

Sanna Konola & Päivi Kähkönen

ARCTIC WEARS

PERSPECTIVES
ON ARCTIC CLOTHING



Arctic Wears - Perspectives on Arctic Clothing

Sanna Konola • Päivi Kähkönen

Arctic Wears

- Perspectives on Arctic Clothing

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FOREWORD

» ARCTIC NETWORK -
A SOURCE AND INSPIRATION
FOR ARCTIC PROTECTIVE
CLOTHING

INTRODUCTION

Arctic issues are rising around us on every field at the point of view of environment, sustainability, climate change, indigenous peoples' rights, design and society, snow and ice building knowledge, challenges and possibilities in Arctic areas. The Arctic is written in Finland's future strategies, and in 2017 Finland assumes the chairmanship of Arctic Council.

In the northernmost university of European Union, University of Lapland, the northern issues have always been written in the DNA of university's actions, visions, strategy and curricula. At the moment, "northern" and "Arctic" are written in the university's strategy. According to these themes, several projects and research topics are oriented to the Arctic problems. In this context, the ArcticPro network and ArcticPro Lapland project are up to date but at the same time very normal and natural approaches in the Northern areas.

ARCTIC DESIGN

"Arctic design is about the conception of products that consider one's relation to the land and express its singularity." (Marchand and Marques Laitao, 2012,66). It is easy to agree with Michael Hardt, who argues that *"The Arctic is not about Latitude, it is about attitude"* and "it is not Arctic design, unless it is sustainable." Arctic design devises actions to sustain the knowledge and skills regarding the culture of the people and nature in the Arctic, and to share this knowledge as a source of understanding the sustainable system and to design sustainable products and services (Hardt 2012,57-59). In the ArcticPro Lapland project, the goal of the university's research was clearly focused on gathering user-based data in the cold climate environment, to be able to develop Arctic protective clothing for outwear and for all ages including ageing groups. At the same time, information was gathered on research and product development needs from companies connected to cold protection. Issues companies were

interested in were for example producing clothing services for working in cold climate and utilising user based research knowledge about the needs and hopes of different user groups.

ARCTICPRO NETWORK

After completing the research and development project *Body Fit* in autumn 2011, there seemed to be quite a considerable need for continuing to solve many problems linked to functional clothing design as well as further developing working clothing in cold climate and Arctic environment. Summer 2012 brought to us, at the University of Lapland, messages from other northern countries, especially from Norway, where universities and employer unions, Norwegian industry representatives and research centre SINTEF were interested in same sort of questions and developing tasks as we were at the University of Lapland and Lapland University of Applied Sciences. Therefore, after several negotiations with interested parts, there finally came the opportunity to have a joint meeting around these Arctic issues. Finatex arranged a Preparatory meeting for Possible Joint Project on Cold Wear between the Nordic Countries, 15-16 January 2013, in Rovaniemi. This can be estimated to be the starting point for the idea of joint network, focused on problems and research about protective clothing in cold climate. Very soon after that we named the network “ArcticPro” and established web pages for the joint network (www.arcticpro.org).

ARCTICPRO LAPLAND

It soon became clear that in order to participate in joint meetings with ArcticPro network University of Lapland and its partner Lapland University of Applied sciences would need a sound organisation and sound funding for future actions. That is when the ArcticPro Lapland project was established. Our application for funding was accepted and we started the intensive project working firmly together with demanding goals and challenging schedule. As a responsible leader of the project part of the University of Lapland I can proudly announce that considering the very short period of the project (16 months) we have managed more than well in achieving the goals of project. Project measures undertaken have produced versatile knowledge about Arctic protective clothing, developed new kinds of methods for gathering user data and developed service design and workshop methods to co-create and co-design cold climate clothing together with users, documenting everything in pictures and text. In addition to this, project has arranged several happenings, seminars and workshops to confirm the possibilities to have the maximum amount of information around the topic of Arctic protective clothing. It is utmost important that the project has also mapped the existing knowledge about the projects, articles and research that has been going on around smart textiles, intelligent clothing, working garments and functional,

aesthetic clothing design in cold climate and Arctic environment, in University of Lapland (Lumontulista Luksukseen, Ryttilahti 2015). The corresponding mapping has also been done at Lapland University of Applied Sciences.

HIGHLIGHTS

Besides the results according the goals of the ArcticPro Lapland project I want to highlight the “extra” results surfaced, which were not yet expressed as such in the project plan but which proved to be important. They confirmed the tasks and methods to gather new information from users and provided tools for collaborative concept design and research of Arctic Protective Clothing, as well as gave strong bases for inspirations in design and research actions.

ArcticPro Road Show, Hämeenlinna

In October 2014, the ArcticPro Lapland project coordinated a road show of national ArcticPro network. This took place in connection to a national meeting of working garments and protective clothing. Road Show offered good possibilities to meet the ArcticPro Finland network’s people, exchange knowledge and present expertise areas of each participant. Companies also connected to protective and working garments participated in the meeting and some held presentation on their arctic work wear challenges. The project staff of University of Lapland and Lapland University of applied sciences arranged together a workshop for all participants gathering and analysing interesting data with World Café -method. The main themes and questions presented in workshop were: 1. Which societal challenges and problems concerning especially? 2. Which are the challenges and possibilities of future technologies and materials as tools of welfare in Arctic regions? 3. Cold protective garments and equipment as part of safe, efficient and productive work – Is there still something missing? Results and analyses confirm and develop the knowledge of these important themes and can benefit both future research and teaching materials.

Japan-Finland Workshop

In November 2014, University of Lapland arranged already traditional JFW clothing workshop in Lapland and theme was to design cold climate clothing for grandmothers and grandchildren from user-centred perspective and utilise co-creation methods. Project coordinator Sanna Konola had an opportunity to participate in the workshop – one week at the University of Lapland, Finland and another week at Yamaguchi Prefectural University in Japan, December 2014. Konola documented the user-centred process and methods for future utilisation, assisted in the realisation of garments.

To deepen knowledge on cold protective clothing for elderly people, she interviewed a few elderly ladies in Yamaguchi and visited in a Japanese elderly people's home, as she had also visited a Finnish one. Konola also gave a presentation on the ArcticPro Lapland project for Japanese students and university staff. From this workshop, the ArcticPro Lapland project could receive international knowledge about the research area of designing cold climate clothing, elderly people's clothing habits and different cultural traditions, as several exchange students in addition to Finnish and Japanese students also participated to the workshop.

ARCTIC WEARS Future workshop during Arctic Design Week

One of the most innovative and visionary happenings of ArcticPro Lapland Project was no doubt the Arctic Wears workshop during Arctic Design Week in February 2015. Event was planned and realised by D.A. Ana Nuutinen from Helsinki University with help of APL project staff. The whole workshop took place in cold climate chamber of Arctic Power Laboratory by the Arctic Circle. Temperature in the room was at the beginning of the workshop some 20 degrees below zero! More about the results and outcomes of this unique cold climate workshop from Nuutinen's article later in this publication.



Figure 1. Presenting ArcticPro Lapland project. (Picture: Gao Bo 2015)

Arctic Design and service design workshops at Tongji University, Shanghai

In March 2015, the staff of University of Lapland visited Tongji University, College of Design and Innovation in Shanghai, China. We organised lectures, presentations, fashion show and two service design workshops dealing with young women's welfare

and challenges in campus community and society. Project designer Sanna Konola had the chance to present the ArcticPro Lapland project for Chinese students and University staff (Picture 1). Student works of the University of Lapland were presented and they aroused great enthusiasm in the Chinese audience. In the picture (Photo 2), an example of the outfits presenting Arctic luxury with fur, silk and reindeer leather, designed and produced by master student Riikka Kälkälä.



