural change among consumers, who are still accustomed to the speed and convenience of fast fashion.

References

McQuillan, H. (n.d.). *About*. Holly McQuillan. https://hollymcquillan.com/about/

Make/Use. (n.d.). *Make/Use*. https://makeuse.nz/

Part 3 – The Toolkit:

Applying Zero Waste Design in Fashion

Introduction to the Toolkit: translating theory into practice

Purpose

This toolkit translates the theoretical concepts of zero waste design into a structured process that guides designers through every stage of garment creation, from concept to pattern development, with the aim of completely eliminating fabric waste.

Learning Outcomes

By the end of this toolkit, designers will be able to:

1. Integrate zero-waste thinking into the creative process.
2. Apply pattern-making and layout strategies that use 100% of the fabric.
3. Assess the suitability of materials and the feasibility of production.
4. Prototype garments using zero-waste manual or digital techniques.

Brief summary of key concepts

- Zero Waste Design: pattern making that eliminates cutting waste.
- Systemic thinking: linking design, production and user involvement.
- Design for disassembly: allows garments to be taken apart for reuse or recycling.
- Digital prototyping: using simulation tools to visualise layouts before cutting.

Phase 1: Understanding Zero Waste in the Design Process

Analyse your current design system

- How much waste do my current designs generate?
- What pattern shapes or cutting decisions create waste?
- Can my design be achieved through tessellation or geometric planning?

Objective: to assess the basic efficiency of the designer's fabric and identify where waste occurs.

Tip: Keep a 'waste diary' by weighing or photographing the waste from previous projects.

Area	Key questions	Current practice	Opportunities for waste reduction
Pattern design	Are shapes optimised to utilise the full width of the fabric?		
Fabric selection	Does the fabric width match the design layout?		
Cutting method	Is waste reused or recycled?		
Assembly	Could the placement of seams reduce waste?		

Phase 2: Patternmaking Strategies for Zero Waste

Key approaches:

1. Tessellation and geometric planning, using repeated geometric shapes (rectangles, circles, triangles).
2. Subtractive or additive cutting, shape patterns by folding, pleating or adding rather than cutting.
3. Puzzle patternmaking, assemble components like pieces of a puzzle.
4. Interwoven/seamless structure, integrate the shape of the garment during textile production.

Objective: translate design intentions into waste-free patterns.

Tip: experiment with paper patterns before cutting the fabric to visualise fit and efficiency.

Strategy	Description	Advantages	Design challenges	Examples
Geometric shape modelling	Exclusive use of squares, rectangles, triangles	Elimination of waste, modular logic	Limited fit and silhouette	Kimonos, panel skirts
Fabric used in its entirety	The pattern occupies the entire width and length of the available fabric	Zero waste, time saving	Requires compromises on proportions	Sheath dresses, ponchos
Puzzle pattern making (interlocking)	The pieces fit together like tiles without leaving gaps	Maximum fabric efficiency	Requires complex planning	Tops and trousers made from the same rectangle
Zero waste draping	Direct modelling on the mannequin without cutting	Creative and experimental approach	Difficult to standardise	Asymmetrical dresses, unique garments
Incorporation of scraps into the design	Any leftovers become decorative elements	Zero real waste	Requires creativity in finishing	Pockets, patches, appliqués

Checklist: "Is my design zero waste?"

☐ All pattern pieces fit onto a single rectangular block of fabric
☐ Minimal finishing is required
☐ Seams positioned on the edges of the existing fabric
☐ Full width of fabric utilised
☐ Pattern repetition calculated for scalable production

Phase 3: Material and Digital Considerations

Material selection

- Choose consistent, medium-weight fabrics (cotton, linen, Tencel™) with stable grain and low fraying.
- For a flexible fit, consider fabrics that match the geometric layout or knits.
- Avoid patterns that disrupt the alignment of the layout.

