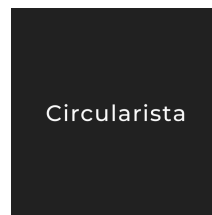FILIPPA K

ATELJE UNITEX
MADE IN SWEDEN

Circularista

trustrace

C-PLM, Circular Product Lifecycle Management System

Transforming the Fashion Industry: A Pilot Project on Circular Fashion and Data-Driven Sustainability written by Åsa Fehrm, Emil Petersson, Angelo da Silveira, Jenny Wärn, Linn Lindfred

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Foreword

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Content

1. Sammanfattning

Modebranschen präglas av ineffektiva linjära modeller vilket leder till stora mängder avfall - en stor bidragande faktor till dess omfattande klimatpåverkan. Chockerande statistik från Ellen MacArthur Foundation (2017) avslöjar att en sopbil med kläder dumpas varje minut. För att möjliggöra skiftet till en mer cirkulär och hållbar textilindustri behöver vi gå från slit och släng till att konsumera mindre nytt och cirkulera plagg i flera livscykler. För att skala upp cirkulering av plagg på ett tillförlitligt och ekonomiskt fördelaktigt vis är en nyckel att enkelt kunna få tillgång till data i det returnerade plagget och kunna spåra denna.

Pilotprojektet har utforskat datadriven försäljning av begagnade kläder inom modebranschen och involverat nyckelpartners som Filippa K, TrusTrace, Unitex och Circularista. Projektet utvecklade ett system för cirkulär produktlivscykelhantering (C-PLM) som kan registrera produktinformation som stilkod, namn, storlek, färg, inköpsordernummer, materialkomposition, säsong och år men också detaljer om åtgärder som vidtas på plagget, såsom reparationer. Systemet beräknar kostnaderna för olika åtgärder och samverkar med fyra huvudintressenter: process-anläggningen, varumärket, butiken och konsumenten.

Under pilotfasen processades 1591 plagg av Unitex, varav 278 plagg sorterades till återförsäljning och tilldelades en unik digital identitet som nås genom att skanna den påsydda NFC-taggen. Av dessa 278 plagg reparerades 58% medan 42% kunde säljas i befintligt skick. De flesta reparerade plaggen hade saknade sömmar, hål i sömmar eller skador på tyget.

Piloten påvisar ett ekonomiskt försvarbart case för Filippa K när det kommer till att samla in deras använda och/eller söndriga plagg, sortera, registrera, sy på NFC tagg, generera unika produktID och sälja på andrahandsmarknaden. Om produkterna skulle säljas till utsatt pris skulle bruttovinsten uppgå till 102 000 SEK, efter avdrag av kostnader relaterat till föregående nämnda aktiviteter. Inga kläder såldes i projektet på grund av att Filippa K under projektets senare skeden tog ett beslut att påbörja etablering av online-försäljning av begagnade kläder istället för försäljning i fysiska butiker. Kostnaderna inkluderar därmed inte försäljning av plaggen.

Projektet möjliggjorde för Filippa K att förbereda cirka 500 plagg till försäljning och samla in data om ytterligare 1000 för framtida granskning. Tidigare har 25% av plaggen som går in i "Collect" programmet nyttjas och fått en förlängd livspann. Vid slutet av 2023 siktar Filippa K på att sälja 50% av plaggen i "Collect"-programmet,vilket då minskar avfallet med 25%, med

prissättning baserad på projektets kostnadsinformation för att maximera den ekonomiska potentialen.

Det Europeiska digitala produkt- och materialpass-direktivet kommer att möjliggöra mer lönsam försäljning av begagnade kläder. Att utrusta produkter med digitala identifierare i produktion skulle eliminera de kostnader som denna pilot har haft för dataregistrering.

Insikterna i projektet möjliggör Filippa K att ta strategiska beslut för att stödja övergången till en mer cirkulär affärsmodell. Genom C-PLM kunde FIlippa K analysera olika produktgruppers benägenhet att reklameras, förstå hållbarheten i olika plagg, samt se vilka reparationer som är vanligast per produktgrupp. Informationen används för att förbättra företagets cirkulära hållbarhetsstrategi som bland annat inkluderar design för hållbara och cirkulära produkter. Insikterna hjälper även att utveckla företagets "Collect program" som består av att laga, återförsälja och återvinna produkter.

Projektet avslutas för nu för att Filippa K ska undersöka affärsscenario för fortsatt andrahandsförsäljning. En fortsättning av projektet kräver utveckling i den tekniska infrastrukturen från ett säljperspektiv såväl som samarbeten med branschkollegor för att nå nödvändiga volymer. Därmed söker projektet branschkollegor och partnerskap för att hitta innovativa lösningar och tillsammans transformera fashion till ett mer hållbar och cirkulärt ecosystem.

2. Summary

Fashion faces a challenge with inefficient linear models, leading to significant clothing waste, a contributing factor to its major negative climate impact. Startling 2017 statistics from the Ellen MacArthur Foundation reveal that one garbage truck of clothing is dumped in landfills every minute. In order to enable the shift to a more circular and sustainable textile industry we need to shift from the prevalent throwaway culture to one where we consume less and loop the products in several life cycles. In order to scale up the recirculation of garments in a reliable and economically viable way, one key is to be able to easily access data about the used garment and be able to track it.

This pilot project has explored data-driven secondhand resale in the fashion industry, involving key partners such as FK Studio, TrusTrace, Unitex, and Circularista. The project developed a Circular Product Lifecycle Management (C-PLM) system, capable of recording essential data on each garment's journey. This data includes product information such as style number, name, size, color, purchase order number, material composition, season, and year. It also encompasses details about actions taken on the garment such as repairs. The system calculates the costs associated with various actions. The system interfaces with four key stakeholders: the process facility, Filippa K HQ, the store, and the consumer.

During the pilot phase, 1591 garments were processed out of which 278 garments were given a unique digital identity accessible through scanning NFC tags. Of these garments 58% required repairs, while 42% were suitable for resale as-is. The majority of the repaired garments had issues like missing trims, holes in seams, or fabric damage.

This pilot project concludes that there is a viable business case for Filippa K when it comes to collecting used or flawed products, sorting, registering, adding NFC tags, and generating unique product IDs for resale in the second-hand online market. The analysis indicated a gross profit of 102,000 SEK if the 278 garments were sold to the set price. The gross profit includes costs for handling, sorting, registering data, repairing and also the costs for sorting the rest of the garments to recycling/donation but it did not encompass potential expenses related to secondhand sales. Originally, the primary sales outlet for used garments was envisioned as physical retail stores. However, during the project's later stages, Filippa K opted for online secondhand sales due to operational and functional reasons and thus no garments were sold during the timeline of the pilot.

The project facilitated Filippa K in preparing resale of around 500 garments. Previously only 25% of the garments that the Filippa K studio were processing was utilised and repurposed. By the end of 2023 Filippa K aims to resell 50% of these garments, therefore minimizing our garment waste by 25%.

The EU digital product passport directive holds the promise of enhancing the second-hand sales business case. Equipping products with digital identifiers and passports in production can eliminate data registration and NFC tagging costs in systems like C-PLM, making circularity more economically viable.