Figure 2. Arctic luxury in Shanghai.
(Picture: Konola 2015)

FUTURE

The ArcticPro Lapland project is about to end, but issues, conferences and global discourse around Arctic themes, Arctic design and Arctic strategies continue and Arctic and northern will stay as strategic goals of the University of Lapland. A lot of data and user-based knowledge has been now gathered to support the development of cold climate protective clothing and research of clothing design, but at the same time thousands of new questions and challenges still need to be solved. It would be ideal if the ArcticPro network could develop new cooperative projects which would solve these problems. In November 2015, City of Rovaniemi, the University of Lapland and its Arctic Centre are organising an international Arctic Conference “In the Spirit of Rovaniemi Process – Local and global Arctic”, which addresses the interaction of the global, regional and local levels in the Arctic, such as impacts of global processes and local communities in the Arctic as well as roles of different institutions. According to the themes of the conference, it poses questions like: “*How do local perspectives and values translate to regional and global context?*” and “*How do the structures of Arctic regional co-operation fit between global and local forces that shape Arctic Realities?*” (Rovaniemi process 2015). Hopefully, the Conference will find some answers, some answers could be produced in future projects and finally in 2017 Finland must find some answers while assuming the chairmanship of the Arctic Council.

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REFERENCES

Hardt M. B. 2012. The story of the frozen Ice or the art of sustainable design in the Arctic. In Tahkokallio P. (ed.) Arctic Design. Opening the Discussions. University of Lapland, Series C: Overviews and Discussions 38.

Marchand, A. & Marques Leitao, R. 2012. Design as means of empowerment within aboriginal communities in Quebec. In Tahkokallio, P. (ed.) Arctic Design. Opening the Discussions. University of Lapland, Series C: Overviews and Discussions 38.

Rovaniemi process 2015. Theme of the conference 2015 - connecting the local, the regional and the global in the Arctic. Referenced 24 February 2015. <http://www.rovaniemiprocess.fi/en/Theme>.

Rytilahti P., 2015. Lumontulista Luksukseen.

INTRODUCTION

» ARCTICPRO LAPLAND PROJECT

Lapland is the most Arctic region in the European Union. The region's Arctic Specialisation Strategy envisions a leading position in the exploitation of arctic conditions and natural resources by 2030. Lapland commercialises its arctic expertise and acts as a hub for arctic transportation and information. (The Regional Council of Lapland. 1, 4) Naturally, the higher education institutions in Lapland have their strategic emphasis on 'Arcticness'. The University of Lapland highlights Arctic arts and science while the Lapland University of Applied Sciences focuses on mastering Arctic special conditions. (University of Lapland; Lapland University of Applied Sciences)The ArcticPro Lappi project has its background in these focus areas.

As the name of the project reveals, the ArcticPro Lappi project was highly based on the ArcticPro network as well as in tightening cooperation between the Lapland University of Applied Sciences and the University of Lapland. The aim of the network is to enhance the knowledge of cold weather clothing and cold protection, to enhance human well-being in the Arctic climate, to prepare joint research projects and to find new product applications in regards to the cold area specific requirements, as well as the latest knowledge and know-how in the field.

The long term vision of the project is to create an internationally recognised centre of arctic design and testing in Lapland, while the project's main purpose was to market and develop the user-centred clothing design and clothing testing in an international level.

Results sought were

1. increased visibility and interest towards the expertise of Lapland UAS and University of Lapland,
2. increased internationalisation and wider networks in the field of cold protection wear, and
3. improved test facilities and educational material related to cold and protective clothing.

A lot of work had to be conducted in a short period of time, as the implementation period of the project was 16 months, starting from 1 January 2014 and ending 30 April 2015. The overall budget for the project was a little more than €160,000 of which European Regional Development Funds (ERDF) covers approximately €114,000. Therefore, special thanks need to be given to the Regional Council of Lapland for granting this financing. The rest of the financing was covered by the two universities themselves.

This publication only partly covers the work carried out in the project as there were also other activities. As an example, ArcticPro roadshows were partly arranged by the project and separate visits and trips were arranged for enhancing cooperation with the ArcticPro network and for getting to know the latest trends in the field.

REFERENCES

The Regional Council of Lapland. The Arctic Specialization Programme of the Lapland region. Online document. Referenced 7 April 2015. http://www.lappi.fi/lapinliitto/c/document_library/get_file?folderId=1483089&name=DLFE-21422.pdf.

University of Lapland. Strategy 2025. Referenced 6 February 2015. <http://www.ulapland.fi/Suomeksi/Tietoa-yliopistosta/Strategia-2025>.

Lapland University of Applied Sciences. The Strategy of Lapland UAS. Referenced 6 February 2015. <http://www.lapinamk.fi/fi/Esittely/Lapin-AMKin-strategia>.



BACKGROUND

» FROM FIRES OF
ENCHANTMENT TO THE
EMERGENCE OF LUXURY

Piia Rytilahti

From cold-protective and smart clothing to luxury research

An overview of the clothing research and development projects of the Textile and Clothing Design unit of the Faculty of Art and Design at the University of Lapland in 1998–2007

INTRODUCTION

From the Rovaniemi Institute of Art and Craft (Rotko) to the degree programmes for Textile and Clothing Design at the Faculty of Art and Design.

The purpose of this report is to create a retrospective of the research and development projects that have taken place at the Textile and Clothing Design degree programmes of the Faculty of Art and Design at the University of Lapland in 1998–2007; the projects approached the future prospects of the clothing industry from the perspectives of research and development of smart and cold-protective clothing and leisure and luxury products. The research and development activities in these fields of specialisation were initiated in a situation where the Rovaniemi Institute of Art and Craft (Rotko) was merged into the University of Lapland and professorships in the fields of both Textile and Clothing Design were established (Koukkula & Uotila 1999, 5). Minna Uotila, Doctor of Education, was appointed the Professor of Clothing Design; during her term in office, the research project portfolio of Clothing Design grew to a substantial degree, and comprised research and development projects funded by both the Academy of Finland and Tekes, which is also known as the Finnish Funding Agency for Technology and Innovation. The goal of this period of approximately ten years was to conduct research and development in the new clothing technologies and contexts of use. Leading companies in the field of clothing in Finland have been involved in the projects, as have other research institutes from all levels of education. This overview is a concise summary of these research and development projects, completed during the ten-year period, and their central results.

TEXTILES AND CLOTHING OF THE FUTURE 1998-1999

In 1998, the Faculty of Art and Design at the University of Lapland was granted the right to provide university-level education and research in the field of design as the second university in Finland. At the unit of Textile and Clothing Design of the Faculty of Art and Design, updating the competence of the unit providing university-level education and research was initiated with the preliminary information project *Textiles and Clothing of the Future*, realised with funding from Tekes. At the same time, the research and development project *Future Design in Textiles and Clothing* was under preparation. The company funding of the Textiles and Clothing of the Future project was provided by Nokia Mobile Phones and The Federation of Finnish Textile and Clothing Industries. The goal of the preliminary information report was to find out about industry views on the possibilities offered by the new design and material technology and the so-called smart systems in the design and product development, as well as explore needs for their use and their usability in the Finnish textile and clothing industry. The research indicated at the time that in the textile and clothing industry, Information Technology (IT) had established itself well as a basic tool for designers, but was not yet used to assist in more advanced design and representation methods. The advantages of the Internet were first and foremost acknowledged to contribute in marketing. The role of smart textiles was considered minor at the time, and the thought was that they would require approval from larger clientele before their production could be expanded. (Koukkula & Uotila 1999, 5–7.)

