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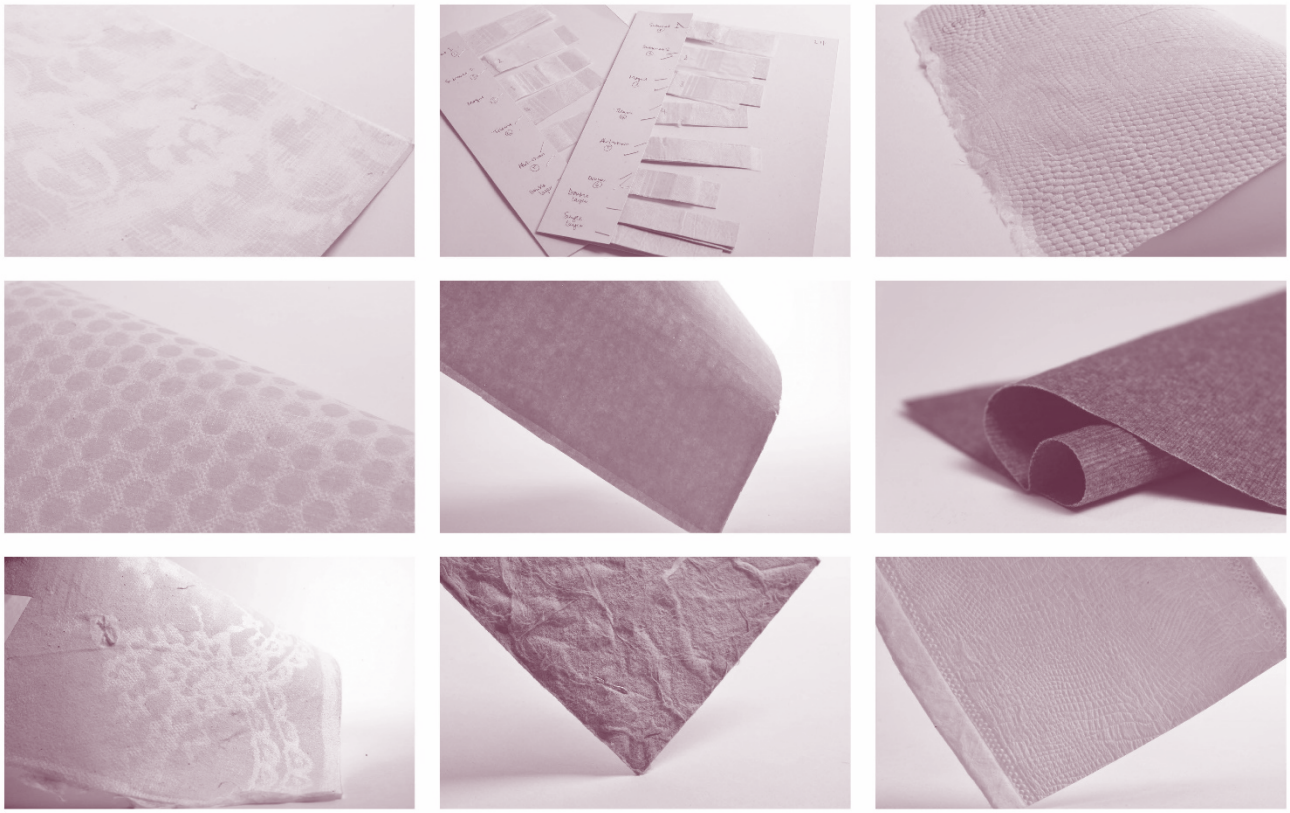

circular design speeds: prototyping fast and slow sustainable fashion concepts through interdisciplinary design research (2015-2018)

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A Mistra Future Fashion Report

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preface

This report is the final outcome of the work of the Mistra Future Fashion 'Design Theme' (2015-2019), led by Dr Kate Goldsworthy, University of the Arts London. The main driver of the research was to find more collaborative ways for design to work with other disciplines towards systemic change in the fashion industry and as such has involved many academics from different disciplines across the other three MFF themes; supply, recycling and user behaviour.

The design research task was both to challenge established understanding of best practice in sustainability and circularity but also to present alternative visions for consideration. Through the design of the project we aimed to develop new ways to work which fostered the deeper collaboration needed if we are to solve the complex problem of making our fashion system circular.

As we developed this practice research we simultaneously ran an implementation pilot with Swedish brand 'Filippa K. We shared our developing approaches and insights with FK as part of a structured project which ran from 2016-2018, to enable commercial prototypes to be developed alongside the research garments. The work resulted in several major outcomes: The Circular Transitions conference and Making Circles exhibition in 2016, exhibits in the V&A's Fashioned from Nature exhibition and permanent collection in 2018, the Disrupting Patterns exhibition and Front Runners product launch event with Filippa K also in 2018 and the Circular Design Speeds exhibition in Stockholm, 2019.

The methods and results of this project was written up as a separate report - Circular Design Researchers in Residence: Workshops Report for the Circular Design Speeds Project with Filippa K, Stockholm (2016-2018) (Task number: D.SRF.1.1.1). The final concepts developed through the pilot are described alongside our research concepts in this report.

Whilst the project officially ended in November 2018 a detailed 'digital sketchbook' of the project is available online at: www.circulardesignspeeds.com

Published papers and reports can be found online at:
www.mistrafuturefashion.com

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summary

The 'Circular Design Speeds' project was developed as part of the Mistra Future Fashion Design Theme research (2015-2019). The proposition was to develop 'ultra-fast' and 'super-slow' design prototypes for different extremes of use, in order to better understand the design implications of different circular fashion scenarios. Design and science researchers worked closely with material developers and service providers, to design appropriate materials for different speeds of use, production and recovery. Our main aim was to compare and contrast two approaches at the extremes of potential short-life and long-life design concepts. Would product longevity and the slowing down of existing fashion systems hold up as the only sustainable option? Or could we defend a complementary approach moving at a faster pace than most environmentalists might approve of, but with effective recovery of materials outweighing the many negative impacts in more frequent production cycles? This was our challenge:

To explore and evaluate the environmental potential of the design of short-life and long-life garments for a sustainable circular economy.

Wardrobes contain a spectrum of archetypes and speed stories. Certain clothes in our wardrobe can be the quality agents we need to carry the bonds to permanence and connect to memories. They improve in value with age and are cherished. Others can be designed to be durable and connect with a system for revision, repair and renewal, where the whole or in part they could be replaced and redesigned. Others can function in a way that engages us in collective interaction, provides services and operates through temporary ownership to allow us guardianship for a specific period. Still more can be the outcome of mass production for a positive form of planned obsolescence, where the material is recovered for re-manufacture, after a short time in use, because the purpose of the artefact has been served and the polluting effects of laundry outweigh the effects of production. The meaning of an object is timeless, whereas an individual garment might last only weeks before recovery.

Whilst there are often trade-offs to be made between designing for durability and recyclability, which make it difficult to choose one over the other, there are also opportunities for synergy and double-wins. In order to fully understand the range of potential improvements across this varied spectrum of speed we focused on the extremes; a super-slow approach may include multiple fast lives which build over time to reveal a super slow product, which can serve not one but many users over a long time-frame; an ultra-fast approach might entail a short-life compostable or easily recyclable product which is designed with only a few or even a single use in mind at the outset, but by recovering it over and over again actually keep the materials in use over the longest time.

In the exploration of these extreme poles of fast and slow we begin to see a middle ground, where light production methods might be used to produce slow garments or distributed manufacture hubs utilised as hubs for recovery and repair; or fast garments being produced in such a way as to enable extended use within a limited timeframe in order to further increase the benefits to the environment. A mixed economy for fashion and textile design can then be developed that relies on a range of engagements with users.

The key working hypothesis which has driven this research from the outset is a reframing of 'longevity' from a circular perspective. We explored this reframing both conceptually and by experimentation at the extremes. The result of that exploration has resulted in a contribution to circular design theory, as well as to the different design approaches appropriate to the speeds and cycles relating to product and to material.

- We consider 'material longevity' as the perpetual recovery potential of synthetic fibres, which although embodied in short-life garments are not lost to the materials system at end-of-use.

- We consider 'product longevity' as a way to describe extending the life of garments to improve their cost per wear impacts during their useful life.

Of course, neither approaches are mutually exclusive and it is hoped that readers will see the exciting potential of these concepts to be part of a single and effective circular fashion system where resources are retained and valued for the benefit of all.

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1. introduction

1.1. background

The culmination of the first four years of design research in phase one of the Mistra Future Fashion project was a series of ten artefacts or prototypes which explored design strategies for sustainability through the development of physical materials (Textile Toolbox, 2014). These textile and fashion artefacts, could be described as propositions for a new way of thinking about designing sustainability into fashion, using The TEN strategies as a starting point and framework for the briefs.

Each of these propositions was developed by an individual researcher, or a small group of collaborating researchers, in response to the following challenge – examine the range of decisions that designers make during the product development phase using The TEN as a framework. When analysing the final results it became clear that whilst each responded to the challenge of circular design there was a polarisation of the ideas in relation to product longevity or speeds.

Unsurprisingly most of the approaches were looking at ways to extend the use phase of the product whilst three of the prototypes had little or no reference to product longevity and rather, were concerned with easing the flow of materials back around the lifecycle. These garments were designed for a particular material-recovery system or even intervened with the material at the point of recovery itself. They were not aiming for 'product longevity' as such, but the materials could, in theory, be fully recovered resulting in what we could describe as 'material longevity'.

a) super-slow / extending the life of a product = product longevity
b) fast-forward / designing in recovery of materials = material longevity

These polarised approaches can be either proactive (designed in at the outset) or reactive (responding to existing waste-streams) and both natural and synthetic material systems could be considered if applied in appropriate circular contexts (Goldsworthy, 2014). Thus, according to these definitions of circularity relating to 'speeds' the prototypes could be ordered on scale opposite.

Designing in order to enable joined-up cycles of material use is the ultimate aim for both. The two approaches, are extreme opposites but complementary; 'short-life' closed-loop systems and 'long-life' user engagement strategies both have an 'extending' effect on materials in the value-chain, by either keeping products in use over multiple cycles in perpetuity or by extending the single use cycle of a product over time. By exploring this polarisation of 'speeds and needs' in this research, we set out to gain insights for an effective circular materials economy, which acknowledges the complex nature of our current and emerging fashion system.

Design prototypes from Textile Toolbox (2014) arranged as a spectrum from short to long life.

1.2. purpose of the research

The driving aim of the research was to better understand the implications of 'fashion speeds' in a circular economy, in order to provide insight for future improvement.

We framed the research around the following questions which were all explored through close collaboration with our science partners throughout the project:

- If Circular Design can work in cycles of different speeds, how can longevity be related to both material and product retention?
- How can we think about 'speed of cycle' in our design processes in order to make more appropriate design choices?
- LCA studies in Mistra Future Fashion have calculated 'impacts per wear'. How can we understand the implications of this at all stages of the lifecycle and incorporate into our design decisions?
- Can we achieve the same 'impact per wear' by reducing production & material impacts as an alternative to extending product life?
- How can we implement our research with a commercial fashion brand and understand challenges in the 'now, near and far' future?

2. a design framework for circular fashion

2.1. circular speeds in fashion

Design and production have changed to meet the need for speed, growing populations and the cultivated fast fashion appetite. Conversely, the idea of designing durable and long-lasting fashion textiles has been a part of the fashion industry from the outset – long before product obsolescence had been dreamt up in the 1950's, yet the idea of slow fashion has been promoted in recent years as a new counter approach to fast fashion. For this report we propose another way of viewing the speed of fashion products by building on the work of Fletcher & Tham around 'clothing rhythms' (Lifetimes, 2004), as well as drawing insights from this reports authors' practice research from phase 1 of the Mistra Future Fashion program (2011–2015).

The notion of a circular economy, as promoted by the Ellen MacArthur Foundation, and its associated principles, has gained rapid ground and widening political support since the project began. Circular approaches are now being explored by many fashion companies, and new technological advances bring us ever closer to circular materials systems. The challenge to create products which are truly circular within the fashion and textile value chain seems a logical step towards the better use and retention of our valuable material resources.

Circular design first became relevant to textile designers through McDonnough and Braungart's 'The Hannover Principles' (1992) followed by the more widely cited Cradle to Cradle (2002), where the sixth principle "eliminate the concept of waste" pointed towards a far more holistic notion of materials recovery as compared to the then common reduce, reuse, recycle mantra. They called for the optimisation of the "full lifecycle of products and processes to emulate natural systems, in which there is no waste", and suggested that current methods perpetuated a cradle-to-grave strategy, which was ultimately a linear one. Circular design aims to redefine sustainability models as a more cohesive and connected approach. It is not simply about recycling materials, or even about closed-loops of material recovery. Circular design is at its very core a concept of systems thinking with cycles of every size and speed considered.

The two-dimensional concept of a closed-loop only becomes useful if applied to a real context and in the case of fashion products that context is broad and complex. In this project we are seeking to explore different fashion speeds, in order to ask whether 'slowing down the system' is the only way to create a less impactful industry for the future? Or whether in fact we need a more mixed-approach to best serve the environmental challenges we face. 'We're caught between two economies of time... One fast and furious, the other slow and steady. Industry need not design what it makes to be durable beyond a certain amount of time, any more than nature does.' (Kendall, 2014).

The insight (that longevity can be considered from either a materials or product perspective) reveals an opportunity for broadening our current understanding of how to design environmentally-sound fashion products, which acknowledge the complexity and variation present in the current fashion system. We now need to bring this understanding into the design process, to address a gap in knowledge relating to the understanding of garment rhythms in the context of circular design, the ultimate goal being preservation of material resources in the system.

2.2. fast, slow and everything in-between

Through an initial review of academic literature and industry research we found an overwhelming majority of sustainability approaches in design relate to making products of higher quality which last longer. There are obvious gains with this approach and a recent report by Wrap, UK (2015) states that "extending the life of clothing by an extra nine months of active use would reduce carbon, waste and water footprints by around 20-30% each".

The problem with focusing only on product longevity is that you may end up with a 'durable' material (such as recycled polyester) being used in a short-life product (a fashion top, for example), with no means of recollecting or recycling it at end of life. This high impact non-renewable resource (polyester) has already been recycled once, which is to be commended, however if that reuse creates only a few weeks of extra usefulness (with perhaps only 5-6 wears), then the material which has taken millions of years to form in the earth, and more valuable resources to process it, will very quickly become discarded and take a further 200-years minimum to degrade, whilst leaching contaminants back into the soil as it does so.

The intention, whilst not wrong, is lost very quickly in the real-world use and action of the user. Appropriate materials need to be developed and selected by designers to be used in fashion products where the duration of use by the owner/s has been noted and understood. This notion exists to complement the work by other concerned actors in the system who seek to also change the behaviour of users, moving them away from consuming trend-based clothes to alternative approaches. The research ideas in this report are concerned with ways to provide more choice for our wardrobes – seeking to understand where behaviour change can be achieved and perhaps where product-based change is needed.

If we reduce our focus to only a 'part' of the system (the use phase) we are playing into the hands of 'unintended consequence' and often simply shifting impacts further along the product lifecycle, albeit out of view. We need to find ways to understand the potential impacts of each and every design decision we make, and the specific attributes of the products we are designing in relation to their life-journey. We need to stop viewing only the product as the ultimate vehicle for longevity and start to see the materials themselves as holding the true value.

So how should we consider 'speeds' as part of a circular design process? The intention was to develop the discourse on from simply fast and slow, to a level where multiple and proportionate speeds can both be understood - tested scientifically and ultimately engineered - to improve the circular efficiency of a product. The idea presented here is that we consider both long-life (slow) and short-life (fast) as models for clothing to suit a broad range of user contexts – different needs, tastes, incomes and styles.

There are examples of every lifecycle speed in the natural world, pointing us towards positive appropriation of both fast and slow systems. We can see positive and expansive examples of the full spectrum from fast to slow in other industries too, for example food and architecture. Street food offering fast yet authentic and healthy alternatives to the highly-processed and mass-produced fast-food on offer in another part of the market; even fast architecture provides temporary building structures for contexts ranging from disaster zones to short-life exhibition concepts. Perhaps slowing down is not the only solution to the environmental challenges we face, yet the sustainability discourse consistently focuses it call for slower consumption and more durable products.

In the natural world, 'small and fast' lifecycles exist in combination with 'large and slow', to arrive at a suitable ecosystem for survival. The combination of different natural speeds related to durability enables the entire system to continue. Brand (1985) proposes that we should "adopt this approach in the imaginative design of systems". Fletcher suggests in The Speed Factor (2011) that, "applying ideas of speed and rhythms of use to fashion and textiles helps us develop a new vision for the sector that has the potential to reduce some of the negative impacts of consumerist 'fast' fashion. If we look at how speed is dealt with in nature, we see combinations of fast and slow. Ecosystems achieve balance and long-term resilience of the larger system by adjusting to change at different paces."

Rather than pursue a polarised approach to viewing 'speed of use' (which often limits attention to a small part of the whole lifecycle), the authors here argue that a more nuanced method of analysing speed is needed which acknowledges the entire lifecycle of a product. We should in fact be considering the right speed for each garment within specific lifecycle stages.

2.3. reframing circular speeds

The first task was to review potential design approaches in line with this initial framing of design speeds. In order to understand how this framing might serve the existing fashion industry we conducted a review through the lens of fast and slow examples. We first developed a visual framework 'The Speedcycle' as a way to represent multiple rhythms and speeds within a product's entire lifecycle – a graphic model that visually demonstrates that notions of speed are relevant across all stages of the lifecycle.

This model was tested in multiple workshops during 2015/2016 where we developed concepts of fast and slow with industry and academic participants (see Fig 2.) In these interpretations the common conclusion is that only longevity and a slowing down of the fashion system could ever reap environmental benefits. In order to articulate a holistic view of speed related to all stages of the lifecycle we considered four categories; raw materials, production, use and recovery. Each is discussed in relation to speed and longevity below.

