ual: centre for circular design

Circular Speeds: A Review of Fast & Slow Sustainable Design Approaches for Fashion & Textile Applications

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Abstract

In this paper, developed by a group of design researchers at UAL, we define circular design in the context of a sustainable fashion system and consider how a polarisation of thinking in relation to "speeds" has occurred. By reflecting on the practice outcomes produced as part of the Textile Toolbox in Mistra Future Fashion (MFF) Phase 1, we question the idea of "circular speeds" for textile design and analyse concepts which relate to "super-slow" and "fast-forward" approaches. The MFF programme's cross-disciplinary approach brings together design and scientific researchers with industry experts in a bid to understand and recognise the potential for design in creating a circular fashion future at multiple lifecycle speeds. We review the historical context of "slow" before presenting contemporary case studies from industry which relate to one of three key approaches defined as a framework for "super-slow" design. We also review the current context of "fast" before presenting contemporary case studies from industry which point towards the potential for redefining the "fast" context in fashion by relating it to circular strategies and material recovery possibilities. Again, these themes are presented in a framework of three key approaches for "fast-forward" design. Finally, we bring together the analysis of both fast and slow and a single proposition for designing for the circular economy and as a starting point for the work to be developed by the design researchers. We discuss synergies and trade-offs between the approaches and suggest a middle ground for future investigation. Through this process we aim to generate insights about design that can be applied and tested by others. By reviewing current industry approaches and activity alongside academic design research, we propose a useful framework to demonstrate that the lens of speed can offer new opportunities towards a more sustainable industry.

KEYWORDS: circular textile design, design research, sustainable fashion, fast & slow

1 Introduction

This article aims to further the understanding of designing for textile product speeds in a circular fashion context, by examining theoretical, industry and practice-based research contexts (Earley et al. 2016).

Design and production has 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. In this paper the authors propose another way of viewing the speed of fashion products by building on the work of Fletcher & Tham around rhythms (Lifetimes, 2004), and also drawing insights from the authors' practice-based work during MFF Phase 1 (2011–2015).

The concepts of fast and slow fashion have gained increased attention during recent years. This may in part be due to a renewed and intensified media coverage of the unwanted implications of the fast fashion industry, which can be seen on a local, regional and worldwide scale (including water, air and soil pollution, climate impact, shortage of arable land, harmful and unsafe working conditions, poor workers rights', fatal factory accidents, etc.). In addition, the slow movement, which has been promoted by NGOs and other groups and individuals, is growing stronger. Slow living, spanning from food to fashion to other daily practices, is now an established phenomenon of the Western world – offered as an antidote to the fast-paced living that dominates our societies.

Furthermore, 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 over the last years. Circular approaches are now being explored by many fashion companies, and new technological advances bring us ever closer to a truly circular materials system.

1.1. Circular Design

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.

1.2. Fast, Slow and Everything in Between

The research on fashion and speed is well underway, starting with the research of Fletcher and Tham through their definition of "clothing rhythms" (2003) and the Lifetimes project (2004) which explored rhythms through wardrobe studies and classification of existing clothing archetypes. More recently these concepts have been explored through practice-based research with the work of Earley, Goldsworthy, Politowicz and researchers at University of the Arts London (Textile Toolbox, 2014), as part of MFF, Phase 2. This study aims to further add to the slow-fast fashion framework, by setting the scene in theoretical, industry and practice-based research contexts.

Carl Honoré's "In Praise of Slow" (2004) proposed that we seek balance – the right speed – and that we question the notion that faster is always better. This sits at ease with the sustainability discourse which calls for slower consumption and more durable products. But equally there are examples of all speeds in the natural world which point towards positive appropriation of both fast and slow systems. We see the same positive and expansive examples of the full spectrum from fast to slow in other industries, for example food and architecture. Street food offering fast yet authentic and healthy alternatives to the processes and mass-produced fast-food on offer in another part of the market, and even "fast architecture" providing appropriately temporary building structures for disaster zones or short-life exhibition concepts. Perhaps slowing down is not the only solution to the environmental challenges we face.

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 Towards Designing for Circular Speeds

In this paper the authors set the scene for MFF Phase 2 research (2015–2019). The intention is to develop the discourse on from simply fast and slow, to a level where multiple and proportionate speeds can be both understood, tested via LCA 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.

The results from this research will feed into ongoing research, with the production of prototypes in 2018 and the publication of design guidelines for the circular fashion industry in 2019.