At that stage, in accordance with industry estimates, the research activities were channelled into the direction that could help in introducing the new design and material technologies and smart systems to use at a fast pace in the Finnish textile and clothing industry (cf. for example Virta 2005, 2). The research material of the preliminary information report entitled Textile and Clothing of the Future consisted of questionnaires to the member companies of The Federation of Finnish Textile and Clothing Industries; the survey on material technology and digital design was submitted to 276 companies (response rate at 26 per cent) and the more in-depth interviews conducted during company visits (a total of 17), where digital design, material technology, product development, education and company image were discussed in more detail. (Koukkula & Uotila 1999, 10–12.)

Another project concentrating on research and product development and carried out at the University of Lapland's unit for Textile and Clothing Design around the same time was *Lapin lumo tekstiileissä ja vaatteissa* (*Enchantment of Lapland in Textiles and Clothing*) in 1998–2000. Known as *Winds of Enchantment* in its English translation, this project was funded by the European Regional Development Fund and the Finnish Ministry of Education. The target group of company cooperation and the project partners included ten businesses in the field of travel services in Lapland – such as the Levi

Center Hullu poro and Hotel Luostotunturi from Ivalo – and twice as much other Lappish companies from other sectors. (Talvitie 2000.)

CYBERIA 1999–2000

The next stage in covering the future of the clothing industry led to the field of smart clothing. The research and product development work in smart clothing at the Faculty of Art and Design of the University of Lapland began at the turn of the millennium with the 18-month, Tekes-funded research project entitled *Cyberia: Survival garment prototype for harsh winter environment for Reima-Tutta Ltd.* (1999–2000). Partners in the project included Nokia Mobile Phones, Reima-Tutta Ltd., Reima – Smart Clothing, Reima – Clothing+, Suunto Ltd., Polar Electro, DuPont and the unit for Fibre, Textile and Clothing Science at the Tampere University of Technology. This research group was mostly made up of young student designers, fashion designers and experts in electronics who would graduate with a Master of Science degree in Engineering, together with more mature researchers in Material Technology (Matala 2007, 103).

“A survival suit for Arctic conditions was developed in the Cyberia project, with electronic components such as a wearable computer and new non-electronic parts, for example integrated ice picks in the suit sleeves. Locations for various gadgets and equipment were created in the suit by applying previously obtained research data and existing technology. Simultaneously, ways for using sensor technology in clothing were created. The idea of the smart clothing prototype was to extend the user’s body in ways which would help the user to survive and better cope with the prevailing extreme conditions, for example in an accident situation.” (Matala 2007, 102.)

The goal of the project was to examine the different alternatives in which clothing could be developed by utilising information technology (IT), electronics and advanced fibre and textile materials. The project produced a prototype of a survival suit developed for snowmobiling, with the purpose of both preventing accidents and helping to survive in accident situations. Snowmobiling was selected as the context, because Reima-Tutta had experience in manufacturing clothing for the Arctic conditions, and snowmobiling in particular. Approximately one year after the project was finished, in August 2001, Reima-Tutta launched its first commercial piece of smart clothing, the *Reima Smart Shout*, at the Cebit IT Trade Show organised in the German city of Hannover. *The Smart Shout* offered a new way for group communication through a garment. In practice, the gadget was a textile-embedded version of a wearable mobile phone and a group user interface designed for a specific target group, of snowboarders and mountaineers for example, for communication and positioning in harsh outdoors conditions.

This project in smart clothing was, at the time, one of the few technological development projects of which there were public reports and information (Rantanen et al. 2000; Rantanen et al. 2002, 5, 15.)

INTELLIGENT CLOTHING MATERIALS: INTEGRATING INTELLIGENCE AND CLOTHING FUNCTIONALITY WITH PRODUCT DESIGN, 2000-2001

The research and development activities continued after Cyberia in the *Interactive Materials* project, also funded by Tekes, the goal of which was to integrate technological usability, functionality and design even closer. The collaborative partners – Nokia Research Center, Reima-Tutta Ltd. and the unit of Fibre, Textile and Clothing Science at the Tampere University of Technology – resumed cooperation in another 18-month Tekes project. At this stage, Reima – Smart Clothing and Reima – Clothing+ discontinued their partnership and continued with the commercial applications of smart clothing independently.

Of the students of Clothing Design and Industrial Design involved in the Cyberia project, two were employed by collaborative partners during the Interactive Materials project and continued in the development process of integrating clothing materials and technology with such applications as a concept called Clothing²¹. In the light of the Cyberia project and the other research and development projects of the unit of Textile and Clothing Design at the University of Lapland, the next potential step was to extend the target group to professional clothing and work wear. This meant that the challenging target group of for example firefighters and miners entered to the picture as users to protective clothing and work wear. (Rantanen et al. 2000).

1 See the Clothing+ concept today in the action: www.clothingplus.fi; <https://twitter.com/ClothingPlus>

WEARCARE 2001-2002

The WearCare research project stood for *Intelligent garment design innovations and usability methods for work wear and health care*. The WearCare project looked at the intelligent garment design in a new context of work wear, protective clothing and health care. The funding was, again, provided by Tekes. Collaborative partners included Nokia Mobile Phones, Nokia Research Center, Suunto Ltd., L-Fashion Group Ltd./Rukka, Laitosto Ltd., Finlayson Forssa Ltd, the Fibre, Textile and Clothing unit of the Tampere University of Technology and the unit responsible for the Sports and Leisure education at the Rovaniemi University of Applied Sciences.

In the initial phase of the WearCare project, the concept of intelligent textile material was still new, almost completely unknown idea in the market. The purpose of the project was to assess, on a general level, the usefulness and usability of intelligent textile materials. Two sectors with different features were selected as the context of the research: the health care and well-being sector and industrial, high-temperature working conditions. A second project goal was to analyse and determine how the intelligent materials' microscopic special properties, not perceivable by the human eye, could be illustrated with the help of 3D modelling techniques (Mattila, Talvenmaa & Mäkinen 2006, 360).

Illustrating futuristic, concept-level, not-yet-existing designs without a prototype product has always been an issue characteristic to the design sciences. The third purpose of the project was, in fact, to develop visual methods for illustrating the needs and requests for the use of smart clothes that are expressed by potential users. Of the research partners in this project, University of Lapland concentrated on design and usability testing, while Tampere University of Technology's focus was on the intelligent textile materials. The emphasis of concept design was strongly placed on the user research that was carried out at two hospitals and a steel mine (ibid., 360).

With respect to this purpose, the possible advantages of 3D modelling and animation were studied in regard to usability testing and enquiring the opinions and first impressions of potential users in particular. When this modelling functions, it is possible for the research and design team to analyse the concepts and eliminate unfit solutions and pitfalls in the product development process before the actual product manufacturing begins. The WearCare research project confirmed the importance of the role of early-stage usability testing in research and development activities in the future. (ibid., 67–368.)