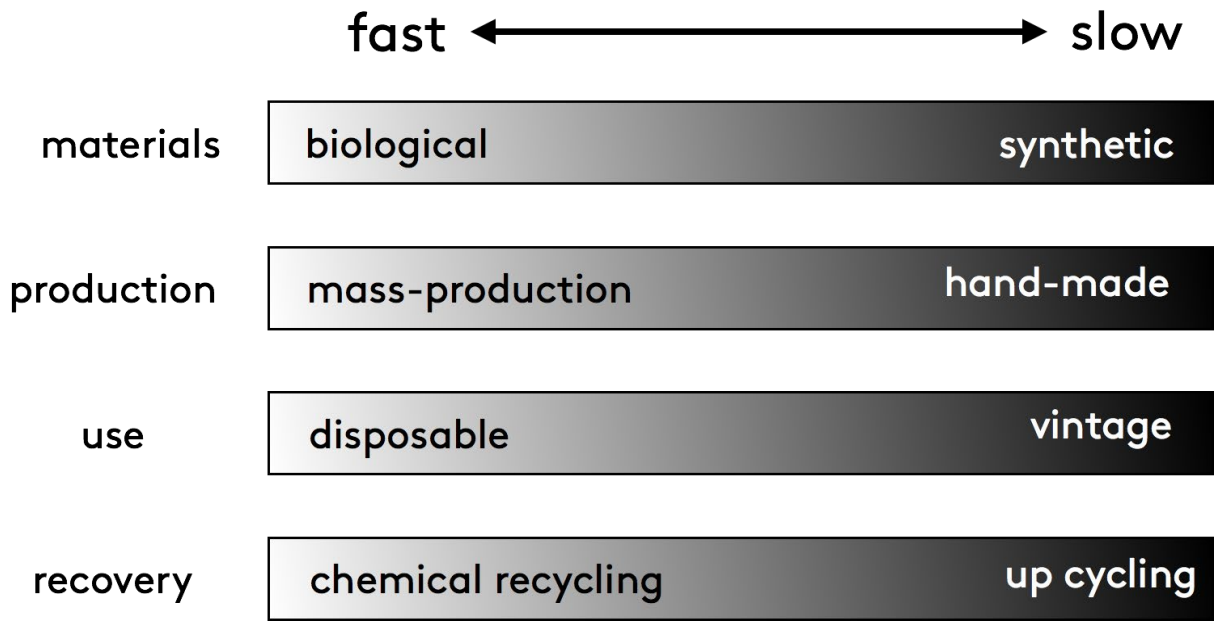
Extending
the Use Phase:
Reduces the environmental 'cost-per-wear'

Reducing
the Use Phase:
Increases the environmental 'cost-per-wear'

Speedcycle examples based on LCA framework from phase 1.

Workshops with students, industry and academic collaborators during 2015 and 2016 exploring the fast and slow concepts.

Raw Material Speeds **(Embodied Energy of Resources)** One of the key aspects of a product's lifecycle is its raw material source. 'Natural' fibres, based in agriculture are 'renewable' resources, that is to say they can be grown over and again from the same resources. They need water and sunlight (and often a dose of chemicals); then they can keep providing material resources. The time taken to 'grow' the materials is short (fast) and therefore they could be considered to have a 'low embodied energy' and low impact – so could they be considered fast materials? In contrast, materials such as polyester are made from oil which takes millions of years to form and are considered 'non-renewable' - certainly in our lifetime - and therefore could be described as slow. This is perhaps counter-intuitive when 'slow fashion' so often relates to natural rather than synthetic materials, but it is a prime example of how the way we have learned to associate certain materials as fast or slow is sometimes misleading.	**Fashion Speeds** **(Durability of Style)** The need for fashion to be constantly evolving, making us want more and more is embedded in our economic system, and designed obsolescence is seen as contributing to the hugely consumerist position we find ourselves in today. A product can be seen to be fast if it goes quickly out of style or is discarded due to low quality materials and construction (are these actually bad design decisions?). In order to avoid an 'inappropriate marriage of excessive material durability with fleeting product lifespans' (Chapman, 2008), we must stop isolating parts of the system during the design process. It would no more make sense for a high-fashion / short-life product to be made to last eternally than to make a potentially long-life 'classic' from such low-quality materials that it falls apart before it is no longer desired. If material-quality is part of the aesthetic of 'desire' even in a 'fast' product - how do we reconcile that material value at the end of its short life?
Production Speeds **(Impacts of Manufacture)** In terms of production the spectrum from fast to slow could be compared to that of 'hand production' (slow) through to automated, mass or digital production (fast). How do we consider which is preferable here? Are the impacts of production less per garment if you were to consider a holistic LCA (lighting and heating a room with only one person in it, for example) versus the economies of scale in mass-production? Is it feasible to expect all manufacture to be slower? Is it necessary for all products to be of the highest quality? These questions again relate so heavily to the specific context of the product. Are impacts of industrial production only perceived as greater because they relate to a mass-industry? If production methods are out of balance with the expected lifetime of a product (high impact production in a short-life non-renewable material) then we have a mismatch.	**Recovery Speeds** **(Ease of Material Regeneration)** What about the end of life story? This is something not often discussed in terms of speed, and is still very difficult to analyse through existing metrics (much of the technology here is so new we are not yet able to quantify the impacts conclusively). The ease of recovery at end of life can range from a complete block through to efficient and economically viable techniques for regeneration back to virgin quality fibre. If a fast-use product can be designed in such a way as to enable this smooth transition between subsequent product lives then it is possible that material benefits may be similar to a scenario where a single product lifetime is extended. Many of the current barriers to effective fibre-to-fibre recovery could be 'designed out' at the product concept stage if they were to be considered as part of the design brief.



Lifecycle Sliders; exploring fast & slow concepts through a lifecycle framework, (Goldsworthy,2016)

Exploring the lifecycle sliders in a brainstorming session with UAL Masters students (Goldsworthy, 2016)

2.4. a review of fast & slow design approaches

The second task was to understand how framing circular fashion products with the added dimension of speed might help us to define more specific and appropriate design guidelines. The goal was to further the understanding of designing for textile product speeds in a circular fashion context, by examining existing theoretical, industry and practice-based research contexts and developing new ones.

The spectrum stretches from super-slow to fast-forward, and was used to frame six potential design themes. Through a review of both historical and contemporary approaches, synergies and trade-offs, a framework for design was developed to offer guidance towards a more sustainable industry.

During the first phase of the MFF project UAL researchers identified a gap in knowledge through their Textile Toolbox design prototypes (Earley et al., 2016). Although lifecycle thinking had become a widely adopted and tested approach in academic and industry contexts, the dimension of time or speed was not fully resolved as a factor within existing design guidelines for design, especially not in fashion textiles.

We conclude this section with a reflection on these approaches from a design-driven perspective. How might these approaches be turned into useful design briefs for future development? table 1 & 2, present our emerging circular design proposals; three Super Slow and three Fast Forward design approaches.

The full review including industry case studies from both fast and slow fashion sectors can be read in the Circular Transitions Special Edition of the Journal of Textile Design Research & Practice. Eds. Goldsworthy & Earley (2018)

slow: designing for product longevity

The original model of 'slow' in fashion is a long-standing one, being a solution throughout history of applying craft-skills to make products of physical and (arguably) aesthetic longevity. In fashion terms haute couture has always adopted this approach. Affluent clients can select garments from beautifully made collections, with opportunities for bespoke, customised detailing.

In the market today slow fashion has become synonymous with sustainability, representing high quality, durability and low-impact production. Ironically this often relates only to the slowing of use and production phases, often failing to acknowledge the slow nature of synthetic materials in the raw material part of the lifecycle. Oil-based synthetic fibres are made from fossil material built up over millions/billions of years, synthesised into fibres such as polyester, which in itself takes 200 years to degrade in nature.

There are many contemporary industry responses to 'slow' which are having impact. In this section we look at ways to extend product longevity by design through the following framework.

table 1 approaches for product longevity

Extending Single-User Lifetimes;	**Enabling Multiple-User Lifetimes;**	**Scaling Garment Upcycling;**
Designing to keep products in use as long as possible for their first life.	**Services which give existing products a new life opportunity.**	**Reinventing existing products through design intervention/s.**

fast: working towards material recovery

It might seem that a link between fast fashion and sustainable development would be impossible. But something exciting is happening in the materials recovery space; we are beginning to see the emergence of some spectacular leaps in technology towards full fibre-to-fibre recycling, many of which can handle a supply of mixed fibre waste - the reality of most post-consumer waste streams. This may allow us to think of longevity in a very different way, from a materials perspective; longevity could be enabled through the recovery and reuse of materials at resource level (material longevity), and not only through product longevity.

These technologies are emerging and not yet at commercial full-scale but as progress gathers momentum we can begin to imagine the potential. Some garments may come to the end of their useful life sooner than others, but if reduced impacts in the production or recovery stages (as compared to virgin production) can show an overall reduction in cost per wear, then this may be equally beneficial in the long- term.

In this section we review the approaches & technologies which may point us towards a reconsidering or reshaping of the mass-fashion market.

table 2 approaches for material longevity

Advancing Material Recovery	**Designing FOR Recovery; Starting with the End**	**Reducing Production Impacts;**
Recovering virgin-quality materials from existing textile waste streams.	**In-built design features which enable more efficient recovery to support material recovery.**	**Innovative production systems which reduce overall impacts of garments.**

3. methods

3.1. designing a collaborative and iterative design process

The design concepts were developed between 2015-2018 in close collaboration with the material and social science partners working on the project. The resulting research concepts spanned the fast to slow spectrum. They explored the themes proposed at the start of the research and evolved through an iterative process during the project.

From the outset, it was clear that we would need to find new methods of collaboration if we were to be able to implement scientific insight into the heart of the design process. We wrote these collaborations into the project at the development stage; with recycling science to set the brief for recyclability; with social science to test the user perception and acceptance of our materials; with business innovation experts to understand the future scenarios which could influence our interactions throughout the supply chain and user network; with material scientists to co-develop new materials; and with environmental scientists to understand the implications of our design decisions along the way.

These inter-related areas of expertise had to be combined into a holistic process in order to make real progress. Rather than simply informing a new concept or offering analysis on a fully formed commercial product, in this project we sought to develop a truly connected and iterative design process. By working together we hoped to be able to bring a new level of understanding and insight to our proposals for change.

3.2. an interdisciplinary approach: the role of design

Integral to the development of good design practice are the current ideas from relevant disciplines: anthropology, business studies, materials science, behavioural economics, design studies, histories of dress and theories of sustainability. This multi-disciplinary integration is at the very heart of the project. Systemic solutions, such as is its remit, can- not be nurtured and developed in academic silos and so research was developed in four discipline-crossing themes in order to promote a truly collaborative process.

Design research serves as a vital means of connection between these scientific practices. In 1986, Appadurai described the social role of artists as critical as “they are thinking about new ways to arrange things”. He commends their ability to imagine new possibilities and form alliances with other disciplines, which can have practical applications. To benefit social progress, the imagination of artists and designers needs to be connected to innovation in science and technology. In an interview, Tonkinwise (2015) pointed out that the job of design is not connected to “the creation of artifacts, whether communications, products, or environments. But the

practice of design is actually about persuading a wide range of actors – fellow designers, suppliers, investors, logistics managers, users in households, workplaces or public spaces, etc. – to work together on materialising a future in which such an artifact exists."

figure 1 Workshop images from collaborative aspects within the project (UAL, RISE, Filippa K).

design & material development

In this task design researchers at UAL worked closely with the material scientists at RISE to develop e new bio-based textile-like nonwovens on a paper machine (see figure 1). In order to make a convincing material for garment use there were a number of properties associated with wear and tear, such as strength, foldability and resilience to water from rain and perspiration, which had to be fulfilled. The purpose of this part of the project was to improve the

understanding of how the choices made at the paper machine and later, at the finishing stage, can influence the span of textile-like properties of the finished textile.

Samples with low PLA fibre content showed excellent strength, and hand crimping imbued samples with stretch and a muffled sound. Samples with a large PLA fiber content showed considerably smaller strength but were softer to the touch. A spot-welding pattern at a 3 mm distance, similar to the fibre length, increased both strength and strain at break. Industrial dry creping resulted in excellent stretch and some drape.

This study demonstrated that it is the interplay of choices made at the paper-machine, such as mixture of input fibers, in combination with choices at the finishing stage, such as crimping and welding, that determines the span of textile-like character possible to obtain in a paper-based nonwoven (see figure 2).

design & new business models
The methods involved in the development of new insights around the business models for long life fashion and the Service Shirt involved a collaborative process between Earley, the designer, and the CBS researchers, Pedersen and Andersen.

The process involved the researchers each writing different parts of a journal article, with reviewing and editing together across the whole piece. Earley created the diagrams (see figure 3) to communicate the concept to the co-authors. Each aspect of the diagram – a production and user lifecycle stage - was then described and written into a table.

The CBS researchers produced insights through conducting literature reviews about the definitions of the term circular business model and the barriers to integrating and adopting circular products and systems within linear companies.

Additional methods were used to examine the potential of the Service Shirt at a systems level – where the business models work extended to more social innovation-based questions - through a stakeholder analysis process with Dr. Marion Real.

For this work, a series of short internal workshops were designed, using tools designed by Real, that noted all the interactions that the process of making and using the shirt created. These included the people, the places, the processes and the technologies the product travelled through. The workshop insights were then drawn into a co-created diagram that left spaces for interactions from the audiences at the exhibition and showcasing events, enabling further questions and ideas to be added to the map.

figure 2 Developing a new nonwoven with the team at RISE Bio Innovation, Stockholm

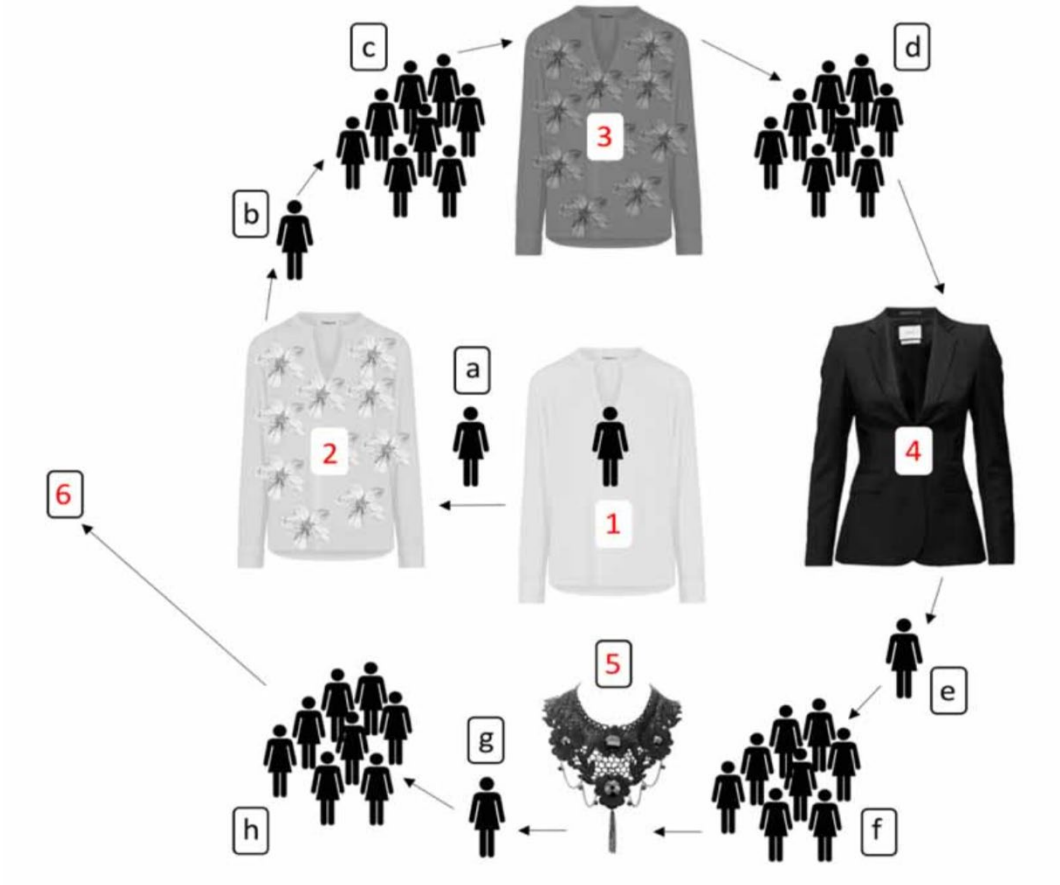


figure 3 The Service Shirt and its user cycles (Earley, 2018)

design & recycling technology

The task ´Recycling models for Short-Life Garments´ (Karpenja et al, 2019) focused on material recycling of both the newly developed paper nonwovens. One PLA rich and the other CEL rich.

Experiments were set around both the recyclability of the materials 'as paper' (i.e. their reslushability) and their potential for industrial composting (see figure 4 & 5).

Firstly, both materials, were re-slushed into their fibre components in order to understand possibilities and limitations of the material due to their added PLA content and also the welding finishing process.

The second task, 'industrial composting of paper-based non-woven textiles' focused on the biodegradation of the PLA rich material in two variations: with and without the welding finishing.

The results of both studies, added an extra layer of knowledge (through material understanding) to the 'design scenarios' for the garment prototypes. One notable result found that the laser-finishing of the PLA rich material not only improved the handle and performance of the material in use, but also increased the speed of biodegradation. (Granberg et al, 2019)

design & user perception

The consumers' experience of the textile-like material is important, and it is natural to consider the materials conformity to properties that are usually associated with textiles, such as softness, tactility, flexibility, stretch, strength, drape and a sound dampening effect. To be able to influence the consumers perception and final acceptance of the material, there need to be finishing and conversion processes that supports a large span of possible visual and haptic expressions.

In this study, consumer responses to our new nonwoven paper-based materials were tested (Lindberg, 2018). Our original brief was to try to achieve a paper textile which felt like cashmere as this was perceived as the ultimate luxury fabric.

In the results (see figure 6) over 65% of the test group found this sample acceptable to wear. Samples 52 and 53 were the ones eliciting most surprise over the fact that they were not textiles, with sample 53 being judged as very close to cashmere.

