Re-FREAM

Re-Thinking of Fashion in Research and Artist collaborating development for Urban Manufacturing

Working Package WP4

Hub “Additive manufacturing”

Deliverable 4.5

Hub “Additive Manufacturing” Final Report

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Dissemination Level		
PU	Public	
CO	Confidential, only for members of the consortium (including the Commission Services)	x
Type		
R	Document, report (excluding the periodic and final reports)	x
DEM	Demonstrator, pilot, prototype, plan designs	
DEC	Websites, patents filing, press & media actions, videos, etc.	

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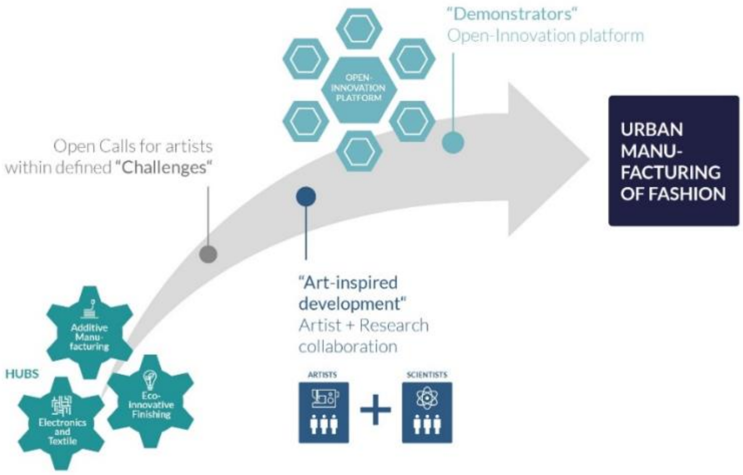
0 Context Information

0.1 The Re-FREAM Project



Re-FREAM will support **art-driven innovation** in European R&I projects by inclusion of artists in research consortia via linked third-parties. The artistic community receives a strong support from art-related partners like the Art University of Linz (UFG) and the European Institute of Design (IED), creative hubs and facilitators like Wear-IT Berlin (FashionTech), AITEX, ARCA and CREATIVE REGION combined with remarkable technology from IZM Fraunhofer (E-textiles), STRATASYS, HARATECH (3D-printing), EMPA (3D body simulation), CARE APPLICATIONS (Garment nebulization) and PROFACTOR (Additive manufacturing).

Re-FREAM boosts **art-inspired urban manufacturing**, where the city becomes a new production space. Especially for **creative fashion**, urban manufacturing offers a great opportunity to create an alternative to the much criticized production in low-wage countries.

Three technologies (additive manufacturing, electronics on textiles and eco-innovative finishing of fashion) will be explored together. **In co-creation** 20 awarded Artist/ Researcher teams, digitalized manufacturing of fashion will be developed up to TRL 5 to enable small-scale production of fashion in urban environment. An **Open-Innovation Platform** will finally link the know-how and the communities of the hubs, will offer access to relevant facilities and make the Re-FREAM art-inspired urban manufacturing working model sustainable.

0.2 Document history

Version	Date	Change/Reason for change
V1.0	07.10.2021	Draft template prepared for partner input
V1.1	10.11.2021	Draft 1 by CRE
V1.2	25.11.2021	Draft 2 by CRE
V1.3	07.01.2022	Final review by PRO
V1.4		Cleaned and finalized by CRE

0.3 Purpose and Scope of Deliverable Report D4.5

A final report about the Hub "Additive Manufacturing" activities for the project time and outlook for the after-project phase.

1 Executive summary

The research at Hub Linz focused on the PolyJet technology from project partner Stratasys besides other 3D printing technologies, such as dispensing, fine filament fabrication (FFF) and robot-based inkjet printing. Polyjet technology is similar to the well-known ink-jet printing processes but uses curable liquid acrylic-based photopolymer resins onto a build tray to build up 3D structures. With this technique it is possible to build up objects by additive manufacturing, also commonly known as 3D printing.

The goal of this research hub was printing directly on clothes and fashion articles or this pieces directly. The development of a virtual software guide for 3D printing fashion products will enable artists and interested people the facilitated use of modelling for 3D printing with this technology and other technologies.

These pioneering projects used the technologies in the hub:

- Digital Vogue – Between Synthetic and Organic Processes (Julia Körner)
- WeAreAble (Ganit Goldstein)
- Re-Think Manufacturing (Yokai Studios)
- Fragments Garments (Elisabeth Jayot)
- Syntropia by Sophia Guggenberger & Eugenia Morpurgo
- Footwear Time Based Design by Assa Ashuach
- Needs-Based Clothing by Silke Hofmann
- Thallasic Masks (Post-Natural Prostheses) by Filippo Nassetti & Vincenzo Reale

Technologies used in this hub:

- 3D Printing – PolyJet
- 3D Printing – Fused Filament Fabrication (FFF)
- 3D Printing – Stereolithography (SLA)
- Body Scanning
- Laser Cutting and Engraving
- Vacuum Casting
- Injection Molding
- Design modeling software

Scientific partners working in this hub:

- Profactor
- Stratasys
- Haratech
- UFG
- EMPA

This report will mainly focus on the process of co-research and co-creation of Round 2 artists and their project development in general. For round 1 artists co-research a more details summary report was prepared in month 24 and submitted to the project officer.

Furthermore, for more detailed report on the individual tasks within this hub and on the research parts, refer to the other deliverables D4.3, D4.4 and D4.6 besides the half year reports D1.2 – D1.7.

2 Re-FREAM Hub Linz – "Additive Manufacturing"

2.1 Process of Co-Research, Co-Creation and Presentations

2.1.1 Interhub Management

After a project meeting in Berlin (15-17th January, 2019) there have been regular, bi weekly online Interhub meetings (via zoom video) between the three Hub managers (Wear It Berlin, Creative Region Linz and Aitex Valencia) as well as an intense exchange via the chat program "Slack" where hub managers established an "interhub" channel for a fast and uncomplicated exchange of information. A close exchange between hubs is important to ensure a certain quality level of processes and structures for artists / co-creation projects over all hubs. The main objective of these meetings at the first month of project time was to discuss relevant structures for the future hubs, intersections between work packages that has been affecting all hubs (WP3/WP2) and other actions that will be affecting all hubs or partners within hubs.

In the early project phase this especially focused on the launch of the call (first round) The meetings had been very useful in order to agree on the selection and evaluation process (contribution to WP3) and prepare and align information such as application guidelines, evaluation criteria and application process for the future artists. This information is updated on the webpage and serves for artists to understand Re-FREAM processes. Also, the sub Grand Agreement and procedure of the Grand Management with awarded artists is discussed and established in the interhub meetings.

After the first Re-FREAM call was launched, the main topics addressed were regarding the preparation of the tech-webinars that took place in the beginning of May 2019, where all partners of the three hubs were presenting the challenges and technologies in their hubs, in order to give artists more information to improve their proposal. While each Hub coordinate the respective input (see "Coordinate partners within the hub"), in the interhub meetings the overall structures and concept is established in order to deliver a good webinar experience to future artists of Re-FREAM.
In the interhub meetings, also, the services of the hubs were defined and agreed on to and communicated on the webpage:

- Providing different fields of tech expertise and technology access
- Facilitation of the co-creation procedure (including organisational support for artists)
- Network access and knowledge access for accelerating the artists projects

Additionally, discussions regarding the facilitation and mentoring of the awarded artists had finished with the design of a monitoring structure draft (Task 4.2) and contributed to WP2 Art & Tech Transfer.

