
closed loop smart athleisure fashion

application WEAR sustain

closed loop smart athleisure fashion, May 2017
by Marina Toeters, Margreet de Kok & Melissa Bonvie

Executive Summary
Description of the proposal (tell us about your idea)

We want to develop a closed loop smart athleisure fashion collection based on previous work of Marina Toeters and Margreet de Kok. Via 3 iterations they developed a smart shirt that continuously measures the wearers' key vital signals based on Holst Centre's advanced printed sensor technologies on flexible substrates for textile integration. The laminated sensors are truly wearable, comfortable, robust, invisible during use, washable up to 25 cycles, and designed for unobtrusive integration in conventional fashion production. Unfortunately market pull is still hardly there.

This collection will target fashionable sportive ladies at office work and right after work, they embrace forward thinking. It will be validated and disseminated in a service model in order to accelerate market pull. Our approach is based on three pillars:

1. Technical Materialization: The technical part will be a research on separation of the laminated sensor technology from the textile after the lifetime of the garment. This is innovative and necessary to be able to recycle the product in a proper way.
2. Designing based on Fashion Rhetoric: In the 3 previous iterations we focused merely on the functionality. From now on we focus exclusively on the fashionable aspects like aesthetics, desirability, fit current trends and societal tendencies to comply with conventional fashion design processes.
3. Business Loop: We want to certify that these garments become fertile in a closed loop system in which we design for the afterlife or next life of the product/parts. Together with the key stakeholders we will put the service- model into place around the target group. We will make a start to calculate and assess the feasibility of the model from a business perspective.

This closed loop system is an innovative approach in the field of wearable technology as, till now, there is not too much research available on afterlife of electronic garments and potential recyclability. By introducing reuse of the electronic components and garments in the service model we foresee to contribute to solving some of the environmental (1) issues of wearables. With this service model we also anticipate to develop a sustainable economic model (6) by decreasing the cost of ownership of the sensor functionality by multiple usages. With this economic model we fund the development of more caring and supportive garments and contribute to a stronger and more environmentally responsible garment industry.

Team

Please briefly describe your team (including their expertise, previous realised projects that might be related to/ or in wearable technology, and e-/smart textiles?

Marina Toeters operates on the cutting edge of technology and fashion design. She earned her Master of Art in fashion design with honours at MAHKU Utrecht. Through her business by-wire.net she stimulates collaboration between the fashion industry and technical innovators for a relevant fashion system and supportive garments for everyday use. She advises – via prototyping and a research through design approach – Philips Research, fashion designers and work wear companies on product development. She designs and develops concepts to show the world how fashion could be. As a teacher, coach and researcher, she works for a fashion department in Art school, a textile department at an university for applied science and industrial design faculty. More info: by-wire.net

With a PhD in organic polymer chemistry Margreet de Kok joined Philips Research in 1999 as a scientist to develop materials and applications of organic LEDs like displays, lighting and well being. She joint Holst Centre in 2008 to continue the development of conformable systems with printed electronics. Holst Centre is an independent R&D center that develops technologies for wireless autonomous sensor technologies and flexible electronics, in an open innovation setting and in dedicated research trajectories. Holst Centre embraces a wide scope of partners including material suppliers, equipment manufacturers and end user both in the medical and consumer market. It was founded in 2005 by the Belgian organisation imec and the Dutch organisation TNO and employs over 250 researchers. More info: holstcentre.com

Melissa Bonvie started 10 years ago the website Katoenenzo where consumers order clothes that are made only by order in your size and style. She put an online system in place that enables that the designs are all personalized and made to fit. Melissa developed several collections with various guest designers. One of which was a clothing line for women who lost a breast to breast cancer. A lot of these women loved to come over and see Melissa, feel the fabrics and explore the options. She learned how consumers think. Her designer signatures and personal identity breathes a love for comfortable athleisure wear. More info: www.katoenenzo.nl

Describe your team composition and how you intend to collaborate over the course of your project development.

Marina, Margreet and Melissa will be the core of the closed loop smart athleisure fashion team:

Marina Toeters has been dedicated to designing and prototyping innovative garments for the last 10 years. Via her company by-wire.net she worked amongst other projects on medical products, workwear and haute couture. Educated as a fashion designer it frustrates her that commercially available garments have hardly shown any innovation over the last 60 years while their environmental impact is so big! And there are many relevant technologies waiting for commercialisation on the shelves in research institutes and universities. Marina's aim is to make these innovations available for the garment industry and, with that, the everyday user, so that garments can start taking care of consumers.

Since two years Marina has been collaborating with Margreet de Kok from Holst Centre. Margreet holds a PhD in organic polymer chemistry and has been devoted in her career to (printed) electronics at Philips Research and afterwards Holst Centre. Together with fashion designer Melissa Bonvie from Katoenenzo, specialized in ultra personalized fashion production, Margreet and Marina will develop a closed loop smart athleisure fashion collection.

Marina is the initiator, coordinator and driving force in this project. She will keep the total overview and connects the needed parties at the right moment. Margreet is the technologist of the team. She knows all ins and outs of printed electronics and sensing technology. Melissa will be responsible for the athleisure design and garment prototyping.

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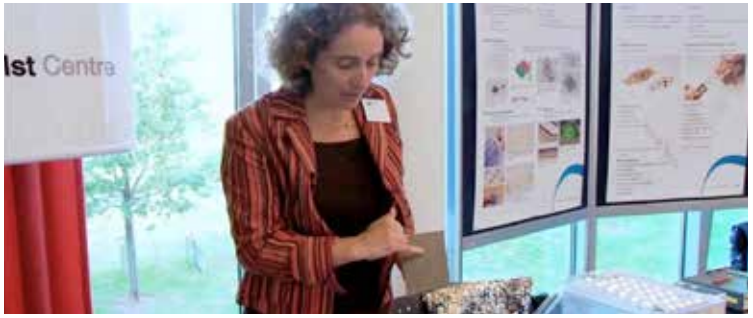
Please upload the CV of every team member: next pages

Marina Toeters @by-wire.studio in Utrecht, with lots of prototyping tools



Margreet de Kok @Holst Centre in Eindhoven, demonstrating printed electronics

Melissa Bonvie @Katoen enzo in Utrecht, making garments

Bio: Marina Toeters operates on the cutting edge of technology and fashion design. She earned her Master of Art in fashion design with honours at MAHKU Utrecht. Through her business **by-wire.net** she stimulates collaboration between the fashion industry and technical innovators for a relevant fashion system and supportive garments for everyday use. She advises – via *prototyping* and a *research through design* approach – Philips Research, Holst Centre, fashion designers and others on product development. She designs and develops concepts to show the world how fashion could be. As a teacher, coach and researcher, she works for the fashion department in the Utrecht school of Arts, textile department at Saxion University for applied science and industrial design faculty in Eindhoven University of Technology. More info: www.by-wire.net