The project has facilitated the generation of comprehensive analytics concerning used garments, including their durability and the costs involved in the take-back and repair process. These insights can empower Filippa K to make informed strategic decisions in support of transitioning to a more circular business model.

The project temporarily pauses to allow Filippa K to develop an online resale business case, acknowledging the evolving fashion landscape. Going online requires technical infrastructure development and collaboration with other brands to achieve necessary volumes. Ultimately, the project seeks industry partnerships to innovate and collectively transform fashion into a more sustainable, circular ecosystem
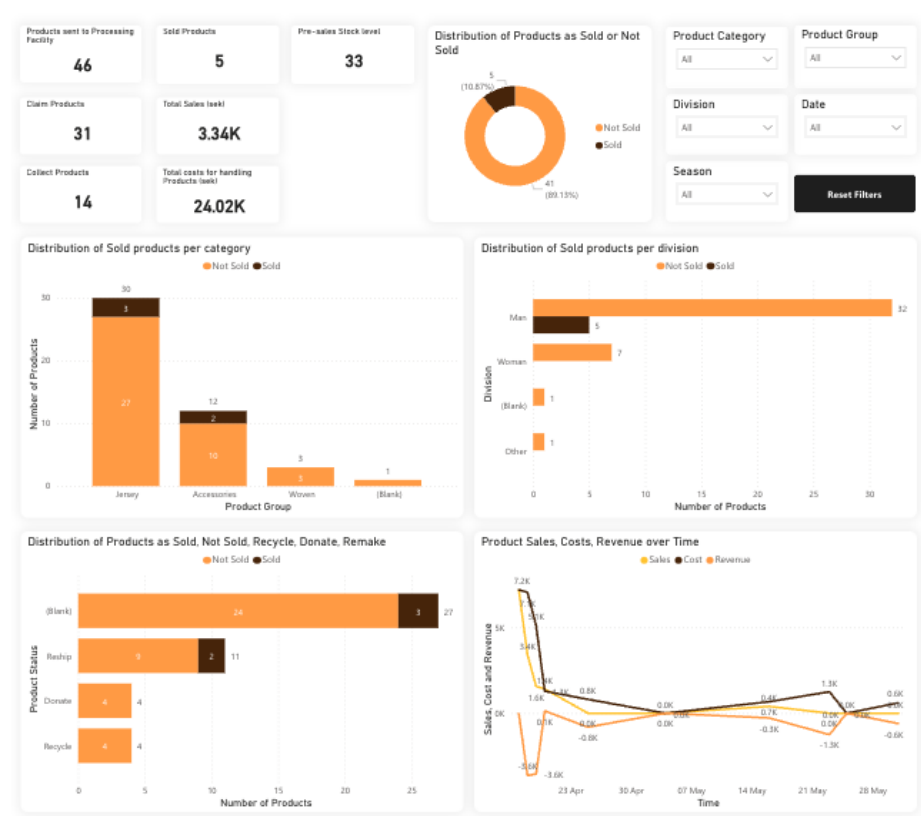
Picture 1. A screenshot of the dashboard in the C-PLM system (mock data).

3. Introduction and Background

The clothing industry has a major impact on the environment. Recent studies from Sustainable Fashion Academy (2021) estimate that the apparel industry accounts for approximately 3-7 % of the share of global emissions, and 80% of the environmental impact of the Swedish clothing consumption occurs during the production phase. In order to decrease the environmental impact, increase the reuse percentage and support more circular business models it is important that fashion companies collect their sold and used garments and process them to be re-sold when possible. A vital addition to this is to be able to systematically record data held within the returned garment in order to scale-up the second life usage in an economically beneficial way and improve the quality and longevity of the new collections.

Each partner involved in this project is connected to the clothing industry and circularity in different ways. FK Studio is a concept and a physical space which has the responsibility of handling Filippa K's reclamations and the take-back garments from its 'Collect' program. Swin Technologies has a strong knowledge and experience in technology around traceability in the textile and apparel industry working on their platform and brand TrusTrace. Unitex is a growing and innovative actor in building both socially and environmentally sustainable garment production in Sweden working from order-on-demand production to repairs, washing, upcycling and recycling of garments. Circularista is an expert in circular economy and works with coaching and managing circular innovation pilots.

One of the fundamental issues is the linear business models are ineffective reuse of the garments when they are broken or defected. Shockingly, statistics from the Ellen MacArthur Foundation in 2017 reveal that one garbage truck of clothing is sent to landfills every minute. The lack of a shared infrastructure for collecting, sorting, repairing, and recycling garments places the onus on individual brands to ensure their products are reused. The FK Studio was created for this reason--to handle Filippa K's reclamations and the secondhand garments from its 'Collect' program. Through the work at FK Studio the challenges and the possibilities of the repair, reuse and recycling of garments are apparent. Second hand clothes are typically sold through several retailers. Once they are damaged no one takes the responsibility to repair them and they end up in landfills. The current mindset is that it is more economically beneficial to throw-away a garment, than to mend or repurpose and resell it. The industry has a long way to go if by 2025 producers are to be responsible for the end of life collection and treatment for certain products (Extending Producer Responsibility EPR).

While fast fashion remains a significant force in contemporary society, there is a growing demand among consumers for more sustainable and circular alternatives. A Statista survey in

2021 reported that 42% of millennial and Gen Z respondents expressed a willingness to shop for secondhand items. Data from the ThreadUp Resale Report in 2023 predicts a rapid expansion of the secondhand market, set to nearly double by 2027, with a projected value of 350 billion dollars. Furthermore, the report indicates that the global secondhand apparel market is expected to grow three times faster than the overall global apparel market.

Circular solutions, such as the resale of used products, are crucial not only for reducing the fashion industry's climate impact but also for generating economic value. According to Anders Wijkman, the president of the Club of Rome, a Circular Economy in Sweden could reduce carbon emissions by two-thirds and create at least 100,000 new jobs, equivalent to nearly 3% of the labor force. Transitioning from linear to circular business models requires substantial investments and data to support decision-making, underscoring the importance of systems capable of collecting quality data on circularity.

In order to enable data collection on circularity, a feedback loop in the form of a technical platform that rolls up the on-product data collected is necessary to support companies with circular business models. The overall purpose with the project is to develop a technical plug-in system that is compatible not only with the existing PLM systems fashion companies use but also suitable for other actors working in the circular value chain as well i.e., companies working with repair or recycling. By creating a system that connects the different players – existing fashion technology, brands and garments processing partners, it is possible to start providing quality data to back up investments and scale up otherwise small-scale isolated initiatives.

The objectives of the projects have been to complete a pilot of 1000 garments that are collected, processed, repaired, registered digitally, tagged with a NFC linked to a unique product ID and prepared for resale. From these pilot garments the aim is to obtain quality and usable data which will enable Filippa K to take strategic decisions to support the move to a more circular business model.

By the end of 2023 Filippa K's goal is to be able to resell 50% of of the garments collected in the collect program, therefore minimizing our garment waste by 25%. These garments will also be priced according to the costing information we will have gathered from the project, enabling us to capture the full economic potential.

Finally, Filippa K's long term goal is that this project will enable a reduction of the amount of reclamations in the company by 20% by 2026. Aligning with our company strategy to produce high quality, long lasting clothing.