After the first Re-FREAM call was closed and the selection process proceeded, the coordination between Hub managers focused mainly on coordinating and developing structures for the artists to work within the Hub and implement the co-creation projects. To ensure a certain quality that is same over all 3 Hubs, a close coordination and exchange in the Interhub was necessary to develop a strategic concept for this, also in agreement and alignment with the Art & Tech collaboration guidelines (WP2). This included among others also a concept for reporting and documentation structures for the co-creation process, that help hub managers to ensure the project do not run out of time and budget and deliver results. Additionally, close exchange was needed to develop a Sub Grand Agreement Template that could be used in all 3 Hubs.

Further, a common Welcome Day for all Artists and the Re-FREAM Team needed to be prepared and organized. The decision made was to set it up for the 5th and 6th of September 2019 in Linz, in order to include the Artists to the S-T-ARTS program of the Ars Electronica Festival. Hub managers developed the concept for the Welcome Day, in alignment with WP2 and coordinated and included the input from the partners in their hubs.

After the welcome day, each hub set up an individual kick-off event for the partners of each hub. Here, the coordination of the interhub team focused on coordinating the agendas in order to cover similar content, also in alignment with the Art & Tech concept from WP2. A close exchange of experiences and ideas among hub managers was necessary and extremely helpful in order to find a good way of putting the Art & Tech concept from theory in practice. Exchange in this phase focused on:

- strategies on how to create a common basis for project development between Artists & tech partners
- strategies on setting up a work plan for the co-creation pairs
- strategies on how to adapt the sub grant agreement to make it work for each project

As in March 2020, the interhub exchange become increasingly necessary in order to align over all hubs on how to deal with the covid19 situation The interhub management was even more intense in order to keep general hub management and administration of the projects as equal as possible in the three hubs. Nevertheless, each hub had its special infrastructure, topic and situation.

With bi-weekly interhub meetings the Hub managers kept up the exchange on a regular basis and follow consistent handling and decisions over all Re-FREAM projects. Also, to implement adaptions for round two call and development after the experiences of the first call.

2.1.2 Hub Management: Art & Tech Collaboration Support, Facilitation and Monitoring

The main task of the hub management was here to establish and facilitate the ongoing communication to and with the selected artists, discussions between the tech partners, as well as providing space for a direct exchange between the artists and tech partners via Zoom meetings, calls or email communication in order to develop a better understanding of the artists project proposal and technical possibilities.

Within the Hub Linz, several meetings were organized to bring together all actors that are included to build up the hub in Linz locally. Whilst the meetings of first round project teams were held in person, the second round project teams were only able to meet digitally by zoom calls or video conferences due to the Covid-19 pandemic situation. The aim of the meetings was to forward information that was agreed or discussed in the interhub meetings, gather feedback and input for further decisions within the interhub meetings, include partners of hub Linz that have intersection to the topics discussed in the interhub meetings and additionally to talk about how the location of Linz will realize the concept of the hub. Also, the meetings gave space to discuss work packages that have intersection within the partners of hub Linz.

This update meetings were planned on a regular basis via personal meetings or online meetings, in order to give partners within the hub an overview of the actual progress in every task and work package.

The coordination of this meetings was especially important for coordinating partners as pre-selectors for the first call, and also for the phase after the final jury selection and the exchange increased especially in this time. Only in the time between jury selection and welcome day (mid July to beginning of September) in total 7 partner meetings were coordinated and facilitated (in person or via zoom video calls) with a focus on:

- exchanging about technical possibilities in regard to the artists project proposal
- exchanging with the selected artists directly in order to get a better understanding of the proposals
- exchanging about possibilities for co-creation pairs (which tech partner could work with which artists)
- exchanging about structures and set-up of the co-creation projects

The main task of the hub management was here to establish and facilitate the ongoing communication to and with the selected artists, discussions between the tech partners, as well as providing space for a direct exchange between the artists and tech partners via in person meetings, calls or email communication in order to develop a better understanding of the artists project proposal and technical possibilities. For the latter, video calls between each 3 artists and all tech partners of hub Linz were set up.

At the welcome day, the hub management organised and facilitated a session for the Hub Linz Tech Partners to have a first personal exchange between the Hub Linz artists and respective tech partners. The aim of each session was to inspire the Hub Linz Artists with the existing technology access in Hub Linz in order to have a common understanding and fruitful basis for finding a focus of the co-creation project between artist and tech partner. Additionally, right after the welcome day some artists were given the possibilities to visit facilities of tech partners to get a first-hand impression of existing technology in action.

Further coordinative effort was brought up for organising the kick-off events (on per co-creation project) for the Hub Linz (Task 4.2.) where tech partners of Hub Linz were coordinated and facilitated to establish working structures together with the artists and start forming a project team.

Additionally, right after the kick-off event, several calls and meetings were organized in order to continue the discussions for the sub grant agreement (contract) between hub management, tech partners and artists. Especially exchanging about IPR related issues required more time and effort than anticipated, since this turned out to be a sensitive topic for both sides. Also, the signature process was led by Hub Management.

As the co-creation project have started and are up and running, the hub coordination started to organise and facilitate monthly update calls with the respective tech partners of hub Linz and the respective artist. The hub management facilitates the call with the aim to align the co-creation team on the work that has to be provide in the co-creation project, also helping them to reflect their co-creation processes in terms of team communication, information flow, team exchange and team alignment as well as progress. Additionally, hub management is facilitation and supporting their decision finding for the development of the prototype.

The special situation turned out in March 2020 where the co-creation teams were strongly affected by the beginning **COVID 19 pandemic**. Hub management organised and facilitate regular sessions with each co-creation team to have discussions about current constraints in each tech partners facilities and facilitated the evaluation process how the projects can be kept on track, how the scope of the project can be changed in order to finish a prototype and develop a new, aligned work plan and time line with scenario methods in order to navigate through the time of the crisis.

Over the whole project duration the Hub Manager accompanied the teams, monitored the implementation of work packages, costs and project progress.

2.1.3 Co-Research and Co-Creation Milestones

The project plan considered several milestones and general meetings within either the Hub or the whole Re-FREAM network in order to present co-research results, co-creation developments, concepts and final outcomes. Due to the special situation due to Covid-19 causing long-term travel restrictions, the second round artists started their projects in January 2021 completely online. The whole Co-research process was done via online meetings, calls and email communication. This was a challenging situation for all involved parties. Coming to a common understanding of the research targets, different perspective of Art and Tech partners, technical possibilities and innovative approaches, required a huge effort from all team members.

As the co-research had started and was up and running, the hub coordination started to organise and facilitate monthly update calls with the respective tech partners of hub Linz and the respective artist. The hub management facilitates the call with the aim to align the co-creation team on the work that has to be provide in the co research and co-creation process, also helping them to reflect their processes in terms of team communication, information flow, team exchange and team alignment as well as progress. Additionally, hub management is facilitation and supporting their decision finding for the development of the prototype.