ISPORT

In 2001–2002, the possibilities offered by new technologies in clothing and design were studied with funding from Tekes' iWell – Well-being Technology research programme. Partner companies in this project were Nokia Mobile Phones and Suunto Ltd. A special characteristic of the project was the interesting, synergic cooperation with different levels of education, with the Rovaniemi University of Applied Sciences' study programme in Sports and Leisure responsible for the target group-specific competence and expertise, in this case specifically concerning the usability of the clothing needed in sports and leisure activities. The ISport project was divided into two parts, *ISport I and ISport II*.

ISport I – Intelligent clothing design for recreational sports and the well-being of the fitness enthusiast – needs evaluation for the end user was, funding-wise, more significant than the subsequent concept and product design project *ISport II*. In *ISport I*, end-user needs with regard to sports and outdoors activities were studied with an emphasis on intelligent clothing. Winter extreme sports enthusiasts were in the focus. Attention was paid to the well-being and safety of those going for the maximum performance in extreme conditions, with technical and physical aspects, such as protective qualities of clothing (Mäyrä 2002) and cultural understanding of the individual (Juntunen 2002), social and other context-specific needs of engaging in these activities (Uotila 2002b).



Figure 1: ISport

The project generated data and guidelines for the features, constructions and development needs of intelligent sportswear of the future (Virta 2005). The activities and results of the *ISport I* project were recorded in detail in the Faculty of Art and Design's publication '*Jälkiä. Kohti urheilu- ja vapaa-ajan vaatetuksen uusia ulottuvuuksia.*' ('Tracks. Towards the new applications in the sports and leisure activity clothing.') (Uotila 2002a.) In this research project, the basis and starting points were established for the design of technologically oriented intelligent clothing in the future, but also such project and research activities in the clothing and design industry that take interest in culturally distinguishable user groups, such as trends and the cultural and social factors in regard to the consumption of elite products (Uotila 2002b, 82).

ISport II – Intelligent clothing design for recreational sports and the well-being of the fitness enthusiast – concept and product design research programme's studies were further developments of the I-Sport project coordinated by the University of Lapland. The purpose of the research project was to design what are known as intelligent sports and outdoors leisure clothing concepts based on the background research carried out in the ISport I project, and to further study their usability with the use of 3D modelling and simulation. The target areas included occupational health and its maintenance, consisting also of adventure -and experience treks organised by the employer and related guide work. Focus was also on the physical education at school, especially in the application areas of games, play and dancing. (Virta 2005).

When launching the iWell programme, the development pace was not correctly estimated, as the hypothesis in the programme planning was that structures of services would be more quickly reformed and technology would be put into use faster. In the planning of the programme it was estimated that it would create a productive environment for new business operations, with new services generating new needs for products, and new products would generate new forms of services. However, estimating the pace of market development proved to be challenging. Expectations were overly optimistic when the programme was launched, especially in the IT bubble of the late 1990s. The FinnWell technology programme launched in 2005, focused more on the health care sector systems than the iWell programme; the needs for public service research were now given the priority. (Virta 2005, 2–3.)

After technology-led projects, the projects of the Textile and Clothing Design degree programmes had a shift of focus more into the direction of design and the cultural elements in design (Matala 2007, 103). Operating in the field of humanistic and social university research, the unit did not possess strong technological expertise. The required technological competence, necessary for the development projects in the sector, was secured with the help of collaborative partners – the Tampere University of Technology, the Rovaniemi University of Applied Sciences and businesses specialised in the clothing industry technology. At this stage, the need for extending the competence that was concentrated on classical clothing and design began to emerge, and shifted into the direction of locating new and innovative research topics and taking up increasingly diversified and multi-disciplinary research activities. The funding instruments began to promote areas of research that were located between different interfaces. It would be the most natural development to extend competence by benefitting from the other fields of education at one's own university, and the disciplines offered by the other faculties. In practice, this meant more social- and culture-oriented end-user research and, on the other hand, planning project activities that concentrate on the development of the specific methods used in each field of design.

MEMOGA - METHODS AND MODELS FOR INTELLIGENT GARMENT DESIGN

The development of intelligent clothing continued in the MeMoGa project (Methods and Models for Intelligent Garment Design. Interdisciplinary approach to accessible and usable wearable products). This project emphasised a user-oriented approach and was funded by the Academy of Finland. A goal of the MeMoGa project was to develop the applicable methods and models needed for the research and design of wearable intelligence and for the study of matters relevant to the usability and social acceptability of smart clothes. The MeMoGa project's approach to this multidisciplinary field of research was that of clothing design, fibre material technology and physiological research.

Wearable intelligence was studied as a part of the more extensive PROACT research programme, managed by the Academy of Finland in 2003–2005. Participants of the MeMoGa project were the Textile and Clothing Design unit of the University of Lapland, the Institute of Fibre Materials Science of the Tampere University of Technology and the Department of Physiology of the University of Kuopio (Loukiainen 2007).

“A piece of clothing is referred to as intelligent if it contains new technology: technical advancements have made it possible to add electronic components to traditional pieces of clothing. In demanding conditions, such as the heavy industry, specific requirements have been determined for the staff work wear and its materials, because the clothes must provide the employees optimal protection from the hazards in the working environment. Intelligent clothing design is considered to offer new applications in material technology for making the staff work wear even safer and better applicable to the tasks and the working environment. Intelligent clothing makes it possible to monitor the vital functions, such as the electromyography (EMG), of the user (Loukiainen 2007).”

The MeMoGa research project continued to determine the position of intelligent clothing research in the multi-disciplinary field of research, a process initiated in the WearCare and ISport projects. This entails, in addition to the traditional theoretical study of clothing and the evaluation of the usability of intelligent clothing, a more complex empirical evaluation of the intelligent clothing concepts and prototypes. One example of such questions that are of interest to the human sciences research and relevant hybrid products was studying the prejudices and other user-culture specific meanings in the integration of technological devices and clothing. Acceptability of technology is an area of competence in which the Faculty of Art and Design of the University of Lapland has produced distinguished, academic research (Alakärppä 2014). The new terminology relevant to the clothing industry and studied as a part of the MeMoGa project included, in addition to intelligent clothing, the concept of prototype,

which had been treated, in the discussion in the field until then, mostly in the context of industrial design and in the term's industrial design definition:

“A virtual prototype refers to materials, for example 3D models, 3D animation, that can help the prototype to appear real to the user in a completely different manner than just looking at sketched images. Animation can be used to introduce the prototype's applications in a working environment, which will help to understand the possibilities of use of the intelligent clothing design in the heavy industry work environment (Matala, quoted by Loukiainen 2007).”

An essential part in the user-oriented approach of intelligent clothing is the evaluation of usability. For this purpose, virtual prototypes were produced in the project; with their help, it was possible to introduce the not-yet-existing piece of intelligent clothing for end-user evaluation before producing the actual, tangible prototype. The purpose of the evaluation was to involve the user in the design process and possibly minimise resource use in the initial phase that would be allocated to the time-consuming production of tangible, often expensive prototypes. (Loukiainen 2007).