2.1. The Role of Design in a Creative and Collaborative Methodology

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, cannot be nurtured and developed in academic silos and so research is being 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 confined 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 materializing a future in which such an artifact exists.”

Design can play a pivotal role in improving performance at every stage of the socio-material lifecycle. By working in communities of practice, designers can identify both the physical and psychological barriers to more sustainable solutions, translating them into creative proposals for transformation.

Design can work at both micro and macro scale (both materials/products and systems innovation) to avoid the often-unintended consequences which can come from looking only at parts of the lifecycle and value chain. Designers need to work with circularity principles within a sustainability framework and to fully understand the technical and biological cycles within the circular economy. Yet innovation in the field has shown us that for textile designers, circular

design also needs to consider how these cycles can interconnect; and how understanding the speed of these cycles is also important in making appropriate design choices. The inter-disciplinary practice-based textile design being carried out in this project aims to generate new insights for this emerging design field.

The overwhelming complexity and lack of transparency of environmental problems can be discouraging. But designers have an ability to apply systems thinking, in a creative method that Ackoff (2006) terms "problem dissolving", which shifts the problem into a new context. Designers can then construct new approaches based on reflection, logic and the generation of creative, speculative ideas. To do this, the poetic and lateral-thinking outcomes of the design process are best achieved in collaborative communities of practice. In order to be influential to innovation on a large scale, design outcomes need to be pre-emptive rather than reactive and locate physical products as part of material and immaterial systems.

We are seeking to relate these material (in the broadest sense) choices appropriately to a specific lifecycle context. All garment journeys are not the same and all users are not uniform in their behaviour and wardrobe curation. Each fashion consumer will have a complex and varied collection of garments in their care and this variety and complexity is essential in any consideration of a solution.

2.2. Circular Design Through the Prototype

Designers are intrinsically connected to materials in proposing their transformation into objects, which have both meaning and practical application. However, a C21st understanding of the expenditure of energy, water and valuable material commodities to make artefacts, is also leading us to seek "immaterial" extensions of objects in use, as propositions to lighten the material load. A way forward for the fashion designer is to study the preferences and behaviour of a particular social group. Understanding their aspirations and the triggers to purchases can enable designers to propose desirable models for an improved fashion system.

To achieve sustainability and circularity through design, an understanding of impacts through all stages of the life-cycle must be understood in order to tackle the reduction of damage resulting from existing practices. A product can be redesigned to improve its overall performance, by understanding its context in this lifecycle system. "Re-directive practice" results in what Fry describes as design "re-coding": "the exposure of the unsustainable and the declaration of means of sustainment" (2009). When this is embodied in a prototype, the reflective "conversation" takes place in a series of project revisions. As a result of surprise realisations or "backtalk" from the prototype, the designer can test, redesign and collaborate with other disciplines and ultimately, with the consumer, who can become part of the prototype community (Winograd 1996). In this way we are using the prototype alongside multi-disciplinary collaboration in order to question and find insight on these circular models. First to expose the unsustainable elements in order to then design them out of the system.

But how can designers know that they are not simply sustaining the unsustainable, in working towards reduced impacts? They cannot. Popper (1984) summarized the dilemma: "It is important that we realise just how little we know about these unforeseeable consequences of our actions. The best means available to us is still trial and error: trials that are often dangerous and even more dangerous errors. What remains is the problem of selecting among our tentative solutions, "our guesses" according to a method that is open to us." Designers can only integrate the components they believe are necessary for sustainability, while making key trade-offs in search of better design solutions. The "re-direction" of generic design observed in all individual and social activity, is best complemented and reinforced by a systems approach in "transition design" (Irwin, Tonkinwise and Kossoff 2015).

However, we are mitigating this uncertainty through developing relationships between the hard and soft elements of the research. By working closely with both science and industry partners on the project we aim to reveal deeper insight and map metrics into the design process (Goldsworthy et al., 2017). Further work with stakeholder groups and a programme of designers-in residence (both with science and industry partners) will expand and evolve the understanding of issues.

3. The Polarisation of Fast and Slow Fashion

During the first phase of the MFF project researchers from UAL identified a gap in knowledge through their "design prototypes" developed for the Textile Toolbox project. 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 guidelines for design. Thus "speed of cycle" became the focus of the research as it moved into phase 2. This paper represents the results of an academic review of the literature conducted during 2016–2017 in order to better understand the challenges this may bring to design and to prepare for an action research phase, including workshops held with participants in the UK, Sweden and USA, as well as the development of design research prototypes.