2.1.3.1 Mid Term Meeting

All artists presented their results of the co-research phase and plans for their co-creation in a 15 Min presentation followed by Q&A sessions. The Mid Term Meeting in May 2020was also held online as it was still not possible and reasonable to travel due to the ongoing difficult Covid-19 situation.

2.1.3.2 Prototype Concept Presentation

Also, the Prototype Concept Presentation at the end of the co-creation phase a hub-internal presentation, so only Hub members from Linz attending. In July 2021 travelling became easier within a country, but still difficult within Europe. Hub Berlin and Hub Valencia round 2 project teams did the Prototype Concept Presentation in person. For Hub Linz it was still not possible to do so. Nevertheless, the presentations of the concepts were versatile and comprehensive and have shown the versatile possibilities 3D printing possibilities.

Of round 2 project teams, at this time, only one team (Sophia Guggenberger and her partners and team members) had the chance to meet in Person (with Haratech in Linz). All other artists still did their project only by online meetings, calls and email communication.

2.1.3.3 Final Presentation

Also, the final presentation in September 2021 was held online. Initially it was planned to take place in Bilbao and be offerd as a hybrid event for those who can not come due to Covid-19 situation. Hub Linz artist and Hub Linz Manager planned to go there. In a short notice, the live event was canceled and the final presentation was online too. All artists presented their final videos and project outcomes in a 15 Min presentation followed by Q&A sessions.

2.1.3.4 Final Meeting

The final meeting in November 2021 was a live event in Berlin and the personal exchange was highly valuated by both artists and tech partners, but also organisational Re-Fream partners. The event also offered the chance to present the results of the 20 projects to an external audience. The Hub Linz Manager organized posters of all 20 projects in order to present these during the event in Berlin. The attending artist also presented their prototypes and material samples.

2.1.4 Difficulties due to Travel Restrictions caused by Covid-19

Except of one artist (Sophia Guggenberger), all other artists of Hub Linz round 2 realised their project by only having online communication with their tech partners. It was not possible and reasonable to travel between England, Israel, Germany and Austria. While in the co-research this was easier to handle, this restriction was causing a lot of difficulties and additional effort in the co-creation phase. Especially in terms of testing samples. Printing samples needed to be shipped from the tech partners to the artists and sometimes also the other way round. Shipping within Europe often take days which caused latency time until a confirmation or common decision for continuation of a process or technique could be done.

Retrospective, in general a personal exchange was missed a lot as it is essential for a common understanding, a faster project progress and exchange.

3 Hub Linz Projects: Developments and Prototypes

In the following chapter the overview on the co-creation projects is given, how the Re-FREAM demonstrators were developed. An outline summary is provided for each project/demonstrator together with a short description on the co-creation experience and knowledge gain by the Re-FREAM partners. Also, an overview is given on the artist projects and how they were addressing the specific objectives and expected impacts of Re-FREAM.

Worth to be mentioning, the profiles of first round co-creation projects where compiled on request in a "summary report" in month 24 and are also placed here in this report. The same logic is used for 2nd round co-creation projects, which are sketched below in the following subchapters.

3.1 Julia Körner - Digital Vogue

Artist	**Julia Körner**
Supporting Re-FREAM partners/role	Pavel Kulha - Profactor Guillaume Clement - Haratech Naomi Kaempfer - Stratasys Sander Hofstee - University for Art Linz

Project description and innovation

Creating unique and personalized garments with utmost skill is a tradition and privilege of couture – which Julia Koerner aims to develop at scale. Her architectural and computational expertise have allowed her to configure many haute couture designs, redefining 3D digital code as a craft in the process. Her central Re-FREAM objective was applying her digital mastery to develop wider access to personalization, replacing standardized sizing. As the tactile comfort of 3D designs remained a challenge, she began by designing and printing Digital Vogue structures directly onto fabrics, exploring the bonding capabilities with sustainable textiles. Printing without any support material drastically reduced the negative waste generated in traditional 3D printing. Next, she focused on pattern creation, opting to use 3D scanned muscle definitions to define the garment structures. This led her to new paths for garment fabrication, including new methods of joining garment parts through 3D printed snap joints. Finally, drawing on her explorations, she created a cascading remodulable 3D printed garment design, which can be recomposed around the body. Customization is thereby integrated beyond the initial fit – the wearers can also recompose the garment at will.

Koerner's seductively tactile designs explore new digital fashion fabrication workflows. The soft topographies of her 3D textiles fabrications envelop the body with couture precision – without sewing. By fully digitizing each step, she steers us towards a future in which long-lasting garments can be sustainably printed and assembled locally. In addition to reducing shipping, carbon footprint and traditional manufacturing energy costs, color-printing garments also allows for wide color palettes without the water consumption from dying processes.

Apart from comfort, a central limit to large scale 3D garment printing has been the printer bed size, just as in traditional woven fabric dimensions are limited by the sizes of looms. This results in the necessity of assembly. Koerner addresses this resource-intensive procedure through the imprinting of snap closures. The new joinery methods developed during Re-FREAM could lead to large scale applications in 3D garment printing, and potentially impact garment and textile assembly in general.

Koerner's final 3D printed prototype can be worn as a dress. Its 38 earth tone composites can also be disassembled and reassembled into a variety of garments, such as a jacket, a skirt, a choker, as well as accessories including a bag and rings. They catch the light when they move, evoking the shimmering crystalline formations of the Dead Sea, whose mineral structures were a key source of inspiration for Koerner. Triggered by a Re-FREAM conversation, the modular compositions also echo the interplay of the Hub collaborations, enmeshing design and industry with science and technology.

Shooting her final garment in the desert heat, while wildfires were raging across the world, took her designs one step beyond the concept of "bio-inspiration". The name of the final collection, Arid, dawned on Julia in the dry air, documenting another shift. Whereas her synthetic-organic designs were always inspired by natural structures, they were now drawing inspiration from climatic change.

The project started under the name Digital Vogue – Between Organic and Synthetic Processes; these processes eventually evolved into a modular garment collection Arid, first presented at the ARS Electronica Festival. The high mediatization and museum exhibitions of Koerner's work across the globe guarantee the visibility of the prototype on a large scale. Yet the single prototype can only start to reflect the experimentation she undertook with the four different technology partners. Future commercial developments of the research could be found in the wealth of scientific, empirical and artistic insights gained from Re-FREAM – to ultimately develop a full collection.

Figure 1: Julia Körners prototype and printing technique detail © J. Körner

<u>The Technologies</u>

The digital textile innovation consists of multicolor 3D Polyjet printing directly onto textiles, using the 3DF Polyjet printer by Stratasys, without any support material. After benchmarking adhesion for a wide variety of fabric testing, including different weaves and dyes, a sustainable hemp-based non-dyed fabric best fulfilled the purpose and goals of the project. The applied 3D printed textile geometries were inspired by organic structures, while the garment structures were based on human tissue, allowing for optimal modular assembly. Sewing is replaced by 3D printed joining closures.