Contact Details:

Name: Marina (Mientje Jennigje) Toeters MA
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Country: The Netherlands
Phone: +31625451128
E-mail: marina@by-wire.net / m.toeters@gmail.com
Website: www.by-wire.net
Birth: 16-07-1982, Den Ham
Nationality: Dutch (The Netherlands)

Personal Data Resume (page 1/2)

Education

2016 BKE educational training for teaching and assessments
2013 Life Cycle Analysis training by Natascha van de Velde
2012 Workshop C2C as basic pattern – Cradle2Cradle method – Refinity
2010 Coach training – TU/e
2008 Quick start course for education – WdKA
2006-2007 **Master of Art and Design**; Fashion Design - MAHKU Utrecht - Cum Laude
2003-2006 **Bachelor of Art**; Fashion Design - Hogeschool voor de Kunsten Utrecht
1998-2002 CIBAP Zwolle (middle vocational education) Graphic Design: Presentation and Communication
1994-1998 Regge-Vecht College, Den Ham MAVO (high-school)

Work history

2017-2016 Industry Liaison Wearable Senses, Industrial Design, **Eindhoven University of Technology**
2017-2015 **Holst Centre,** Smart and Light garments
2017-2009 Edu: **HKU** Utrecht, 2nd year Fashion eco- & technology, 4rt year project coaching.
2016-2015 **Ilja Visser ASSIMILA SS16** haute couture collection, 6 interactive outfits
2016-2015 **Radboud University**, Junior Researcher Wearables in Society. Social Studies.
2016-2009 **Philips Research** and **Philips Design**, textile / electronic applications on the body
2015-2013 Theme leader Wearable Senses, Industrial Design, **Eindhoven University of Technology**
2016-2011 **Saxion,** Member of the research group Smart Functional Materials, project leader CRISP-Smart Textile Services
2015-2010 Edu: **Eindhoven University of Technology**, coach Industrial Design, Wearable Senses
2015 **It-fits** & **Coldenhove**, freelance projects in innovative textile products
2015 **Michiel Cornelissen**, responsible for soft product design
2014 European Texitle Traineeship, student guiding & coaching, **TextielMuseum**
MVO-NL **Zorgzame Bedrijfskleding**, project management and design
Curating the exhibition Traditie ontmoet Toekomst, **Museum the Kantfabriek**, Horst
2014 Workshop development Smart Textiles, **Waag Society**, ZigZag project
2014-2010 **Philips Medical,** design & research for textile product design, prototype development and production consulting, Philips Blue Touch / Philips Blue Control
2014-2012 Edu: **Saxion,** Lecture & lessons New Production Techniques for textile & garments.
2013-2011 **TNO, Marc Grootjen,** tactile textiles.
2011-2008 Edu: **WdKA**, 2nd year Crosslab fashion eco- & technology
2010 **Moon Life Academie,** fashion design project, workshop leader and tutor **FBKVB**
Philips Lumalive Research of Lumalive guidelines for garment designers
Kwintet design, development & communication of work wear collections
Marloeke van der Vlugt sensor suit, artistic accessory
Bram van Waardenburg en WdKA modularic friends
Sense Company research project: body vibration on music
2008 initiator **by-wire.net, design & research in fashon technology**
Boost Products Design & integration of Lumalive technology in garments
HKU research project: navigation on the body
2007 **by-wire.projects** in collaboration with: **TNO, Ten Cate, TU Delft, Kwintet, Ecological Textiles, HKU** textile department,
2006 **Company clothing Kwintet KLM nv,** Enschede
Freelance, presentation and design projects in collaboration with stylist
o.a. Mc Donald's, Arriva, Gall & Gall, H. Radboud and Q8
2006 **Romy Smits, design studio for fashion, interior and art,** Antwerp
Trainee: Assistant fashion-, print- and graphic design
color cards, concept, working drawings, product presentation
2006-2000 **Graphic Design Agency Ten Design and Alfabet sign,** graphic design, Den Ham
Vacation work and internship: Graphic Designer and DTP.
Pamphlets, trademarks, brands, printed matter, advertisement, sign, sponsor garments
Design and prepare for press, print or digital mailing

Personal Data Resume (page 2/2)

Special skills

Experience with the Research Through Design practice and theory
Outstanding skills in e-textiles, embedding technology
Prototyping tools at hands
Owner of a small company; entrepreneurial
Very good creative computer skills: InDesign, Illustrator, Photoshop, etc.
Dutch - native tongue. English - speech fluent, writing good

Projects (for recent projects see: www.by-wire.net)

2015 Curation: CRISP Smart Textile - Wearable Service, **TextielMuseum**
2014 Keynote speaker @SIA-congres
2013 **Amsterdam Fashion Week** show Drapely & Solar Fiber
Speaker at **Smart Fabrics Conference Barcelona**
2012 **Gouden Geesten** Utrecht, **Picnic**, **Dutch Design Week** Eindhoven, **Pretty Smart Textiles** Ronse Belgium,
2011 Exhibition **Modemuseum Hasselt** (be) & lecture **z33** about Alture nature
2010 **Lecture FTN,** Chain sustainability
2009 **Fair Corporate Fashion Event**, lecture: chain innovation in fashion
2009 **Awearness Fair Fashion,** 4 outfits in collaboration with JSS.SJS
2008 **MaHKU,** presenting project Master students fashion 'Beyond Green'
HKU Fashion Design, 1st and 2nd year; seminar ecology and seminar Lumalive in Fashion, 3rt year; lessons in Fashion Technology
2007 **by-wire.net** fashion & technology network - o.a. Ten Cate, TNO, Dynafoam
work wear event initiator and organizator - Casco Utrecht
presentation modebiennale Arnhem - wearables project
exposition Beat the Fashion Drum - by-wire.net - Stadhuis Utrecht
Hot-100-Debat 21 feb. 2007 - Club 11 Amsterdam
2006 **cat-walk-show** 3rd year INDUST collection - Ottone Utrecht
seminar Fleshing Out - wearable interfaces, smart materials, living fabrics
congress for Nanotechnology in Fashion&Textile Industry, London
wearables project in collaboration with TNO - Cum Laude
Marimekko Project Center Antwerp - Concept and presentation advice
design competition HEMA - boys jacket - Honorable indication
cat-walk-show 2nd year GRIP collection - Gorinchem & Utrecht
2006- 2005 **junior lecturer in presentation** - 1st year fashion students HKU
Poznan exchange project Fashion design with Karel Bakker
2004 **Event organization** - Slapeloze Nacht - concept, organization, design, development & production

Publications / Exhibitions (for recent publications see: www.by-wire.net)