4. Execution

The project was divided into three phases: (1) Identifying scope and developing the digital platform, (2) Registering data and monitoring the flow of garments and (3) Increasing the profitability of processing post-sale garments and utility of incoming material. The work packages were divided in; (1) Project Management, (2) The digital platform, (3) Creating digital IDs and entering data, (4) Repairs.

4.1 Project Management

Filippa K managed and coordinated the overall project progress. This work package consisted of planning, following up the project and concluding it. The goal was to ensure a good communication flow between the project partners and the other stakeholders as Re:source, ensure the progress of the project and create understanding and synergy in the project group. The following key deliverables were fulfilled in the project.

(KD0) Project plan
(KD1) Final report
(KD2) Plan for implementation, scaling up and distributing the results.

4.2 Identify scope and develop digital platform

In the initial project phase, we defined the project's scope and developed the necessary technological solutions. To begin, the team conducted research by examining similar initiatives and exploring textile data protocols to determine the essential data that needed to be recorded for each product. The data that received the highest priority for inclusion in the solution were as follows:

1. **Product Data:** This category encompassed information such as style number, name, category, size, color, purchase order number, material composition, season, and year. This type of data could be sourced from a Product Lifecycle Management (PLM) system, an Excel spreadsheet, or directly from the care and size labels attached to the garments.

2. **Data Related to Garment Actions:** This involved recording data about the condition or flaws of the garment, the type of repair performed, and capturing images of the garment before and after the repair. In the system's backend, the costs associated with these various actions were automatically calculated.

In order to understand the data needs and actions done to the garment it was necessary to draw up a user journey with the starting point at the return of the garment from the consumer in the Filippa K store.

1) Consumer returns garment
2) Store writes condition on paper tag and attaching it to garment
3) Store sends garment to Unitex
4) Unitex sorts garment
5) Unitex attaches NFC tags, enters data digitally and/or washes and/or repairs garments
6) Unitex sends garments to Filippa K
7) Filippa K sets re-sell price on garments
8) Filippa K store sells garment
9) Filippa K analyses the result in a dashboard

Based on the user journey, we were able to determine the necessary functionalities and design four distinct interfaces. These interfaces include:

1. An interface for the process facility: This interface allows the facility to input information about the garment and link it to the digital product ID.
2. An interface for the brand HQ: This interface provides HQ with the ability to view all shipped products, set resale prices, and analyze the collected data.
3. An interface for the store: Store personnel can use this interface to categorize garments as sold, not sold, sent to another store, or designated for donation (in cases where the garment won't be sold).
4. An interface for the consumer: When scanning the NFC tag, consumers can access product information through this interface.

Picture 1 illustrates the interface presented to the brand and processing facility. Within this interface, they can access unique product IDs along with accompanying product information, incurred costs, information about previous flaws, details of repairs performed, and images depicting the garment's condition before and after repair.

Picture 2. A screenshot of an example of a product that is registered in the C-PLM system (mock data).

In the process of designing these interfaces, several user tests were conducted. After numerous iterations, the design was finalized, and the platform was ready for development. As described in point 8, a critical aspect of the platform is the ability to comprehend and analyze the collected data effectively. Therefore, a dashboard for displaying data analytics in a user-friendly manner was developed utilizing Power BI. The analytics provide insights such as the quantity of garments sorted into various categories, the top five most frequent flaws and repair types, the total costs associated with different activities, the distribution of claim/collect garments, and the sales figures broken down by category. Picture 3 and 4 illustrates parts of the dashboard.
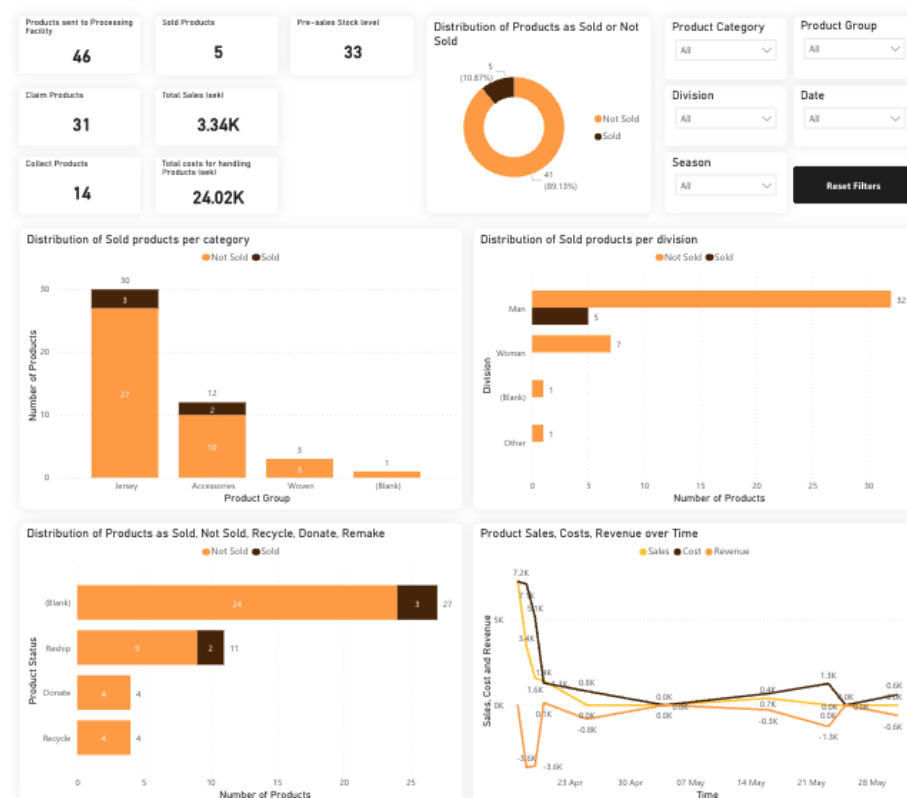
Picture 3. A screenshot of the Power Bi dashboard in the C-PLM system for stock and sales (mock data).
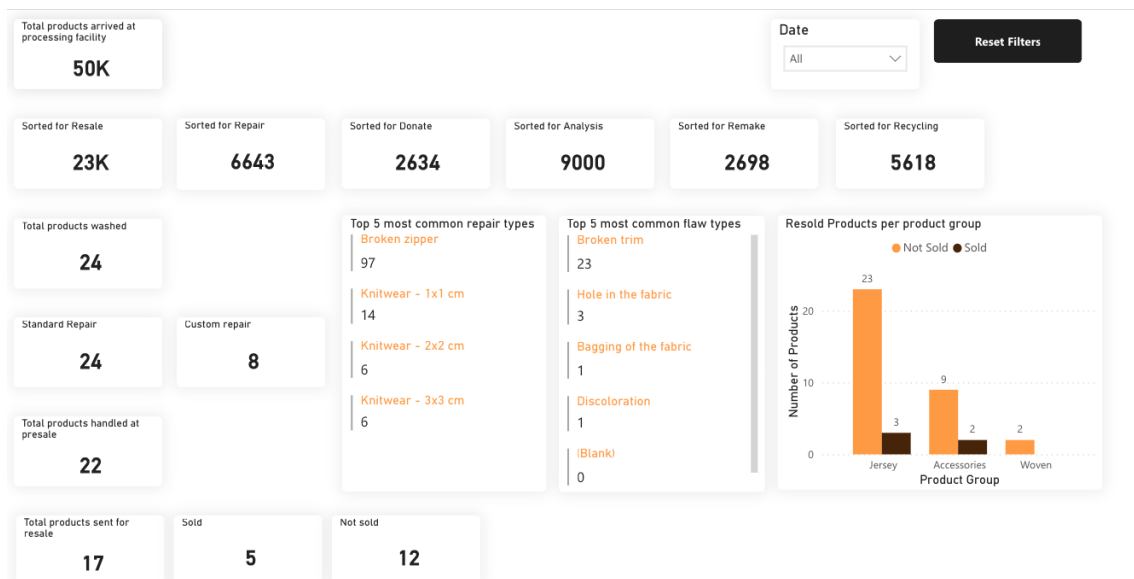
Picture 4. A screenshot of the PowerBi Dashboard for analyzing repairs in C-PLM (mock data).