Figure 2: Julia Körner with her tech partners from Profactor and Haratech © J. Körner

In the following table the main achievements per partner are summarized, reflecting their role within the co-creation projects and technology developments within Re-FREAM

Partner	Achievements
PRO	• Printing directly on textiles • Multimaterial printing • Expanding and realizing design possibilities
STR	• Printing directly on textile • Joinery between the printed patches • Urban manufacturing DIY.
UFG	• Design strategies. • Virtual clothing support
HAR	• Testing and validating various uses of laser cutting in the manufacturing process: cutting a flat pattern, cutting holes for the buttons. Finding optimal parameters • Testing the use of filament-based 3D printing for various designs. • Using full body 3D scanning into the designing digital workflow

3.2 Ganit Goldstein – WeAreAble

Artist	Ganit Goldstein
Supporting Re-FREAM partners/role	Leo Schranzhofer - Profactor Guillaume Clement - Haratech Naomi Kaempfer - Stratasys Sander Hofstee - University for Art Linz

Project description and innovation

Ganit Goldstein navigates multiple dimensions at all times: transitioning from 2D to 3D back to 2D, then dipping into virtual reality. The ornate surfaces of her designs reflect her deep concern with craft, scale, and volume. In collaboration with her Re-FREAM partners, she developed highly customized new design workflows, creating both upcycled low-tech and high end multi-color Polyjet printed garments. Along the way, pandemic travel restrictions also pushed her towards entering the territory of virtual fashion display - in couture splendor. Her 3D-printed garments appear in virtual space in all their precious detail: a highly tactile display of digital manufacturing, eager for its closeup. The collection of seven 'WeAreAble' garments produced through two parallel processes are a spectacular combination of past and future techniques, allowing tailor-made garment manufacturing with unique materials, color complexities, and parametric patterns. Both develop new workflows for garments with multi-color Polyjet printing. As Goldstein explains, "there are limitations and freedom in both". The high tech methods resulted in stunning kimono styles by printing directly unto fabric, a new and innovative approach. These garments were assembled without any sewing. Her "working-from-home" low tech creations provide a proof of concept for the use of upcycled materials in 3D printing. The pandemic travel restrictions and the need to see the details from all the angles motivated Goldstein to further develop the project into a novel form of fashion exhibition, in virtual reality. Goldstein's approach to digital manufacturing and the future of textiles is enmeshed in traditional systems of production of precious hand-made techniques, such as weaving and embroidery. By using her reverse-engineering methods, she bridges the link between digital and physical manufacturing, pioneering new levels of value and refinement for digital design processes. Her sophisticated software customizations allow for garment production tailored to the uniqueness of each body shape. Her low tech personalized garments provides a proof of concept for 3D-printing with upcycled materials, a major step forward for sustainable digital manufacturing.

The visually sensational Re-FREAM co-creation project garnered worldwide attention through exhibitions, and was highly publicized – including a nomination as the best experimental design by Fast Company. The project has driven her to explore new textile compositions required by new manufacturing techniques. After completing her MA at the Royal College of Art, Goldstein decided to delve into further material research with a Master of Science at the Massachusetts Institute of Technology in Boston. The link of manufacturing technologies with the virtual display of garments has also led her further into the cultural metaverse : "How can these technologies allow museums to make their collections - and history - more accessible?".

Figure 3: By Stratasys 3D printed Kimono ©G.Goldstein

<u>The Technologies</u>

The topographies of each of Goldstein's intricate designs are the result of a complex series of 3D CAD manipulations. First, she flattened the curves and nooks of body scans by Haratech. Then she combined parametric software to build unique custom patterns, based on the scans and inspired by traditional IKAT weaving. The resulting reverse-engineered 3D model was infused with multiple color complexities, then directly printed onto fabric with integrated embroidery elements, and finally assembled into wearables. The kaleidoscopic kimono parts were printed by Stratasys in different locations, then seamlessly assembled without sewing. In parallel, Goldstein hacked her own printers at home, to allow the insertion of the project developed through Stratasys, using upcycled materials.

In the following table the main achievements per partner are summarized, reflecting their role within the co-creation projects and technology developments within Re-FREAM

Partner	Achievements
PRO	• 3D printing strategies • 3D and 4D loam approach • Printing on and into textiles
STR	• Combination of textile fibers and digital materials • Printing directly on textile • Joinery between the printed patches as post processing as dove tail
UFG	• Design strategies • Software workflow that combines design tools with direct digital fabrication • Virtual clothing simulation support
HAR	• Using full body 3D scanning into the designing digital workflow

3.3 Jokai Studios – Rethink Manufacturing

Artist	Yokai Studios - Viktor Weichselbaumer and Micheal Wieser
Supporting Re-FREAM partners/role	Sebastian Zambal, Julia Kastner - Profactor Guillaume Clement - Haratech Naomi Kaempfer - Stratasys Sander Hofstee - University for Art Linz

Project description and innovation

The focus of the team's Re-FREAM project is the use of 3D printing for garment assembly. Using the Yokai expertise in robotic printing for customizing garments, could robots enable new automated seaming solutions? Initial tests centered on thermal 3D bonding techniques to replace traditional seams, then on form making with filament printing. A large variety of samples of seams were produced through material testing and machine calibration. Wieser explains: "It was completely unexplored territory. Now we know which materials we can and can not work with!". The process revealed that mixed and artificial fibers react strongly to thermal seaming, whereas natural and smooth fibers such as silk do not. The main factor determining the strength of the bond however is the precision of the seam placement and its relation to the surrounding surface. EMPA in St. Gallen tested all samples created by the technology partners Profactor and Haratech, as well as the DIY solution of 3D formlock seams created at the Yokai studio.

The main outcome was a seam solution which achieves the sturdy military standard for uniforms – a strength of 1650 Newton, confirmed by the EMPA testing lab. "Knowing that our products are truly functional for everyday use was one of the most encouraging outcomes of Re-FREAM!", says Wieser. Another outcome was the collection of manufacturing data. How close must the tip of the 3D printer be to the textile? How much material is necessary to the left and right of the seam ? What are the parameters that needed for these new production processes? Taking these tests further with sensor technologies could change production on a large scale.

Through the Re-FREAM exchanges, the team has a better understanding of the large-scale funding that would be required to develop the machine to mass-production industry standards. But even on the DIY scale, new seaming techniques which replace traditional sowing and allow for 3D customizations can transform manufacturing – and creative outputs. Replacing static sowing machines with kinetic robotic processes enables three-dimensional rather than flat joinery. The possibility of transparent seams also opens doors to further design innovations – including for the domain of repair.

Reliable decentralized manufacturing assembly can reduce the outsourcing of garment and accessory assembly, encouraging urban regeneration. It reduces shipping costs and the carbon footprint that transportation entails. The Re-FREAM project also generated new reflections on more playful human-machine interactions in manufacturing. Could standardized repetitive interactions with sowing machines be replaced by more intuitive collaborations with robots? Could manufacturing mean tending to machines, feeding them code, preparing and training them to perform? Beyond the re-localization of production, the ReFREAM project also led to a reflection on how new ways of manufacturing can allow for new kinds of human-machine interactions.