3.1. Circular Speeds Emerging from Textile Toolbox

The culmination of the first phase of MFF was a series of design artefacts or prototypes which explored the themes of the research through making. These textile/fashion artefacts, could be described as "propositions" for a new way of thinking about designing sustainability into fashion, using THE TEN (TED 2013) as a starting point and framework for the briefs (see Figure 1).

The resulting ten prototypes were each developed by an individual researcher, or small group of collaborating researchers, in response to the following aim – "examine the range of decisions that designers make during product development phase using the framework of

TED's The TEN". When analysing the ten prototypes it became clear that whilst each responded to the same challenge of "circular design" through their creation there was a polarisation of the ideas in relation to design approaches and "speeds".

Figure 1: Textile Toolbox concepts & showcase, MFF, 2014 www.textiletoolbox.com

As expected most of the approaches were looking at ways to extend the use phase of the product (in both physical and emotional durability strategies) whilst three of the prototypes had little or no reference to product longevity and were rather concerned with easing the flow of materials back around the lifecycle, creating garments which were designed for a particular material-recovery technique or even intervened with the material at the actual point of recovery itself. These garments could be short- to mid-life in "product longevity" terms but the materials could be potentially recovered over an extended period of time resulting in "material longevity".

The analysis in Table 1 shows the reviewed circular design approaches grouping around the seemingly opposing ideas of a) extending the life of a product and b) designing in recovery of materials; fast and slow. 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.

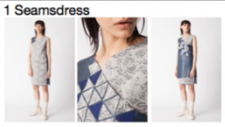
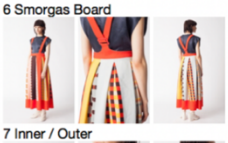
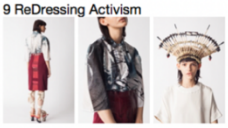
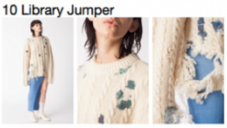
Exhibit	Concept	Circular Design Approach	Exhibit	Concept	Circular Design Approach
1 Seamsdress 	Vertical laser production for monomaterial garments increases recyclability at end-of-life stage	Material Longevity: designing for ease of material recycling	6 Smorgas Board 	Designers who provide playful tactile tools for users, empowering them with democratic digital design approaches and emotionally durable products	Product Longevity: designing for emotional attachment (through co-design)
2 DeNature 	Coded materials generate unified identification for enhanced recyclability in a closed-loop chemical recycling system	Material Longevity: designing for ease of material recycling	7 Inner / Outer 	The transition of design practice as 'social entrepreneur' connecting inner and outer change through making	Product Longevity: designing for emotional attachment (through mindfulness)
3 A.S.A.P. 	Short-life, high-speed production, carbon-low materials for fast recovery and repurposing for appropriate user behaviour in a high volume fashion context	Material Longevity: designing for ease of material recycling	8 Shanghai Shirts 	Aesthetics and symbolism, combined with upcycled garments, encourage better consumption decisions made by users	Product Longevity: upcycling for extended material use (by user)
4 Sweaver 	Discarded Swedish fashion becomes high-end upholstery and accessories when crafted by a network of cabin weavers	Product Longevity: upcycling for extended material use (by craft industry)	9 ReDressing Activism 	Upcycling and activist approaches inspire, educate and support emerging fashion textile entrepreneurs	Product Longevity: upcycling for extended material use (by user)
5 Fast ReFashion 	Designers who provide democratic upcycling design services for users, employ online and domestic tools	Product Longevity: designing for emotional attachment (through co-design)	10 Library Jumper 	Designers employ collaborative consumption and collective repair approaches	Product Longevity: designing for extended material use (through user repair)

Table 1: Analysis of design concepts from Textile Toolbox, 2014. Photography; Philip Koll

Thus, according to these definitions of circularity relating to "speeds" the prototypes could be ordered on the following scale (Figure 2).

If we look at the prototypes at each extreme of the scale (ASAP and Fast ReFashion) we can see that they could both be described as "design for circularity" through a proactive approach to retaining material value within "circular fashion systems". Designing in order to enable joined-up cycles of material use is the ultimate aim for both approaches, but this "speed" of cycle creates very different challenges when making informed and appropriate design choices.