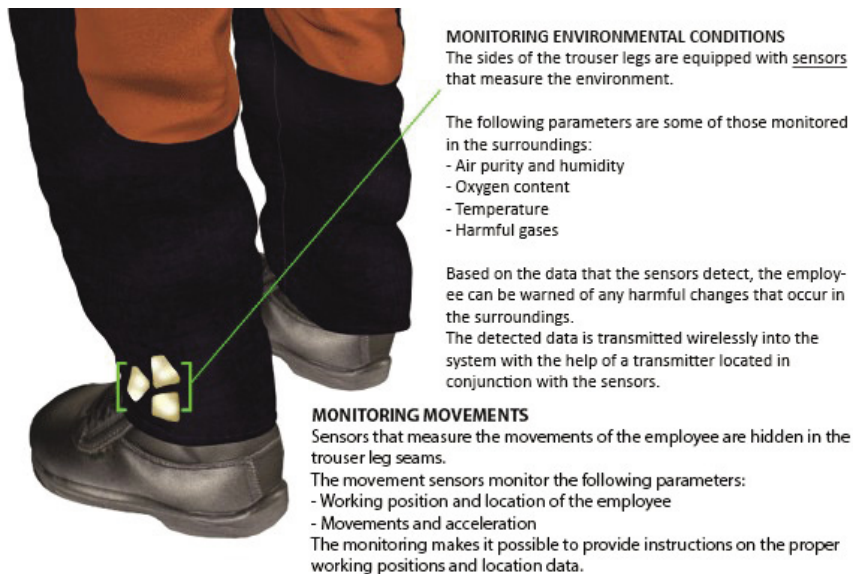


Figure 2. A detail of the HardWorkers intelligent clothing concept trousers. (Pursiainen et al. 2006).

The MeMoGa project consortium involved 12 researchers, designers and research assistants in addition to the directors in charge, the Professors Minna Uotila, Heikki Mattila and Osmo Hänninen. The budget for the project consortium was €500,000. According to the Academy of Finland's Review panel (2007, 26–27), the project was successful. The presented test models, the prototypes, were impressive as to their design and also acceptable from the user perspective. Furthermore, many of the applications proceeded to manufacturing, but a real break-through in the market

would have perhaps demanded cooperation with an even larger group involving sociologists and cognitive scientists. The project was also influential from the scientific perspective, promoted by the Academy of Finland, as an international research community began to form around the involved project teams. The most tangible manifestation of this was the international Ambience2005 conference², which brought together in Tampere two hundred researchers interested in ‘intelligent ambience’, including the study of intelligent materials and textiles. The list of textile materials that were being researched was comprehensive. Chromium-containing, conductive, transforming, aerogel and nano applications took their turns in the experiments and testing, for example biosignal-based measuring. (Mattila 2002; Academy of Finland’s Review panel 2007, 26–27.)

CODES

The *CoDeS – Facilitating Social Creativity through Design* research project was conducted in close cooperation with the MeMoGa project. The CoDeS project was a part of the Life as Learning research programme of the Academy of Finland. The goal of the research project was to develop computer-assisted communications methods and models to support collaborative design processes, illustration and visualisation, simulation and evaluation. One of the central research findings of the CoDeS project was that computer-assisted design activities, taking place in an online working environment, are an inevitable element of the future in the field, making concrete cooperation possible for interdisciplinary and global design teams. At the time, the digital and technological equipment available were still under development, as were their ways of use and using culture. Most of those in the design field did not have solid experience of these equipment. (Pursiainen 2007).

LUXURY - EMERGENCE OF LUXURY (2004-2007)

The *Emergence of Luxury* research project was a multidisciplinary project, located on the field of design, with the definition of exclusiveness and luxury over the product-oriented definitions as one of its ambitious goals. Design research connected to what is known as everyday luxury and high standard design products was carried out in the framework of the project. The approach to luxury was to analyse the essence and meaning of luxury and design products as the user experience of different user groups and communities. The project was funded by the Industrial Design research programme of the Academy of Finland (Falin 2005).

2 Cf. Ambience 7–9.9.2014 in Tampere. Ambience, Scientific conference for Smart and functional textiles, Well-Being, Thermal comfort in clothing, Design, Thermal Manikins and Modelling, <http://www.ambience14.fi/index.php>

Lapin Yliopisto
Minna Uotila professori
Piia Ryttylähti tutkija

emergence of **LUXURY**



Uusi luksus

Vanha luksus tarjoaa materiaalista statusta ja hohdokkaita brändejä. Uusi luksus on nautintojen kokemista ja niiden tekemistä. Se syntyy spontaanisti ja muuntautuu joustavasti erilaisiin käyttökonteksteihin.

Ekoluksus

Kohdatessaan ihmisten elämäntyyliensä ja harrastuskulttuureissa vanha ja uusi luksus muokkaavat tulevaisuuden trendejä. Sekä suomalaisen muotoilun että teknologisen osaamisen avulla uusi ja vanha luksus ovat yhdistettävissä ja tuotteistettävissä. Tuloksena on tulevaisuuden ekoluksus.



Hankkeiden vastuulliset johtajat,
professori Minna Uotila (Luxury, FF, SuMac)
professori Veikko Louhevaara KUY (SuMac)

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Piia Ryttylähti, Petra Falin, Pertti Aula,
FutureFinders: Pertti Aula, Kati Vehmas
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Maxim Narbraugh, Miia Mattila, Marja Pitkänen
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muotoilun opiskelijat

Yritykset:
Nokia, Elisa, BPR Finland,
Rukka/ L-Fashion Group,
Taigakoru, Lapin Safarit

Suomen Akatemian Teollisen muotoilu -tutkimushjelma 2004 - 2007
Emergence of Luxury: Multidisciplinary Approach to Hidden Values and
Pleasure Factors in New Design Products in Different Societal Communities
Luksuksen syntymekanismit

Tutkimuskonsortio: Lapin yliopisto ja Helsingin yliopisto
<http://www.ulapland.fi/luxury>

Tekesin MUOTO 2005 -Teollisen muotoilu teknologiaohjelma 2002 - 2005
FutureFinders - Strateginen muotoilu ja edelläkävijyyden
mallintaminen 2004 - 2005
<http://www.ulapland.fi/futurefinders>

Suomen Akatemian Kestävät Tuotteet ja tuotanto -tutkimushjelma 2007 - 2010
SuMac | Sustainable Innovative Materials in High Tech Applications
Kestävät ja innovatiivisten materiaalien High Tech sovellutukset

Tutkimuskonsortio: Lapin yliopisto, Kuopion yliopisto ja
Tampereen teknillinen yliopisto
<http://www.ulapland.fi/sumac>

Kansainväliset tieteelliset konferenssiulkaisut:
Nordic Design Research -conference 2007, Stockholm: Understanding the essence of environmentally sound products
Design & Emotion -conference 2006, Gothenburg: Understanding Cultural Diversity in Design Consciousness.
DPP1 -konferenssi 2005, Eindhoven: Experience of Luxury and Pleasure with Products.
Pre-Conference of World Design Congress Era05. 2005, Helsinki: End-User Knowledge as a Tool for Strategic Design.
International Symposium on Fashion Marketing and Management. Research 2005, London: Designing luxury
Nordic Design Research Conference 2005, Copenhagen: Quality Clothes
An Outline of a Model for Assessing the Quality of Customized Clothing.

Muut julkaisut:
Uutta luksusta etsimässä. 2006. Lapin yliopiston taiteiden tiedekunnan julkaisuja (cd-rom).
Käsiyö ja muotoilu - tulevaisuuden luksusta! 2006. Akatemia, Artefakta: Tekstejä ja kangastuksia, Helsinki.
FutureFinders, Strateginen muotoilu ja edelläkävijyyden mallintaminen Lapin yliopisto (cd-rom).
Luxury - its multiple aspects and as subject of design research. Tekes: Designfacts 2/2005.
FF-Tool -menetelmä strategiseen tuotekehitykseen ja muotoiluun. 2006. Muotoilun johtaminen/käsikirjat, Kauppa-lehti.