Due to the complexity of the platform the start of the pilot of sorting and repairing products was delayed which in turn affected the number of garments that were processed in the pilot within the project timeline.

This first phase of the project relates to work package 2 - *The digital platform and traceability technology* where TrusTrace was lead together with Circularista. All project partners were highly involved in setting scope, prioritizing data and testing and developing the platform. The project created a digital solution that has potential to integrate with existing systems and that can record product data and the different actions performed on the product. Any user can scan the NFC tag and see information about the product throughout the product lifecycle.

As part of the work package the below key deliverables were delivered in the project:

(KD3) Finalization of detailed requirements of the platform with project partners
(KD4) Identification of the product tagging method
(KD5) Ensuring the compatibility of the platform together with accessibility through web
(KD6) Sharing product ID`s to be embedded in the product
(KD7) Ongoing support of the solution during roll out and piloting.

4.3 Registering data and monitoring the flow of garments

During the project's second phase, we began processing garments received from Filippa K stores in Sweden, validating both the theoretical garment workflow and the developed C-PLM platform. We conducted multiple user tests in collaboration with TrusTrace to improve the platform's user experience and verify the practicality of the theoretical workflow. The pilot workflow is based on the below steps and is detailed in the following sections.

1. Collecting the garments
2. Sorting the garments
3. Creating digital IDs and entering data
4. Repairing garments
5. Shipping garments
6. Pricing and selling the garments

4.3.1 Collecting the garments

Incoming garments at Filippa K stores originated from two sources: Claim and Collect. Claim garments were either returned to the store by customers or withdrawn directly from the store's stock due to malfunctions. Examples of claim reasons include holes in seams, broken zippers, missing trims, and twisted linings. On the other hand, the Collect category consisted of garments returned to the store through Filippa K's take-back program, which may not necessarily have had any faults but were returned for customers to gain an economic benefit

on their next purchase. When Filippa K store staff collected garments from customers, they affixed a paper tag to each garment containing information about its condition and whether it fell under the Claim or Collect category. Subsequently, the garments were transported to Unitex.

4.3.2 Sorting garments

At Unitex the garments were manually sorted into four different categories. Repair, Resell-as-is, donation and recycle. C-PLM allowed for two more categories in sorting, Remake and Analysis, which were not included as part of the sorting process of the pilot to limit the scope. The definition of each category and how to sort was based on a sorting guideline developed by Filippa K and Unitex.

Picture 5. A screenshot of the sorting step in C-PLM (mock data)..

To streamline the sorting process, reduce individual decision-making, and prioritize garments for resale through Filippa K's sales channels, a sorting guideline was developed. Initially, this guideline categorizes all Filippa K products into 13 distinct product categories and further classifies them into four different price levels, ranging from the lowest (Level 1) to the highest (Level 4). Subsequently, the guideline considers the garment's faults and their location for the final sorting. Garments that didn't qualify for Repair or Resell-as-is were directed to either donation or recycling. The distinction between these two categories lies in the wear and tear of the garments. Donated garments could exhibit some wear and tear, but not in visible areas. Conversely, garments heavily damaged in visible places and showing significant signs of wear were categorized for recycling.

Certain product groups were immediately designated for donation or recycling, as they were considered to have a shorter lifespan. Examples of such "short lifespan" products include jerseys like T-shirts or leggings, which are worn close to the body and are more prone to stains and holes than other categories, such as heavy knitwear. Given that these items are generally lower-priced, Filippa K determined that investing in repair and resale would not be economically viable. Another product group sorted into recycling or donation consisted of

denim products with less than 95% cotton content due to the composition of the garment where a higher amount of Elastane has been used .

"Resell as-is" refers to garments that can be directly sold to the consumer in their current condition, potentially requiring only a simple wash. In contrast, "Repair" garments are those in need of repair. Garments categorized as "Donation" were dispatched to The Red Cross, while those classified as "Recycling" were sent to a recycling facility. To streamline the project's scope, garments placed in the "Donation" and "Recycling" categories were not individually tagged with NFC chips. Instead, they were grouped, allowing for the identification of the source store and the quantity of items in each group.

4.3.3 Creating digital IDs and entering data

NFC chips were sewn onto garments categorized as "Repair" and "Resell-as-is." The C-PLM system captured individual product data, which was then transferred to the NFC chips using an Android cell phone equipped with NFC tag-scanning capabilities. This process allowed for the creation of unique product IDs. The data recorded during this phase included product details such as style number, purchase order number (PO), color, style category, and size. Information about each garment was extracted from the care and size labels, as well as from the paper tags attached to the garments by the store. In instances where the care label and/or paper tag were missing or had faded due to washing, the C-PLM system had to accommodate situations where not all information about the garment could be retrieved. Picture 6 shows the NFC chip attached to the care label of a garment and picture 7 visualizes the interface in C-PLM for registering product information.

Picture 6. The NFC chip attached to a pair of trousers.

Picture 7. A screenshot of the registering of specific product information in C-PLM (mock data).

4.3.4 Repairing garments

To streamline various aspects of the process, including the calculation of repair time and cost, as well as sorting, data collection, washing, and shipping of garments, timekeeping measures and material cost estimates for standard repairs were hardcoded into the backend. This allowed us to associate a cost per hour at Unitex with the time required for repairs. In cases where a garment needed a repair that wasn't part of the standard repair list, we introduced the option for custom repairs. This feature enabled users to manually input details such as time, materials, trims, thread, and the associated costs. Additionally, we incorporated the capability to include pictures of the repair before and after in the C-PLM solution. Below, in picture 8, you can see a snapshot of the stage in C-PLM where users input information about the flaw and repair.

Picture 8. A screenshot of the process of registering information about the flaw and repair in C-PLM (mock data).

4.3.5 Shipping garments

The Resell as-is and Repair garments with their unique IDs were packed into boxes, identified as Lots and sent to Filippa K HQ or the Filippa K Store, ready for their second lifecycle.

Picture 9. A screenshot of a specific lot that has been shipped in the C-PLM system (mock data).

4.3.6 Pricing and selling the garments

To input resale prices for Filippa K products, users have two options. They can either scan a particular garment using a mobile phone, granting them access to the interface for price entry. Alternatively, users can log in to the platform and search or filter for the appropriate product IDs to access the same interface. The C-PLM system will suggest a price, and if Filippa K approves, the user can designate the item as "ready for sale." However, if Filippa K believes the price should be adjusted, they can manually update it in the interface before sending the item to the sales point. Below picture 10 shows the interface for registering pricing data.