2017 •A Cellular Automaton for Pied-de-poule (Houndstooth) with Professor Loe Feijs, Proceedings of **Bridges 2017**: Mathematics, Music, Art, Architecture, Culture **Bridges 2017**
2016 •Toeters, M. (2016). E-fashion fusionist aiming for supportive and caring garments. Paper presented at the Proceedings of the 2016 **ACM International Joint Conference on Pervasive and Ubiquitous Computing**.
•Cliff: the automatized zipper. With PhD Mohamad Baharom. Proceedings **Global Fashion Conference 2016**
•Mathematician meets Fashion designer: The future of fashion will be multidisciplinary innovation! with Professor Loe Feijs Proceedings of **Organizational Aesthetics** 2016 in Bled
•Pied de Pulse: Packing Embroidered Circles and Coil Actuators in Pied de Poule (Houndstooth) with Professor Loe Feijs, Proceedings of **Bridges 2016**: Mathematics, Music, Art, Architecture, Culture **Bridges 2016**
•Australian Elle publication
•Zishi: a smart garment for posture monitoring with PhD Qi Wang for **CHI2016**
•Paris Fashion Week, interactive light garments with during the show of ILJA
2015 •Drapely-o-lightment, An Algorithmic Approach to Designing for Drapability in an E-Textile Garment with Professor Loe Feijs for **Leonardo**
•Dutch Design Week, exhibition on 5 different locations.
•Aires: a supportive wearable for women in their menopause with Tamara Hoogeweegen for **DeSForM**
•Activating Wearables: The Butterfly Effect with Ruben Daems for **DeSForM**
•A Novel Line Fractal Pied de Poule with Professor Loe Feijs, Proceedings of **Bridges 2015**: Mathematics, Music, Art, Architecture, Culture **Bridges 2015**
P+ (MVO) March, April, May & **Financieel Dagblad Modespecial** March 7th.
2014 • **Edinburgh International Science Festival,** Drapely-o-lightment in expo
•Actuating movement in refined wearables, Marina Toeters & Loe Feijs, Global Fashion 2014: **International Fashion Conference**, Ghent Belgium
ABN-AMRO publication Smart Fashion / Netherlands: Designing a Country publication
Workshop + presentation 'a better world by design', **Providence, Rhode Island USA**
• Night of the Nerds, exhibition during an technology event in Eindhoven.
•Design of a Nature-like Fractal CelebratingWarp-knitting, Loe Feijs et all. Proceedings of **Bridges 2014**: Mathematics, Music, Art, Architecture, Culture
•2013 E-Textile Swatchbook Exchange: The Importance of Sharing Physical Work, **ISWC '14** ADJUNCT, SEPTEMBER 13 - 17, 2014, SEATTLE, WA, USA.
•Transforming the dance experience with expressive social wearables, Theadora Kyrgia, Marina Toeters, **Global Network for Dynamic Research**.
•PRACTICAL DESIGN EXAMPLES FOR HUMAN HABITATS IN SPACE, OFF-GRID, AND IN LOW-IMPACT COMMUNITIES, IAC-14.E5.2.3, 65th **International Astronautical Congress**, Toronto, Canada. 2014, Irene Lia Schlacht et all.
2013 •Research-through-design; a way to drive innovative solutions in the field of smart textiles, Marina Toeters, Martijn ten Bhömer, Eliza Bottenberg, Oscar Tomico, Ger Brinks, **Cimtec2012: Advances in Science and Technology** Vol. 80 (2013) pp 112-117 © (2013) Trans Tech Publications, Switzerland doi:10.4028/www.scientific.net/AST.80.112.
•Constructing and Applying the Fractal Pied de Poule (Houndstooth), Loe Feijs, Proceedings of **Bridges 2013**: Mathematics, Music, Art, Architecture, Culture
• Nemo, technology museum for cildren in Amsterdam: Solar Fiber head in the exhibition
2012 •Analysis of parallel collaboration assignments in smart textile design, Toeters, Brinks, **Onderzoek voor de vitale regio**
2011 •Disseminating knowledge of electronic textiles at art schools and universities, **isea2011**, http://isea2011.sabanciuniv.edu/paper/disseminating-knowledge-electronic-textiles-art-schools-and-universities
2011 **Alter Nature:** The future that never was, exhibition + booklet page 20 & 53
2010 **Kunstgras 2010,** exhibition by-wire.net
2009 **Arnhem Fashion Biennale,** presentation Fair Fashion Event
2008 **Second Sight "Technology"** article about Lumalive 20080802
Mediamatic presentation by-wire.net 20080417
TAG MAG 05, article about "The Fashion Paradox" 20080322
NieuweOntwerpers.nl, Expo, Rotterdamse Museumnacht 20080301
De Pers, article about me and others in fashion technology 20080301
Fashionsnoops.com, article about by-wire.net by Helen Gras 20080201
ESTA, one by-wire.experiment shown: Huggy Care 20080129
Modefabriek exhibition Rai Amsterdam, 20 & 21 January
2007 **DAG.18.12,** 18-12-2007 by-wire.net naar aanleiding van Bright.TV
Bright.TV, video interview 11-12-2007: http://www.bright.nl/dinsdag-designdag-marina-toeters
Bright 19, Eye Candy, 'Marina Toeters met Huggy Care' 01-12-2007
Twentse Courant Tubantia, 'Studie cum laude afgesloten', 5-09-2007
De Twenterand Courant, 'Marina Toeters studeerd cum laude af voor fashion design', 13-09-2007
Video interview AD, Wearable project: Nepkoe op pojectenmarkt HKU 08 February 2007, www.ad.nl/multi-media/article1028602.ece?start=2

Margreet de Kok

Born	15 juli 1970
Education	Drs. University Nijmegen 1996 PhD. Limburgs Universitair Centrum Diepenbeek 1999
Present Position	Senior Scientist TNO Holst Centre
Experience	
1999-2008	Philips Research: OLED materials for displays and lighting, wearable applications
2008 - 2016	Holst Centre: conformable electronics, interconnection technologies, wearable applications, textile electronics

Selected publications and patents
h Index: 13
38 refereed publications
Total number of Citations: 1317

Patents (36)
US9070902, EP1991114, US8308641, EP2374171, EP2374172, US20110227117, EP2308116, US20100179389, WO2010064190, WO2010064186, WO2010046830, WO2010010523, EP2029229, EP1927145, WO2007141720, WO2007100959, WO2007031923, EP1727876, US20060231828, EP1695393, EP1656707, EP1594939, WO2005087893, EP1572832, WO2005057675, WO2005015654, EP1459604, WO2004072205, WO2004055129, EP1397411, EP1382075, WO03051091, EP1290059, WO02096970, WO02084759, WO0192369

Key Publications: (38 in total)