Aikakauslehdet:
Uuden luksuksen aika. Avotakka 10/2007.
Yhtä luksusta. Happi Magazine 2/2007.
On the trail of Luxury. Proacademia 1/2005.



Figure 3. Promotion material for the Emergence of Luxury project: a poster.

Western luxury products became the focus of the project research. It was detected that the new generation of luxury is something else than gold and glitter. The impression was that, at least at the turn of the millennium when the project took place, traditional forms of luxury had a stronger standing in places other than Finland. There was significant interest in the phenomenon of luxury and its research on a general level both when the project was carried out and long after. As a research topic, it turned out to be an easy one to popularise, and, as a result, not only the media but also the designers, manufacturers, end-users of products and the business life were interested in it. Luxury also had its moment as a fashion trend during the six years that luxury research was ongoing in the faculty. Theses related to the topic have been constantly produced ever since. The research of luxury phenomena will hardly ever reach its final destination, as the phenomenon has such close links to time, culture and subjective experiences. Traditional methods of user research were used in the project, but research methods that involve the users in co-design were considered to have plenty of potential in the future (Santasalo 2010; Uotila & Ryttilahti 2008).

Consumption of luxury items is usually associated with status. Approval from one's own community and improving one's status within a community have been central points of reference in consumption research dealing with luxury items in the social sciences, for example. This interpretation of luxury as a socially distinguishing feature has left the conversation with a very negative imprint. If treated as an emotionally focused phenomenon that is connected to human experience and, in some contexts, turns into a debate of happiness, the definition of luxury gains more than just elitist dimensions. Status is not necessarily socio-economic and money-centred. It can also be social; acquired by learning new things and developing one's skills. (Santasalo 2010; Niemelä 2012; Koskennurmi-Sivonen & Uotila 2006; Ryttilahti et al. 2007; Uotila et al. 2005).

It was detected that new luxury was increasingly often connected to education, areas of interest and conscious consumption, even to an extent of ecological and luxury aspects going hand in hand these days. Luxury items are not disposable nor unnecessary consumption that exceeds needs, if measured with usability criteria. Luxury has plenty of common features with the process of completing a handicraft and the handmade final product. Additionally, the acquisition of luxury items requires knowledge and skill nowadays. These have been traditionally thought of as features characteristic to a professional designer. Competence and learning new skills are features that are required from consumers today to an increasing extent (Santasalo 2010; Niemelä 2012).

The research results obtained in the *Emergence of Luxury* project have established the basis for yet another project that continued with the common research themes in the technical and humanistic-social fields concerning luxury, such as quality and sustainability. *The Sustainable Innovative Materials in High Tech Applications* research project (SuMaC, 2007–2010) studied the textile and clothing industry's material and

product context and expanded it towards a more versatile field, including industrial design products and using cultures as research topics.

FUTUREFINDERS - STRATEGIC DESIGN AND MODELLING OF FUTURE FINDERS 2004-2005

The latest project of the Textile and Clothing Design unit in this continuum was the *Future Finders*, funded by Tekes' DESIGN 2005 – Industrial Design Technology Programme. The objective of the Future Finders, Strategic Design and Modelling project was to continue cooperation with a number of fields in design, such as clothing design and industrial design. The tangible target of design activities, the world of products, was turned into a heterogeneous environment of operation, where the values and cultural contexts of use for the end users are primarily subjects of interest (Aula et al. 2006). The artefactual and material environment make up a kind of research platform and context, whereas the actual target of development and application is in the production of the humane social and cultural worlds – even design. As viewed from this position, the R&D processes and extensive design processes, such as strategic outlook in design and developing the tools of strategic design, became the subject of design activities.

IN CONCLUSION

The purpose of this overview was to describe, in a concise manner, the research and development projects of the Textile and Clothing Design degree programmes of the University of Lapland at the turn of the millennium (1998–2007). During this period of approximately ten years, the aim was to add some of the uniqueness fused into the Northern and Lappish environment into the university-level education and R&D activities in the field of clothing.

The goal of the research and development project activities has been, during this time, to add to the Finnish and international field of design some of the unique expertise and, on the other hand, stand out from the model used at the University of Art and Design Helsinki, the other Finnish university in art and design, in such a manner that the two can support each other with regard to contents and methods. The current strategy of the University of Lapland enforces channelling the research and project activities of the Faculty of Art and Design of the University of Lapland into the direction of developing the social, socio-cultural and Arctic competence. This specialisation can be seen as a response to what is known as the academic division of tasks at the national level, as the former University of Art and Design Helsinki, today part of the Aalto University, sets its focus on the trinity of art, technology and business (Ylä-Kotola 2012, 79).

The reference materials used and referenced in the overview consist mostly of the research literature produced as part of these projects. The writing style can be identified as the first-hand, empirical method of narration, typical to the field of art and design, with the author reflecting on activities that she has been involved in. *From Fires of Enchantment to the Emergence of Luxury* is such an overview of, in particular, the clothing research and development projects of the Textile and Clothing Design unit of the Faculty of Art and Design at the University of Lapland in 1998–2007. The author has participated in them, first as a student of Clothing Design, and later as a young researcher; and has had the opportunity to witness the change in design and its interdisciplinary features and fast changing roles.

REFERENCES

- Alakärppä, I. 2014. Teknologiasta käytäntöihin: Käytäntöteoreettinen malli hyvinvointiteknologian hyväksyttävyyden arviointiin. Acta Universitatis Lapponiensis 270. Lapin yliopistokustannus: Rovaniemi.
- Aula, P., Ryttilahti, P., Uotila, M., & Vehmas, K. 2006. FF-tool -menetelmä strategiseen tuotekehitykseen ja muotoiluun. In Ruokonen, A. (ed. by). Muotoilun johtaminen, johtamisen käsikirjat. Helsinki: Kauppalehti.