Picture 10. A screenshot of the C-PLM solution for setting the resale price of the garment (mock data).

This phase of the project was part of work packages (3) *Tracking the process of different actions done to the product post sale garments*, and (4) *Repairs. In WP3* Unitex executed the work-flow and TrusTrace and Circularista monitored and altered the solution and Filippa K was responsible for the final stages of the work-flow. In WP4 Unitex conducted the repairs. Phase 2 fulfilled key deliverables 8-10. Although, key deliverable 11 was not fully achieved, see below for explanation.

(KD8) Standardized way of calculating the cost for different actions
(KD9) Defining the process for data input
(KD10) Care labels with unique product ID (NFC)
(KD11) Repair of 30-50 garments per month - A total of 160 garments underwent repairs within the project timeline, which is fewer than initially anticipated for this key deliverable. This deviation can be attributed to altered project prerequisites. The initial plan did not factor in the added expenses associated with sorting the garments before repairs. Consequently, while the total number of garments exceeded the goal (1591 instead of 1000), fewer of them were repaired compared to the original plan. Further details can be found in Section 5 - Result.

4.4 Increasing the profitability of processing post-sale garments and utility of incoming material

The third phase of the project focused on the analysis of data captured from the pilot. From analyzing this data, Filippa K has been able to start to optimize the processing of post-sale garments and determine the profitability of the take-back and resell of garments. The team has also re-evaluated what data should be tracked and stored on the technical platform and ensured that the system is optimized for its purpose. The data analysis is presented and discussed in the next section. The data was analyzed by TrusTrace, Circularista and Filippa K.

5. Result and discussion

During the project, Filippa K gathered a total of 1591 products from customers, all of which were subsequently sent to Unitex for processing. These customer-returned garments fell into two main categories: "claims," denoting items with defects or damages, and "collect," indicating garments returned by consumers as part of Filippa K's take-back initiative. Notably, nearly two-thirds of the garments were categorized as "claims," while the remaining one-third were designated as "collect." The rest of the analysis is divided into the respective activities in the garment processing flow.

5.1 Sort

Within the project timeline, 55% of the garments were sorted to Donation and subsequently sent to The Red Cross. 28% were sent to Recycling, 10% were sorted as Repair and the final 7% were sorted as Resell as-is.

Repair	Resell as-is	Recycling	Donation	Total
160	118	441	872	1591
10%	7%	42%	55%	100%

Table 1. Number and percentage of garments sorted per sorting category

The garments sorted as Resell as-is are garments that can be resold to a new customer in its current condition, the garments sorted as Repair need a repair before they can be resold. On both the Repair and Resell as-is garments, an NFC tag was sewn onto the garments' care labels by Unitex. Unitex then entered data about the garments in the C-PLM system and linked the data to the specific NFC tag which enables anyone to scan the NFC tag and access information about the unique garment. In this way, these 278 garments were given a digital identity that will follow them throughout their life-cycles.

Out of the 278 garments that were given a digital identity, 58% were sorted as Repair (160 garments) and 42% were sorted as Resell as-is (118 garments). Due to time constraints in the pilot, additional 235 garments sorted as Repair and Resell-as-is have not been given a digital identity yet, but are scheduled to be added to the system accordingly after the official end of this project. Hence, these garments are not part of the pilot analysis. Subsequently, the following analysis will be based on the 278 garments that were given a digital identity in the pilot and sorted as either Resell as-is or Repair.

Regarding specific product categories, knit tops were the most frequently returned garments by customers, accounting for 32% of returns, followed by trousers (22%), dresses (15%), and shirts/blouses (13%). Collectively, these three categories constituted 83% of the total number of garments returned by consumers and subsequently sorted as either "Resell as-is" or "Repair." The remaining product categories included beachwear, jackets, leggings, jersey tops, outerwear, skirts, and socks/tights.

Approximately half of the returned dresses and shirts/blouses required repairs, while the other half could be sold as-is. Knit tops, which account for a significant portion of Filippa K's sales, had about 70% of returned items in need of repairs, while for trousers, the figure was 60%. This higher return rate in knit tops and trousers can be attributed to their popularity as Filippa K's top-selling categories.

Among the two product categories most frequently returned by consumers during the project (knit tops and trousers), nearly half of the garments in each respective category were returned as "claim" (in need of repair), while the other half were returned as part of the "collect" program, indicating they were in relatively better condition. Specifically, 56% of knitted tops were returned as "claim," and 44% were part of the "collect" program. For trousers, the split was 50/50.

In summary, out of the 278 products that successfully passed through the sorting process for resale in Filippa K's channels, 73% of the "claim" garments required repairs, while 27% of the "collect" garments needed repairs. This means that 70% of the "collect" garments could be resold as-is indicating that a majority of the used garments returned by the consumer in Filippa K's take-back program are still in great condition.
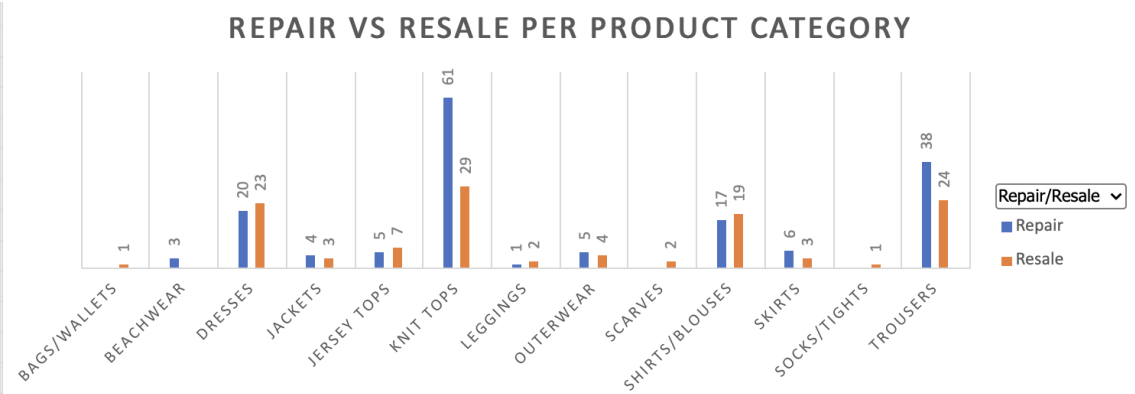
Graph 1. Product categories sorte in Repair/Resell as-is

5.2 Repair

Most of the garments that were repaired had a missing trim (16%), a hole in a seam (21%) or a hole in the fabric (8%). The repair costs vary depending on the type of repair. The costs for the repairs are calculated as cost for material used and labor cost for the time spent repairing.

Flaws/repairs	Percentage of products	Number of products
Standard repairs		
Broken Trim	2%	5
Hole in lining fabric	0.4%	1
Hole in seam	21%	60
Hole in fabric	8%	23
Missing trim	16%	47
Unravelled hem/edge knitwear	1%	2
Unravelled top stitch	3%	8
Total standard repairs	*90%*	*144*
Custom repairs		
Broken buttonloop	0.6%	1
Broken threadloop	0.6%	1
Hem	0.6%	1
Lining fray, repair lining fray	0.6%	1
Loose buttonloop	0.6%	1
Missing buttonloop	0.6%	1
Sew and press new hem stitch	0.6%	1
Take in run in thread	0.6%	1
Threadloop	1.3%	2
Threadloop missing	0.6%	1
Top stitch	1.3%	2
Twisted lining	1.9%	3
Total custom repairs	*10%*	*16*
Total repairs	*100%*	*160*

Table 2. Type, numbers and percentage of repaired products and their associated costs.