1. de Kok, M., de Vries, H., Pacheco, K., & van Heck, G. (2015). Failure modes of conducting yarns in electronic-textile applications. Textile Research Journal, 85(16), 1749–1760. http://doi.org/10.1177/0040517515573405
2. Nardes, A. M., Kemerink, M., Janssen, R. A. J., Bastiaansen, J. A. M., Kiggen, N. M. M., Langeveld, B. M. W. de Kok, M. M. (2007). Microscopic Understanding of the Anisotropic Conductivity of PEDOT:PSS Thin Films. Advanced Materials, 19(9), 1196–1200. http://doi.org/10.1002/adma.200602575
3. de Kok, M. M., Buechel, M., Vulto, S. I. E., van de Weijer, P., Meulenkamp, E. A., de Winter, S. H. P. M van Elsbergen, V. (2004). Modification of PEDOT:PSS as hole injection layer in polymer LEDs. Physica Status Solidi (a), 201(6), 1342–1359. http://doi.org/10.1002/pssa.200404338
4. de Kok, M. M., Buechel, M., Vulto, S. I. E., van de Weijer, P., Meulenkamp, E. A., de Winter, S. H. P. M. van Elsbergen, V. (2005). Physics of Organic Semiconductors. (W. Brütting, Ed.), Physics of Organic Semiconductors. Weinheim, FRG: Wiley-VCH Verlag GmbH & Co. KGaA. http://doi.org/10.1002/3527606637
5. Kemerink, M., Timpanaro, S., de Kok, M. M., Meulenkamp, E. A., & Touwslager, F. J. (2004). Three-Dimensional Inhomogeneities in PEDOT:PSS Films. The Journal of Physical Chemistry B, 108(49), 18820–18825. http://doi.org/10.1021/jp0464674

Main contributions
(O)LED in textile integrated, interconnection technologies, printed organic electronics

Awards/Honors
Invited talks at conferences on printed electronics, smart textiles etc.
On-line youtube: https://www.youtube.com/watch?v=487kjUHrIeQ (O)LED integration into textile > 6000 views

Melissa Petersen-Bonvie

Personal Data

Surname & Name	: Petersen-Bonvie Melissa
Address	: Harpstraat 41 3513 XA Utrecht, The Netherlands
Telephone number	: 0031651640540
E-mailadress	: melissabonvie@gmail.com
Date & Place of birth	: 30-08-1982, Merton, England
Sex	: Female
Nationality	: Dutch
Marital Status	: Married

Education

Period	: HKU Bachelor Fashion Design (Utrecht, August 2007)
Period	: Artemis, Styling (Private school Amsterdam September 2002)
Period	: MBO fashion design (The Hague 2001)

Relevant work experience

Period	: Katoenenzo, current (Utrecht, 2007- now)
Job title	: owner
Job description	: meeting with clients, design and production of the patterns. Development of wedding gowns.
Period	: Magnes Sisters, New York (2 weeks, 1-12 Oct. 2007)
Job description	: intern, design a new presentation and organize the new collection.
Period	: Pi2, Amsterdam (3 months, 18 April- 8 July 2007)
Job description	: intern, design and production of the costumes, accessories and patterns

Presentations&Publications

Period	: first prize HEMA design contest 2006, design Children's coat
	: Central museum Utrecht, Elle living Herenhuis Amsterdam.

Additional skills

Languages	: fluent in written and verbal communication, Dutch and English
Computer skills	: Photoshop, Illustrator, Flash, InDesign, Internet and word
Drivers license	: yes

References available upon request

Project Pitch

Need

Lacking innovation market pull: The fashion industry is famous for its ability to promote consumers desire to change. However, the last material innovation widely accepted by the fashion industry is dating from 1953. There is not really an innovation market pull happening. Also the conventional labels do not care about R&D or innovation in technological sense. Especially in sustainability of the fashion industry there is a lot to gain on energy, material usage and functionalities to sustain mankind much more than currently applied. If the vogue world would gospel innovation and collaboration 'for the better' they can make a huge change in just 3 seasons. (Toeters, 2016)

Stuck in the TRL's: Current E-fashion innovations are mainly executed at research level. Projects are showing feasibility advance fashionable garments and not increasing its technology readiness level to upscaled production allowing market introduction. TRL levels for the smart garment are currently, however, at the level at which market introduction is close by: Neatly, unobtrusively integrated, accurate, washable, and robust as proven on small scale by the sensing shirts of Holst Centre. Sustainability in the value for the wearer's health support has become true. How to take the last step and introduce it in a sustainable manner to the market? In order to achieve that technology should be further matched with the fashion process resulting in an attractive product proposition.

Masculine vs Feminine: The act of dressing and fashion is perceived more feminine, while technology is perceived more masculine (Ryan, 2014). Wearable technology focuses mainly on the tech and functional side; the masculine aspects. While the majority of the consumer products – for sure garments – are being bought by (great influence of) woman. We think here is something misaligned that works as barrier (Dunne, 2010) for market implementation. We want to target fashionable ladies opposed to the nerdy wearables now available.

Approach

Methodology: Operating on the cutting edge of technology and fashion design is all about Participatory Innovation and Collaborative Design (ten Bhömer, 2016). We want to approach this project with an attitude in which creating material samples (for the technical materialization part) and fitting models (for the designing based on fashion rhetoric part) plays a central role is essential to benefit from expert quality. We work in an iterative transaction between design and research: a research-through-design process (Toeters, ten Bhömer, Bottenberg, Tomico, & Brinks, 2013) to gain depth and empathy in product concepts (business loops).

Technical Materialization: The following steps are needed to be able to work with the sensing technology as a material.

- Laminate the sensing technology on different sustainable knits without loosing the functionality.
- Test the separation of the laminated technology from the textiles. With heat and pressure the sensor is applied. How to separate?
- Test which body tension gives optimal sensing results. We have done tests with our current garments but not on female bodies.
- Test which back position gives optimal sensing results on females. We have done some tests with our current products.
- Conclude the list above with a list of fashion design criteria suiting this laminated sensing technology and test this with fashion students.

Designing from Fashion Rhetoric: We will design an iconic athleisure collection. With 4 looks and some complementarity items it will target ladies.

- Aesthetical textile research
- Design the E-fashion collection of about 4 looks.
- Each garment will be produced 4 times, so 16 garments in total.
- Design a complementary iconic fashion items.
- Make the complementary items.

Business Loop: We will calculate and assess the feasibility of this service model from a business perspective via the next steps.

- Test market acceptance and social wearability (Dunne, et all 2014) of the 4 looks. We will make use of Living Lab Experiments in 3 iterations
- Specify the target group and the market.
- Develop the production and service process with garment manufacturers and recycling parties. Considerate data storage to get the total system working.
- Disseminate the athleisure service system via shows and exhibitions like, ISPO, DDW, Fashion Week and online platforms.

This holistic approach is unique. Find visuals and elaboration of this approach in the prototype and project plan.

Benefit
We have to take a holistic approach to be able to put a closed loop service model in place based on the fashion rhetoric design scope. A hands-on research-through-design process enables us to consider all aspects in parallel. This closed loop system is an innovative approach in the field of wearable technology as, till now, there is not too much research available on afterlife of electronic garments and potential recyclability.