- Falin, P. 2005. Luxury – its multiple aspects and as subject of design research. (suom. luksuksen monet muodot - ylellisyys muotoiluntutkimuksen kohteena). Designfacts. Design2005., 2, ss. 5-6.
- Juntunen, P. 2002. Seikkailulajien harrastajan profiili. In Uotila, M. (ed. by) Jälkiä. kohti urheilu- ja vapaa-ajan vaatetuksen uusia ulottuvuuksia. (ss. 39-46). Tutkimusraportteja ja selvityksiä.: Lapin yliopiston taiteiden tiedekunnan julkaisuja B4.
- Koskennurmi-Sivonen, R., & Uotila, M. 2006. Käsityö ja muotoilu - tulevaisuuden luksusta! In L. Kaukinen, & M. Collanus (ed. by) Tekstejä ja kangastuksia. puheenvuoroja käsityöstä ja sen tulevaisuudesta (ss. 207-224). Akatiimi: Hamina.
- Koukkula, V., & Uotila, M. 1999. Tulevaisuuden tekstiilit ja vaatteet : Tutkimus- ja tuotekehityshankkeen esiselvitys .Taiteiden tiedekunnan julkaisuja. Lapin yliopisto, taiteiden tiedekunta, tekstiili- ja vaate suunnittelun yksikkö. B; 1). Lapin yliopisto: Rovaniemi.
- Loukiainen, T. (20.9.2007). Tiedotteet 2005: Älyvaatteet voivat parantaa työturvallisuutta. Referenced February 22th 2014. <http://www.aka.fi/fi/A/Suomen-Akatemia/Mediapalvelut/Tiedotteet/Tiedotteet-2005/Alyvaatteet-voivat-parantaa-tyoturvallisuutta/>.
- Matala, R. 2007. Kyborgit älyvaatesuunnittelussa. In M. Hildén (ed. by) Ryijyistä kyborgeihin. tekstiili- ja vaatealan muotoiluntutkimusta luomassa. (ss. 101-113). Rovaniemi: Lapin yliopiston taiteiden tiedekunnan julkaisuja B: Tutkimusraportteja ja selvityksiä 7.
- Mattila, H., Mäkinen, M., Talvenmaa, P., Uotila, M., Hildén, M., Matala, R., et al. 2002. WearCare - älykkäiden materiaalien soveltaminen ammatti- ja työvaatteeseen. (Unpublished final report) Tekes funded project 2001-2002.
- Mattila, H., Talvenmaa, P., & Mäkinen, M. 2006. WearCare – usability of intelligent materials in workwear. In Mattila, H. (ed. by) Intelligent textiles and clothing (ss. 359-368). Cambridge: Woodhead Publishing. Available: <http://www.tex.tuiasi.ro/biblioteca/carti/CARTI/Textile/Intelligent%2oTextiles%2oand%2oChoting/Intelligent%2oTextiles%2oand%2oChoting.pdf>.
- Mäyrä, J. 2002. Urheiluvaatetuksen keskeisimmät ominaispiirteet. In Uotila, M. (ed. by) Jälkiä. kohti urheilu- ja vapaa-ajan vaatetuksen uusia ulottuvuuksia. (ss. 57-67). Tutkimusraportteja ja selvityksiä. Lapin yliopiston taiteiden tiedekunnan julkaisuja B4.

Niemelä, K. 2012. Pröystäilyn uusi aika. Ennen luksusta olivat näyttävät autot ja kullatut vesihanat, Nyt on yleistä syödä luomuruislepää. Helsingin Sanomat. Wednesday August 15th 2012.

Pursiainen, M. 2007. Verkkotyöskentely-ympäristö vaatekonseptin suunnittelu-projektissa. Suunnittelijoiden näkökulma Discendum Optiman käyttöön. In Hildén, M. (ed. by) Ryijyistä kyborgeihin. tekstiili- ja vaatetusalan muotoilututkimusta luomassa. (pp. 86-100). Rovaniemi: Lapin yliopiston taiteiden tiedekunnan julkaisuja B: Tutkimusraportteja ja selvityksiä 7.

Pursiainen, M., Matala, R., Mäyrä, J., Latva, M., Pohjapelto, K., Pyykkönen, M., Janhila, L., Falin, P. & Uotila, M. 2006. Hardworkers : Intelligent clothing concept for heavy-industry workers : Evaluating usability of intelligent clothing concept. Lapin Yliopiston Taiteiden Tiedekunnan Julkaisuja, Sarja C: Katsauksia ja puheen-vuoroja.

Rantanen, J., Alfthan, N., Impiö, J., Karinsalo, T., Malmivaara, M., Matala, R., Mäkinen, M., Reho, A., Talvenmaa, P., Tasanen, M., & Vanhala, J. 2000. Smart Clothing for the Arctic Environment. In Digital Proceedings of the 4th International Symposium on Wearable Computers. Pp. 15-23, Atlanta, GA, October 16-17 2000. IEEE. pp. 15-23. Referenced March 31th 2014. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.86.6402&rep=rep1&type=pdf>.

Rantanen, J., Impio, J., Karinsalo, T., Malmivaara, M., Reho, A., Tasanen, M. & Vanhala, J. 2002. Smart Clothing Prototype for the Arctic Environment. Personal and Ubiquitous Computing, 6(1), 3-16.

Rytilahti, P., Falin, P., Uotila, M., & Aula, P. 2007. Uutta luksusta etsimässä. In Hildén, M. (Ed. by), Ryijyistä kyborgeihin. tekstiili- ja vaatetusalan muotoilututkimusta luomassa. (ss. 114-130). Rovaniemi: Lapin yliopiston taiteiden tiedekunnan julkaisuja B: Tutkimusraportteja ja selvityksiä 7.

Santasalo, J. 2010, (August 24th 2010). Voi mitä luksusta! Tietysti.Fi. Uutta Tieteen Ääreltä, Vuoropuhelua tieteestä. Referenced March 31th 2014. <http://www.suomenakatemia.fi/fi/T/Nuoret/Vuoropuhelua-tieteesta/Aiemmin-julkaistut-jutut/Voi-mita-luksusta/>.

Suomen Akatemian arviointipaneeli. 2007. Proaktiivinen tietotekniikka (PROACT) -tutkimusohjelman loppuarviointiraportti. (research programme on proactive computing (PROACT) 2002-2005) (Arviointiraportti No. Suomen Akatemian julkaisuja 2/07). Helsinki: Suomen Akatemia.

- Talvitie, M. 2000. Lumontulet : Lapin lumo tekstiileissä ja vaatteissa. (Winds of Enchantment) [english translation: Robert kinghorn] No. Lapin yliopiston taiteiden tiedekunnan julkaisuja. C, Katsauksia ja puheenvuoroja). Lapin yliopisto: Rovaniemi
- Uotila, M. 2002a. Johdanto. In Uotila, M. (ed. by). Jälkiä. kohti urheilu- ja vapaa-ajan vaatetuksen uusia ulottuvuuksia. (ss. 9-15). Tutkimusraportteja ja selvityksiä.: Lapin yliopiston taiteiden tiedekunnan julkaisuja B4.
- Uotila, M. 2002b. Urheiluvaatteen hyvinvointitekijät ja älykkäät palvelut. In Uotila, M. (ed. by). Jälkiä. kohti urheilu- ja vapaa-ajan vaatetuksen uusia ulottuvuuksia. (ss. 71-84). Tutkimusraportteja ja selvityksiä.: Lapin yliopiston taiteiden tiedekunnan julkaisuja B4.
- Uotila, M., & Rytilahti, P. 2008. Ethically sound innovations. The phenomenology and taste of the outdoor elite. In Digital Proceedings of Changing the Change. Design, Visions, Proposals and Tools. Changing the Change –conference. 10–12 July 2008, Politecnico di Milano, Politecnico di Torino, Turin, Italy.
- Uotila, M., Falin, P., Aula, P., & Varanka, P. 2005. Designing luxury. Towards understanding the hidden values and pleasure factors of luxury and high level design products. Paper presented at the International Symposium on Fashion Marketing and Management Research, London College of Fashion, UK.
- Virta, K. 2005. iWell - hyvinvointi ja terveys -teknologiaohjelma 2000-2003. Final report. No. Teknologiaohjelmaraportti 2/2005. Helsinki: Tekes.
- Ylä-Kotola, M. 2012. Tulevaisuusvisiot. In Seppälä, T. (ed. by) Taidetta, kulttuurien yhteistyötä ja uusia verkostoja. Pohjoisen kulttuuri-instituutti (ss. 78-79). Tornio 2012: Kemi-Tornion ammattikorkeakoulun julkaisuja. Sarja B. Raportit ja selvitykset 10/2012.