The garments that had a missing trim were dominated by trousers (14 trousers) and knit tops (11 knit tops). Most of the garments that had a hole in seam and hole in the fabric were knit tops. One of the more expensive standard repairs are broken trims. In this pilot, all 5 garments that had a broken trim were trousers.

For knit tops, the most common flaw was a hole in the seam (50%), a hole in the fabric (25%), Missing trim (20%) and Unravelled top stitch (5%). In total, Filippa K paid 17 764 sek for sorting, handling, registering and repairing the flawed knit tops and the average cost for only the repairs of the knit tops was 68 sek per garment.

It becomes evident that when scaling a solution like C-PLM, it yields valuable insights into garment durability and consumer usage. These insights have the potential to facilitate targeted initiatives that can have both economic and environmental benefits. For instance, since knit tops emerged as the most frequently returned product category (comprising 32% of returns), and they also exhibited the highest repair needs (with 70% of knit tops requiring repairs). With access to data detailing the most common flaws in this specific garment category, Filippa K could consider several strategies:

1. Provide users with DIY repair guides for addressing common issues, such as repairing holes in seams (the most prevalent flaw in knit tops). These guides could be accompanied by the necessary materials, available at the point of purchase.
2. Offer free "standard" repairs in stores, a practice Filippa K is already implementing.
3. If a recurring pattern of issues emerges for a specific product line or if there are opportunities to redesign garments for increased durability, these insights could inform design decisions.

Implementing actions 1 to 3 could extend product lifetimes and create items better suited for circular lifecycles. Understanding the costs associated with transporting, sorting, handling, and repairing faulty items simplifies the evaluation of initiatives aimed at reducing these costs in the long term.

5.3 Costs

The costs related to the garment take-back and handling were allocated to various activities, which included: Handling products at point of take-back, sorting, recording data and creating a digital ID, attaching an NFC tag, repairing the garments, deciding on resale price, shipping the garments. The repair costs varied depending on the type of repair conducted, but the average garment repair cost can be found in Table 3, along with the other costs used to calculate the expenses incurred during the pilot project. Important to add is that the C-PLM platform's cost calculations do not encompass potential expenses related to secondhand sales. Originally, the

primary sales outlet for used garments was envisioned as physical retail stores. However, during the project's later stages, Filippa K opted for online secondhand sales due to operational and functional reasons. This decision introduced the need for a complex integration between C-PLM and the brand's ERP or OMS system, a factor not initially factored into the project's scope. As a result of the shift in plans no garments were actually sold to end consumers within the pilot's timeline.

Activity	Cost per garment (sek)
Handling products at Point of takeback	12.5
Shipping to processing facility	7.5
Sorting products	34
Recording data	66
Attaching NFC tag	35
Average cost of repair in pilot	68
Packaging	17
Resale price	21
Shipping to HeadQuarters	2.25
Shipping to Point of resale	7.5

Table 3. Cost input for different activities performed in the process

The average costs associated with handling garments in the pilot project were as follows:

1. Donation and recycling: This included costs for transport, handling, sorting, and additional transport, amounting to **62 SEK per garment**.
2. Resell as-is: This encompassed expenses for transport, handling, sorting, creating a digital ID, data entry into the system, NFC tag attachment, price determination, and further transport, totaling **223 SEK per garment**.
3. Repair: This category covered costs for transport, handling, sorting, creating a digital ID, data entry into the system, NFC tag attachment, actual repair, price determination, and additional transport, **totaling 291 SEK per garment**. However, it's important to note that repair costs varied based on the type of repair performed. On average, repair costs in this pilot were 68 SEK but repair costs ranged from 40 SEK to 250 SEK per repair in the pilot. The median cost for a repaired garment was 268 SEK, with the lowest cost starting at 224 SEK and the highest reaching 472 SEK.

The most expensive activities throughout the process are the repairs and recording the data digitally in the C-PLM system. The average cost for repair is 68 sek and the average cost for recording data is 66 sek. To elaborate on this, the business case would be substantially improved if the garments collected would already be provided with a unique product ID and

an information carrier (such as a NFC or QR code) attached in production. This would ultimately reduce the costs of handling and processing the returned garments and information could be accessed instantly.

As it happens, nearly a year after the start of the C-PLM project, the European Commission introduced new legislation under the Ecodesign for Sustainable Product Regulation (ESPR), mandating the use of Digital Product Passports on textiles sold in the EU by 2030. This means that all produced products should include an information carrier linked to a unique product ID carrying stipulated information about the product. Since the C-PLM project was already underway, it was unable to accommodate the new EU mandate in the pilot, especially as the mandate solely applies to new products. However, a key aspect of the digital product passport is its ability to allow stakeholders in the circular value chain to continuously add data to the digital product passports throughout the product's life, mirroring the intent of C-PLM.

The EU's digital product passport directive enhances the business case for secondhand sales. When products are already equipped with an information carrier/digital identifier and a digital product passport, the costs associated with adding an NFC tag to a used garment and registering the product data would be eliminated. The processing facility would only need to scan the product to access the required repair information, and third-party resellers could instantly provide consumers with comprehensive information about the garment. This would significantly improve the business case, as data registration was one of the most costly activities in the C-PLM process. However, it's unlikely that used garments with a digital product passport will be collected by brands in the near future, given that the passport is set to be introduced seven years from now.

5.4 Profitability

The pricing of the garments was established at approximately 60% of their original retail value. This pricing strategy was determined based on various factors, including seasonality, the garment's age, quality, and product category, drawing from the experience gained at the Filippa K Studio. The initial reference point for pricing was always the original retail price, and the final price for the pre-loved item typically ranged from 40% to 80% of the original price. In the C-PLM system, we aimed to implement a standardized pricing model to streamline the process, as opposed to making individual pricing decisions. After a review of historical sales data, Filippa K opted to utilize the average percentage observed at the Filippa K Studio, which equated to 60% of the original retail price.

The average resale price for a garment was set to 920 sek with the lowest priced garment at 100 sek and the highest priced garment at 2500 sek. The median number is 800. The profitability calculated based on the average costs (including the cost for donated and recycled garments) and the average resell price results in:

- Resell as-is: +636 sek per garment
- Repair: +568 sek per garment.

Since no garments were sold in the project, and no online resale channel had been established, the costs for selling the garments has not been taken into consideration in the following calculations. That is why the result is defined as "gross profit". The costs that are included in the gross profit are shown in the previous section 5.3 costs in table 3.

The analysis shows that if all the 278 garments would be sold to their suggested resale price, the gross profit would be 102 000 sek. If the costs for recycling or donation garments were to be excluded from the equation, the gross profit would increase to 183 000 sek. Looking at specific garments, the profitability ranges from losses on -257 sek per garment to profits on +2 170 sek per garment. The median value is +515 sek in gross profit.