Criterion	Why it matters	Examples
Fabric width	Determines layout efficiency	Woven cotton 140–160 cm
Fibre direction	Ensures shape stability	Straight or cross-fibre arrangement
Surface design	Affects visual continuity	Stripes aligned at pattern junctions

Digital tools and simulation
Use software (CLO3D, Optitex, Browzwear) to simulate pattern placement, fabric usage and draping.

Objective: to validate waste-free layouts before sampling.

Tip: Record layout efficiency (%), aim for 95-100%.

Phase 4: Construction and Assembly Methods

Construction strategies:

- Align seams with fabric edges to avoid finishing.
- Use pleat-based shaping (pleats, darts formed by pleats).
- Apply edge finishing methods that do not require finishing.
- Consider reversible or convertible garments for greater versatility.

Objective: to ensure that the design remains functional and aesthetic within a zero-waste framework.

Tip: document seam adjustments, as they often reveal hidden sources of waste.

Phase	Description	Tools	Objective
1. Fabric analysis	Identify dimensions, weight, drape, fabric width	Tailor's tape measure, fabric card	Use the entire piece without cutting
2. Layout planning	Draw the pieces directly onto the rectangle of fabric	Pattern paper, pencil, 2D CAD software	Eliminate waste during pattern making
3. Creating a modular pattern	Geometric shapes (squares, rectangles, semicircles)	Set square, ruler, software	Shapes that fit together without producing waste
4. Strategic cutting	Cutting along the edges of the layout	Scissors, rotary cutter	No unnecessary scraps
5. Waste-free assembly	Sewing the pieces in logical sequence	Needle, sewing machine, pins	Avoid fabric waste when sewing
6. Alternative finishing techniques	Raw edges, folds, minimal turning	Press, fabric adhesive tape	Remove elements that generate waste (linings, excessive margins)
7. Use of any micro-waste	Creation of accessories (belts, patches, labels)	Needle, thread, textile glue	Reuse 100% of the material
8. Documentation of the process	Record stages, errors, solutions	Camera, worksheets	Transmission of the method
9. Prototype evaluation	Analysis of fit, aesthetics, sustainability	Evaluation sheets, model	Confirm waste reduction
10. Iteration and improvement	Revise layout or model	3D software, paper	Further optimise fabric use

Criteria	Success indicators	Score (1-5)
Fit and comfort	The garment fits the intended shape	
Structural integrity	Appears stable, no distortion	
Waste elimination	The layout achieves 100% utilisation	
Aesthetic quality	Balanced form and proportions	

Phase 5: Evaluation and Iteration

Methods:

- Compare fabric consumption between iterations.
- Gather feedback from colleagues on silhouette and comfort.
- Track time and material savings during production.

Objective: Continuously refine efficiency and usability through feedback.

Tip: Treat each prototype as data, photograph layouts, and note improvements.

Evaluation checklist:

☐ Layout achieves 0-3% waste
☐ Scalable model repetition for small batch production
☐ Aesthetics consistent with the concept
☐ Construction achievable with standard tools
☐ Garment maintains comfort and movement

Phase 6: Practical Activity - 'Zero Waste Pattern Lab'

Objective: to apply zero-waste design methods through experimentation.

Time: 2–3 hours

Materials: paper, fabric scraps, rulers, markers, scissors, optional digital tools.

Step-by-step activity

1. Choose a simple garment (shirt, skirt or tunic).
2. Draw pattern pieces within a defined rectangle (e.g., 1 m × 1.5 m).
3. Assemble the pattern to assess its fit and proportions.
4. Redesign the pattern to eliminate waste.
5. Compare both versions (visual + waste %).

Food for thought:

- How did geometric constraints influence your creativity?
- What compromises were necessary between form and function?
- How could this method be integrated into industrial processes?

Guided reflection:

- How has zero-waste design changed your approach to modelling?
- What role did materials and technology play in achieving full utilisation?
- How could zero-waste principles be combined with those of modularity or longevity?