The technicalities are of very high standard. The service model includes the advanced and reliable technology of Holst Centre. The laminated sensor technology integrates imec's validated medical-grade electrocardiogram (ECG) monitoring with breathing rate and breathing depth. The use of state-of-the-art printed electronics technology offers complete freedom in design and optimization of printed sensors and electronics, being as thin as 60 µm and up to 100% stretchable. The properties of the electronics thereby become similar to those of textile, allowing unobtrusive integration. These electrodes are produced using screen-printable, electrically conductive inks, which allows their shape to be optimized for maximum skin contact for strong signal resolution and monitoring performance.
The underlying technology has been proven in previous generations of the vital signs shirt and numerous health patch demonstrators from Holst Centre and imec.
The sensor technology is also fully compatible with standard garment manufacturing processes: the electrodes can be laminated to any garment as the final stage of production.
We target fashionable sportive ladies at office work and right after work; they embrace forward thinking and are taking care of themselves. Foremost, they can look stunning these garments!

Competition
This idea is not the first sensing shirt; amongst others there is the Hexoskin shirt and the one from OMsignal. Compared to the Holst Centre technology both compromise on reliability because the use of knits as sensor technology. Knitted conductives are problematic to separate for recycling.
The first sensing shirt where a fashion label was involved was the PoloTech from Ralph Lauren. The attempt was to work from fashion rhetoric as Ralph Lauren is used to, but in practice the used OMsignal shirt was only completed with a Ralph Lauren logo, so the true fashion principles during design was not followed.
Unlike existing heart monitoring clothing, Holst Centre's smart shirt uses compact and distinct dry electrodes rather than a chest band, for example Polar, or rubber strip glued on the textile like the sensing shirt of Decathlon. This makes it more comfortable to wear and gives higher data reliability. The detachable sensor module is also much smaller and lighter (dimensions of 50 x 30 x 10 mm and 12 grams only) again making the shirt more comfortable to wear at all times. The shirt can operate for up to two days on a single battery charge because of the low-power sensor and radio electronics. The mechanical properties and encapsulation are engineered for reliability in the laundry process. With Holst Centre technology a washability of 25 cycles in domestic laundry can be achieved thereby complying with market requirements.

Our envisioned closed loop service model for smart fashion is unique, as far as we know. We can learn from Andreas Köhler (2013) about e-textiles and its recyclability aspects and Natascha van der Velden (2016) about life cycle assessments of fashion goods. And we can learn from pioneer Bert van Son from www.mudjeans.eu/ to create a full cycle approach for jeans. This is a very new approach in the fashion industry and integrated technology plays no role yet.

Impact and risk mitigation plan: risk > likelihood > mitigation
Sensor technology can not be reused > low > Sensor techno to be optimized, alternative techno to be found
Design for intended customer not attractive > low > Select different customer or adjust design
LCA expert not available > middle > Accept lower significance of costs analysis
Contribution from experts not in time > low > Alternative experts from the extensive network of by-wire.net
Overall cost price too high for intended market / stakeholder > middle > Select different market / stakeholder

If you would rate your project on a Technology Readiness Level (TRL), what would be the level of your aspired project?
TRL 4 – Solution has been developed and tested in a closed environment (ie lab, atelier etc.)

Describe your prototype and project plan
To avoid doubling of text we uploaded the total prototype and project plan in one file together with the available visuals. The key milestones and deliverables are also listed in the 'approach' part and – more in detail including budget – in the Gantt Chart prototype and project scheme. See next pages.

Prototype and Project Plan

Part of: *closed loop smart athleisure fashion*
by Marina Toeters, Margreet de Kok & Melissa Bonvie

This plan comes from several years of extensive collaboration between by-wire.net, a design and research studio in fashion technology and Holst Centre, an R&D centre that develops technologies for wireless autonomous sensor technologies and flexible electronics. The last two years Marina and Margreet worked on a smart shirt sensing vital body signs. Via explorations, technology advances and 3 garment iterations a proof of principle is developed and validated on the body and in the washing machine.

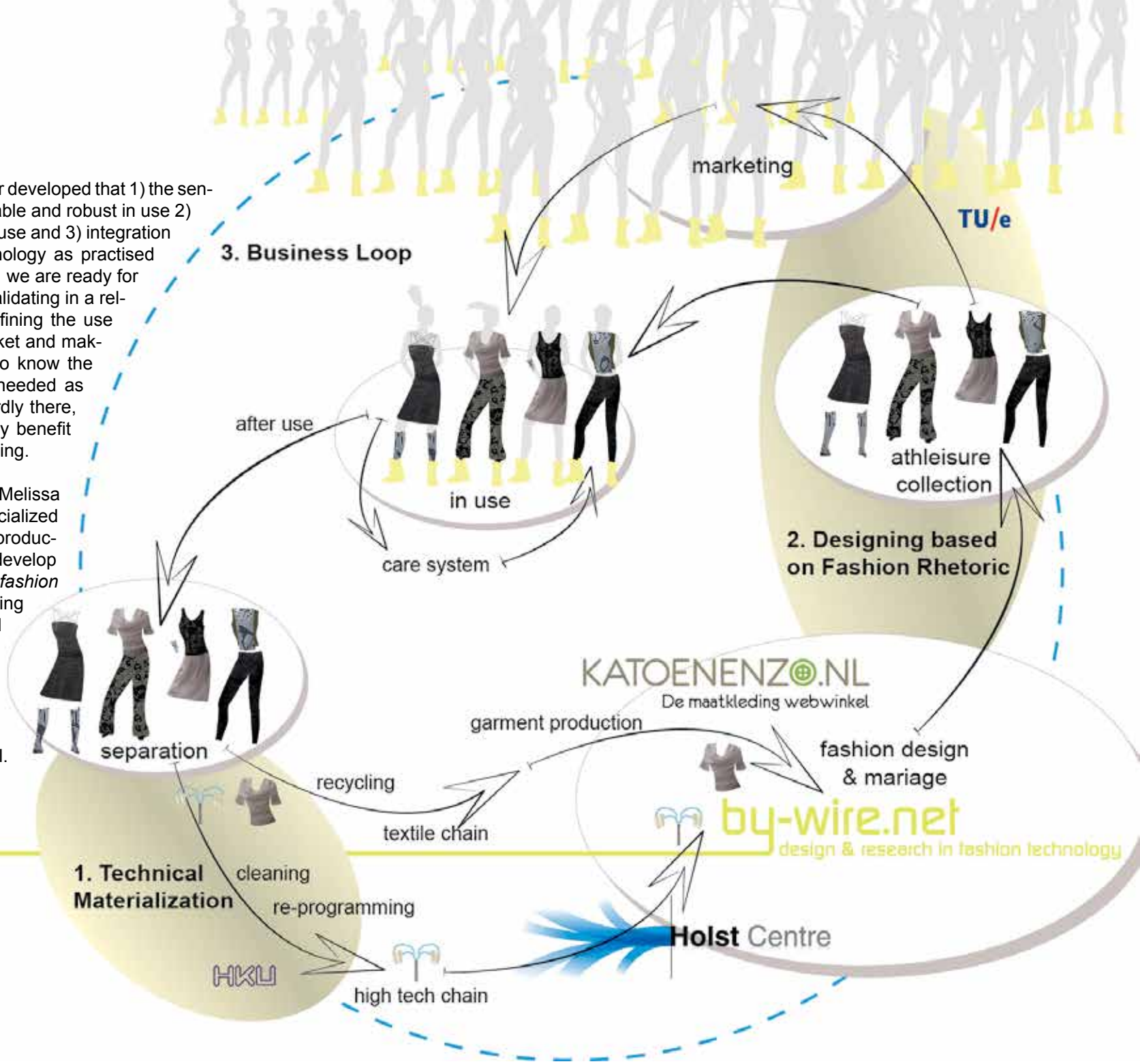
The blue shirt is the first iteration. The technology is still visible through the fabric. The red one is the second iteration in which technology integration was still difficult. The black shirt is that last iteration in which enhanced form factor of the electronics is complemented with an advanced design of the shirt to both ensure attractive aesthetics and improved functionality by enhanced signal resolution. Results look promising, but are only tested in a lab setting for not yet completely defined use case. Also the assessment of the sustainability by reversibility of the lamination process to separate electronics from the garment needs to be further explored. (TRL 3-4)