The average cost for a garment, whether categorized as "Resell as-is" or "Repair," and including the average cost per garment for sorting and recycling/donation, stands at 323 SEK. This means that for Filippa K to reach a break-even point, considering only the costs incurred from collection to pricing, the average resale price would need to be 323 SEK. Since the average resale price for the piloted products was set at 920 SEK, there is room for reducing the resale price if the garments do not sell at their current price. This adjustment would still allow for a viable business case with a healthy gross profit and the potential for self-sufficient if the initiative continues.

83% of the garments collected were analyzed as not worth repairing or selling second hand but chosen to be sent to donation/recycling instead and only 17% of the garments "made it through" the selection process. This brings to light the dilemma of whether to sell a larger quantity of second-hand garments at a lower price, albeit at a lower quality, in order to keep them within Filippa K's sustainable cycle with attached product IDs. Conversely, the alternative (as in this pilot) is to sell a smaller quantity of garments through the brand's own channels, redirecting the rest to donations. In either scenario, the garments find a second life, but those sent for donation wouldn't be assigned product IDs and, as a result, would no longer fall under Filippa K's direct oversight.

To advocate for the approach undertaken in this pilot project: Filippa K maintains stringent quality standards for the items they resell, allowing them to set appropriate pricing. This underscores the significance of incorporating circular business models right from the inception

of a product's lifecycle, emphasizing the importance of products designed with circularity in mind. The majority of garments gathered during this pilot project fell into categories typically associated with shorter lifespans, such as jerseys or leggings, which are prone to close-body wear and staining, as outlined in the Execution section.

In light of the above rationale, Filippa K could consider (1) reassessing their sorting criteria to determine which items are sent for donation/recycling and which are earmarked for repair, potentially increasing the volume of garments that can be resold within Filippa K's circular loop. This might involve refining sorting guidelines with more detailed subcategories. Additionally, (2) Filippa K could explore garment redesign strategies for those with perceived shorter lifespans, focusing on circular design principles to enhance repairability and overall durability.

As mentioned earlier, no garments were sold to end consumers during this pilot, resulting in no actual profits. Nevertheless, Filippa K did carry out test sales as part of an effort to evaluate the outcomes in the C-PLM system. The intention moving forward, in 2024, is for Filippa K to retrieve the garments from Unitex and make them available for sale on an online second-hand platform. Additionally, Filippa K plans to collaborate with a third-party second-hand marketplace partner for this endeavor.

6. Conclusion, expected contribution and next step

The project has enabled Filippa K to have the possibility to resell approximately of the garments going into the collect program. The project has facilitated the generation of comprehensive analytics concerning used garments, including their durability and the costs involved in the take-back and repair process. These insights can empower Filippa K to make informed strategic decisions in support of transitioning to a more circular business model. This could for example be information on what product groups result in claims, or if there are any patterns in the type of flaws that tend to occur per product groups or what product groups can be repaired versus recycled. Information such as this aids the company to design for cyclabilty, create high quality, durable products as well as to continue the work on their "collect program" which include repair, resale and recycling.

This pilot project concludes that there is a viable business case for Filippa K when it comes to collecting used or flawed products, sorting, registering, adding NFC tags, and generating unique product IDs for resale in the second-hand online market. However, the strength of this business case may vary depending on the types of products returned by customers and their current condition. For instance, if the majority of repairs were of the more expensive "unraveled top stitch" category, which costs 249 SEK per garment, as opposed to the predominantly cheaper repairs in this case (averaging 68 SEK), it would have a notable impact on the business case. Nevertheless, it is likely that Filippa K would still achieve a gross profit, given the low representation of more costly repairs among the 1591 garments collected in this pilot.

Therefore, this pilot demonstrates that when returned garments exhibit durability and good quality, resulting in reasonable repair costs, it is highly probable that it would be financially advantageous for brands to engage in the collection, sorting, and creation of unique product IDs to prepare for resale. Even though a majority of the collected garments are sorted to donation and recycling, incurring costs for the brand, this expense can potentially be offset by the sales of items categorized for repair or resale at higher prices. However, Filippa K will persist in refining the sorting process to determine which garments are suitable for resale in their own channels and which should be directed to donation or recycling after the conclusion of this project.

Filippa K's objective for the end of 2023 is to resell 50% of the garments gathered in the collect program, thereby reducing our garment waste by 25%. This pilot project has been a crucial step toward achieving this goal. Firstly, it has allowed us to optimize garment pricing based on

the cost data we've acquired from the project, enabling us to realize its full economic potential. Secondly, by the conclusion of the pilot, approximately 33% of the collect program garments have been prepared for resale, marking an 8% increase from the pre-project levels. Moreover, we have plans to process around 200 more garments in the system. However, it's important to acknowledge that we have not yet reached the 50% resell goal, and we understand the need to adjust our strategy for online resale in order to attain the 50% resell target and achieve a 25% reduction in garment waste.

Furthermore, Filippa K's long-term objective is that this project serves as a stepping stone to reduce the number of reclamations in the company by 20% by 2026, aligning with our company's strategy to produce high-quality, long-lasting clothing. We recognize that we would need to scale the data collection to understand more about the reclamations and we also acknowledge that reaching a long-term goal may necessitate adjustments along the way, so we will continue to analyze and assess data related to reclamations. This includes identifying common reasons for reclamations and monitoring trends that may impact product quality. We will also conduct root cause analysis to gain a deeper understanding of why reclamations occur. Nevertheless, this project has provided invaluable insights that will contribute to reaching our goal.

6.1 Expected contribution

The expected contributions of this project to the fashion industry are outlined below.

1. Data-Driven Sustainability: The project demonstrates the value of data-driven sustainability. By implementing systems like C-PLM (Circular Product Lifecycle Management), brands can collect vital data throughout garment life-cycles, durability, and consumer usage patterns, enabling informed decision-making.
2. Garment Reuse: Through initiatives like C-PLM, brands can resell used garments, maximizing economic potential while reducing waste. This not only benefits the environment but also aligns with consumer demands for sustainability.
3. Collaboration: The fashion industry's transformation towards sustainability requires collaboration among industry partners. Brands like Filippa K aim to work together with others to innovate and collectively create a more sustainable and circular fashion ecosystem.
4. Digital Product Passports: Addressed in the EU strategy for sustainable and circular textiles 2023 the EU's coming regulation Digital Product Passport directive offers promising opportunities to enhance the business case for secondhand sales. It can

streamline data collection and improve traceability for used garments, insights of how circularity will impact business models within fashion industry. This pilot represents one of the pioneering efforts to implement a unique product ID for reused garments and could serve as a valuable learning experience for the development of the digital product passport system slated for implementation by 2030.

In essence, these contributions aim to drive circularity, increase reuse and longevity of garments, reduce waste, and promote responsible consumption within the fashion industry by harnessing data, circular business models, and collaborative efforts.

6.2 Next steps

As discussed in the background, one of the primary challenges when expanding circular business models and textile resale within the industry is the ability to establish a compelling business case at scale, complete with tracking and measurable outcomes. Data and traceability play pivotal roles in enabling this, and the C-PLM system, while piloted on a small scale, has demonstrated the economic viability of providing digital IDs for used Filippa K garments intended for resale.