Currently, the Yokai team is focused on building their brand, developing their design language, and offering a range of products with their machines. The natural next step from printing are other functional work-processes, such as (multidimensional) pattern-cutting. Longterm and with additional funding, the goal is the establishment of micro-factories. The studio aims to generate large scale further funding with the help of their current partners, the Creative Robotics Lab of the Kunstuniversität Linz, and is in discussion with Rickard Lindqvist of [a]industri in Sweden.

Though performative automation may not be the Yokai team's end goal, the appeal of their production process has proven to be a viable and unusual new business model. One example is the studio's collaboration for deadstock upcycling through robotic customization with the fair sportswear label Das Merch. The made-to order customized Roboprint Tshirts each featured its own unique generative design, and customers had the option to attend or watch the production performance Their robotic manufacturing arms have also generated income for the studio through events at malls in the Middle East and company events.

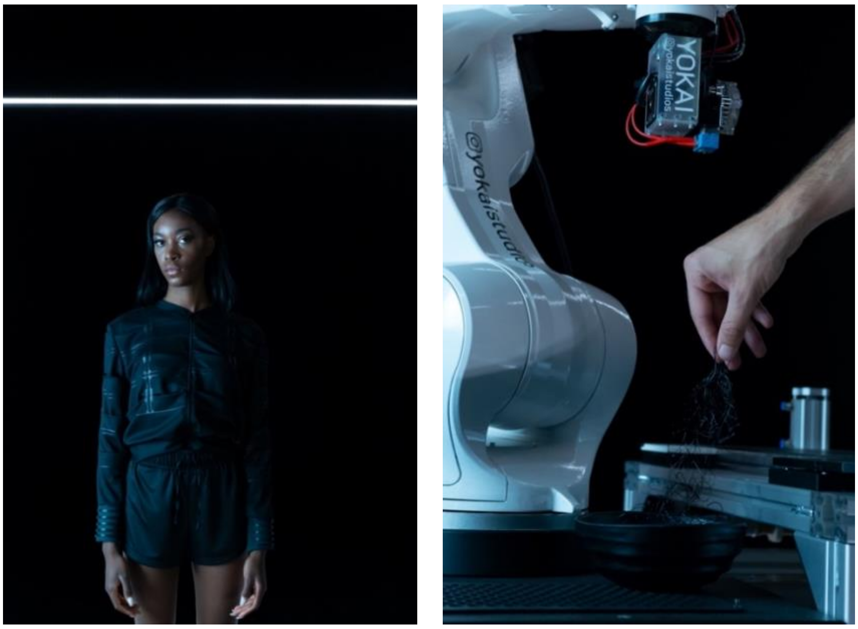


Figure 4: © Yokai Studios

The Technologies

To investigate seaming possibilities, Yokai chose 10 materials to test. These included natural and artificial fibres in both woven as well as knitted textiles. Haratech tested joining fabrics by FFF printing on the textiles. Fused filament fabrication (FFF), also known as fused deposition modelling or filament freeform fabrication, is a 3D printingprocess that uses a continuous filament of a thermoplastic. In parallel, Profactor tested PU (polyurethane) dispensing in order to join fabrics. Polyurethane is a common polymer composed of organicunits joined by urethane links. At the Yokai Studio, the team put their robotic arm and a Trotec laser cutter in motion to produce a 3D formlock seam. They also developed pieces using transparent seams, adding the new design element of light travelling through the seams. All three teams grounded their research in the detailed instructions by Empa to allow for testing at their facility in Switzerland. The results of the Zwick test and Tension test carried out by their Federal Swiss Laboratories for material testing showed similarly successful results for the 3D formlock seams as for the FFF approach by Haratech.

In the following table the main achievements per partner are summarized, reflecting their role within the co-creation projects and technology developments within Re-FREAM

Partner	Achievements
PRO	• Printing of TPU on fabrics • Robot- based printing approaches • Path planning and robot tracking
EMPA	• Softshell testing
HAR	• Testing filament-based 3D printing onto lose and stretched fabric. The goals were replacing sewing (stronger, waterproof, automatized), and 4D printing (by creating a 3D shape after releasing the stretched fabric that has just been printed on).

3.4 Silke Hofmann – Needs Based Clothing Design

Artist	Silke Hofmann
Supporting Re-FREAM partners/role	• Leo Schranzhofer, Max Scherf - Profactor • Guillaume Clement - Haratech • Naomi Kaempfer - Stratasys • Sander Hofstee - University for Art Linz

Project description and innovation

The achieved result of this Re-FREAM project is the developed bra alternative, a professional and refined modular garment that supports the wearer's specific bodily situation. This soft construction is achieved through the engineered knit patterns and self-directed tessellated support structures, which rely on the clever concept to lock the elasticity of the knitted loops in strategic places on the garment. This locking mechanism can be executed with simple equipment, such as custom plotted heat transfer foils. The self-directed tessellated support structures algorithm reacts to the individual body topography of the 3D scanned garment wearer. One of the highlights during the project development was a moment in the last prototype fitting. Silke's project participant Viktoria tried on her final custom garment for the first time. She reported to the team that she could feel the soft support on her body, especially on the side that might have been impacted most by her breast cancer treatments. In the engineered knit development, they worked out the knit patterns in detail, up to a professional standard.

It also showed that the base garment is, in fact, mass customizable. Besides the base garment, the team completed two versions of the bra alternative according to the individual needs of our project participant. Besides this analogue development, there have been other project outcomes during the last months.

Together with Sander Hofstee from the University of Art and Design Linz, Silke came up with a short visualization that aims to help the understanding of how bra diversity could look. They digitally tailored ten versions of the 3D knitted bra alternative to scale with exact analogue textile properties (thanks to CLO fabric digitising by EMPA). The chosen are versions based on a collection of actual bra needs of affected females (there are many more versions possible, and this is just a small selection). The video begins with a glimpse into the design ideas that two females drew on paper vests in one of my facilitated design sessions. After that several, possible versions of the bra alternative are portrayed. The three last versions are worn by Viktoria Prantauer's – the project participant's – digital double, which Nedim Šećeragić created from Viktora's 3D body scan. Viktoria co-designed the first two of these versions according to her own needs. The last version is again the bra alternative base garment.

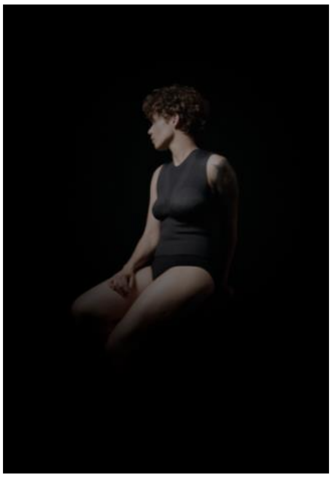



Figure 5: Silke Hofmann's prototype ©Hofmann, Arnaud Ele and Laura Knoops

The Technologies

Together with her project partners Case Studies and Wint Design Lab, Hofmann developed the analog modular bra alternative prototype through two additive manufacturing processes. The bra alternative is a 3D knit engineered, modular and mass-customisable garment that supports the wearer's specific bodily situation. This soft support construction is achieved through the specificity of the tessellated knit patterns and the parametric breast support structure that sits on top of the knitted garment. The support of individual body topologies is based on 3D body scans. Agnes Psikuta from Empa contributed textile digitizing processes, 3D-dispensing trials using robot-assisted dispensing systems on 3D shaped surfaces were carried out by Profactor, digital characters were designed by Nedim Šećeragić. CLO 3D digital prototyping and compositing was realized by Sander Hofstee for the Fashion & Technology department at UFG Linz.