Technicalities: This third generation of the vital sign monitoring shirt is created with Holst Centre's smart clothing integration platform. It continuously measures the wearers' electrocardiogram (ECG), respiration and motion using imec's wireless ultralow power multi-sensor data acquisition chip with efficient motion artefact reduction that can share the data via a wireless BTLE system to a smartphone. Moreover, the design of the shirt and its electronics can be easily tailored for best electrode contact to skin. This is important to further suppress motion artefacts which are depending for instance on the type of movements typical in different sports. Therefore printed electronics allow maximizing performance of both electronics and thereby the users for specific athletic and fitness applications.
The sensing technology uses patented technology (imec/Holst Centre). Printed electronics on a thin film are laminated onto the textile. The track structures (conductive paste) and electrode materials in the smart T-shirt comprise organic electronics. The interconnection technology is the use of conductive adhesives. The power and communication module is an example of non-organic, conventional electronics based on a PCB board.
In the third generation the sensing module and interface are placed on the upper back, tight to the skin for optimal sensing properties. This positioning makes the product comfortable, easy to use and manufacture The sensors are totally invisible, it looks and feels like a normal shirt with its technological additions unnoticeable. Important for our context is that the sensor positioning makes the garment suitable for measuring on the female body as well, which is quite unique. Fine knitted fabrics are the preferred material worn next to the skin as their stretch construction communicates well with body movement.

Our Plan

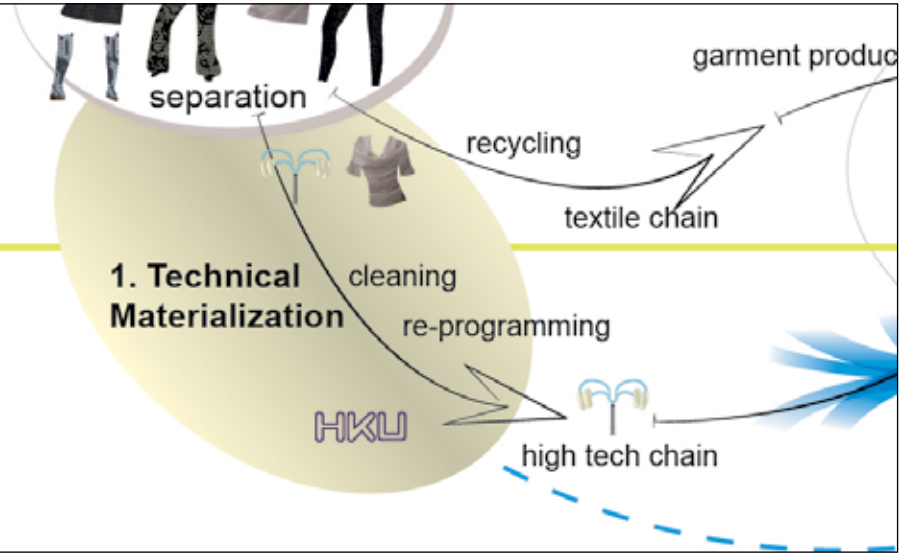
Now that the technology is that far developed that 1) the sensors are truly wearable, comfortable and robust in use 2) almost for 100% invisible during use and 3) integration in the conventional textile technology as practised in fashion production is possible, we are ready for the next step: Developing and validating in a relevant part of society, further defining the use case and proposition to the market and making sure that this society gets to know the possibilities. (TRL 5-7) This is needed as up till now the market pull is hardly there, while this technology can greatly benefit to societal tendencies as well-being.

Together with fashion designer Melissa Bonvie from Katoenenzo, specialized in ultra personalized fashion production, Margreet and Marina will develop a *closed loop smart athleisure fashion* collection based on the sensing technology. This collection will target fashionable sportive ladies at office work and right after work, they embrace forward thinking. It will be validated and disseminated in a service model in order to accelerate market pull.



Our approach based on three pillars:

1. Technical Materialization: The technical part will be a research on separation of the laminated sensor technology from the textile after the lifetime of the garment. This is innovative and necessary to be able to recycle the product in a proper way. Developments will be achieved in collaboration with a TPU supplier and a textile recycling company. Via this materialization process we envisage the sensor technology merely as a textile component like other applications that can be hot pressed, instead of the concept or aim itself. This is necessary to comply to conventional fashion design and production processes.



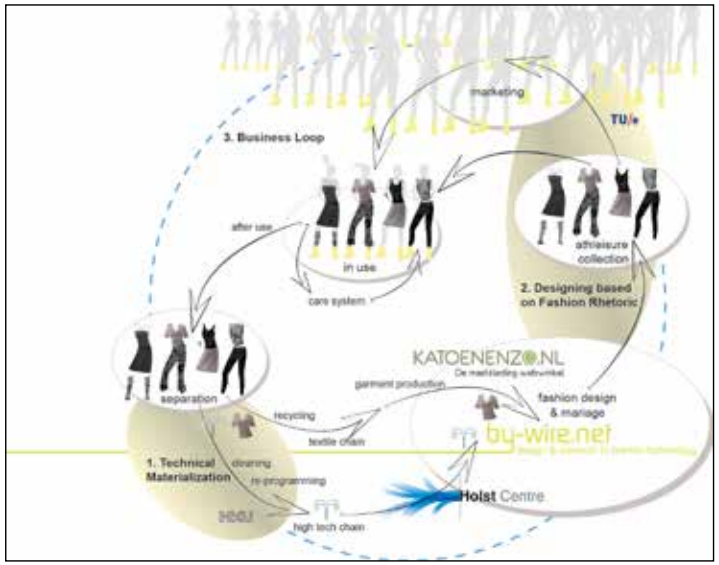
2. Designing based on Fashion Rhetoric: The current sensing shirt generations breathe a sports appearance, which is in line with the functional approach we took in the development process till now.