The two approaches, are extreme opposites but complementary; “short-life” closed-loop garments 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 MFF2, we aim to gain insights into creating an effective circular materials economy, which acknowledges the complex nature of our current and emerging fashion system.

Figure 2: The Circular Design Speeds spectrum of Textile Toolbox concepts, 2015, Photography: Phillip Koll.

The following two sections review design approaches from an industry context in line with this initial framing of “design speeds”. In order to understand how these two approaches might serve the existing fashion industry we conducted a review through the lens of fast and slow examples.

4. Slow: Brands Designing for Product Longevity

4.1. Context of Slow

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” and to represent “high quality, durability and low impact production”. Ironically this often relates only to the slowing of use and production phases and often fails to acknowledge the slow nature of synthetic materials in the raw material part of the lifecycle. Oil based synthetic fibres are based on 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.

4.2. Extending Single-User Lifetimes

This approach is achieved through functionally durable materials, timeless style & care/repair services.

This approach seeks to keep products in use as long as possible during their first life. There are many examples of companies, both traditional and contemporary focusing on material quality and durability as their manifesto, with some even guaranteeing extended durability. Many of the brands seek to use design to achieve a “classic” product – one that does not adhere to changes through trends. A few of the brands in this section invest resources in offering the user extended care and repair options or advice to the user for home care in order to maximise the life of each garment. Often companies provide all these services and approaches in tandem.

Companies who provide a focus on durable materials, timeless style or care & repair services aiming to prolong the life of a garment include; leading sustainable fashion brand Filippa K (Sweden) who develop their “Front Runners” collections to be covered by a “10 years of care” warranty system. Care of garments is emphasised with a simple guide available online giving the consumer information on how to wash mend and care for their garments; Tom Cridland (UK), created the “30-year collection” of T-shirts, sweatshirts and jackets that have a 30-year guarantee. Designed to last, any item within the range can be returned to be mended for three decades, and have been shrink-tested over 100 wash and dry cycles; outdoor company Houdini (Sweden), offer a repair programme in store to avoid replacing products that can still be used, and also promote customer involvement with garment care extending life with a set of comprehensive guidelines available online.

Other companies offering a repair service as standard include; Eileen Fisher (USA) who offer a free repair service covering moth holes, missing buttons and broken zips; Nudie Jeans (Sweden) place their repair stations visibly in store and repairs are conducted on the spot or if no longer wanted are washed, repaired and resold as second hand; Hiut Denim (UK) provide free repairs for life on all their jeans, which come with a unique number that the consumer can

use to sign up the Hiut HistoryTag website. This allows customers to update the story of their jeans, where they have been, and the memories that go with them. If the jeans end up in a second hand store the story can go with them.

4.3. Enabling Multiple-User Lifetimes

The focus here is on brand leasing and clothing libraries, peer-to-peer sharing platforms and resale, charity and branded resale.

These business models provide services to give existing products new life opportunities through multiple users without material changes. All of the featured examples offer services which give products a new user life through leasing, sharing, charity options and branded resale.

Multiple-user lifetimes can be enabled in many different ways but many fashion brands are beginning to offer leasing services as part of their portfolio; Filippa K (Sweden) Lease collections are available to be leased, at a cost of 20% of the full price (this includes the cost of cleaning) for a loan of 4 days. Taking this even further the brand has developed the "Filippa K Collect" a return program which invites customers to bring unwanted garments to be resold in dedicated stores and are rewarded with a 15% voucher off the next purchase; Uniforms of the Dedicated (Sweden) runs a service called "Time Share" which is a way to rent selected suit jackets and outerwear. The scheme is offered at 15%-20% discount on the full price depending on loan period; MUD Jeans (Netherlands) was one of the earliest examples of lease wear with their "Lease A Jeans", which functions through a monthly subscription for 12 months. At the end of the year, the jeans can be kept at no further cost or exchanged for a new pair with a continued monthly fee.

Other brands are basing their whole business on a "clothing library" model; Klädoteket (Sweden) is a fashion library made up of second hand, vintage and designer collaboration pieces. Garments are categorised, and each category is worth a certain number of points to allow for a range of price-points to be included in the service; Vigga (Denmark) is an online rental service that gives parents subscription for organic children's clothing and maternity wear. Items can be returned and exchanged for the next appropriate size when needed; RentezVous (UK) is also an online rental service that has two strands with its business model. The first is a collaboration with designers allowing its customers to rent garments that they otherwise might not be able to afford. The second approach allows the consumer to profit from the rental of their own clothing which they can list online; Curatorz (Sweden) is a high-end fashion rental business that allows its customers to lease quality fashion items for 3 or 7 days at a time and returned to be laundered.