Fragmented support structures were applied by Hofmann to the knitted garment with heat transfer processes. Südwolle Group sponsored Hofmann's project with a natural and innovative yarn composition that accommodates specific skin sensitivities and thermal needs. An extremely fine 15.5 microns merino wool (the area in which cashmere is classified) and silk, it combines the warming effects of the wool and the cooling feeling and smooth surface of silk, resulting in a highly pleasant haptic experience.

Figure 6: left and middle: 3D Scanned bust with asymmetric breast and prototype ©Haratech & Hofmann; right: prototype via 3D dispesning ©Profactor & Hofmann

In the following table the main achievements per partner are summarized, reflecting their role within the co-creation projects and technology developments within Re-FREAM

Partner	Achievements
UFG	• creation of avatar and pattern pieces to create a digital double in CLO • completion of a digital fashion video for the presentation at Ars Electronica Festival • planning a joint lecture session with the learnings of the digital video making co-creation
EMPA	• textile measurement tests to inform the CLO digital double design • planning scientific publications of the project outcomes with Agnes Psikuta, including a textile preference questionnaire
PRO	• TPU dispensing directly on fabrics • Dispensing on 3D geometries (breast parts) using robot
HAR	• 3D printing a bespoke bust (if that can be counted as a major outcome…)

3.5 Sophia Guggenberger & Eugenia Morpurgo – Syntropia

Artist	Sophia Guggenberger & Eugenia Morpurgo
Supporting Re-FREAM partners/role	• Guillaume Clement - Haratech • Agnes Psikuta - Empa • Sander Hofstee - University for Art Linz

Project description and innovation

The combinations of findings from the polyculture, materials, and footwear production research resulted in four variations of the Syntropia shoe. The shoe can be seen as a flexible framework, where each component can be produced with different levels of technological complexity according to the infrastructure locally available. The upper can be hand crafted as much as industrially manufactured. The outsole can be 3d printed on demand, cut from standardised rubber sheets or produced in higher numbers by mold casting. This approach proposes a system which uses appropriate technologies in relation to the potential local context of production. This flexibility can be found also in the materials used to manufacture the shoes. Working with materials derived from a biodiverse agro ecological system challenges us to implement the same richness in biodiversity of materials in the design of the shoe. Following seasonality through the years, the aim is not to rely on one resource alone. We designed a product where each component can be manufactured using a variety of different resources respecting the unpredictability of natural cycles. Four prototypes which represent the quest of allowing flexibility in the materials used and in the production systems employed. Shoe made from industrially produced hemp fabrics, PLA and an outsole made from natural latex mixed with wool fibres. Shoe made from industrially made hemp and nettle fabric, PLA and an outsole made of natural latex mixed with cochineal dyed sisal fibres. Shoe made from handwoven nettle and hemp yarn, woven hemp fibres and nettle yarn, PLA and an outsole made of natural latex mixed with cork dust. Shoe made from sisal fibres handwoven with hemp yarn and woven hemp fibres with hemp yarn, PLA and an outsole made from natural latex mixed with sisal fibres. Once the final species, a few theoretical locations and materials had been defined, the team moved back to the shoe prototyping process. Four variations of the Syntropia shoe were designed and produced. Each of them represent multiple aspects of the research from material experimentations to the quest of allowing flexibility in the production systems employed. Finalising these four models was fundamental to understanding the quantities of materials needed for the production of the four shoes which consequently defined the quantities of raw materials and therefore species which needed to be present in the blueprint for our polyculture. Once these final quantities were known, Fernando Bautista Expósito, in combination with the information on the geographical requirements of the location, was able to design the agro- ecological system.

Figure 7: Sophia and Eugenia's prototypes and field design ©S.Guggenberger & E.Morpurgo

Material and Sample Gallery - Publication

Having worked on this project for the past nine months, the team was constantly confronted with the complexity of the systems they were trying to reflect as a whole as well the sub- systems we were connecting in their own particularities. Agriculture, materials and the production of goods, are highly complex matters. The results we have produced are attempts to connect these matters. They show the opportunities for future strategies of production, where often individually understood perspectives are thought through their intertwined realities. There is not one solution and not one strategy but rather a multitude of interconnecting paths.

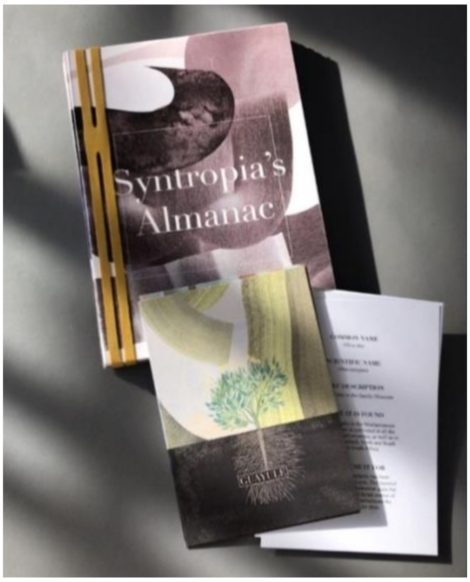


Figure 8: printed publication

In order to reflect this idea of parallel thoughts and crossing disciplines, the team decided to create an unbound documentation (Materials and Sample Gallery publication) , which allows the reader to freely choose how to read it. It is based on the idea of almanacs, which in the field of agriculture are yearly publications reflecting on the "events"/cycles/... taking place throughout the seasons. It starts in winter, where we expand on the basic framework this project is built on. We then move on to spring, where seeds and collaborations are planted, which can be seen growing in summer and finally taking shape in autumn. Since the year begins and ends with winter, which is a time of reflection on the year past as well as the year ahead, we then again end in winter.

The individual chapters are:

- The seasons defined by pattern: winter, spring, summer and autumn
- The topics defined by colour: agriculture, material and shoes

This allows the viewer to read as they please linear or parallel, focused on one subject or season, or cross-referencing in between the sections.

The Technologies

Sander Hofstee from the University of Arts and Industrial Design (UFG) reengineered the grading steps for the shoe lasts digitally on Rhinoceros and Grasshopper. Agnes Psikuta from Empa shared insights on the shoe's thermal regulatory system, while Guillaume Clement and Florian Bauer from Haratech advised on the possibilities for 3d printing, testing and creating samples, and put the designers in touch with WoodKplus. Together they developed 3D printable fiber-reinforced filaments. The filaments needed to fulfil the technical requirements for the frame of the shoe. The designers 3D-printed the frames of the shoes with flexible PLA filament. The outsoles are made from natural rubber and fibre compounds, and cast in molds. Outsole material tests included rubber and cork dust, sisal fibre, wool fibre and fibre of the spanish broom. Together with the Spanish agronomist Fernando Bautista Expósito, they developed the design of the polyculture, while with the French company Reltex they worked on some material testing. Furthermore they collaborated with illustrator Anastasija Mass and photographer Elisabeth Handl for the production of the project documentation.