Although the garments entail high accuracy sensing capabilities, from now on this won't be the marketing focus at all. Consumers should and will perceive it as logical that measurements are highly accurate when brought to the market by high tech firms like Holst Centre and fashion technology parties like by-wire.net. Now that functionality is proven it is time to develop market pull by approaching the development via the more feminine fashion rhetoric.
We focus exclusively on the fashionable principles. We will concentrate on material qualities from aesthetical perspective, desirability, fit current trends and societal tendencies – to create E-fashion, as we think this is a key element to fuse E-fashion in society.
We will design a *smart athleisure fashion* collection out of 4 looks and some complementarity items. The collections will be targeting fashionable sportive ladies at office work and right after work, they embrace forward thinking.
The items will wake the desirability; a specific aesthetics with plain materials, clean shapes and subtle details of technology-inspired artworks. Athleisure is a trend in fashion in which clothing designed for light athletic activities is worn in other settings, such as during work, casual or social occasions. Taking care of yourself and well-being are long term social tendency amongst engaging consumers. *You look stunning while taking care of yourself! Don't worry, the service model takes care of the rest.*

The subtle details in the shape of technology-inspired artworks may sound contradictory as we finally managed to integrate the sensing technology totally invisibly and unobtrusively. We are planning to start using the visual aspects of the technology to create a new form of semiotics in the Vogue industry. This is connected to the material take on the sensing technology instead of a functional take. The pure functional sensing shapes are so inspirational and attractive we would like to make use of this but solely as an approach to come to shape, materials and probably artworks.

We use the development of a *smart athleisure fashion* collection – via this more feminine rhetoric and its target group – as a vehicle to bring the service models and right stakeholders into place to be able to put it in the market and take care for the use and afterlife of the garments.

3. Business Loop: The notion of group identity and the consideration of fashion as a desire for social inclusion and differentiation are well researched (Simmel, 1957). HCI researchers who reflect on fashion marketing strategies like Pan, Roedl, Blevis, & Thomas (2015) and the cultural studies of Rocamora & Smelik (2016) suggest a place for E-fashion in society and how these can influence bigger groups of people. (Toeters, 2016) As designers have the responsibility to consider the environmental impact of the collection before market penetration.
We want to certify that these garments become fertile in a closed loop system in which we design for the afterlife or next life of the product/parts. Close the loop in a proper manner.
The athleisure collection will be used for the crucial market and target group research. Together with the key stakeholders we will put the service model into place around this group. This can be a lease model. We are aware of the privacy discussions and will critically assess data storage. We will make a start to calculate and assess the feasibility of the model from a business perspective.

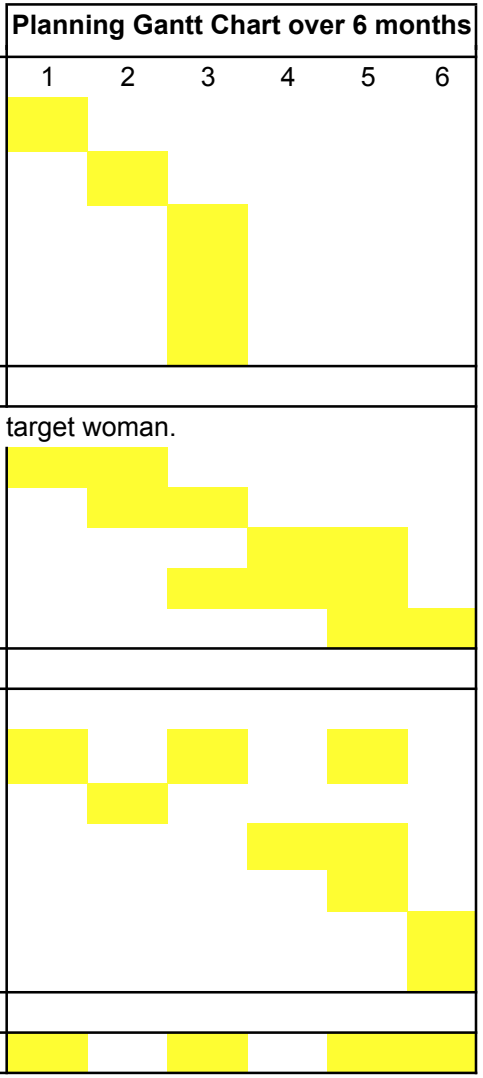


Six months is a limited time frame, so we have to leave some key aspects aside. We strongly believe in integrated feedback-loop garments. Garments that don't only sense, but also are activated, for example by giving tactile data back to the user. Actuation in garments isn't as developed as sensing technology (TRL 1/2). For this short timespan we have chosen to focus on developing a closed loop system and business implementation for a garment that only senses. We are aware that this could be a market barrier.
We also leave the data interpretation and how to act on the data for further research. The app-design will get only a superficial review during the service development.

All the activities within the 3 core topics: Technical Materialization, Designing based on Fashion Rhetoric and Business Loop are specified in the prototype plan in the first column. The following columns show how the activities relate to all involved parties and how the costs are divided over the vouchers. In the last column the Gantt Chart shows what will happen when over the 6 months.

Gantt Chart: prototype and project scheme

key activities	team days	costs €	partners	days	vouchers	costs €
Technical Materialization: The following steps are needed to be able to work with the sensing technology as a material.						
• Laminate the sensing technology on different sustainable knits without loosing the functionality. Till now we used (PA 72% EA 28%).	3,0	2400	TPU supplier	2,0	A, prototyping, Italy	1600
• Test the separation of the laminated technology from the textiles. With heat and pressure the sensor is applied. How to separtate?	3,0	2400	textile recycling	2,0	A, prototyping	1600
• Test which tension gives optimal sensing results. We have done tests with our current garments but not on female bodies.	2,0	1600	Holst Centre	1,0	A, prototyping	800
• Test which back position gives optimal sensing results on females. We have done some tests with our current products.	2,0	1600	Holst Centre	1,0	A, prototyping	800
• Conclude the list above with a list of fashion design criteria suiting this laminated sensing technology and test this with fashion students.	1,0	800	Utrecht School of Arts	1,0	C, Living Lab Experiments	800
Designing from Fashion Rhetoric: We will design an iconic athleisure collection. With 4 looks and some complementarity items it will target woman.						
• Aesthetical textile research	1,0	800				
• Design the E-fashion collection of about 4 looks.	2,5	2000				
• Each garment will be produced 4 times, so 16 garments in total.	7,0	5600	Holst Centre	2,0	A, prototyping	1600
• Design a complementary iconic fashion items.	3,5	2800				
• Make the complementary items.	6,0	4800				
Business Loop: We will calculate and assess the feasibility of this service model from a business perspective via the next steps.						
• Test market acceptance and social wearability (Dunne, et all 2014) of the 4 looks. We will make use of Living Lab Experiments in 3 iterations	4,0	3200	TU/e	1,0	C, Living Lab Experiments	800
• Define the target group and the market.	1,0	800				
• Develop the production and service process with garment manufacturers and recycling parties. Considerate data storage to get the total system working.	5,0	4000	Holst Centre	1,0	B, Business	800
			textile recycling	1,0	B, Business	800
• Disseminate the athleisure service system via shows and exhibitions like, ISPO, DDW, FashionWeek and online platforms. Including travel costs.	6,0	4800	Holst Centre	1,0	C, Business & Venturing	800
Extra: Mentor Wear Sustain. Preferable in Ethics & Sustainability and/or Business & Venturing				4,0	A, Ethics & Sustainability	3200