Peer-to peer sharing and resale platforms are also growing in popularity; Sellpy (Sweden) works as a resale tool for unwanted items with more of a focus on customer convenience than other more well-known peer to peer resale sites. A Sellpy bag is ordered and filled with unwanted items and collected from your door. Items are sorted, photographed and sold via the Sellpy website on behalf of the customer and a percentage charged on the sale. Anything not sold is either donated to charity or recycled; Shareware (Sweden), is an initiative which works with the use of social media platform Instagram. Using the hashtag #sharewear users can comment on a garment they would like to share. Once the owner has been contacted, a meeting is arranged for the garment to be handed over. Consumers are encouraged by a set of "rules" to only keep the item for one week, and then to pass the item forward in the same way they received it; Swishing (UK) was originally established by Futerra, who describe Swishing as "to rustle clothes from friends". Swishing parties, as they are known, are formally or informally organised on the premise that each person in attendance brings at least one item of unwanted clothing to contribute.

Charity and branded resale businesses include; Eileen Fisher (USA) who have a service called "Fisher Found", a national take-back programme launched in 2009 to take back any Eileen Fisher items to any store where they are resold with all profits of the second-hand resales going to charity; Myrorna (Sweden) is the largest retail chain of second-hand goods with the largest collection of goods in Sweden. All items are donated from the public or businesses and are sold within stores around Sweden or overseas; Oxfam (UK) is a charity based on public donations of unwanted clothes and sells them on in a large network of UK stores as well as an online store (Oxfam vintage); Remake (Sweden) is a design brand offshoot from Stockholm's Stadmission second hand stores. Although it has been around for fifteen years it is only in 2016 that the designs have been sold in a dedicated remake store.

All of these initiatives could encourage product longevity through multiple-user lifetimes.

4.4. Product Reconstruction & Recycling

This approach involves reinventing existing products through design intervention.

The approaches discussed so far achieve longevity with little or no "recycling intervention". These next examples create new product lifetimes through designer-upcycling, product reconstruction, remanufacture and mechanical recycling. Examples represent the first stage of material reinvention in order to re-elevate the value of existing products and make them suitable for further lives. This group of brands use remanufacturing approaches – achieving longevity through reinventing existing products with design intervention; Christopher Raeburn (UK) is a luxury fashion designer who has made his name as through various innovative collections and collaborations re-appropriating military material to create contemporary clothing and accessories; Rood by Rens (Netherlands) is a clothing collection that is "connected by the colour red" giving unwanted clothing a new lease of life through dyeing it with the same

red dye to create a varying shaded collection. The red shade of each garment is dependent on the original colour, and raw materials of the garment; Lindex Re:Design (Sweden) collaborated with Re:textile at The Swedish School of Textiles in Borås to work on a pilot project, launched March 2017 upcycling denim garments collected from their previous collections; C/O Cheap Monday (Sweden) is an "upcycling project made entirely from recycled textiles" that was launched in 2016. The 500-piece unisex capsule collection is formed by disassembling and reforming unwanted clothing, many of which were collected through the bins in store, and upcycled at the Cheap Monday Stockholm HQ studio.

But material reconstruction can also happen at a more material level through mechanical recycling methods. Many craft-focussed designers are finding innovative ways to reuse waste textile materials and fibres, from crafted reconstruction of post-consumer fibres back into yarn or nonwoven textiles or into composite materials for other industry uses. Anneka Textiles (UK) is a startup business using post-consumer fashion waste to create new materials. Collecting unwanted knitted garments comprised of a mix of fibres and blends, they are colour sorted into shades ready to be mechanically pulled back to fibre, before finally spinning or felting into new materials; Sophie Rowley (UK) collects waste materials, such as denim offcuts and using a bio-resin, creates sculptural pieces that can be carved into products. In this process the layers and patterns appear, which resemble marble; Precious Waste (Netherlands) by designer Michelle Baggerman was a project that created a new material by spinning used plastic bags and weaving a cloth, that can be used to make new bags with an extended life span. This process is all done by hand without chemicals, heat or electricity and is still able to be recycled at the end of life.