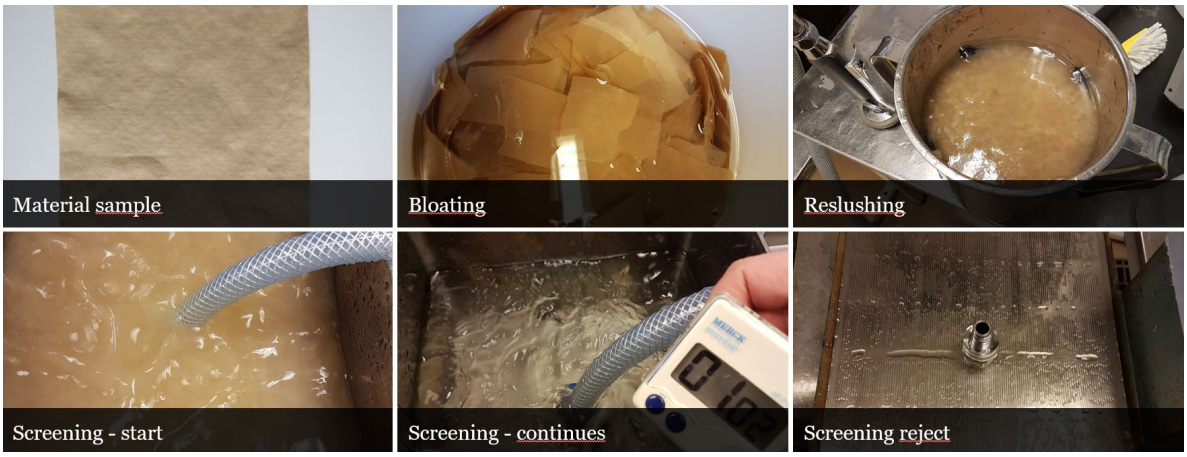


figure 4 Material recycling (reslushability) test visualisation

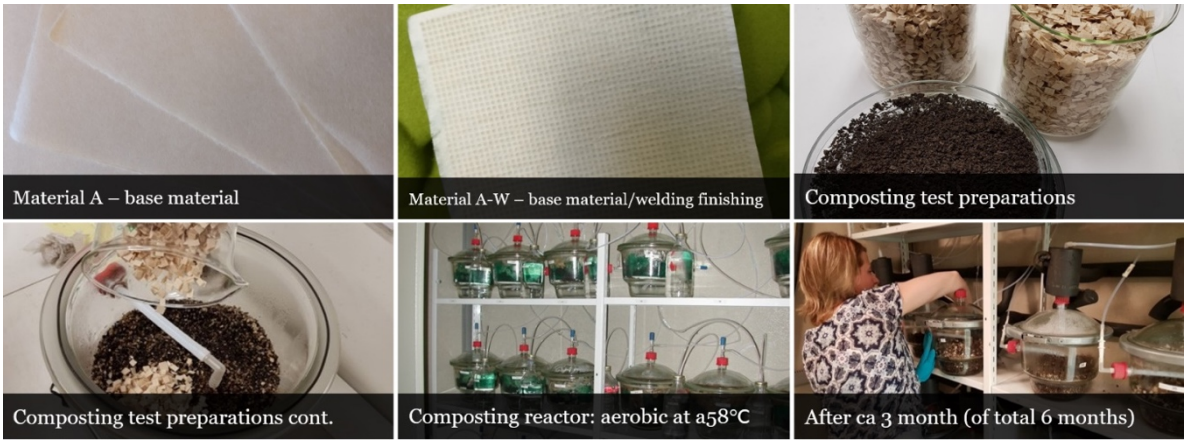


figure 5 Composting process visualisation

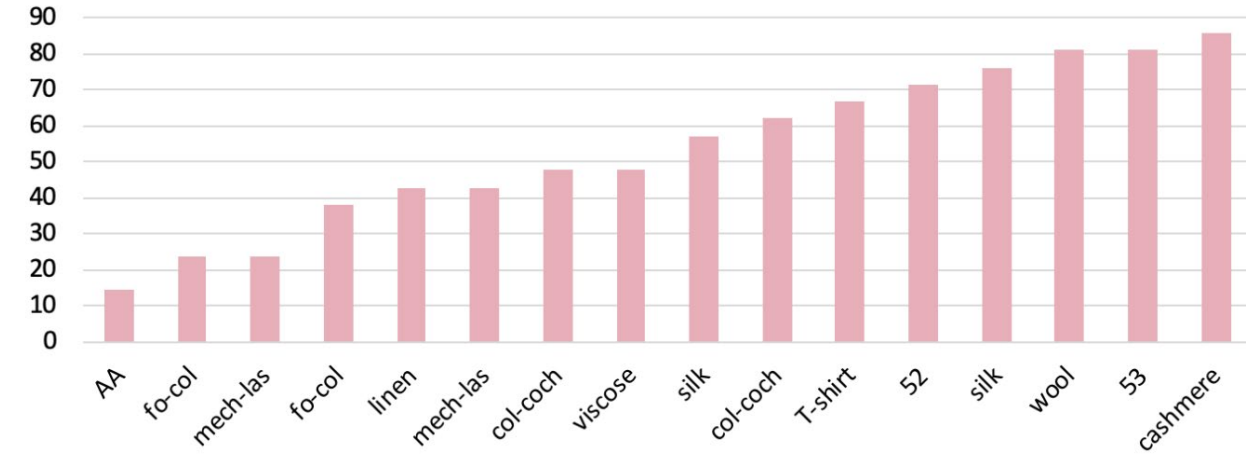


figure 6 Results from user perception studies (Lindberg, 2018)

design & LCA

One of the least familiar areas of collaboration in the project was that between the design researchers and the environmental scientists. For success it required a joint effort in overcoming the disciplinary barriers for collaboration which at the outset seemed considerable. LCA was perceived as an end-analysis activity and we had no blueprint for the way to work together.

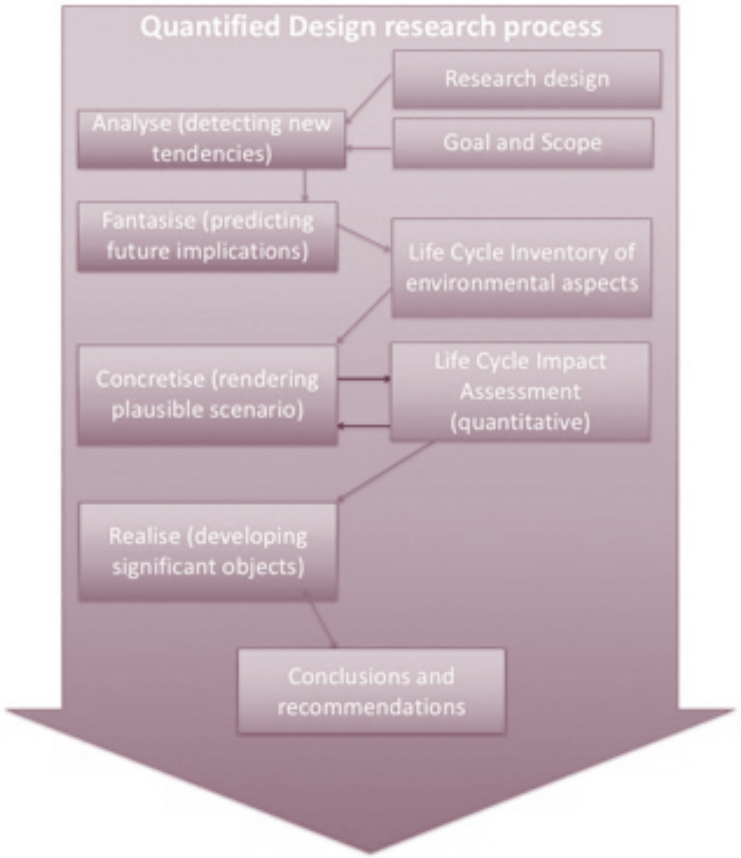
To tackle this lack early in the process we worked together to compare our existing processes and identifying potential opportunities to propose methods for building a bridge between disciplines. A model we called quantified design was generated, published (Goldsworthy et al, 2016), and subsequently explored, during the pilot project.

It involved a number of multidisciplinary workshops where both research processes are merged and responsive to one another, building a new understanding, whereby the impact on the environment acts as an integrated part of the design brief and informs each stage in the design concept development (Peters et al, 2018).

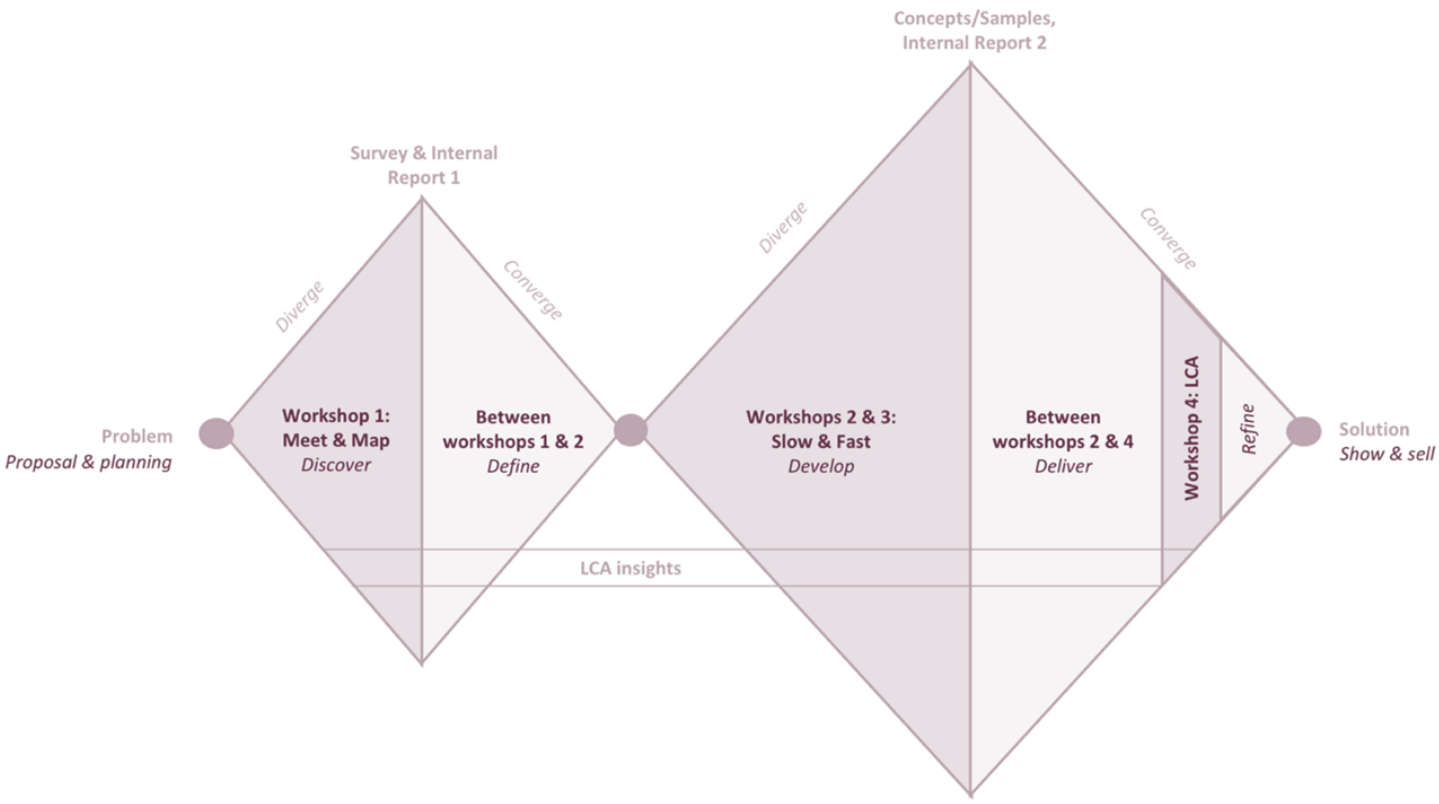
working with industry: embedded research at FK

During the same period we embarked upon an innovative 'researchers in residence' pilot project with Filippa K. During this project we exposed our thinking and concept development to the FK team and supported the development of their 2018 Front Runners garments. The project surpassed expectations and resulted in both a fast and slow concepts from FK; both being launched in London in November 2018 with a co-curated exhibition and press-launch 'Disrupting Patterns' (Goldsworthy, Earley & Larsson) and again in Stockholm's Fashion District at the Mistra Future Fashion closing event 'Outlook Days'. Filippa K's 'Eternal Trench Coat' was immediately acquired by the V&A museum in London as part of their permanent Fashion Gallery showcase.

The methods and detail of this project is presented in full in a separate report (SRF.1.1.1) but the Front Runner garment concepts are presented here alongside the academic research in the following chapter.



Our emerging methodology blending LCA and design approaches (Goldsworthy et al, 2016)



CDS / Circular Design Researchers in Residence workshops model (Earley, 2019)

4. results

4.1. the final concepts and prototypes

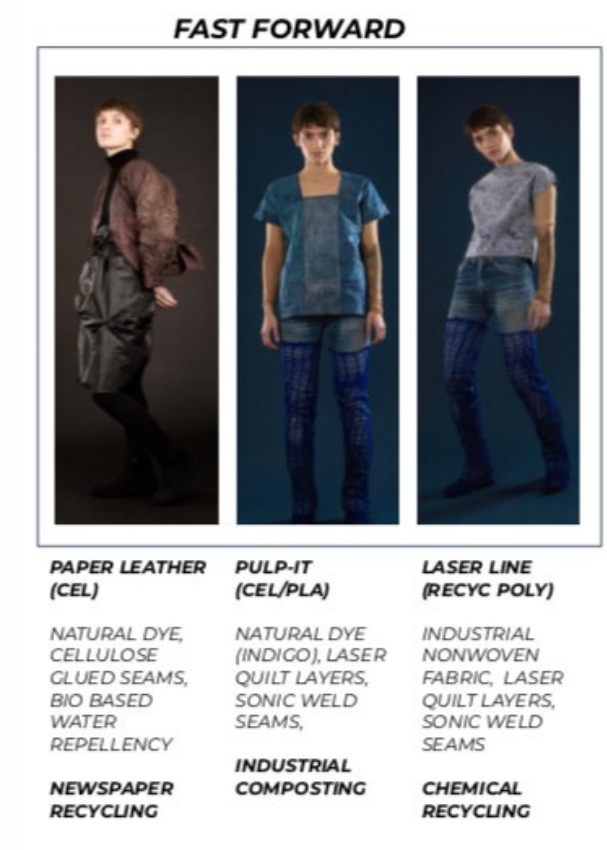
Alongside the academic research, concepts were tested and reviewed as results started to come in from our partners and eventually were expressed as physical garment prototypes and samples.

As in our initial analysis of the phase 1 design concepts, they were seen as a spectrum of speeds from ultra-fast-forward through to super-slow.

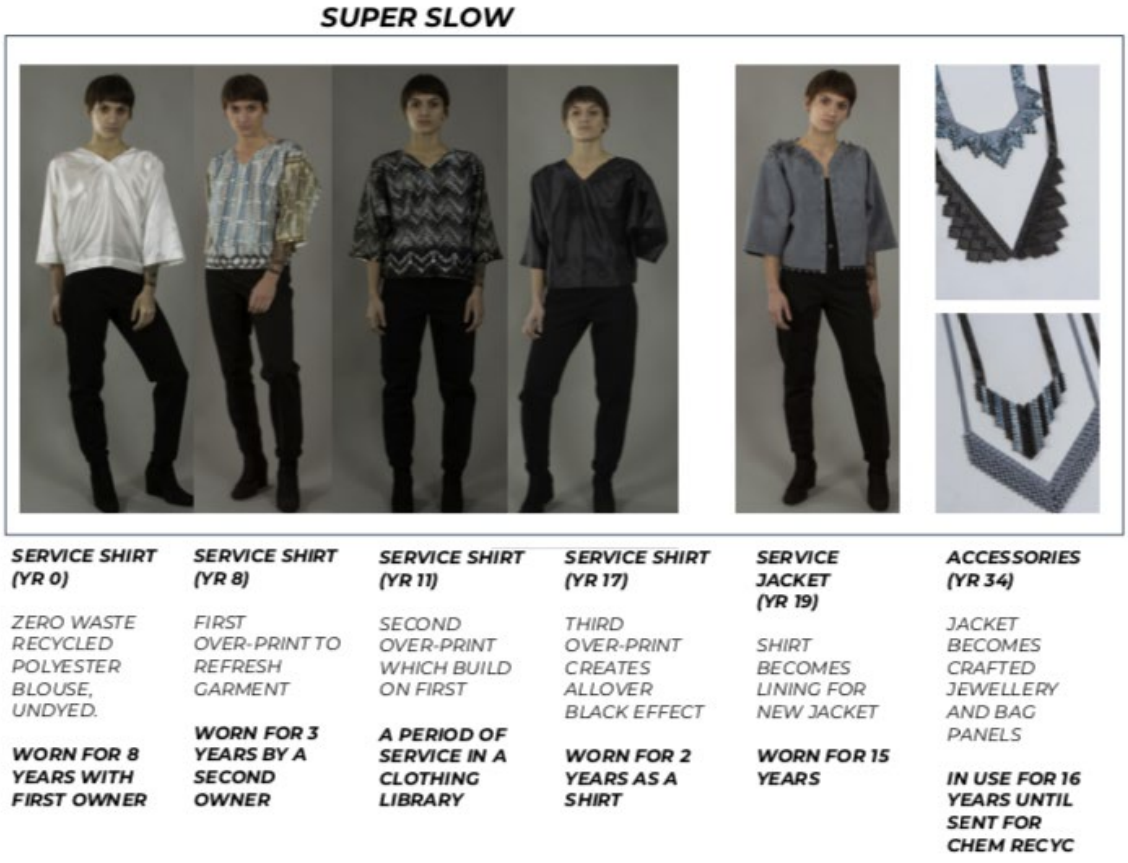
One key development in this considered range of concepts was the apparent blurring of boundaries between fast and slow and the potential for inter-connections to be made between the range of approaches.