In the following table the main achievements per partner are summarized, reflecting their role within the co-creation projects and technology developments within Re-FREAM

Partner	Achievements
UFG	• **Digital design workflow:** During the second phase of the project, we have together with Sander Hofstee, refined the reengineered last and worked on the process of modifying and scaling components. The last can now be scaled into the different sizes using the Grasshopper script Sander developed. The different components can be engineered using Rhinoceros and can then be modified and scaled into the different sizes like the last. • **Gcode testing finished:** Working with Guillaume from Haratech and Sander we have discussed and tried various possibilities for creating the custom path needed to generate the gcode needed for printing with the endless fibre filament we have developed. Researching plugins and processes already available, we found that for now, the path has to be generated manually on the last within Rhino. This means there is a series of steps that need to be done within the program to generate the path that is needed for making a gcode we can then use for printing. Sander and Guillaume have then adapted an already existing Grasshopper script that can generate the gcode. We have tested and used this tool for the prints we have made with the SoftPLA and cotton filament.
HAR	• Producing 3D printing filament with biobased material, with or without filler (hemp short fibers, cork powder) or with continuous fiber reinforcement (cotton, hemp) • Testing (and defining the tests) the 3D printing of the bespoke filament. Especially the one with continuous fiber reinforcement needed a specific 3D printing strategy, since the regular layer-by-layer printing was not possible • Developing a bespoke gcode generator for 3D printing filament with continuous fiber reinforcement (in a single path) • Producing prototypes of a shoe frame with the bespoke gcode and with the bespoke materials
EMPA	• Material characteristics of top 4 materials

3.6 Filippo Nassetti & Vincenzo Reale – Thalassic Masks

Artist	Filippo Nassetti & Vincenzo Reale
Supporting Re-FREAM partners/role	• Guillaume Clement – Haratech • Agnes Psikuta - Empa • Naomi Kaempfer – Stratasys • Sander Hofstee – University for Art Linz

Project description and innovation

Can we print and wear the intricate filtering processes of underwater coral forests? The co-creation designs of Filippo Nasssetti and Vincenzo Reale draw on marine organisms to investigate the new visual languages for additive manufacturing. New materials and technologies become a means to augment respiratory masks, fusing functionality with aesthetics. Manufacturing becomes a measure for enhancing both survival and personal expression. The resulting designs anticipate breathable filtering materials, forecasting the use of personalized and artistic medical devices. The organic shapes rest on the head like growths emerged from oceanic depths. An experimental transparent prototype added a new dimension to the masks: the translucence of both air, water, and sweat. Darker gradations of color indicate areas of higher transpiration, visually defining the comfort of wear. Inspired by marine organisms, which combine filtering with the absorption of nutrients, Nassetti and Reale aim to transform masks from protective devices to a form of bodily enhancement. They employ additive manufacturing to allow for highly customized protection, but also aim for a cultural redefinition of prosthetic devices: by rethinking medical shields as fashion or art pieces, which manifest new artistic pandemic and post-pandemic identities. The designs document the disruption of ecological environments and climate change, showcase our relationship between artificial and natural, and propose a powerfully aesthetic solution.
As a major challenge was finding expert tailors for the mask construction, the team envisions digital paths for augmenting the knowledge of craftspeople with traditional skills to include 3D printing knowledge. New design languages and innovative technologies for modelling and for production are central to Nassetti and Reale's approach. According to Reale, "with the development of a more permeable, 3d printable, material, this is a project that can hit the market straight away. That missing ingredient may be available in five or ten years, perhaps sooner". The team envisions future production via external suppliers hubs who receive the orders to print (and if needed, ship) the masks. In the meantime, the visually compelling project aims illustrate the team's research into the new languages of identity and aesthetics generated by new materials and production processes.

Apart from limitations of existing material compositions, the most challenging aspect of wearables was combining the team's extensive expertise in computational modelling with traditional fashion skills. "You can work with software that are state of the art, but fabric moves and changes shape ", Nassetti explains, "so you need to work with people that have the skills to manipulate it". Their Re-FREAM experience generated reflections on future digital training of artisans, but also opened the doors to a variety of new approaches, knowledge networks, and skills. A precious outcome they are looking forward to is the exposure and resulting feedback to their project.

Figure 9: Thalassic Masks ©F.Nassetti & V.Reale

The Technologies

The team focused on redefining protective wearables through the use of 3D-printing on fabric. Key to their approach is the concept of the mask as an interface, which mediates between the external environment and the body. They applied their extensive additive manufacturing expertise to enveloping a moving human being for the first time. Data of bodily needs provided by Empa was transformed into a swirl of coiling growths, printed with Stratasys directly unto fabric. The parameters of average facial thermal and sweat rates defined their structural distribution, informing future mask performance. Based on the 3D printed design, a computer numerical control (CNC) mold was developed with Haratech, allowing both for the creation of a 3D Model to fine-tune the use of different materials, as well as simplifying the production of multiple editions.

In the following table the main achievements per partner are summarized, reflecting their role within the co-creation projects and technology developments within Re-FREAM

Partner	Achievements
HAR	• Testing (and not validating) a casting solution for the mask that grants access to other materials, more suitable for a long contact with the skin and in breathing areas.
STR	• Printing directly on textile
EMPA	• Thermal studies for height optimizing of 3D print
UFG	• Virtual mask draping support

3.7 Assa Ashuach – Footwear Time Based Design

Artist	Assa Ashuach
Supporting Re-FREAM partners/role	• Guillaume Clement – Haratech • Agnes Psikuta - Empa • Naomi Kaempfer – Stratasys • Leo Schranzhofer, Pavel Kulha - Profactor

Project description and innovation

Disrupting design, Assa Ashuach explains, means disrupting production: "we can no longer just make a shoe, put in a box, send it, and say goodbye!". Central to his Re-FREAM design research is the long-term relationship between the fashion object, the user, the manufacturer, and the material. How can we produce not just fashion and accessories, but sustainable use? How can we make fashion items less disposable and make longevity more fashionable? Additive manufacturing has allowed him to steer footwear into several new directions: a flat-printed biodegradable shoe with replaceable parts, a repearable shoe in one piece, an evolutionary shoe with integrated sensors, which adapts to the user's needs over time, and "shoeskins" printed on fabric. Each design uses manufacturing innovation to trigger new ways of consumption. Ashuach's research addresses sustainability through new levels of engagement, creating interaction with and through objects. The decentralized 3D printing manufacturing facilitates local production and the use of local materials and post-consumer waste. The assembly of the origami shoe pattern can create new job opportunities and, like origami folding, can also provide job satisfaction: He imagines "maybe elderly people sitting and working together and just doing that very simple assembly and be happy". Most importantly, his shoes are made to be maintained, kept, and increasingly treasured. Ashuach employs additive manufacturing to generate products which incite thoughtful behavior, becoming more valuable to users over time as they are invested with meaning. Both the customization and the repair activities allow the consumer to engage with the object now, as well as seeding a relation with the object in the future. Intrinsic in these new production and consumption models is the re-evaluation of the longevity of objects.