Larger commercial entities are also improving on mechanical fibre recycling of predominantly pre-consumer (industrial) waste materials which provide a scalable and reliable source of raw materials; Recover (Spain) takes post-industrial cotton waste, and shreds the fibre to upcycle it into yarn. By colour sorting the waste materials, they have developed a "colourblend" product with selected colour fibre waste and a carrier fibre to strengthen the yarns, such as recycled plastic bottles; Pure Waste (Finland) is a fashion company using industrial cutting waste from garment manufacturing. The waste is sorted by colour, and spun in to yarn without using dyes or fresh cotton and saving the environmental impacts created in virgin cotton production; Bright Loops (Netherlands) mechanically recycles post-consumer woollen jumpers, sorting them by colour, and blending with post-industrial waste or new durable fibres to create a new strong yarn.

5. Fast: Brands Working Towards Material Recovery

5.1. Context of Fast

The increasing dominance of "fast fashion" in the current commercial context, results in a fast-moving market full of products designed to be cheap and economically efficient in production.

This in turn results in the use of low-cost materials and labour, short lead times and high volume production systems. The consumer often places little value on these seemingly expendable items, buying in bulk and discarding quickly. A key insight from the 2017 Ellen MacArthur Foundation report showed a trend towards the increased volume of clothing sales and the corresponding decline in clothing utilisation (or longevity). Namely, more items worn fewer times before disposal.

This is the total antithesis of the aim of the sustainable design movement in fashion and it seems 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 truly spectacular leaps in technology towards full "fibre to fibre" recycling. There are many technologies in development which can handle a supply of mixed fibre waste which is 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 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 and even a positive assessment of those garments which are unable to utilise a "slow approach". The reality is that not all garment archetypes can aspire to this.

5.2. Advances in Material Recovery

The focus here is on technologies which can recover virgin quality materials from existing textile waste streams; chemical recycling of PET, cellulose, mixed waste, and sorting technologies.

The "Well Dressed" report (Allwood et al. 2006) stated that there had been "no innovation in the recycling of textile fibres for over 200 years". Whilst this was the case in 2006, it certainly can't be claimed today. There has been unprecedented innovation and progress in technologies which can recover virgin quality materials from existing textile waste streams in the last ten years and many promising processes are now moving from the lab to pilot stage. In this section we review the current leaders in this "space race" and set the scene for a very different landscape of raw-materials, making vast amounts of currently unusable materials available. Here we look at two key areas of growth, fibre-to-fibre recycling and food waste as a raw material for many of the new fibres coming to market. We are not reviewing the entire

landscape of existing processes (mechanical recycling and composting which will be covered later in the project) but rather we point to the potential for virgin-quality recovered fibres as a way to improve the sustainable credentials of a material and even clean up other industries waste streams.

The chemical recycling of PET (polyester) has continued to be developed since Teijin, based in Japan, were the first to bring fibre-to-fibre technology to market with ECO CIRCLE™ in 2006. The process resulted in virgin equivalent polyester and was reported to have reduced CO2 emissions by 77% and energy use by 84% when compared with conventional polyester. However it also commanded a 20–30% higher price (EMF, 2017: 99). Recycling innovators such as JEPLAN and Ioniqa are continuing to push this technology closer to market and research consortia including scientists in the Trash-2-Cash, Mistra Future Fashion (www.mistrafuturefashion.com) and Resyntex projects are also driving progress in the lab.

Cellulose-based textile waste can also be chemically recycled into a high quality regenerated fibre source. Evrnu (US) developed a pair of jeans made from regenerated cotton from five old t-shirts; The Infinited Fibre Company (Finland) has developed a process that processes cotton rich textile waste into new fibre without degrading the quality; Re:newcell (Sweden) takes high cellulosic content post-consumer waste to create a lyocell or viscose fibre, that is high quality in terms of tensile strength and abrasion; Ioncell-F technology (Finland) can convert waste cotton into new textiles using a non-toxic and environmentally friendly Lyocell-type spinning process.

Blended materials, which are challenging to recycle, are also being explored with success. For example, recycling start-up Worn Again (with H&M and Kering) has developed a process that can separate and recapture polyester and cotton from pure and blended materials into virgin-equivalent polyester and a cellulose pulp that can be used to produce lyocell or viscose. The Hong Kong Research Institute for Textiles and Apparel in partnership with the H&M Foundation also recently developed a new process to separate cotton-polyester blends, as have researchers within the MFF project with the ReBlend initiative from RiSE (Sweden).