In this chapter we present summaries and final results of the four key concept collections which included two ultra-fast concepts and two Super-slow, and features the work of the UAL design team alongside the Filippa K Frontrunner garments developed during 2016-2018;

- a 50-year fashion statement: the service shirt (UAL)
- design for permanence: the eternal trench coat (Filippa K)
- fast forward: fast & light fashion (UAL)
- design for transience: the throwaway dress (Filippa K)



Final prototypes presented as a spectrum from fast to slow



Final prototypes presented as a spectrum from fast to slow

4.2. a 50-year fashion statement: the service shirt

(UAL Design Research)

The Service Shirt concept explores the multiple complexities, contingencies, challenges and opportunities associated with design for circular business models in extended use contexts. It was designed as a 'deliberate extreme' to have a total lifecycle of 50 years. This lifecycle includes inhouse and external remanufacture processes, and various sharing cycles – often moving between single ownership and rental contexts. It becomes the lining for a jacket and then crafted into fashion accessories; before finally being regenerated in the year 2068.

The shirt was created with the intention of exploring how designing for this context differs from linear design; to design using lifecycle assessment to guide decision-making; and to stimulate discussion around issues that emerge when companies attempt to make circular business models operable in the fashion industry.

In the end the work went further than this – we asked, 'who are the people and what are the places?' that will make extended-life, circular fashion a reality? The insights we gained also enabled us to see the potential beyond the brand context - to garments that could flow between users, maker spaces and entrepreneurial ventures and charities – to new forms of more social and local fashion production, use and reinvention.

slow research team:
The Service Shirt exhibit is the work of Professor Rebecca Earley (CCD), in collaboration with CCD PhD Researcher Laetitia Forst and designer-maker Katherine Wardropper. Lifecycle insights came from Sweden-based experts Professor Greg Peters (Chalmers), Dr Gustav Sandin and Dr Bjo¨rn Spak (RISE), Dr Sandra Roos (RISE:Swerea IVF). Business model feedback came from Professor Esben Rahbek Gjerdrum Pedersen and Post Doctorate Researcher Dr. Kirsti Reitan-Andersen (Copenhagen Business School). CCD LDOC Post Doctorate Researcher Dr. Marion Real provided mapping insights and structure around people and place.

‘imagine if our clothes lasted as long as the materials they were made from?’

(Rebecca Earley, Professor, UAL)

The Service Shirt (Earley, 2018)

a people-focused brief
In the Service Shirt concept material state changes were embedded into a pre-emptive design process, enabling users to experience a variety of different ownership, rental and updating services, across a 50-year period.

In order for the *Service Shirt* to last 50 years it has to change hands many times; moving between moments of single use and ownership to shared use contexts with the brand owning and releasing the product again. A process of overprinting the shirt would give it new finishes within the first 19 years. Later the shirt would become the lining for a jacket and then finally jewelry, before going into chemical recycling to reclaim the fibres.

To understand more about the potential for extending use with traditional consumers, the researcher spent time with a family to gain insights into how a shirt might be used and reused within the family and friendship circle. figure 5 shows the users at their home; spending time with them aided the design decision-making process for the researcher and generated ideas for how the overprinting services might work with the 16-25 age group.

who & where: what people, what places?
The Service Shirt was examined at a systems level through a stakeholder analysis process, taking into account the people and places involved in this extended life story. It drove a deeper level of understanding through connecting to its social context and narrative. This art of the research asked 'how can the service shirt be used to imagine new models [for change]?' (Real, Earley & Goldsworthy, 2018).

The creation of the Service Shirt has enabled new insights for designers who wish to engage with making long-life fashion textiles for the circular economy. To do this, researchers had to consider the interrelationships between the product, society and the self. It considers new business models – the brand that sells, remanufactures, rents and recycles its material goods, working with new partnerships in localised supply chains. It explores changing user behaviour by designing a product that moves between single owners and multiple users, where the consumers are involved in the service loops that bring about the state changes. This suggests ways for industry to transform, shifting focus from making a shirt for a single season, to sell to one user; to a proposition that connects the brand to several small businesses that enable and support the extended lifecycle.

Images of user group research and print processes, 'The Service Shirt' (Earley, 2018)

“Imagine a network of makers, manufacturers, retailers and end-of-life suppliers working in small-scale networks to ensure more reactivity and interactions with direct users.”

A network of people and places involved in ‘The Service Shirt’ (Real & Earley, 2018)

4.3. design for permanence: the eternal trench coat

(Filippa K Front Runner)

A rainy day layer, protective overcoat, or even an unconventional dress, this garment was inspired by the eternal elegance of the trench coat and its ability to suit any season or occasion. The light material can be packed easily for on-the-go accessibility, and the water repellency makes it wearable in any weather.

Filippa K's philosophy is grounded in designing high quality, timeless pieces that last for many seasons. However, designing for full recyclability brought a new set of challenges to learn from in order to find a healthier approach in fashion. It currently requires making sacrifices when it comes to materials and design, and they challenged themselves to disrupt this pattern to create a Filippa K garment that is 100% recycled, and 100% recyclable.

Inspired by the slow speeds of nature and its ability to protect what exists while creating something new, The Eternal Trench Coat is made from a technical cycle utilising recycled polyester from plastic bottles. It is designed to last for a decade or longer: a classic trench style that works as a timeless topper for all seasons and is easily packable as well as water repellent. FK are committed to supporting the wearer in mending and repairing the garment, and helping pass it along to a new owner if necessary.

When it can no longer be worn, the coat is made to be recycled in its entirety with minimal effort to recreate the materials that it originated from. Through this process they have developed new ways to use recycled materials in fashion, new technology to extend the life of clothing, and new insights for designing with future garments with full recyclability in mind.

A material that often has negative associations, polyester takes millions of years to create and 200 years to biodegrade, has been given extended life in the industry through circularity.

The Eternal Trench Coat' (Filippa K, 2018)

4.4. fast forward: fast & light fashion

(UAL Design Research)

The Fast-Forward concept explores alternative modes of production and use for a sustainable 'fast-fashion' application. LCA advantages are enabled through lighter material choices; nonwoven fabric production; no launder; clear routes to recovery (designed-in at the outset); redistributed manufacturing systems. A sliding scale of 'speed' from ultra-fast forward (shortest-life scenario) through to a more accepted length of use with adaptations to production processes and end of life.

This offer amplifies the opposite approach of designing slow and enduring pieces to better understand the full spectrum of challenges from fast to slow fashion.
Materials have been specifically developed for the project in collaboration with scientific partners, and processes imagined as mass automated systems.

For this version of fast fashion to be complementary to durable quality products, industry must shift profit-making activity from the one-off sale of goods to gain value from the circuit of material flow or service-based models.
These concepts evolve through multiple lifetimes over a 50-year timeframe (in order to provide a useful comparison to the slow proposals) but rather than change over time as a product, this story reflects the idea of 'material longevity' with multiple loops of efficient recovery at the heart of the sustainability focus. We see a great opportunity to mimic the qualities of transient cycles in nature, to provide the nutrients for an ecology of fashion.

fast research team:
The Fast-Forward exhibit is the work of Professor Emeritus Kay Politowicz and Dr Kate Goldsworthy (CCD), in collaboration with Dr Hjalmar Granberg, Scientist at RISE Bioeconomy, Stockholm. Lifecycle insights came from Sweden-based experts Professor Greg Peters (Chalmers), Dr Gustav Sandin, Dr Bjo¨rn Spak (RISE) and Dr Sandra Roos (RISE:Swerea IVF). Material testing and consumer perception was conducted at RISE by Tatjana Karpenja and Siv Lindberg. CCD LDOC Post Doctorate Researcher Dr. Helen Paine provided research into industry mapping and commercial finishing processes.

‘could our clothes be produced, worn and recovered to balance fashion and sustainability?'

(Kay Politowicz, Emeritus Professor, UAL)

Fast-Forward Fashion (Politowicz & Goldsworthy, 2018)

nonwoven textiles for 'fast & light' fashion

Textile nonwovens, in general, are an underdeveloped material in fashion, which can offer sustainable advantages for some garments. We took the decision to work with paper production, as an extreme test for 'fast' material credentials for our specific needs, being an established Swedish industry using ubiquitous materials and processes. It represents the extreme end of textile nonwovens and is an industry with many credentials appropriate for sustainable production and with established recycling systems. So, fashion could lead the way for industries to embrace automation and collaborate across different industries to benefit from speculative design with a sustainable agenda.

Through collaboration with Dr Hjalmar Granberg (RISE) and his team, we worked to produce a wearable paper with its function enhanced through finishes. Using unbleached wood pulp and other bio-based sources, a new paper non-woven material has been developed using natural dyes, laser surfacing and ultrasonic construction methods, to reduce chemicals and energy at all stages of the lifecycle of this 'fast-fashion' replacement.

This twenty first century version of wearable paper capitalises on new technologies, employed to provide automated production and potential for customisation. Rapid manufacture includes the production of the material and garment shapes in the same machine, for a lifecycle that is intentionally short but responsible. Local production and reduced carbon footprint, are enhanced by light, flexible materials and processes. Efficient recovery at end of life, through standard paper recycling processes, avoids plastic in the ocean and introduces a guilt-free approach to the fast section of a modern wardrobe, otherwise composed of quality and vintage pieces.

We identified two paper recipes from RISE research, suitable for fashion prototypes. Using a StratEx semi pilot Sheet Former, layered structures with randomly deposited fibres were produced. The two papers: one predominantly made of wood pulp and one with a large PLA content. In short, a strong but stiff structure which needs finishing to soften it and a soft but weak structure, which needs finishing to strengthen it. The PLA-rich paper The PLA (polylactic acid) is derived from corn starch, while current research in Sweden is enabling PLA to be developed also from wood pulp.

For the third material story we chose to work with existing commercially available nonwovens. In 2017 we conducted a thorough materials review resulting in a library of over 200 samples from most major fibre groups. This collection is housed at CCD in London and was the basis of material decisions for both the UAL and FK garment prototypes.

table 3 The three fast-forward concepts.

	Paper Leather	Pulp-It	Laserline
Nonwoven Construction	Stratex Paper making Machine	Stratex Paper making Machine	Commercial Spun Laid Nonwoven
Fibre Content	CEL Pulp PLA Fibre	CEL Pulp PLA Fibre	RPET (recycled polyester)
Recovery Intention	Recycle as Paper (reslushing)	Industrial Composting	Chemical F2F Recycling
Colouration	Natural Dye (pulp dye possible)	Natural Dye (pulp dye possible)	Disperse Dye (fibre dye possible)
Water Resistence	OrganoClick	OrganoClick	NA
Stitch Alternative	CEL Adhesive	Ultrasound	Ultrasound
Stretch	NA	Micro Pleating	Micro Pleating
Multi-Layers	CEL Adhesive	Laser Quilting	Laser Quilting

sample of finishes developed for nonwoven materials (Politowicz, Goldsworthy & Paine, 2018)

scaling up potential: new expressions for industrial nonwovens

There is potential for these fast-forward concepts to be scaled up in an industrial context. Local networks of manufactures at all scales will be essential for this vision.

Extended technical understanding within an existing manufacturing landscape presents opportunities for future development of local, fast and circular material and fashion systems.

Using garment prototypes we were able to test the viability of the idea, revising the garment to exploit and enhance the sustainable features. In all cases, design for benign obsolescence deliberately ends the life of the garment but preserves the life of the material. Future directions being developed include the use of 100% forest sources: recovered or regenerated materials, pulp-dyes developed from production waste and bio degradable stretch fibres.

In a twenty first century climate of political and environmental uncertainty, designers are trying to develop sustainability strategies in 'best design practice' for diverse global manufacture, where the nature of the material itself and its characteristics are key to design development. In materials science, the selection of a material for manufacture from its performance in tests is less concerned with the selection of the 'right' material than an avoidance of the 'wrong' material. (Ashby & Johnson, 2009).

While the resulting discourse around appropriate material selection for fashion is dominated by promoting avoidance of the causes of damage, we believe there is a need for greater investment in proposals of successful alternatives. Today, we believe we need equilibrium more than ever and no more simplistic binary arguments.

The future for fashion fast and slow rests between the two, where it belongs, to include viable strategies for both. The reality is, throughout a lifetime, owning a mix of 'faster' and 'slower' garments is the solution to a vast range of cultural and economic conditions. How we view and design products, not as static objects but as dynamic and evolving systems, is key to this more sustainable future.

4.5. design for transience: the throwaway dress

(Filippa K Front Runner)

100% bio-based and 100% biodegradable, this concept dress is the Filippa K solution to fast fashion. It provides the wearer with an opportunity to update their wardrobe on a whim and dress up for a special occasion - while also reducing the environmental impact of this behaviour.

An exciting vision that is not far from becoming an industry reality, Filippa K has designed a dress that is made from 100% bio-based material and is 100% biodegradable. Inspired by the fleeting elements of the world around us, the garment uses nature's life cycles to provide the wearer with an opportunity to upgrade a wardrobe on a whim without negatively impacting the environment.

Fast fashion as it exists today is not a sustainable way to consume, but speeds in nature are not defined as 'good' or 'bad'. The butterfly that lives only for a few days is just as essential to the ecosystem as the elephant that lives for seventy years, and who would want to be without cherry blossoms, even though they only bloom for a week?

FK decided to rethink this concept and find out if it is possible to maintain current consumer behavior of fast fashion without the negative consequences. Dressing for an occasion can often result in discarding a piece that was only worn once or twice, so they challenged themselves to disrupt this pattern.

The Throwaway Dress was their proposal for a garment which could be cherished for a short time. Rather than holding on to the clothing, it is the experience of wearing it that lives on through photographs and social media. The transient nature of the dress provides a unique and guilt-free opportunity to create special memories that last.

The Throw Away Dress goes against our traditional association with objects. We buy clothing as an investment - an object that becomes a part of us, a talisman that holds our memories. But what are objects in the digital age? More and more we remember through the photos we put online rather than the physical things we possess. This dress is tactical and tangible, but only for a few fleeting moments, to be recalled in the form of images and memories rather than its physical presence in our wardrobe.

The Throw Away Dress' (Filippa K, 2018)

'the process to make the material uses less water and energy; it is also biodegradable. But the biggest benefit was showing how [this], industrial type of material could be transformed into chic and wearable garments.'

(Jodi Everding, Filippa K Fabric and Trim Manager)

5. discussion

Through our practice-based exploration of circular fashion through the lens of lifecycle speeds, we can more clearly see the opportunities for design to innovate more effectively in the circular fashion economy. Slowing down the system at product level involves extending garment lifetimes but also enabling multiple lifetimes (not necessarily long) with different users and even a level of reinvention. Where product longevity is impossible then there are options to focus on material longevity through the use of closed-loop fibres and progressively improving these recovery systems through design for recycling. We can also consider the reduction of production and use impacts to be as effective as the increasing of time in use, where a short-lifetime is the only option. Fundamentally we need to consider appropriate design decisions based on a realistic and defined context.

All too often approaches to sustainability and circularity are at odds, with competing strategies seemingly incompatible. Yet the potential for circular design is that it connects through holistic relationships, participation and collaboration. The model we should aspire to is based on a synergistic network of cycles and open loops which feed each other at multiple scales and speeds. These are complex and sophisticated transformations of materials and living matter. Within this network we will undoubtedly see both old and new technologies and processes contribute to the whole, with hi- and low-technology working together. The very same system could include slow garments, upcycled from pre-loved ones, or fibres chemically recycled back to virgin quality in a closed loop system where nothing is lost.

The following sections first present insights from each individual design concept. These were collated during the final stages of the research and presented at the final Mistra Future Fashion event in June 2019.

super-slow fashion insights

service shirt:

- Designing backwards together, including the user and the end-of-life partners. To involve everybody at the outset in making decisions required a new way of thinking about each person's role; every decision made had a consequence elsewhere in the cycle. (Earley, 2018)

- The first and subsequent 'reprintings' were designed as a simple overprint using digitally-printed transfer paper. The first colourway was kept light to enable the subsequent remanufacturing options. By 'retro-designing' with images from future-lives, (relating to the final design in the concept) the visual links between product stages was reinforced. (Earley & Wardropper, 2018)

- Designing for Disassembly, enables the product to be taken apart at the end of its useful life in such a way that allows components and parts to be reused, recycled, recovered for energy or, in some other way, diverted from the waste stream. For this project a 'textile lock' technique was developed to combine the Service Shirt with an outer layer so that it becomes a jacket, which can easily be separated and transformed into a new product at the end of its use cycle. (Forst, 2018)

- ‘Service Shirt highlights the paramount role of consumers in the value-creation process (Stahel, 1986), indicating the need for companies to invest in long-term relationships with customers.’ (Pedersen, Andersen & Earley 2019)

- ‘The time and advanced artisanal skills invested in the transformation of the jacket and shirt into intricately decorative objects adds value to the materials yet another time, extending its lifecycle all the way to 50 years. Truly Couture Craftsmanship. (Earley 2018)

- Local remanufacture and midsize companies. The design ideas pursued for the Service Shirt lead to new insights around the future partnership opportunities that could be explored between the mid-size brand, future retail concepts and local craft/artisan producers. (Earley & Real, 2018)

- ‘When the Service Shirt concept was compared with the impacts of a standard polyester blouse, significant ‘climate change’ savings were identified through the overprinting and remaking of existing products rather than buying new each time. This is primarily a consequence of avoided garment production via reprinting and reassembly of the initial garment to extend its useful life.’ (Peters et al, 2018).

- ‘Service Shirt highlights the urgent need to collaborate across professions, departments and organizations. Taking a circular approach, sustainability can no longer be restricted to a single unit, department or profession.’ (Pedersen, Andersen & Earley 2019)

eternal trench coat (FK):

- Using recycled polyester means that the raw material comes from single-use objects like PET bottles rather than virgin oil. This cuts waste from fabrics and reduces the amount of plastic ending up in landfills and the oceans.

- Consulting the expertise of the recycling companies from the very beginning, enabled the understanding needed to create a product for full recyclability.

- Because of the systems approach to the design, FK were able to connect one of their partners with another to utilise a new waste-stream for fashion. They discovered a large waste stream from a completely different industry – 100% polyester shipping straps – that are usually incinerated, but can be used for making recycled polyester material.