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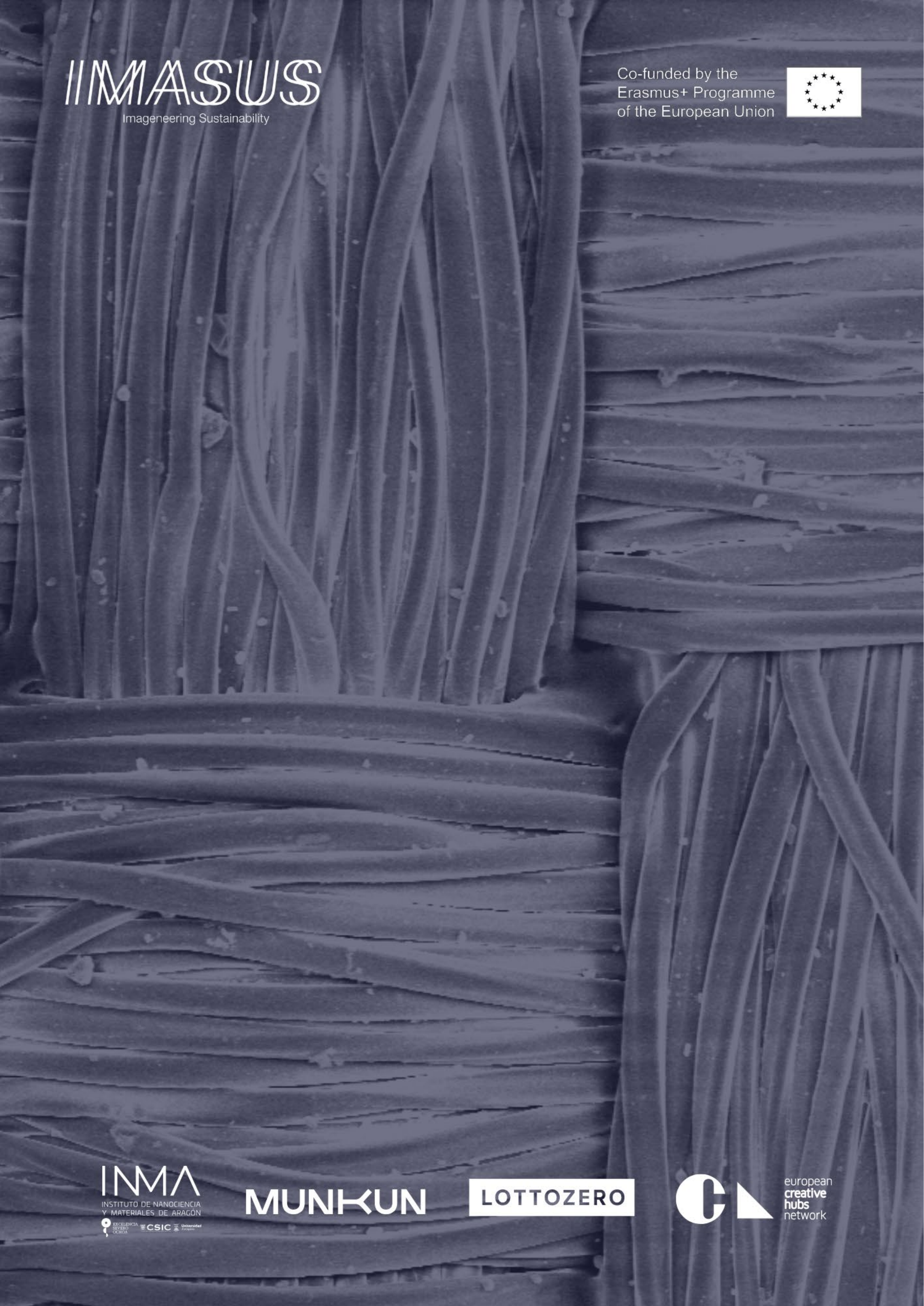

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