Moving forward, Filippa K will continue to investigate the business case, taking into account additional costs associated with various options for selling garments online through third-party resellers. However, the project partners have decided to pause the inflow of garments added to C-PLM. The main reason is to allow Filippa K the time to develop a business strategy for selling the garments incorporated into the C-PLM system. The fashion and retail industries have undergone significant changes in recent years, largely influenced by the pandemic and global economic factors. When the project began two years ago, Filippa K aimed to sell the garments through the Filippa K Studio. However, they now recognize that relying solely on physical retail presence is not aligned with current market demands. Instead, Filippa K sees substantial potential in taking their second-hand assortment online to meet market and customer needs.

Transitioning to online sales will raise the need to investigate how circularity systems like C-PLM should be integrated with other systems such as ERP and OMS. In addition, from Unitex side a garment supplier would need to commit to a minimum of 1000 collected, unsorted garments per year to make a strong business case. As Filippa K's capacity alone is currently insufficient for this commitment, there is a need for more brands to adopt circular and sustainable business models and join in on more traceable second hand sales.

Filippa K, Unitex, TrusTrace and Circularista firmly believe that collaboration with industry partners is the key to success. By joining forces with other brands, the project partners aim to achieve more significant impact. Expanding the initiative requires further platform development, increased integration efforts, enhanced user experience and a more optimized way of capturing data, all of which involve financial investments. Filippa K plans to engage with industry colleagues, and by the end of 2023 assess the progress made in this collective effort.

7. Project Communication

Filippa K and TrusTrace collaborated on a video showcasing selected textile circularity projects funded by Re:Source. In the video, we explained our project and provided a demonstration of the solution. This informative video will be shared across various platforms, including Re:Source's, Filippa K's, and TrusTrace's channels.

For Filippa K, our primary target audience for communication has been fellow professionals in the fashion industry, especially our colleagues within the business. We shared details about the project on LinkedIn and presented it during our global monthly meetings, including discussions within our circular business team.

TrusTrace's and Circularista's communication efforts have been directed towards the textile industry and other project consortiums, such as Trace4Value. Trace4Value is a traceability program with over 65 project partners from diverse industries, all focused on traceability and sustainable, circular value chains. We have presented the C-PLM project on several occasions during both open and closed project meetings within this consortium. Additionally, it has been discussed among the members of the Digital Product Passport work package team. Notably, TrusTrace mentioned the C-PLM project during a press release event, attended by press representatives, textile companies, researchers, and consultancies.

As for Unitex, our target audience for communication primarily includes the fashion sector. We plan to share the project and its report with the board of the Swedish Fashion Association and its members. The project has also been showcased during public events where our founder, Angelo da Silveira, has been a speaker, including D-Congress, Weekdayfestival, and Brilliant Minds. Furthermore, we intend to share the project with Vogue US for inclusion in an editorial about Unitex's innovative efforts in the fashion industry.

8. References

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9. Appendix

1. Appendix 1 Time plan C-PLM
2. Appendix 2 RE:Source Movie
   https://vimeo.com/861225976/22e5fc2435?share=copy

RE:
SOURCE
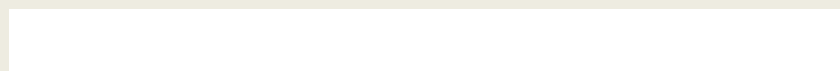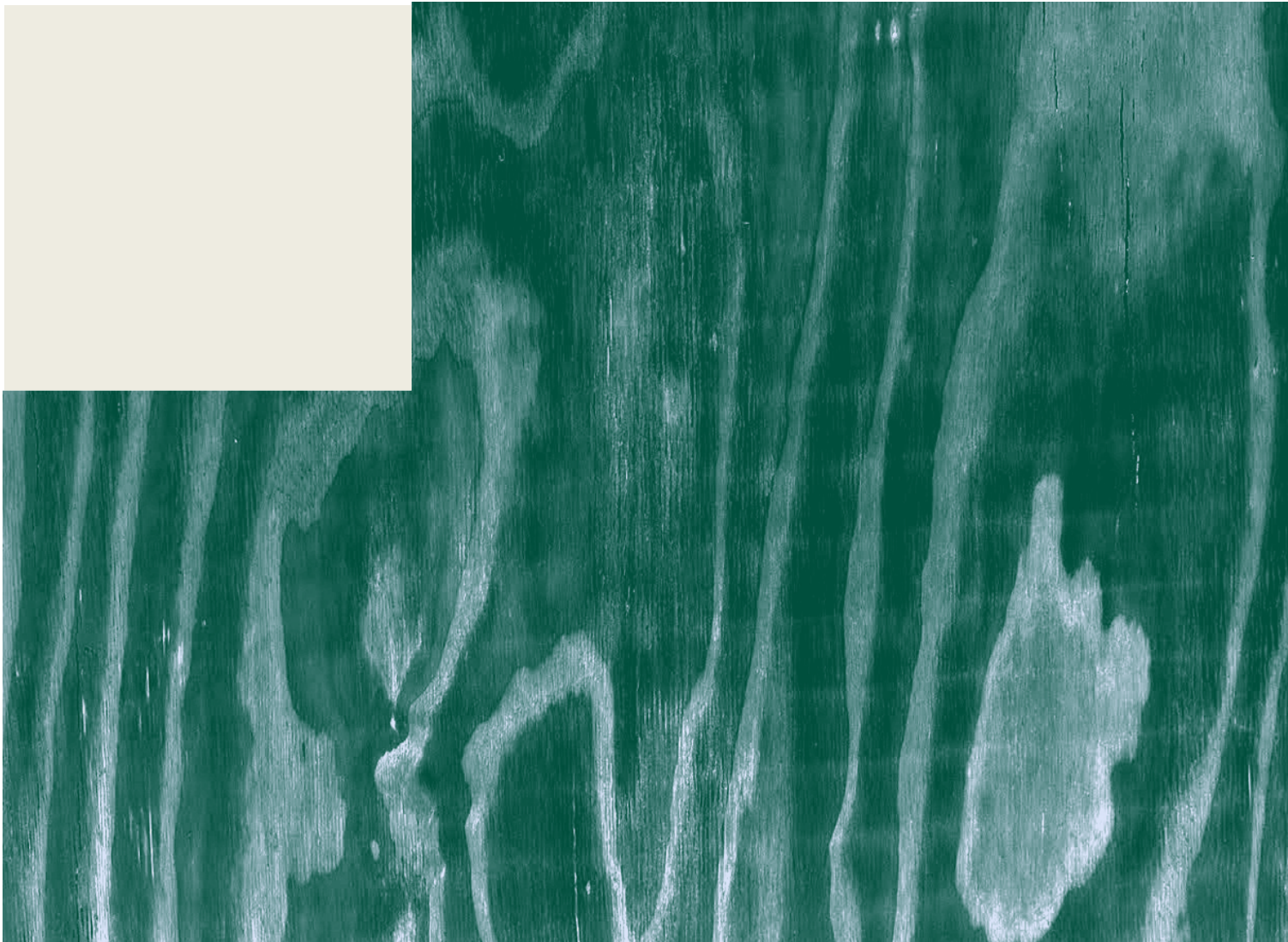
RE:Source är ett strategiskt innovationsprogram som fokuserar på att utveckla cirkulära, resurseffektiva materialflöden. Vårt mål är att uppnå en hållbar materialanvändning där vi håller oss inom planetens gränser.

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