Waste streams from other industries, in particular agriculture and food waste, are also being utilised to create new materials, with both natural and man-made processing. This not only creates new and interesting materials which are often bio-compatible but also provides a solution for eroding waste streams for other industries. Orange Fiber (Italy) uses the tonnes of waste citrus fruit peels produced by the pressing and processing of oranges to create regenerated cellulose fibre (viscose); Fruitleather (Netherlands) is developing a new alternative leather made from fruit waste by collecting local wasted fruit and processing through mashing, cooking and drying; Ananas Anam – Pinatex (UK) has developed a leather alternative non-woven material from pineapple leaves. This innovative and high-performance textile is the by-product of pineapple harvest, and requires no additional land, water or

fertilisers. Effectively, the raw materials for this group of fibres are bringing positive impacts to the industry they originate from.

5.3. Designing FOR Recovery

Here we explore in-built design features which enable more efficient recovery to support material recovery; design for disassembly, monomaterials, biocompatibility.

These imminent technology breakthroughs provide an interesting challenge for design in the future. The increased take-up of circular design thinking is already changing the way industry responds to sustainability challenges and approaches. Many companies are embedding these principles into their product development at the outset, creating garments which are specifically designed for an end-of-life recovery route; either biodegradation or closed loop chemical recovery.

Designing products for composting or biodegrading safely requires the use of wholly biocompatible materials and finishes. Adidas/Biosteel (Germany) collaborated with AMSilk to develop a pair of trainers with an upper made from Biosteel, a material that can be dissolved at home using an enzyme and water; C&A (Switzerland) and DyStar (Singapore) collaborated to create compostable t-shirts made of 100% organic cotton with no exposure to harmful chemicals and using renewable energy; Lauffenmuehle (Germany) produce Reworx, a "regenerative fabric" launched in 2017 which can be safely returned to earth as a biological nutrient including textile fibres and chemicals; Freitag (Switzerland), usually known for their upcycled "truck tarp" bags, have launched a fabric for use in workwear called "F-abric, Broken Twill". The material is 100% naturally biodegradable – including threads and selvage, with metal buttons designed to unscrew for re-use.

Designing recoverable polyester products for closed loop recycling requires, at present, the need for monomaterial (or close to monomaterial) fibre content. reWEARness (Netherlands) has developed a circular service model for its work wear, with garments made of 100% recyclable materials that can be broken down and remade into new woven material ready to be used again; Wear2 (UK) have created a thread which can be "dissolved" using microwave technology thus allowing garments to be disassembled at the end of life; Natulon (USA) has developed zips made completely from post-consumer polyester including the zip pull, teeth and tape, so that the whole zip can be perpetually recycled through a chemical recycling system.

5.4. Reducing Production Impacts

There is great potential in innovative production systems which reduce overall impacts of garments; streamlined and vertical manufacturing, redistributed production, automation, mass-customisation.

Early analysis of life-cycle thinking resulted in a visualisation tool named the “Speed Cycle” (Goldsworthy, 2017), which showed that the same impact savings might theoretically be possible through reducing production impacts as for increasing garment usage. i.e. halving production impacts could have the same result as doubling the use phase. This can mean reducing impacts in an existing production system through energy efficiency, reduction in materials use and increased use of recycled materials. But it can also relate to more radical thinking. Research from Roos et al. (2015) showed that there are considerable environmental cost savings to be gained through the adoption of nonwoven materials for fashion applications due to the reduction of processing steps required in the fabric production phase. There are also several examples of companies focused on this stream-lining of production which show promise, including localised and on-demand production (re-distributed production), mass-customisation, vertical and merged manufacturing processes and augmented reality applications.

In particular the explosion of RdM (Re-distributed Manufacture) could be at the forefront of the next “industrial revolution”. According to a recent UK research project Future Makespaces (Stewart & Tooze, 2015), RdM can be understood to be: technology, systems and strategies that change the economics and organisation of manufacturing, particularly with regard to location and scale. There is a drive towards smaller-scale local manufacturing caused by changes in transport and labour costs, the availability of materials and energy, the need for sustainability, the availability and cost of small-scale equipment, and access to information. “The potential for smaller-scale manufacture has been made possible by a combination of new technologies, small-scale flexible manufacturing equipment, and new manufacturing processes. In turn, these changes are driving the development of new business models and supply chains, changing dynamics of work and communities, and have immediate implications for industrial and social policy”.