- The eternal elegance of the trench coat and its ability to suit any season or occasion was designed in deliberately as part of its enduring character. The light material can be packed easily for on-the-go accessibility, and the water-repellency makes it wearable in any weather.

- To maintain the recyclability adjustments were needed on the original design: open cuffs replaced elastic, recycled polyester sewing thread replaced bonded seams, and polyester buttons replaced a metal zipper.

- The dope-dying process from We aRe SpinDye resulting in 90% reduced chemical usage, 75% reduced energy consumption and a smaller carbon footprint than a typical dyeing process. It provided longer lasting colour vibrancy and extraordinary performance against UV light damage, wear and tear, and washing – compared with traditional dyeing.

fast forward fashion insights

- The All the Fast Forward concepts focused particularly on nonwoven materials. This was due to their potential for simultaneous mass manufacture and impact savings compared with traditional techniques. (Environmental impacts perspectives from Roos et al, 2018 and Peters et al, 2018)

- The key with this material was to develop new and appropriate finishing processes to improve their aesthetic, handle and performance while still preserving the necessary features for onward recycling. Over 200 physical samples were produced around a variety of finishing themes. They could be used to cost effectively produce large quantities of a single generic material in a paper machine, that later can be converted or tailored into a multitude of products fitting the needs of the many.

- One way to circumnavigate the impacts of fast fashion could be to develop materials with significantly lower impacts during production, and which avoid the barriers to recycling faced by conventional garments. These short-life garment proposals have lower material impacts, compared with conventional cotton, from their relatively light weight and also on account of the lower impacts in garment production and use. (Peters et al, 2018).

paper leather:

- The new bio-based nonwoven material was designed specifically for recycling as paper & was made from 95% Cellulose Pulp and 5% bio-based PLA fibre. The final material was tested for 'reslushability' and found to be 99.9% recoverable as paperpulp, meaning it could feasibly be recycled back into paper through existing recovery channels. (Technical results from Tatjana Karpenja, RISE)

- All finishes and construction needed to also be compatible with both recycling and composting processes. Therefore, natural dyes requiring no heavy mordants in their fixation were used; water-repellency was added through a bio-based treatment; garment seams were constructed using a new bio-based adhesive.

- As well as providing a level of water-repellency, the OrganoClick treatment was also found to improve the handle of the material without hindering recyclability.

pulp-it:

- The new bio-based nonwoven material was designed specifically for industrial composting & was made from 43% Cellulose Pulp and 57% bio-based PLA fibre.

- All finishes and construction needed to also be compatible with both recycling and composting processes. The thermoplastic quality of the material enabled an extended range of finishes and construction techniques to be used; laser-finishing; Sonic welded seaming; 'heat-soaking' of the material enabled natural dyes to be applied in a wet-process.

- As well as improving the strength and aesthetic quality of the materials, application of a spot-welding pattern increased the sample strength by up to 100% and the strain at

break by up to 60%. It was also shown to dramatically increase the speed of composting. (Granberg et al, 2019 and Karpenja et al, 2019)

laser line:

- During this project both synthetic and bio-based nonwoven polyesters were explored to extend the potential of the process for chemical recovery (and also to extend the lifespan of an existing fast-fashion product.

- Additional spot-welding processes were also developed in collaboration with RISE using widely-available commercial equipment.

- The potential to enhance the materials in local hubs using digital non-toxic finishing methods also present significant environmental gains.

throwaway dress (FK):

- The final dresses were designed to be 100% bio-based and 100% biodegradable.

- They provide the wearer with an opportunity to update their wardrobe for a special occasion with reduced associated environmental impacts. This dress is tactical and tangible, but only for a few fleeting moments, to be recalled in the form of images and memories rather than its physical presence in our wardrobe.

- Tencel from Lenzing, originates from renewable, sustainably farmed wood and is regenerated from the pulp. The fibres are biodegradable, compostable and can fully revert back to nature. Producing one kilogram of Tencel uses 1.4% of the water used to produce the same amount of cotton, and one square metre of land can produce 10 times more Tencel than cotton (Roos et al, 2019.

- By using a nonwoven, spunlace Tencel rather than a woven fabric, we've eliminated costly production processes and reduced impacts. The spunlace process uses only water (no chemicals) 80% of which is recycled back into the system. Mogul's spunlace process doesn't use external components other than the fabric itself, supplied to the mills in bales of staple fibres from Lenzing. Mogul also reuses all cutting waste to make up about 5% of overall composition, which means no waste stream is created.

6. guidelines for designing circular fashion

The final conclusions are drawn from the findings of all elements of the Design Theme research (as listed in pages 83-85). In this final concluding section, we relate the proposed guidelines back to the approaches outlined in chapter 2 and 3.

6.1. circular design guidelines

Designers need positive examples of fast fashion as a circular model. At present they are difficult to find and much needed for a realistic approach to the industry. Slow seems to reject industry and fast seems to reject sustainability values. One key development in this considered range of concepts was the apparent blurring of boundaries between fast and slow and the potential for inter-connections to be made between the range of approaches.

- Design with the end in mind, to decide right from the outset whether the product should be part of the technical or biological cycle. Then make sure everything in that design is compatible with the chosen cycle.

- Mono-materiality is an important factor for easy end-of-life recycling, but fibre blends and finishing are often essential for aesthetic and comfort. We need more recycling technologies for blends and design solutions to match.

- We may intend our clothes to be 'slow' but for many reasons they end up being 'fast', and vice versa. Our current materials are essentially all slow; they take time, water, energy, chemicals and valuable resources to make.

- Using recycled polyester uses a waste stream from single-use plastics like PET bottles rather than virgin oil. This cut impacts at the material production stage and reduces the amount of plastic in landfills and the oceans.

- Imagine a future where materials and garments are made locally using streamlined production methods and eliminating unnecessary transportation, energy use and overproduction. The Fast Forward concept explores this future reality.

- Fashioning Flexibility: be ready to react and change moment to moment as new routes to change reveal themselves. No innovative process is perfect, so projects need to be able to adapt, and funders need to assist with this.

6.2. guidelines for a super-slow approach

table 4 approaches for product longevity

Extending Single-User Lifetimes;	Enabling Multiple-User Lifetimes;	Scaling Garment Upcycling;
Designing to keep products in use as long as possible for their first life. This can be achieved through the careful selection and development of functionally durable materials, which retain their quality throughout an extended-life and wear appropriately for the intended time frame for use. If these materials can be paired with design intended to last beyond the short fashion cycle and so that they have maximum uses during their time in service there could be additional benefits. In addition, services which enable careful laundry and repair either through a brand or at home could additionally extend the life of the garment.	**Services which give existing products a new life opportunity.** As well as the above material characteristics this approach requires connection to new models for distributing and recollecting our garments. Both industry and the consumer have a part to play here in the use of leasing and peer-to-peer sharing services, and the passing on of unwanted, but serviceable items through charity and branded resale.	**Reinventing existing products through design intervention/s.** This is where designers can create augmented value in products through their recreation and physical transformation or upcycling. Whilst often these responses are based in small or niche fashion brands there might be scope to develop upcycling practices at a larger scale through the examination of remanufacturing processes in other industries. Advances in technology and a pre-designed second life built into new garment design could be used to accelerate this shift.

- Innovative remanufacturing of a garment can be used to extend its useful life and reduce the environmental impacts through avoiding new garment production. Explore novel techniques such as transfer dye reprinting and laser processing which could offer potential new routes of remanufacture.

- To retro-design garments with multiple lives built-in we must imagine their future lives at the outset and design the whole system. This requires multi-disciplinary collaboration and a detailed understanding of user behaviour.

- Design for Disassembly. Enables the product to be taken apart at the end of its useful life in such a way that allows components and parts to be reused, recycled, recovered for energy or, in some other way, diverted from the waste stream.

- Look for ways to enhance the value of garments at the point when users may think of discarding them. Prolonging the lifetime of a garment by 2 will decrease its climate impact by 49%.

- There are tensions and trade-offs between designing for material v product longevity. In creating durable products we may also be preventing material recovery at a later date.

- We need to tackle emotional longevity and issues of planned obsolescence (fashion) alongside physical durability.

6.3. guidelines for a fast-forward approach

table 5 approaches for material longevity

Advancing Material Recovery	**Designing FOR Recovery; Starting with the End**	**Reducing Production Impacts;**
Recovering virgin-quality materials from existing textile waste streams. The rapid progress of recycling technology is providing hope for the future of material recovery. There are potential step changes in fibre-to-fibre recycling technologies; cellulose, polyester and nylon recovery is now possible at pilot scale. Even waste streams from other systems, such as food waste, are being utilised to a much higher value than ever before. Designers are becoming ever more involved in these technological and scientific developments, often bringing new insight and innovation.	**In-built design features which enable more efficient recovery to support material recovery.** Designers now need to understand and assess which of these end of life opportunities is most relevant to their design process and be able to respond accordingly to the requirements of the system. Ease of recyclability can be built into design practices in a multitude of ways; through design for disassembly, use of monomaterials, which relate either to the biological or technical system, and use of biocompatible or technical finishes and production processes which also fit the end of life intention.	**Innovative production systems which reduce overall impacts of garments.** This concept of lighter production systems which impact more gently on our environmental and economic systems is a huge are of potential improvement. We must enable more streamlined and vertical manufacturing opportunities, redistributed production, automation and mass customisation. Local and decentralised production can be connected to highly technological solutions.

- Using nonwovens, such as spunlace Tencel rather than a woven fabric, eliminates many costly processes and reduces impacts through a vastly reduced production phase. There is potential for these, often overlooked, materials to be developed for wider use in the future.

- We should look to waste-streams outside of our own eco-systems for new raw materials. A great example is the natural dyeing developed by Heart & Earth from discarded fruit and vegetable waste.

- Stretch adds comfort to our garments. However, the material added in order to make garments stretchy, for example elastane, cannot be recycled in today's system. To instead add mechanical stretch to non-woven is an alternative.

- Some technologies may provide win-win scenarios. For example application of a spot welding pattern in the Pulp-It project was found to increase material strength by up to 100%, whilst also dramatically increasing the speed of composting.

- One way to circumvent the impacts of fast fashion could be to develop materials with significantly lower impacts during production, and which avoid the barriers to recycling faced by conventional garments.

6.4. guidelines for collaboration

- In order to fully succeed in moving to a circular industry, in the fashion industry, we must look outside ourselves. Transparency, openness, and collaboration are essential aspects of innovation, and by utilising existing infrastructure and value chains it will become even easier to scale up and create global change.

- Service Shirt highlights the urgent need to collaborate across professions, departments and organisations. Taking a circular approach, sustainability can no longer be restricted to a single unit, department or profession.

- Bringing experts from disciplines together takes a lot of effort, from all participants. Between design academics, scientists and industry partners we found that co-creation was possible after building trust and shared goals, along with common tools.

- The methods we found effective in phase 1 were action research, workshop facilitation, individual reflection and creative practice, as well as prototype co-creation and exhibition curation. In phase 2 we built on these with a parallel creation approach – academic and industry designers supporting each other's innovation process.

- The research into circular speeds has revealed how complex the changes required are. Circular fashion will not be the work of a single brand. There are complex materials, complex systems and highly-complex user relationships to navigate. Collaboration is utterly essential.

- Understanding the Space Between: The moments between moments matter most! We need to design cyclical collaborative working processes that enable individual reflection and action, and suggestions on ways to capture this progress and share it back to the collective effort.

- Create Appropriate Timeframes: Fundamental, applied & commercial research can work together, but need to be viewed as different cogs in the gears of the wheels of change. Academic research is slower than industry R&D, so designing a shared supportive experience is tricky. Timing is key!

6.5. future outlook

It is evident that the sustainability challenges of the fashion and textiles industry could be better met through a multi-disciplinary approach. However, descriptions of practices for how design and scientific research can work together to overcome the disciplinary barriers for collaboration are few. This report aimed to address this need by providing a practical example of a multi-disciplinary research project where the differing processes of disciplines were combined where possible to contribute to mutual understanding. The disciplines were often found to be quite far apart, with science aiming to explain how things are, and design to explore how things could be.

By integrating these two models a new, iterative one emerged which places circular design at the centre of a design process, backed up by scientific evidence. By developing scenarios which polarise the designed-in 'speeds' of a fashion product insights have been gained into impacts relating to fundamental design decisions. It was not intended that 'absolute' metric judgements were made, rather that design decisions were linked to empirical evidence on an iterative basis so that the designer may understand and utilise insights into their process. By working together over the 4 years of this project we believe we have come closer to finding this combined model for circular systems design.

The insights presented in this report have been collated from Design Theme research papers and published reports which are outlined in the following section.

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appendix 1 acknowledgements

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A-TEX
A-Tex is part of Trimco Group, one of the leading global suppliers of identity-creating branding items including labels, hang tags, badges, care labels, packaging solutions and store decorations for leading international fashion brands.

Axel Johnson International
A privately owned Swedish industrial group of over 100 companies in 25 countries with combined annual sales of €790m. Axel Johnson International drives business development and growth through a long-term approach to ownership in strategic niche markets, primarily technical components and solutions for industrial processes.

Axfood
With its passion for food and people, Axfood develops and operates successful grocery formats. Axfood contributes to better everyday life where everyone can enjoy affordable, good and sustainable food.

Axfoundation
An independent non-profit organisation focused on practical projects to achieve transformative sustainable change. Divided into four programs: sustainable consumption and production, circular economy, the future of food and inclusive societies.

Case Study
In business since 2003, Case Study designs, develops and produces trims and packaging for the fashion industry. The company is headquartered in Hong Kong, with an international mindset and global client base.

Coats
The world's leading industrial thread manufacturer, UK-based Coats employs 19,000 people in over 50 countries across six continents. For over 200 years it has worked to create new advanced materials - touching everything from sewing thread, to medical sutures, to fibre optic cables.

Fa Tin
Since 1980 Fa Tin has been recognised as a supplier for high-class fashion labels in China. The company grants a comprehensive benefit scheme to all of its employees.

Grafil
The result of a young and energetic mentality, Crafil is part of a generation of companies that still believes in the future of the textile industry in Portugal. With a deep passion for the product and a great desire to explore new ideas and techniques, the company brings a creative response to a competitive and demanding market.

Gronsakshallen Sorunda
From humble beginnings knocking on the doors of homes to offer eggs and potatoes for sale, their five core values: fairness, honesty, economy and common sense have allowed chefs across Sweden to produce the kind of food that they prefer in their own kitchens.

HearteartH production
HearteartH Production is a multidisciplinary design studio based in Stockholm. Focusing on circular design, it is a pioneer at the forefront of the upcycling movement in Sweden, as well as an internationally renowned design studio. Winner of Swedish Elle Decoration 2017 and represented by several objects at the Swedish National Museum.

Lenzing
The Lenzing Group, headquartered in Austria, is an international company that produces high-quality fibers from renewable raw materials like wood with environmentally friendly and innovative technologies. For textile applications these fibres are branded TENCELTM.

Mogul
Founded in 1997, Mogul was the first company in Turkey to produce spun bond and meltblown fabrics. It has grown to include three manufacturing plants in Turkey and one in the US, allowing an international staff of 400+ employees to supply a diverse range of sustainable nonwoven goods to markets in the Americas,
Europe and Asia.

OrganoGlick
By mimicking nature's own chemistry OrganoClick enters a new era in fiber based materials. Textiles become water repellent, wood is made durable and fire resistant, and strong yet lightweight 3D shaped bio-composites can be produced. All in a sustainable way in harmony with nature.

Philtex
Reduce. Reuse. Recycle. Recreate. This is what Philtex Plastics is all about. A specialist in its field, it is devoted to the full recycling
and reprocessing of plastics, offering innovative solutions for each demand, with quality and sustainability paramount to its desire for a 100% recycled chain

Richmond Makerlabs
Richmond MakerLabs is an all-inclusive space for people with an interest in DIV and craft. The space features computer facilities, electronics lab, laser cutting, 3D printing, CNC machinery, metal lathe and an informal wood shop.

Rudholm & Haak
Rudholm & Haak is a worldwide producer and distributor of labels, trims and packaging for the fashion and garment industry. RH is strategically located in all major garment-manufacturing countries.
Stena Recycling
In Stena's ideal world nothing is consumed. It collects all conceivable residual materials that arise from both business and production, reprocessing them into raw materials for new products or energy. In this way, it helps to create sustainable businesses while maximizing the Earth's finite resources.

STOP! Micro Waste
STOP! Micro Waste is a nonprofit initiative dedicated to raising awareness about the (micro)plastic problem. It aims to explore and initiate great ideas on how to avoid, replace and re-use plastics in everyday life and beyond.
STOPMICROWASTE.COM
GUPPYFRIEND.COM

The Welding Institute
The Welding Institute in Cambridge, UK, is the leading professional engineering institution for welding and joining all over the world. They have supported UAL in the development of new finishing processes for textiles since 2008. They provided access to their in-house laser-welding lab for the development of the Laserline Mono T.

Triumph Needle
Triumph Needle specialise in the technical areas of the sewing trade with heavy duty equipment for the shoe, upholstery and automotive industries and have recently added fabric ultrasonic welding equipment to our portfolio. They supported the production of the Pulp-It and Laserline prototypes with sonic seam welding and quilting processing.

V&A Museum
The V&A is the world's leading museum of art and design, housing a permanent collection of over 2.3 million objects that span over 5,000 years of human creativity. The Museum holds many of the UK's national collections and houses some of the greatest resources for the study of architecture, furniture, fashion, textiles, photography, sculpture, painting, jewellery, glass, ceramics, book arts, Asian art and design, theatre and performance. They commissioned the UAL team for their 'Fashioned from Nature' exhibition.

VTT
VTT is a visionary research, development and innovation partner. With a focus to drive sustainable growth and tackle the biggest global challenges they have over 75 years of experience of top-level research and science-based results. They kindly provided their innovative 'aqueous cellulose adhesive' for the construction of seams in the Paper Leather prototype.

We aRe SpinDye
We aRe Spin Dye® has developed a way to colour polyester fabrics with extremely high precision and at the same time drastically reduce the use of water and chemicals. It also results in polyester fabrics that keep their colour, year after year, regardless of wear, washing or sun.