The decentralized manufacturing options of 3D printed shoes both present a potential for local micro-economies and urban regeneration. The material expertise of Haratech allows the origami shoe model to be biodegradable; it also can be used for upcycling post-consumer waste, such as PET. By integrating the concept of "Refix & Repair" and spare parts into the design, the concept of care is promoted and instilled in the consumption process from the start. While the evolving shoe does not (yet) allow for biodegradable manufacture, its local printing on-demand production avoids waste production and reduces the carbon footprint traditionally required for distribution. The evolving design research is informed by Ashuach's knowledge of bio-microstructures, leading towards objects with both physical and virtual attributes, similar to "virtual bacteria". This "learn-as-they-grow" bio-intelligence concept, combined with newly developed multiple density 3D printed structures can be applied to a variety of fields beyond fashion, such as climate-responsive architecture. He envisions the design and production of "learning objects and structures which could adapt to wind, humidity, the sun, and even earthquakes."

Central to the designs are the new symbiotic relationships between humans and objects. Ashuach longs for a shift away from the term "consumer", and its implication of uncontrollable desire, and from the web-based term of "user". He prefers the word "partner", and the collaboration it implies. Learning objects could also be calibrated to adjust for disabilities: Ashuach has reached out to a podiatrist to discuss the enabling of posture and movement adjustments. His collaborations with Re-FREAM industry and science partners - the development of new materials and the understanding he gained from their different approaches - was central to advancing his vision. His 'user informed objects' counter the thoughtless disposal and obsolescence of objects, embedding the objects we make with increasing value. Manufacture becomes a local and meaningful process, while smart objects are enhanced through a dialogue of nourishment and trust.

Figure 10: Evolve IM DAP ©A.Ashuach

Figure 11: Left: Sepida Skins & AI Midsole; right: Monolit Shoe Model ©A.Ashuach

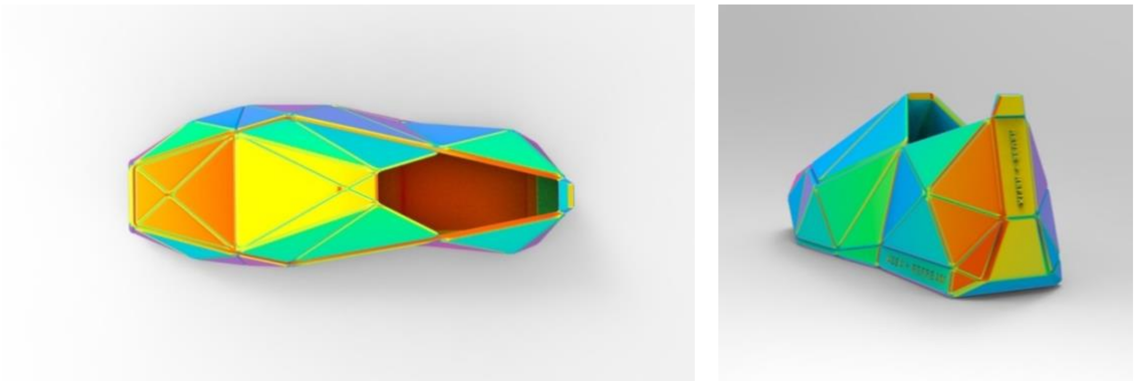


Figure 12: Pelt Origami Shoe Model ©A.Ashuach

<u>The Technologies</u>

The first footwear model, the Pelt Origami shoe developed with Haratech, is based on an origami-style pattern. Its futuristic shape can be flat-printed on-demand locally, with biodegradable/upcycled materials. It engages users with a variety of sleek finishings, making circularity not only ethical but desirable and fashionable. The design also offers future repair and customization options with spare parts - all activities which encourage user engagement and participation.

A second model, the Monolit, is an entirely 3D printed shoe in one flexible piece. It is both fixable and printed from consumer waste.

Deeply inspired by growth in nature, Ashuach developed a third shoe with 3D printed materials based on veins, skins and tissues : the Evolve IM biometric footwear. The physical shoe is connected to a digital shoe twin, which is nourished by users over time. The digital twin incubates user needs in two ways: passively through pressure, humidity and temperature sensors in the shoe, and actively when users communicate with the shoe through an app. The “living” virtual twin stores and communicates user needs for the next generation model. That updated bespoke shoe can be printed overnight on demand, offering individualized cushioning and adapted support. Each shoe is dated with the age of production and becomes a wearable personal archive.

The very latest addition to the shoe innovation series are the colorful Sepida shoe skins, whose highly innovative customized 3D printed fabric structures provide the shape’s skeleton, while the integrated printed Evolve sole record wearer movement.

In the following table the main achievements per partner are summarized, reflecting their role within the co-creation projects and technology developments within Re-FREAM

Partner	Achievements
HAR	• Defining different fabrication strategies for bespoke shoes using 3D printing and other technologies • Co-defining and producing shoe prototypes “origami” using solely filament-based 3D printing • Co-defining and producing shoe prototypes “monolith” using solely filament-based 3D printing • Co-defining and producing (together with STR) a shoe prototype “sepida” (Polyjet + transparent PU coating)
STR	• Learnings on ratio between geometry and mechanical properties of materials • Learnings about inserts: slices, plates, dots, fiber, stripes, hexagonal and three-dimensional mesh matrix, thin and thick skin in combination with different material density
PRO	• Multimaterial printing (soft material, dielectric, electrically condicitve) • Hybrid electronic integration of sensors into printed circuitry • Flexible electronics

4 Summary and Outlook

The initial goal of Hub Linz of directly printing of clothes and fashion articles was a huge challenge. Traditionally, the predominant use of textiles as fashion materials has led to the development of 2D pattern-making methods for dressing the complex shape of the three-dimensional human body. Nowadays, digital design tools allow us to easily design and 3D print complex shapes for the human body. With this technique used in this hub it is possible to build up objects by additive manufacturing, also commonly known as 3D printing. Digital technologies such as 3D scanning and virtual softwares enabled the artists and their teams to go beyond this traditional fabrication and develop unique and innovative products and software guides.

All seven Hub Linz Projects prove the huge potential and versatile possibilities of additive manufacturing in clothes and fashion articles. Moreover, the approach of art and tech collaboration and it's dynamic reveal once more the fruitful characteristic of interdisciplinary projects. Seen from a product development perspective, the project phase of nine month, especially in times of social distancing and travel restrictions, is a very short termed phase and huge challenge. The common goal and common understanding of co-research and co-creation was essential to realize the artist's visions. Exchange ideas and visions, share knowledge and co-create within different disciplines revealed once more how important it is to develop and create together. Not only for clothes or fashion articles, but also for any other sector, challenge or problem we are confronted with.

The three artists from round one partly continued their project and build on the developments. Round two artists have just finished their Re-FREAM project, launched their developed product, released their publication and strive to continue their research and development further on. All of them build on innovative ideas and visions and show huge potential to create a new value chain for fashion.