Local, automated & customised production could be set to have a huge impact on the “long tail” (Anderson, 2006) of small fashion businesses and as such, the industry as a whole. Unmade (UK) has developed software linked to electronic knitting machines allowing quick and interactive knitwear products to be produced according to individual requirements. Using this method, the company has no need to mass produce products, and works on a made to order, local basis; Post Couture (Netherlands) offers an alternative to modern day production by embracing the “maker movement”. Each design is developed to be laser cut and assembled by the consumer, either sent pre-cut to or downloaded as a digital file to be customised, inputting your measurements and laser cutting from your own material at a local machine; Open Knit Project (UK) is a kickstarter that aims to create a low cost automated digital knitting machine available to anyone, with software that allows you to adapt pre-prepared adaptable patterns or the ability to upload your own. Users can create garment pieces that are personalized and available “at the click of a button” while small companies could reduce industry lead times with quick prototyping of small collections of garments according to demand.

These emerging production models are becoming more accessible and have huge potential in lowering the impacts associated with mass production which often happens at a great distance from the eventual consumer.

6. Conclusions and Circular Design Proposals

Through reviewing current industry activity 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.

We conclude this paper 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 2 is a summary of the framework discussed in this section; three "Super Slow" and three "Fast Forward" design approaches.

6.1. Slow and Slower

Extending Single-User Lifetimes design 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. And services which enable careful

laundry and repair either through a brand or at home could additionally extend the life of the garment.

Enabling Multiple-User Lifetimes 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.

Scaling Garment Upcycling reinventing existing products with design intervention. This is where designers can create augmented value 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.

6.2. Fast and Forward

Advancing Material Recovery technologies which can recover virgin quality materials from existing textile waste streams. The rapid progress of recycling technology is providing real hope for the future of material recovery. Designers have a role to play here in spreading understanding of this constantly changing field. These step changes are not only in the area of fibre-to-fibre recycling technologies which promise “virgin quality” materials from discarded textile materials; cellulose, polyester and nylon recovery is now possible at pilot scale if not always commercially available. The recovery of mixed fibre waste is getting ever nearer, and 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, bringing new insight and innovation to many developments.

Designing FOR Recovery 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 in products through their recreation and physical transformation or upcycling. Whilst often these responses are based in small or niche fashion 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. This is a difficult brief to follow as the speed of change is potentially high but there is also an increasing understanding of the features of “design for recycling” through collaborative projects such as MFF which brings together stakeholders from all areas of the value chain to create a progressive and common understanding.

Reducing Production Impacts 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.

The production of novel materials based on nonwoven technologies is crucial here and has clear environmental benefits as compared to traditional processes.

SUPER SLOW APPROACHES for product longevity (extending product life)	FAST FORWARD APPROACHES for material longevity (enabling material recovery)
Extending single-user lifetimes; *keeping products in use as long as possible for their first life* e.g. functionally durable materials, timeless style & care/repair services	**Advancing material recovery;** *technologies which can recover virgin quality materials from existing textile waste streams* e.g. chemical recycling of PET, cellulose, mixed waste, and sorting technology to enable these processes
Enabling multiple-user lifetimes; *services which give existing products a new life opportunity* e.g. leasing, sharing, charity and branded resale	**Designing FOR recovery;** *in-built design features which enable more efficient recovery to support material recovery* e.g. design for disassembly, monomaterials, biocompatibility
Scaling Garment Upcycling; *reinventing existing products with design intervention* e.g. upcycling, remanufacture	**Reducing Production Impacts;** *innovative production systems which reduce overall impacts of garments* e.g. streamlined and vertical manufacturing, redistributed production, automation, mass customisation

Table 2: Summary of approaches for 'Super Slow' and 'Fast Forward' Design

6.3. Synergies, Trade-offs and Next Steps

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.

A “slow” approach may include multiple “fast” lives which build over time to reveal a super slow product. Whereas a “fast” approach might entail an ultra-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 utilized 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.

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”. A mixed economy for fashion and textile design can then be developed that relies on a range of engagements with users.

These themes will be tested during 2017–2018 through a series of industry workshops, scientific collaborations and design-research prototypes which will ultimately lead to a set of “guidelines for circular design” to be published at the end of 2019.

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