Wolkat
A family textile recycling business since 1948. At Wolkat, collected textile is transformed in-house to new products for the fashion, auto and furniture industries. Wolkat is unique in the world in offering a circular solution for textiles

appendix 2 posters

Posters produced for the Circular Design Speeds exhibition at University of the Arts London, in November 2018.

A collaborative exhibition by Filippa K, Centre for Circular Design and Mistra Future Fashion Management.

Service Shirt: A 50-Year Fashion Statement

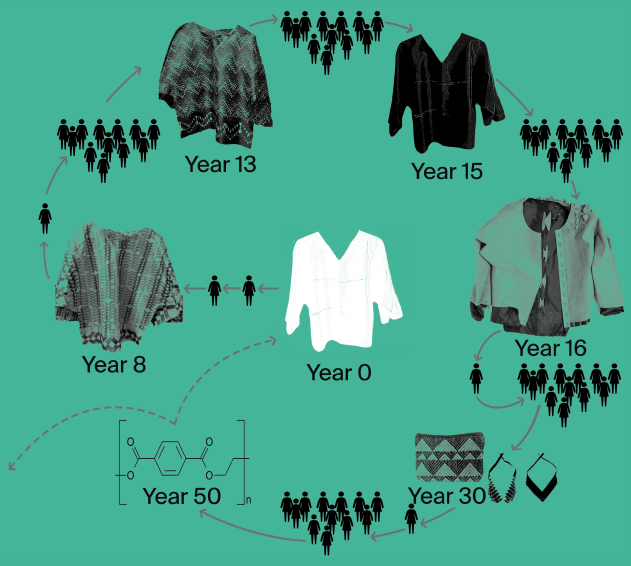
Imagine if our clothes lasted as long as the materials they were made from?

The Service Shirt concept explores the multiple complexities, contingencies, challenges and opportunities associated with design for circular business models in extended use contexts. The Service Shirt was designed as a 'deliberate extreme' to have a total lifecycle of 50 years.

This lifecycle includes inhouse and external remanufacture processes, and various sharing cycles – often moving between single ownership and rental contexts. It becomes the lining for a jacket and then crafted into fashion accessories; before finally being regenerated in the year 2068.

> The shirt was created with the intention of exploring how designing for this context differs from linear design; to design using lifecycle assessment to guide decision-making; and to stimulate discussion around issues that emerge when companies attempt to make circular business models operable in the fashion industry.

In the end we went further than this – we asked, 'who are the people and what are the places?' that will make extended-life, circular fashion a reality? The insights we gained also enabled us to see the potential



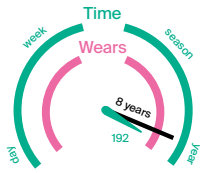
beyond the brand context – to garments that could flow between users, maker spaces and entrepreneurial ventures and charities.

> The Service Shirt suggests new forms of more social and local fashion production, use and reinvention.

Research Team:
The Service Shirt exhibit is the work of Professor Becky Earley, Co-Director of Centre for Circular Design (CCD), in collaboration with CCD PhD Researcher Laetitia Forst and designer-maker Katherine Wardropper. Lifecycle insights came from Sweden-based experts Professor Greg Peters (Chalmers), Dr Gustav Sandin and Dr Björn Spak (RISE), Dr Sandra Roos (RISE:Swerea IVF). Business model feedback came from Professor Esben Rahbek Gjerdrum Pedersen and Post Doctorate Researcher Dr. Kirsti Reitan-Andersen (Copenhagen Business School). CCD LDOC Post Doctorate Researcher Dr. Marion Real provided mapping insights and structure around people and place.

Decision-making with the end-of-life in mind. This shirt needs to know where it is going.

Year 0: Starting as we mean to go on

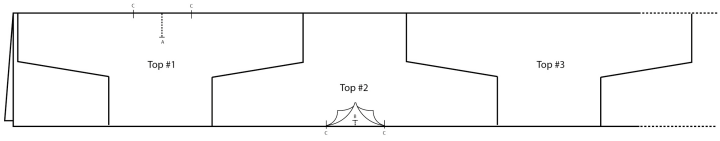


By working backwards from the end point and considering the recycling route for the material, the different lives for the garment that we are imagining here need to be planned in advance.

We chose a recycled polyester 'silk' material as our base cloth and made a zero-waste pattern shape for it. We reinforced key areas and avoided buttons. We made a simple, elegant, classic, circular shirt.

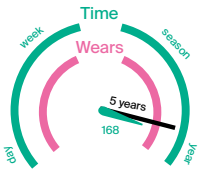
User 1 is a 'typical' Filippa K customer. She buys the shirt for herself and is intrigued by the name and concept she sees instore and in the press. At the point of sale, she reads about polyester, oil, the lifecycle, and the idea of slow and long-life fashion. She is not totally sure what all of it means, but the shirt suits her, and she likes the idea of doing something more sustainable with her wardrobe. She takes the garment home and keeps it for 5 years, after which she does not feel it's 'fresh' anymore.

The label says she can either hand it to someone within her family and friendship circles; bring the shirt into the store on her next shopping trip to town (to have it updated with a new print); or drop it off at the collection desk for it to be used in the fashion library service, FK Re-Fashioned (FKRF) – part of the FK-DESIGN LAB space. FKRF has instore digital paper printing and a heat transfer press printing machine, to enable remanufacturing of the shirts and other products.

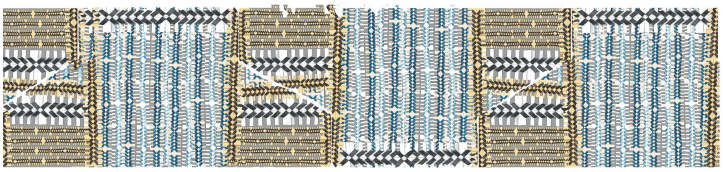


Prints that build the aesthetic and function in a strategic way

Year 8: Strategic Overprinting



The basis of this first remanufacturing stage is a simple overprint using digitally-printed transfer paper.



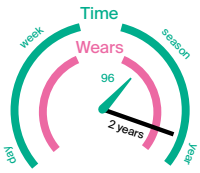
The design colour-way options are kept light to enable subsequent prints to go on top at a later stage. The printed shirt now looks quite different in style to the original plain shirt – it will be worn in different contexts.

User 1 decides to hand the shirt down to her daughter (14 years of age). User 2 has seen the shirt on her mum often over the last few years, and likes its soft, silky feel against her skin. She wears the shirt approximately twice a month for a 3-year period, before growing bored of it. (She also managed to get ink on it from a pen in her bag, and lipstick on it from a night out; so it doesn't feel like a nice, crisp white shirt anymore). From the label, she knows that she can take it to the FK Flagship Store, and the FK-DESIGN LAB, to get it 'overprinted'.

She goes on the FKRF website and uses the online booking system to make a date for a trip to the store the next time she goes to town. User 2 gets to choose from a range of overprints. She is thrilled with the 'new' shirt – it has been totally transformed by the print and the stains have also been covered up. She feels really inspired by the whole experience. She keeps it for another two years, wearing it on summer days out, before handing it on to a friend.

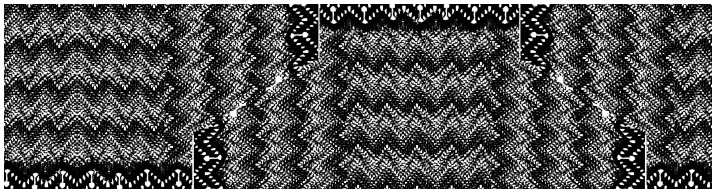
Transforming the aesthetic through a second strategic overprint

Year 13: Serving the Public



This second overprint is designed to transform the look of the garment by almost completely covering up the first print. (Look closely and you can see bits of the first print peeping through).

Both prints have been designed by using the future accessories – from a later lifecycle stage – as aesthetic inspiration.



By 'retro-designing' with images from future lives, the visual links between product stages is reinforced.

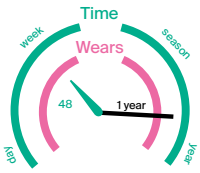
The friend, User 3, keeps this overprinted shirt for one year before deciding it's not really her look. She is 20 and uses fashion to help her explore her place in the world, and she doesn't really know where that is yet. She donates it to FKRF as it suggests on the label.

At this stage, the garment is checked instore for loose threads and is professionally cleaned before being retagged and put on the loan rail.

The shirt is rented out to users on a monthly basis. At the end of a 1-year period, FKRF needs to refresh the item. The original shirt had been created in anticipation of this second overprint. This 'new' piece will then go on the loan rail for another three years.

By designing prints that build in colour and depth over time, we gain an extra 12 years of use

Year 15: Going Black to Basics



We can extend the lifecycle of the shirt with minimal environmental and economic cost; yet gain an extra 12 years of wear since it left the original owner's wardrobe. The shirt now has an unusual black-on-black print.

The black shirt is easy to wear – a wardrobe basic, but with a twist – and gets borrowed often from the FKRF loan rail. It is put to good use, before being turned into the lining of the jacket. At this stage in the product's timeline, the original owner, User 1, has not seen the shirt since it left her daughters wardrobe seven years ago.

As part of the original point-of-sale offer User 1 gets first use of this new jacket. She is surprised when FKRF contacts her to say the new jacket is hers if she wants it. She had forgotten about the shirt but is now thrilled to find out it has had a good, useful life, and has been reinvented; made into the lining of a new jacket.

Designing with the end-of-life plan in place, future changes are anticipated.

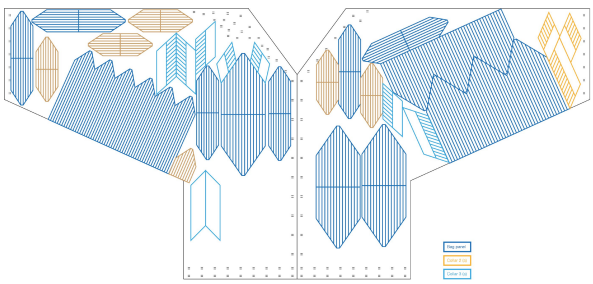
Year 16: Shirt Becomes Jacket Lining

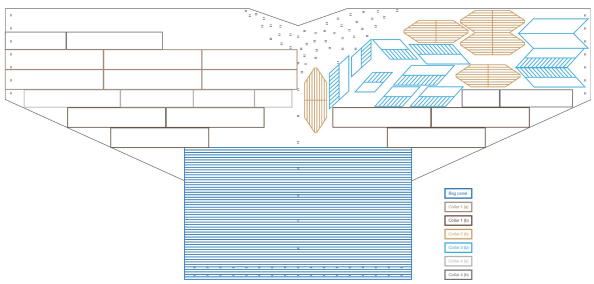
The black shirt is transformed into the lining for an occasional-wear jacket. Through a semi-artisanal process, using laser cutting and hand-assembly, the outer layer (made of a polyester felt and using the same zero-waste pattern) is connected to the shirt.

The jacket is designed for disassembly so that the different components it is made from can be taken apart and reused in the next life of the materials.

This next life is also integrated into the jacket's design by laser etching the outlines for jewellery pieces on the surface of the material as a decoration.

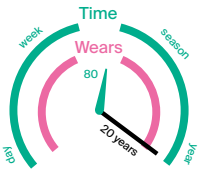
The first jacket owner keeps the jacket for 10 years, then it is passed back to FKRF where it is assessed for its eligibility to become an FKRF Luxury Loan piece. The item may be in need of minor repairs and will undergo specialist cleaning and maintenance. The jacket will go on the loan rail in the FKRF space and will be rented out over a 5-year period.





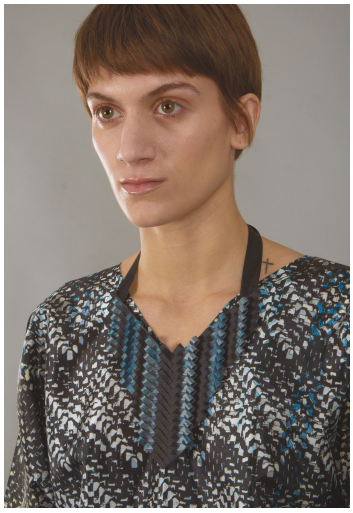
The durability and flexibility of the materials selected enables multiple future lives.

Year 30: Jacket becomes Accessories

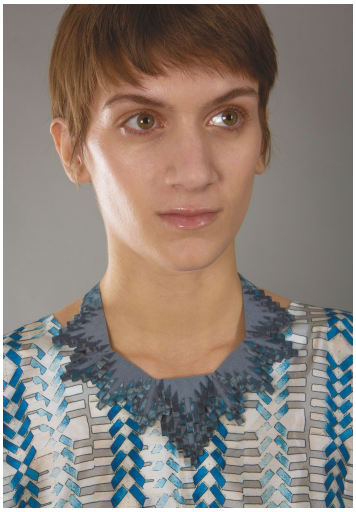


The original item is transformed into these pieces by cutting it into strips and handrolling, folding and stitching, creating a series of unique, one-off bag and jewellery products.

Taking the jacket apart and cutting it up along the etched marks, a skilled artisanal process transforms both the outer-layer and the lining into a collection of accessories.



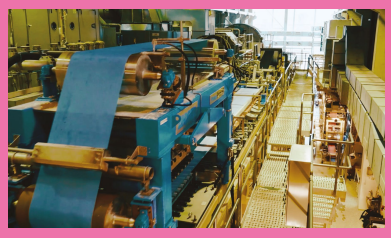
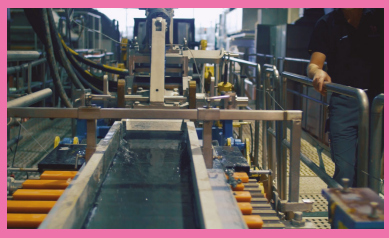
The bag panel folds into a classic clutch; the jewellery is worn as collars over any shirt or top. This collection of high-value objects combines the aesthetic qualities of the contrasting materials and reveals the patterns on the inside of the over-printed shirt lining.



At this stage, User 1 is 80-years old and her daughter is 47. Like the moment when the shirt became the jacket, the original User 1 gets the opportunity to see the shirt again – this time as jewellery or a bag. These hand-crafted pieces are made to last 20 years, being worn twice a year for quite special occasions. The jewellery can also go back into service at FKRF Luxury Loan. At the end of this cycle, the jewellery piece – perhaps quite tattered and no longer wearable – can be returned to FKRF who will put it into one of its polyester fibre-2-fibre recycling programmes.

Fast Forward: Fast and Light Fashion

Could our clothes be produced, worn and recovered to balance fashion with sustainability?

The Fast Forward concept explores alternative modes of production and use for a sustainable 'fast fashion' application. LCA advantages are enabled through lighter material choices; nonwoven fabric production; no launder; clear routes to recovery (designed-in at the outset); redistributed manufacturing systems. A sliding scale of 'speed' from ultra-fast forward (shortest-life scenario) through to a more accepted length of use with adaptations to production processes and end of life.

This offer amplifies the opposite approach of designing slow and enduring pieces to better understand the full spectrum of challenges from fast to slow fashion.

Materials have been specifically developed for the project in collaboration with scientific partners, and processes imagined as mass automated systems.

For this version of fast fashion to be complementary to durable quality products, industry must shift profit-making activity from the one-off sale of goods to gain value from the circuit of material flow or service based models.

These concepts evolve through multiple lifetimes over a 50 year timeframe (in order to provide a useful comparison to the slow proposals) but rather than change over time as a product, this story reflects the idea of 'material longevity' with multiple loops of efficient recovery at the heart of the sustainability focus. We see a great opportunity to mimic the qualities of transient cycles in nature, to provide the nutrients for an ecology of fashion.

Research Team:
The Fast-Forward exhibit is the work of Professor Emeritus Kay Politowicz and Dr Kate Goldsworthy, at the Centre for Circular Design (CCD), in collaboration with Dr Hjalmar Granberg, Scientist at RISE Bioeconomy, Stockholm. Lifecycle insights came from Sweden-based experts Professor Greg Peters (Chalmers), Dr Gustav Sandin, Dr Björn Spak (RISE) and Dr Sandra Roos (RISE:Swerea IVF). Material testing and consumer perception was conducted at RISE by Tatjana Karpenja and Siv Lindberg. CCD LDOC Post Doctorate Researcher Dr. Helen Paine provided research into industry mapping and commercial finishing processes for scaling up.

Designing for short-life with light and low-impact materials and recovery at end of life through paper recycling processes

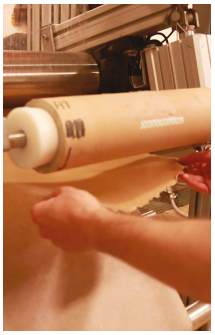
Paper Leather Jacket: Paper recipe no 9

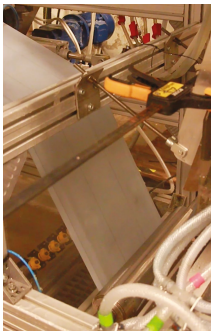
The use phase of this product is intentionally short. It is designed to be worn around 12 times over 6 months without laundry or maintenance and then returned for recovery & reprocessing. The whole cycle from raw material to recovered raw material is 10 months. Over a period of 50 years it is estimated that there would therefore be 60 ownership cycles (and 720 wears).

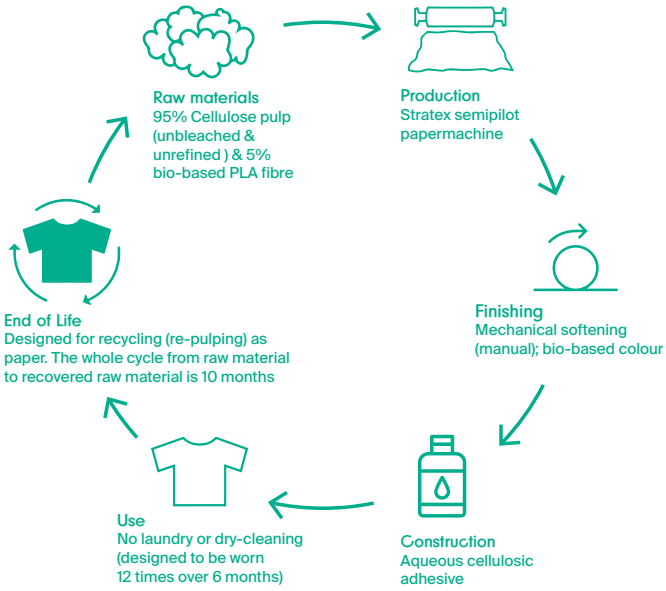
Made from a new bio-based nonwoven material co-developed by RISE & UAL.