Total in days	47,0		17,0	
Total in euro		37600		13600
Total for the project team + partners in euro		**51200**		
Investment Marina • by-wire.net € 1200 (and more)				

Business Idea
What is the business idea behind your project?

We target fashionable sportive ladies at office work and right after work; they embrace forward thinking and are taking care of themselves.
The value for them will be that the smart garment is able to inform the ladies about their very own bio signals. Health support has become true. The garment will look stunning and fits the current trends in well-being. The backend of the system makes sure to minimize the environmental impact and tries to close the loop.

We are putting a full service circular proposition in place. Local production and a closed loop service system are our key aims. To get the cycle running we need to connect to local partners: garment production parties, assemblage, laundry, recycling, distributors, cleaning, (re-)programming. Most of them are in our network. To get the product know in order to develop market pull we need to connect to communication experts.

Our go-to-market strategy will in an iterative one. 1) Within to coming 6 months we execute 3 lab experiments to align the system with user requests. 2) Selected customers close by will be the first paying customers. We will learn if the service model works and how all stakeholders can act on it. 3) Slowly external communication begins by targeting key influencers like local celebrities and vloggers to develop a high-end market pull and getting the service system onto speed. 4) Our ultimate aim is to democratize the market by addressing and stabilizing in the middle segment. We estimate that this is a 3-year process.

We did a first attempt to calculate a service model and will research lease models. The following information is not confirmed yet and will only be used as starting point to build our Business Loop. Up till now all figures are estimated and need further research.

The sensing technology can last 25 cleaning cycles. The amounts of use of the sensing technology aren't tested yet, but let's assume for now 100 use cycles. Fashionable garments are quickly 'out'. Very fashionable garments don't stand longer than 1 cleaning cycle x 3 times use before cleaning = 3 times of use = complete garment lifecycle. If the sensing technology is integrated in a Fashionable item, then the lifespan is totally unsynchronized.

The technology will be (at least for the coming years) the most expensive part of the product. We have to research how to separate and reuse the technology and if this is possible up to 25 times.
Assume that:
Sensing technology costs 50 euro including hardware
Garment production costs 20 euro
Marriage/separation of technology and garment costs 5 euro
App service: 0,10 euro per use
Cleaning service: 1 euro per time.

Fashionable: Product 75 euro + Use 0,3 euro + Cleaning 1 euro = € 76,30 for 3 times of use = 24,43 euro per use. Leftover: 47 euro for the technology (€50-3 uses) + maybe also garment value - Afterlife / separation 5 euro + = at least € 42 value left.

Here we find that it is highly valuable to be able to separate the technology from the textile. Not only because of environmental reasons, but also because this generates business. The value that comes back from a fashionable item is high and probably this target group is willing to pay more per usage.

As this total system and business case is designed around a specific group, they could benefit from its service. Anyhow, we think that the actual target group of this total process could be a completely other one. Aren't the real customers the garment industry parties and technology companies? We try to pave a path towards sustainable service models for smart garments. During this project we research, together with our stakeholders how to deal with this, and how to gain sustainable value during the process of up scaling.

Provide a short video (3 minutes maximum) that explains your project, team, project plan and business idea.
https://youtu.be/7_XCJcfirWc

Required Project Support and Implementation Services
Which of the below Project Support and Implementation Services would be useful for your project and why?
We think to have good team capabilities in high tech systems, prototyping, technology, design, aesthetics and user-centred design. With the partners in our network are able to close the production and recycling system. For the technical research Holst Centre, a TPU supplier and the textile recycling company will be connected to the project via the voucher system. These parties will also be involved

in the calculation and validation of the closed loop business model. Fashion students (Utrecht) will help to test and check the design criteria of the laminated sensing technology. Eindhoven University of Technology will be involved via living lab experiments to test market acceptance. Find a detailed description of the expertise on our envisioned partners in the Gantt Chart with milestones and deliverables and how this relates to the voucher system in column F.

In order to reach out to a large target group and develop the market towards service models for fashionable smart garments we lack expertise in the field of business & venturing and its legal aspects. Implementation services in these fields would help us tremendously.
During development of the Technical Materialization pillar support in analysing life cycles (LCA's) of our garments and technology would be highly appreciated to make the right choices.
Concluding means support in the area of ethics and sustainability. A mentor with Ethics & Sustainability and Business & Venturing qualities would make our team complete.

Contact
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Bibliography

Dunne, L. (2010). Smart clothing in practice: key design barriers to commercialization. Fashion practice, 2(1), 41-65.

Dunne, L., Profita, H., & Zeagler, C. (2014). Social Aspects of Wearability and Interaction.

Köhler, A. R. (2013). Anticipatory eco-design strategies for smart textiles. Perspectives on environmental risk prevention in the development of an emerging technology.

Pan, Y., Roedl, D., Blevis, E., & Thomas, J. (2015). Fashion thinking: Fashion practices and sustainable interaction design. International Journal of Design, 9(1).

Rocamora, A., & Smelik, A. (2016). Thinking Through Fashion. A Guide to Key.

Ryan, S. E. (2014). Garments of paradise: wearable discourse in the digital age: MIT Press.

Simmel, G. (1957). Fashion. American journal of sociology, 62(6), 541-558.

ten Bhömer, M. (2016). Designing Embodied Smart Textile Services.

Toeters, M. (2016). E-fashion fusionist aiming for supportive and caring garments. Paper presented at the Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct.

Toeters, M., ten Bhömer, M., Bottenberg, E., Tomico, O., & Brinks, G. (2013). Research through design: a way to drive innovative solutions in the field of smart textiles. Paper presented at the Advances in Science and Technology.

van der Velden, N. M. (2016). Making Fashion Sustainable: The Role of Designers.


Thank you