The composition of the paper in this prototype is 95% Cellulose pulp and 5% bio-based PLA fibre. The original fibres are unbleached and 'greige' in colour. Whilst the first product in this cycle will be made from virgin materials it is hoped that it would be possible to use recovered or regenerated materials (CEL & PLA) in subsequent cycles, or recycled paper fibre content.

Paper Leather Jacket: Paper recipe no 9







The raw material is designed to be very strong but in its raw state is too stiff to be wearable. Finishing techniques are employed for both aesthetic and functional improvements. The paper is manipulated through repeated rolling in transverse directions, which softens it without appreciable loss of strength. Ground cochineal mixed with 2% Iron, ferrous sulphate powder, and 2–3% soaked logwood chips is applied to finished paper or at the fibre stage. Seaming was achieved through an experimental aqueous cellulosic adhesive applied by hand.

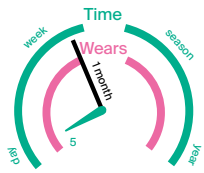
The results of recyclability testing show that the material is 99.9% recoverable as paper pulp which means it could be efficiently recycled.

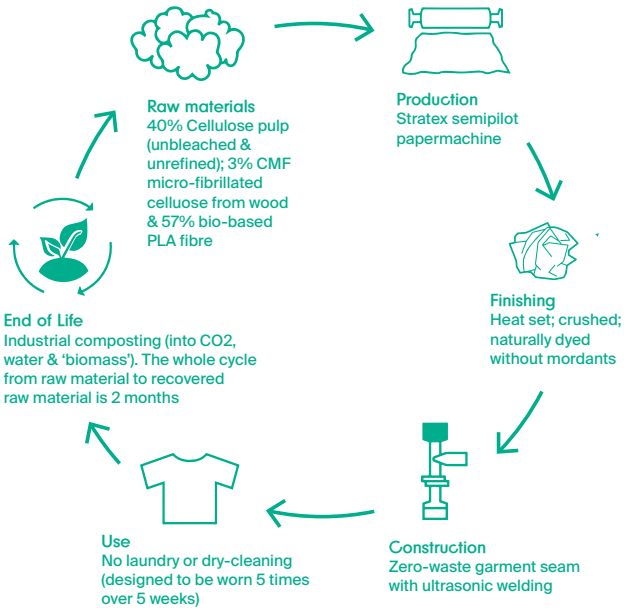
At the end of the 6-month wear period, the user returns the jacket for returns the jacket for recovery through domestic paper recycling channels. This is the beginning of the next material cycle.

Credits:
Concept & Finishing: Kay Politowicz, UAL, UK
Material Development: Hjalmar Granberg & Ann Marie Zachrisson, RISE, Stockholm, Sweden
Natural Dye: Penny Walsh, AO Textiles, London
Cellulose Adhesive: VTT, Finland
Recovery Testing: Tatjana Kapenja, RISE, Stockholm

100% Bio-based materials and finishes designed to be recoverable at end of life through industrial composting

Pulp-It T: Paper recipe no 7





Made from a new bio-based nonwoven material co-developed by RISE & UAL. The 45 g/m2 paper in this prototype is composed of 40% sulphate softwood paper pulp from sustainable forests, unbleached and unrefined; 3% CMF microfibrillated cellulose from wood; 57% polylactide (PLA corn starch) staple fibres. The main attribute of this material is its thermoplastic quality enabling many processes not usually possible with paper.

Credits:
Concept & Finishing: Kay Politowicz & Kate Goldsworthy, UAL, UK
Material Development: Hjalmar Granberg & Ann Marie Zachrisson, RISE, Stockholm, Sweden
Natural Dye: Penny Walsh, AO Textiles, London Laser
Welding: Supported by TWI, UK Ultrasonic
Seaming: Alan May, Triumph Needle, UK
Recovery Testing: Tatjana Kapenja, RISE, Stockholm

Pulp-It T: Paper recipe no 7

The use phase of this product is intentionally short. It is designed to be worn around 5 times without laundry or maintenance intervention and then returned for recovery and reprocessing.

The whole cycle from raw material through use to recovery is estimated at 2 months. Over a period of 50 years it is estimated that there would be 300 ownership cycles (and 1500 wears).

The paper is prepared using a heat process to fix the fibres for further finishes and ‘crushed’ to soften the surface. The material is then naturally dyed without mordants, including dyestuffs: cochineal (Striped-T) and natural indigo (Panel-T). Laminated layers of PLA are added through various laser and welding processes.

The garment is constructed using a Pfaff Ultrasonic machine as an alternative to traditional stitched seams.

At the end of the 5-week wear period, the user returns the top for industrial composting (into Co2, water & ‘biomass’). This is the beginning of the next material cycle.

Penny Walsh from AO Textiles, London, worked with us to find the best natural dyes for the new material. Here she works with natural indigo for the Pulp-It samples.

The materials were tested for their compostability at RISE under Tatjana Karpenja and her team. The results are available in her 2019 report.

100% RPET materials produced with integrated digital production and recovery cycles – local and distributed

Laser Line T: Recycled Polyester

The material in this concept has been enhanced through a laser welding finishing process. Made from commercially available 100% recycled polyester (RPET), the surface material is nonwoven in construction. No additional materials are added during the finishing and construction stages.

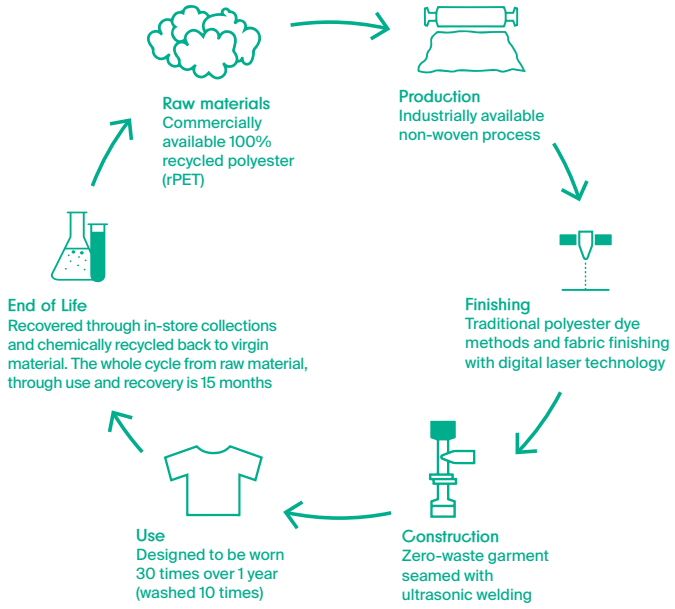
The use phase of this product is comparable to a standard fashion top. It is designed to be worn around 30 times over 1 year with laundry anticipated after 3 wears and then returned for recovery and reprocessing. Durability of the nonwoven material is improved through the finishing techniques.

The double-layer fabric is finished using a laser-based print alternative which simultaneously adds decoration and material reinforcement. The garment is constructed using ultrasonic seaming technology with flat-bed construction.

Designs can be digitally engineered and customised for local production close to market, and recyclability is retained through monomateriality.

Credits:
Concept & Finishing: Kate Goldsworthy, UAL, UK
Materials: with thanks to Teijin Europe and Freudenberg, UK
Laser Welding: Supported by TWI, UK
Ultrasonic Seaming: Alan May, Triumph Needle, UK
Scaling Up Research: Helen Paine, UK

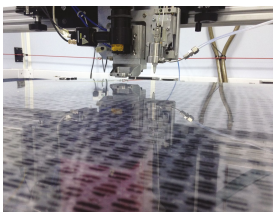
Laser Line T: Recycled Polyester

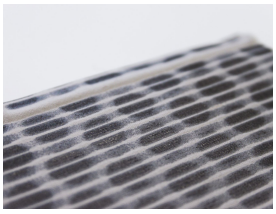


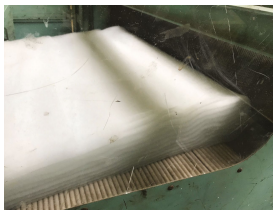
At the end of use the user returns the top for recovery through a chemical recycling system. The whole cycle from raw material to recovered material is 15 months. Over a period of 50 years it is estimated that there would be 40 ownership cycles.

There is potential for fast-forward sustainable concepts to be scaled up for a mass market in an industrial context. Local networks of manufacturers will be essential for this vision, from large scale manufacturing plants through to smaller entrepreneurial start-ups.

Extended technical understanding within an existing manufacturing landscape presents opportunities for future development of local, fast and circular material and fashion systems.





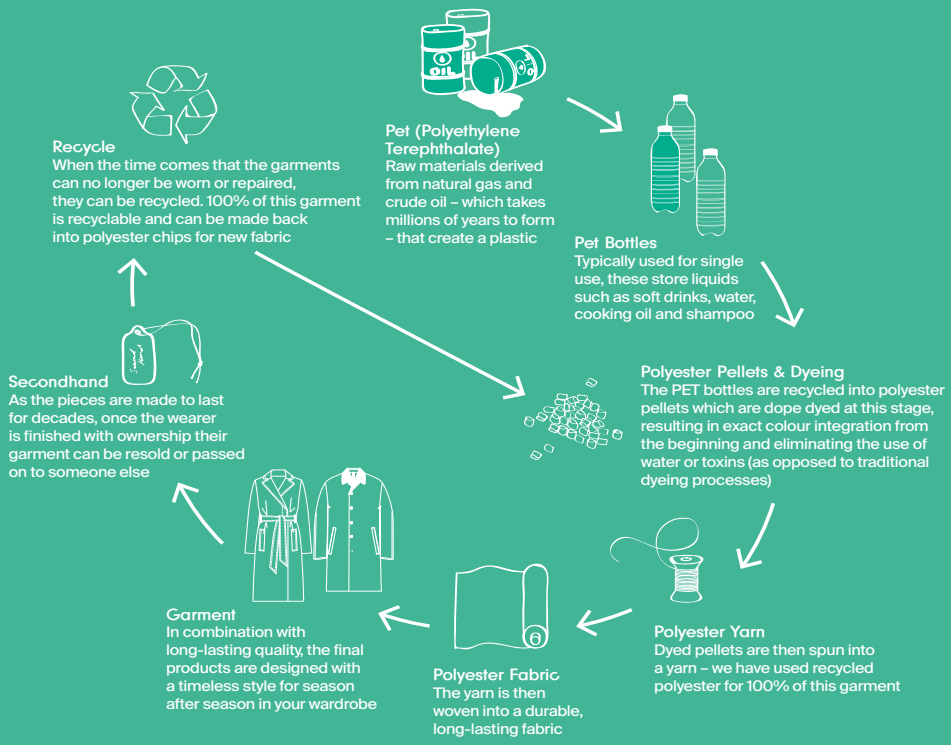


The recycled PET samples in the Laser Line project were developed with end-of-life chemical recovery in mind. Innovations such as Blend Re:wind developed in Mistra Future Fashion will be a key enabler of this concept in the future.

Helen Paine (UAL) spent 12 months exploring the potential of the nonwovens industry for scaling up the 'Fast Forward' concepts. She visited factories and research centres to understand and document the processes.

The Eternal Trench Coat

Material



Filippa K's philosophy is grounded in designing high quality, timeless pieces that last for many seasons. However, designing for full recyclability brings a new set of challenges to learn from in order to find a healthier approach in fashion. It currently requires making sacrifices when it comes to materials and design, and we've challenged ourselves to disrupt this pattern to create a Filippa K garment that is 100% recycled, and 100% recyclable.

Inspired by the slow speeds of nature and its ability to protect what exists while creating something new, The Eternal Trench Coat is made from a technical cycle utilising recycled polyester from plastic bottles. It is designed to last for a decade or longer: a classic trench style that works as a timeless topper for all seasons and is easily packable as well as water repellent. We are committed to supporting the wearer in mending and repairing the garment, and helping pass it along to a new owner if necessary. When it can no longer be worn, the coat is made to be recycled in its entirety with minimal effort to recreate the materials that it originated from.

Through this process we have developed new ways to use recycled materials in fashion, new technology to extend the life of clothing, and new insights for designing with future garments with full recyclability in mind.

'Extending the life of clothing by an extra nine months of active use would reduce carbon, waste and water footprints by around 20–30% each.'

Wrap UK, 2015

Circular Design Speeds Design for Permanence Filippa K

Changing the Timeline

A material that often has negative associations, polyester takes millions of years to create and 200 years to biodegrade. We've extended its life in the industry through circularity.

Recyclability

Consulting the expertise of Wolkat and Philtex* from the very beginning, we learned how to create The Eternal Trench Coat for full recyclability by using recycled polyester made from plastic bottles. Polyester is one of the slowest materials in the industry, and is unfortunately used most often in fast fashion. Using it to create a garment that lasts for at least a decade applies the principles of circular design by giving the material as long of a life as possible before its next phase.

As the industry isn't fully prepared for this shift, we discovered that we had to buy a large amount of fabric in order to reach the the minimum production quantity needed by the supplier. It required choosing the colour of the garment at the beginning of the process which limited our options, and the use of polyester has the side effect of shedding microplastics – a problem our industry partners are working to combat.

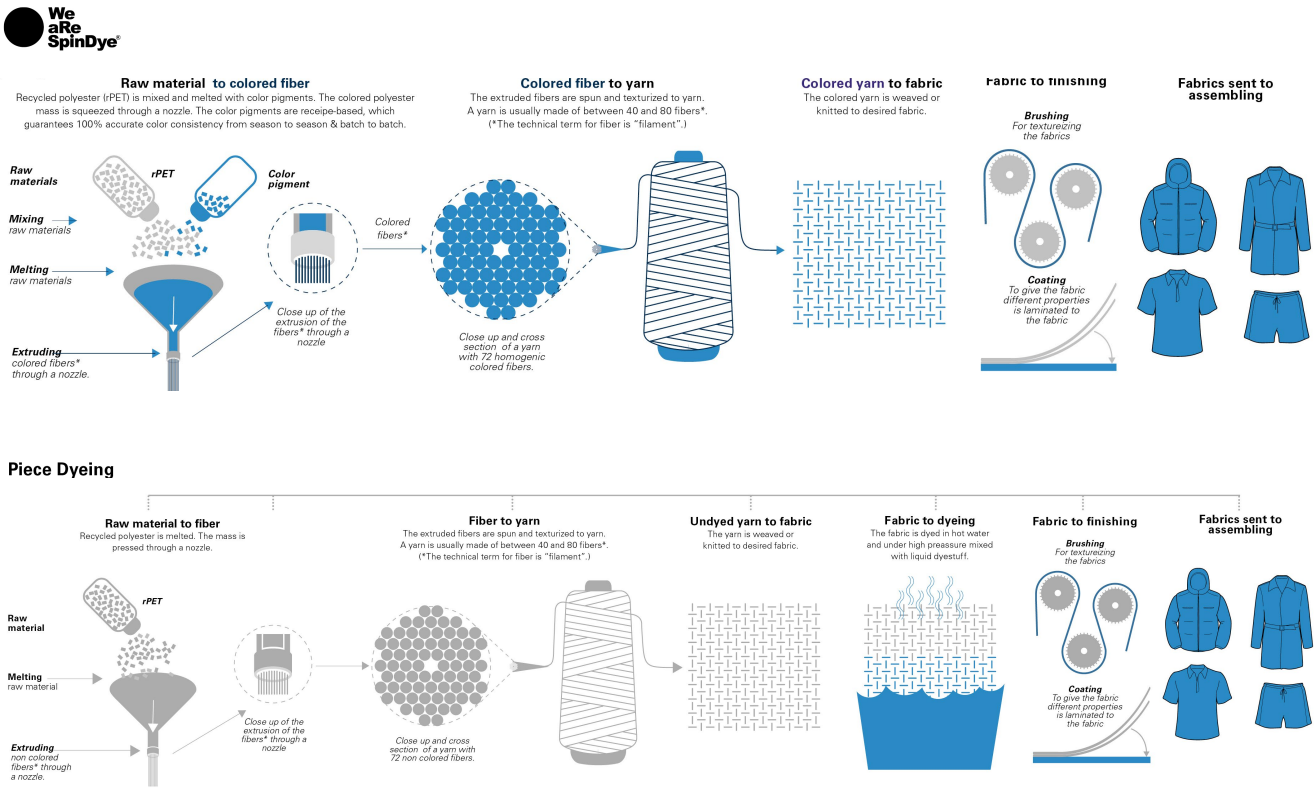
Using recycled polyester means that the raw material comes from single-use objects like PET bottles. This cuts waste from fabrics and reduces the amount of plastic ending up in landfills and the oceans. It also means that no virgin oil has been used to create the fibre. In the future we hope that polyester can be recycled in a closed loop over and over again, eliminating the need for virgin polyester.

*See Partnership Information to learn more about Wolkat and Philtex.

Using recycled polyester means that the raw material comes from single-use objects like PET bottles.

The Colour of Conservation

Material



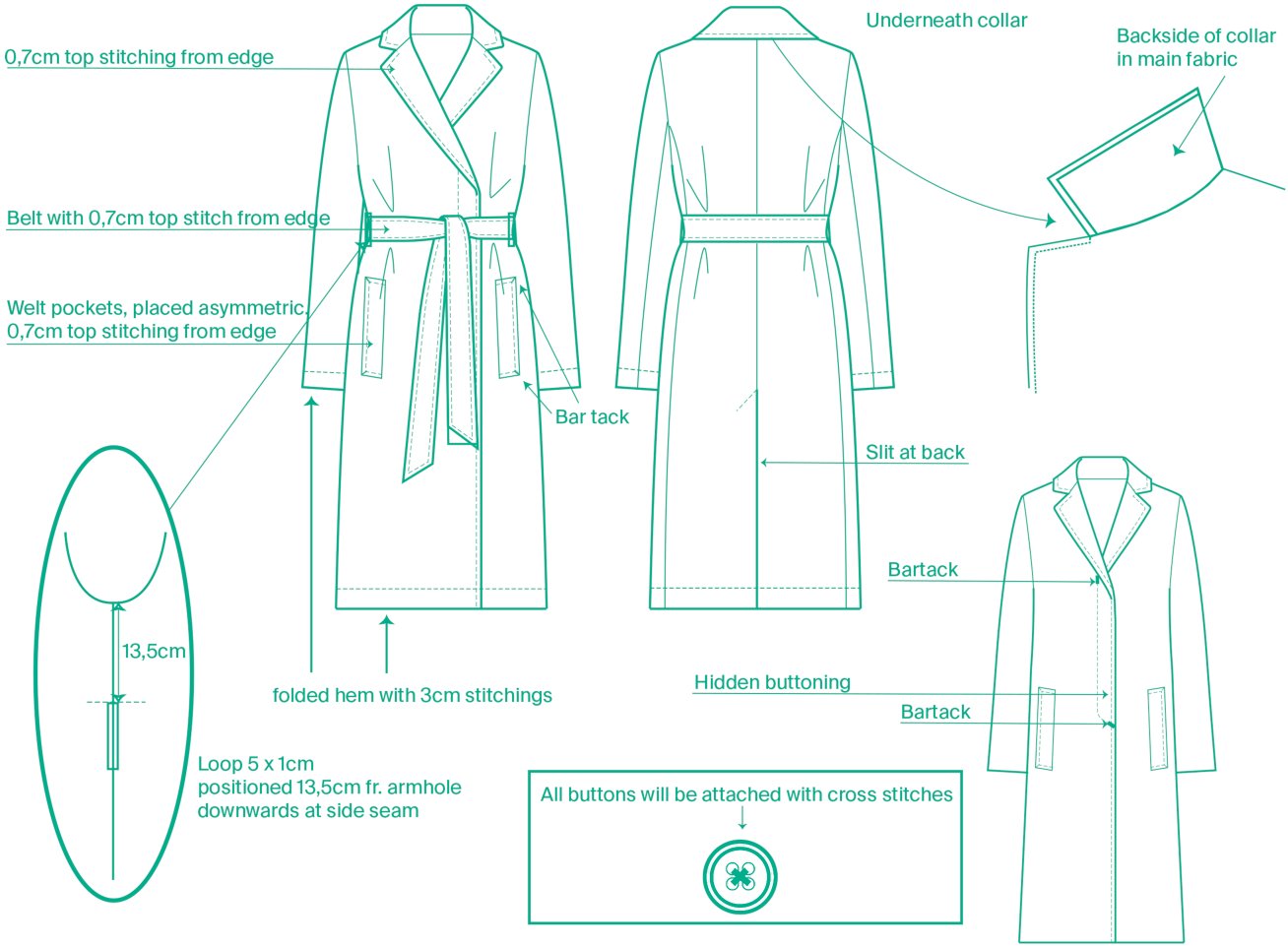
We've partnered with We aRe SpinDye®* to colour The Eternal Trench Coat, resulting in 90% reduced chemical usage, 75% reduced energy consumption and a smaller carbon footprint than a typical dyeing process. It has provided longer lasting colour vibrancy and extraordinary performance against UV light damage, wear and tear, and washing – above what is achieved by traditional dyeing.

In order to create water resistancy, this garment is finished with Organotex: an environmentally friendly technology developed by OrganoClick*. It is inspired by the way plants repel water, developed using biomimicry. This provides durable protection against water, snow, and stains from various liquids. The water repellency is highly durable and withstands numerous cycles of home laundry. Once the garment has been washed a handful of times, Organotex's water repellency spray can be used to refresh the protective ability of the coat. The spray biodegrades within 7 days and is non-toxic and solvent-free.

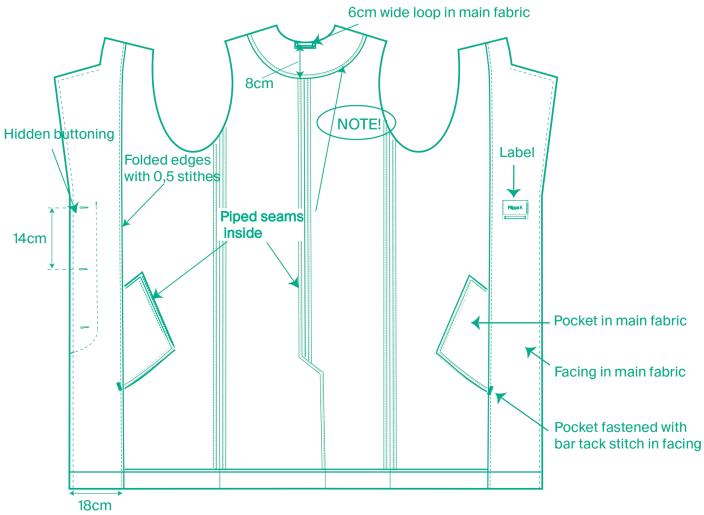
*See Partnership Information to learn more about We aRe SpinDye® and OrganoClick.

An Everlasting Style

Construction



The Filippa K design team cut the pieces in timeless silhouettes to support our aesthetic and the longevity of the garments. To maintain the recyclability we made adjustments from the original design: open cuffs replaced elastic, recycled poly sewing thread replaced bonded seams, and poly buttons replaced a zipper. FaTin*, a supplier Filippa K has worked with for many years, manufactured this coat at their factory which utilises an ongoing QuizRR* educational human rights program for sustainability in working conditions.



*See Partnership Information to learn more about FaTin and QuizRR.

A Finished Product: The Eternal Trench Coat

A rainy day layer, protective overcoat, or even an unconventional dress, the Filippa K 2018 Front Runner styles are inspired by the eternal elegance of the trench coat and its ability to suit any season or occasion. The light material can be packed easily for on-the-go accessibility, and the water-repellency makes it wearable in any weather.

Closing the Circle

Extend your garment's life through loving care and renew it as virgin materials through recycling

10 Years of Care

10 Years of Care is our guarantee to help care for Front Runners garments – for the next decade. Just like its inspiration in nature, the product is designed for a long life in a wardrobe. The customer can bring the coat back into one of our stores and we will help with any repairs the garment may require.

Garment Care Products

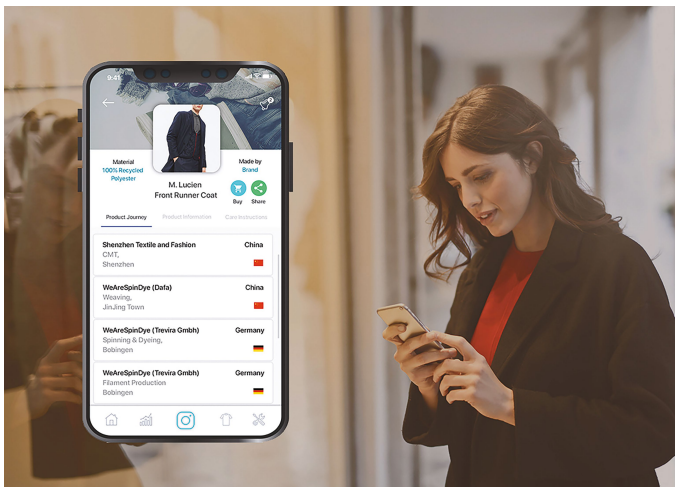
The Filippa K Clothing Mist freshens garments and shoes on the go with an active bacterial culture base that gets rid of unwanted odors, extending the time between laundering and providing a clever alternative to dry cleaning. The Guppy Friend Washing Bag helps prevent and reduce the microplastic waste in our oceans from washing synthetic textiles, and its unique structure protects all materials including natural fabrics to give them a longer life.

Recyclability

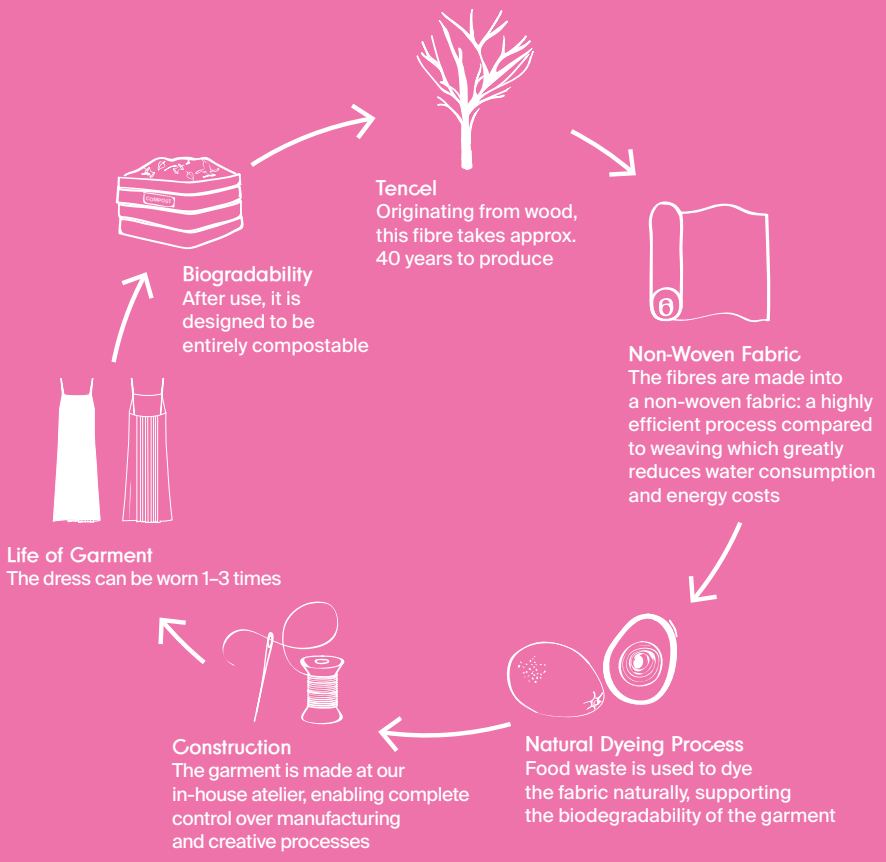
Once the garment is no longer in a state to be worn, it is ready to be chemically recycled. Recycling companies like our partner Wolkat offer the opportunity to recycle back into the polyester pellets used to create polyester from the beginning.

TrusTrace

TrusTrace is a groundbreaking digital platform based on blockchain technology for the fashion industry that provides supply chain and transparency tools that accelerate sustainability. This traces a fibre to the garment and back to the fibre. The ambition is to provide this information to the customers – making a garment's full journey visible. In the future it will also provide circular business model tools that support retailers engaging with customers by sharing product information and gaining insights about customer sustainability preferences. We have mapped the whole value chain for the Front Runners using this platform and will now accelerate the use by integrating the majority of our collection with TrusTrace.



The Throw Away Dress



An exciting vision that is not far from becoming an industry reality, Filippa K has designed a dress that is made from 100% bio-based material and is 100% biodegradable. Inspired by the fleeting elements of the world around us, the garment uses nature's life cycles to provide the wearer with an opportunity to update a wardrobe on a whim without negatively impacting the environment.

> Fast fashion as it exists today is not a sustainable way to consume, but speeds in nature are not defined as 'good' or 'bad'.

The butterfly that lives only for a few days is just as essential to the ecosystem as the elephant that lives for seventy years, and we would not want to be without the cherry blossoms, even though they only bloom for a week.

We decided to rethink this concept and find out if it is possible to maintain current consumer behaviour of fast fashion without the negative consequences. Dressing for an occasion can often result in discarding a piece that was only worn once or twice, so we challenged ourselves to disrupt this pattern.

Introducing The Throw Away Dress: the Filippa K way to cherish a garment for a short time. Rather than holding on to the clothing, it is the experience of wearing it that lives on through photographs and social media. The transient nature of the dress provides a unique and guilt-free opportunity to create special memories that last.

Away from the Drawing Board

We chose a non-woven Tencel fabric from Mogul because of its sustainability benefits and durability, as well as its soft and pillowy delicate texture.

Material

The creation process in fashion typically begins with a sketch. With The Throw Away Dress, designer Emilia Castles quickly realised that in order to fulfil our purpose we would instead begin with choosing a material that fits our needs.

What is Tencel?

Tencel, the lyocell fibre from Lenzing, is one of our favourite fibres to work with at Filippa K The material originates from renewable raw wood in sustainable farms, and regenerates from the pulp. Chemical solvents are then used to create the fibres, 99.5% of which are recycled in a closed loop process. Producing one kilogram of Tencel uses 1.4% of the water used to produce the same amount of cotton, and one square metre of land can produce 10 times more Tencel than cotton. Composed of natural material, Tencel fibres are biodegradable, compostable, and can fully revert back to nature.

Why Non-woven?

Non-woven fabric experts Mogul* provided us with the material for this garment.

By using a non-woven spunlace Tencel rather than a woven fabric, we've eliminated costly production processes. Mogul's spunlace process doesn't use external components other than the fabric itself, supplied to the mills in bales of staple fibres from Lenzing. It only uses water rather than chemicals, 80% of which is recycled for future use. Mogul also reuses all cutting waste to make up about 5% of overall composition, which means no waste stream is created.

'The benefit is that the process to make the material uses less water and energy since it is not made like a traditional fabric. It is also biodegradable. But the biggest benefit was showing how a non-woven, industrial type of material could be transformed into chic and wearable garments.'

Jodi Everding, Filippa K Fabric and Trim Manager

*See Partnership Information to learn more about Mogul.

Letting Nature Decide

Filippa K worked with Heart & Earth Production to develop and execute the dyeing process, using natural food waste provided by Sorunda Grönsakshall and Axfood.

Dyeing

Intuition led this stage of the creation as well, as we needed to use reverse design thinking rather than previous design experience to find useful discarded fruit and vegetable waste and invent new techniques to use it in the best way. What at first was a challenge led to a sense of openness and discovery throughout the dyeing process.

A pop-up lab was set up at the Heart & Earth Production studio, where the colours were tested and developed in a trial and error process of cooking the waste to create the dye. Much like a restaurant, each day began with a 'menu' that dictated what food was available for us to use. While typical dyeing processes consider the effects of washing, we had the freedom of disregarding this limitation which kept the process simple and spontaneous.

We experimented with many methods and techniques such as water colouring,

frottage, feather brush strokes, dip-dyeing, sponges, gravity effects, dripping, and batik with rubber bands.

As the Tencel changed and developed with each test, we were truly led by the characteristics of each natural element and how they interacted with each other. After an inspiring collaborative effort, the best results came from dip-dyeing using beetroot, red cole (horseradish root), blackberry, turmeric, and avocado to create a natural ombre effect.

See Partnership Information to learn more about Sorunda Gronsakshall and Axfood.

Unique Techniques

Made at our in-house atelier, Filippa K designer Emilia Castles used unconventional traditional techniques to achieve a modern concept.

Construction

By creating the dress in-house, Emilia had full control over the manufacturing and design processes. A personal hands-on project, it was a much more tactile experience because normal construction techniques were not effective on this material. The fabric defined what forms it would take, and the finished product had to be developed through creating unique shapes and structures.

Dyeing the fabric caused it to take on a fluffier quality than before. This led a collaborative decision with Heart & Earth Production to use a mangle, and Emilia discovered a machine in her apartment building in Stockholm that was available for use. A mangle or wringer is a mechanical laundry aid consisting of two rollers in a sturdy frame, connected by cogs and powered by a hand crank or electricity.

While the appliance was originally used to wring water from wet laundry, today mangles are used to press or flatten sheets, tablecloths, kitchen towels, or clothing and other laundry. Mangling is a traditional process that dates back to 1600.

The Tencel took on a silk-like feeling after the mangling process, and became easier to fold and construct. It inspired and enabled Emilia to pleat the fabric, adding structure that allowed the addition of more draped and flowing elements.

A Finished Concept: The Throw Away Dress

100% bio-based and 100% biodegradable, this concept dress is the Filippa K solution to fast fashion. It provides the wearer with an opportunity to update their wardrobe on a whim and dress up for a special occasion – while also reducing the environmental impact of this behaviour.

Closing the Circle

The Throw Away Dress is made from materials that are 100% compostable – it gives back to the environment it came from.

Biodegradability

Once the ownership phase of the garment is finished, it is designed to be put into a household compost or sent away for industrial composting.

Biodegradability simply means that the material will break down into its natural components within a reasonable amount of time. The Throw Away Dress has the added benefit of being compostable, meaning it also releases valuable nutrients into the soil, aiding the growth of trees and plants. Composting is seen as the most sustainable method for end-of-life garment disposal.*

This process closes the loop of circular design, moving away from the current linear model of fast fashion and our culture overall. Every part of the linear production process has been individually optimized, and long-term consequences have been largely ignored. In short, it's all about take-make-consume-throw away. In a circular economy, the idea is instead to create as little waste and as minimal of a social and environmental impact as possible, placing a higher value on the components throughout the value chain.

'Because cloth, pots, tools, and machines are solid objects, we can return to them again and again in time; we can linger as we cannot in the flow of a discussion. Nor does material culture follow the rhythms of biological life. Objects do not inevitably decay from within like a human body.'

Richard Sennett, The Craftsman

The Throw Away Dress goes against our traditional association with objects. We buy clothing as an investment – an object that becomes a part of us, a talisman that holds our memories. But what are objects in the digital age? More and more we remember through the photos we put online rather than the physical things we possess. This dress is tactical and tangible, but only for a few fleeting moments, to be recalled in the form of images and memories rather than its physical presence in our wardrobe.

*Information provided by Lenzing.

Mistra Future Fashion is a research program that focuses on how to turn today's fashion industry and consumer habits toward sustainable fashion and behavior. Guided by the principles of the circular economy model, the program operates cross disciplinary and involves 60+ partners from the fashion ecosystem. Its unique system perspective combines new methods for design, production, use and recycling with relevant aspects such as new business models, policies, consumer science, life-cycle-assessments, system analysis, chemistry, engineering etc.

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