OTHER PUBLICATIONS COMPLETED IN THE PROJECTS

- Aula, P., Falin, P., Vehmas, K., Uotila, M. & Rytilahti, P. 2005. End-User Knowledge as a Tool for Strategic Design. Joining Forces - Design Research, Industries and a New Interface for Competitiveness. Pre-Conference of World Design Congress Era05. University of Art and Design. Helsinki. 22–24 September 2005. (Ed. by Järvinen, J. & Palmi, L.) UIAH, Helsinki, Finland.
- Aula P., Rytilahti P., Uotila M. & Vehmas K. 2006. FF-Tool -menetelmä strategiseen tuotekehitykseen ja muotoiluun. In Ruokonen, A. (ed. by) Muotoilun johtaminen. Johtamisen käsikirjat, Helsinki: Kauppalehti.

- Aula, P., Ryttilahti, P., Uotila, M. & Vehmas, K. 2006. Strategic Design and End-User Knowledge in Experience Production. In Digital Media & Games. Kylänen, M. (ed.) Articles on Experience 4, Lapland Centre of Expertise for the Experience Industry (LCEEI), University of Lapland Press, Rovaniemi.
- Falin, P. 2005. Luxury – its multiple aspects and as subject of design research. Design-facts. Design2005 – The Industrial Design Technology Programme newsletter. Information on design research projects financed by the Academy of Finland and Tekes. 2/2005.
- Harlin, A., Mäkinen, M. & Vuorivirta, A. 2003. Development of Polymeric Optical Fibre Fabrics as Illumination Elements and Textile Displays, Autex Research Journal Vol.3, No.1, 2003.
- Hänninen O., Lintu N., Holopainen J., Seppälä S. and Mattila M.A.K. 2003. Preparedness Needed To Isolate Suspected Severe Infection Patients During Transportation. In Proceedings of NBC 2003 Symposium on Nuclear, Biological and Chemical Threats. A crisis management challenge Jyväskylä 15-18.6.2003. Symposium Proceedings edited by Laihia K Department of Chemistry, University of Jyväskylä, Research Report No 98, ss. 154-157.
- Hänninen O., Koskelo R., Kankaanpää M. & Airaksinen O. 2005. Ergonomia terveydenhuollossa. Recallmed Oy, Klaukkala 2005. 144 pages.
- Iivonen, M. & Seitamaa-Hakkarainen, P. 2005. Student reflections on collaborative design process. A paper presented to the Designs on E-learning, Teaching and Learning with Technology in Art Design and Communication conference 14-16.9.2005, London, United Kingdom.
- Koskennurmi-Sivonen, R. 2005. Emergence of luxury prêt-à-porter in Finland in the 1950s. Proceedings from the seminar on Signification, Usability, and Interaction in DESIGN, at the University of Art and Design, Helsinki, Finland 1.–2.12.2004. (Ed. by Turpeinen, O. & Vihma, S.) UIAH, Helsinki, Finland. 26-35.
- Koskennurmi-Sivonen, R. & Pietarila, P. 2005. Quality Clothes – An Outline of a Model for Assessing the Quality of Customized Clothing. Proceedings of the Nordic Design Research Conference. In the Making. 29–31 May 2005, Copenhagen, Denmark.
- Lahti, H. & Seitamaa-Hakkarainen, P. 2005. Towards Participatory Design in Craft and Design Education. CoDesign. Vol 2 ss.103 – 117.

- Lahti, H., Iivonen, M., & Seitamaa-Hakkarainen, P. 2004. Understanding cultural diversity of artifacts through collaborative knowledge building. In Karppinen, S. (Ed. by) *Neothemi: cultural heritage and ICT: theory & practice*. Helsinki: University of Helsinki. *Studia paedagogica* 32, 48-56.
- Lintu, N., Holopainen, J. & Hänninen, O. 2005. Usability of textile-integrated electrodes for EMG measurements. In *Proceedings of Ambience 05- Intelligent Ambience and Well-Being 19-20.2005*, Tampere, Finland, ss. 64-69.
- Lintu, N., Mattila, M.A.K. & Hänninen, O. 2005. Älyvaatteet tulevaisuuden sairaanhoidossa. *Spirium*. 4/2005, 30-32.
- Lintu N, Mattila M, Hänninen O. 2007. Intelligent garments in prehospital emergency care. In: Langenhove L Van, ed. *Smart Textiles for Medicine and Healthcare*, p. 153-165. Cambridge: Woodhead Publishing.
- Lintu, N., Mattila, M.A.K., Holopainen, J. & Hänninen, O. 2005 Älykäs kotiympäristö ja älyvaatteet osana ensihoitopalvelua. *Systole* 3/2005, 39-41.
- Lintu, N., Mattila, M.A.K., Holopainen, J., Koivunen, M. & Hänninen, O. 2006. Reactions to Cold Exposure Emphasize the Need of Weather Protection in Pre-hospital Care: An Experimental Study. *Prehospital Disaster Medicine*. 2006 Sep-Oct;21(5):316-320.
- Lintu, N., Mattila, M.A.K., Holopainen, J. & Hänninen, O. 2005. Älykkäät vaateratkaisut tulevaisuuden terveydenhuollon tukena. *Suomen Lääkärilehti* 18-19/2005 vsk 60, 2057-2060.
- Lintu N., Mattila M.A.K., Holopainen J., Seppälä S., Hänninen O. & Koivunen M. 2003. Hypotermia ja potilaan suojaus ensihoidossa. *Suomen Lääkärilehti* 14/2003 vsk 58 ss. 1643-1647
- Lintu N., Tolvanen P., Mattila M.A.K. & Hänninen O. 2006. Lihastoimintaa mittaava älyvaate kuntoutujan apuna. *Fysioterapia* 2006;53(3):15-18.
- Matala, R. 2004a. Seven Mile Boots: A Piece of Intelligent Clothing, a Sign of Movement, an Entrance to the virtual. *Framework the finnish art review - Innovation and Social Space* 2/2004, 48 - 49.
- Matala, R. 2004b. Sukupuolittuneet kyborgit vaatetus suunnittelun haasteena. Malli älyvaatesuunnittelun tueksi. (Gendered cyborgs as a challenge to clothing design. Modelling a Framework for Intelligent Garment Design). University of Lapland, Faculty of Art and Design, Department of Textile and Clothing Design. Pro gradu -tutkielma. Lapin yliopisto. Taiteiden tiedekunta.

- Matala, R. 2004c. Gendered Cyborgs – The Users of Intelligent Clothing. In Proceedings from the seminar on Signification, Usability, and Interaction in DESIGN at the university of Art and Design, Helsinki, Finland 1-2.12.2004, University of Art and Design, Helsinki, Finland. Turpeinen, O. & Vihma, S. (eds.), 40-45.
- Matala, R. 2004d. Heavy Industrial Workers' Experiences and attitudes towards technology. Four approaches to technology. In Proceedings of The Proactive Workshop PROW 2004. 25-26 November 2004, Helsinki, Finland, Lindén. G. (ed.), 82-86.
- Matala, R. 2005. Conceptions of Intelligent Clothing. In Proceedings of the Doctoral Colloquium of ISWC'05. The 9th IEEE International Symposium on Wearable Computers, October 18 - 21, 2005 in Osaka, Japan.
- Matala, R. 2005. Technophobia in the intelligent clothing design process. In Proceedings of The 2nd International Meeting, Science of Design. Pride & Pre-design -The Cultural Heritage and the Science of Design. IADE-Insituto de Artes Visuais Design e Marketing. 26-29 May 2005, Lisboa, Portugal, 169-173.
- Matala, R., Mäyrä, J., Mäkinen, M., Talvenmaa, P. & Lintu, N. 2005. Multidisciplinary Intelligent Clothing Design and Applied Fabric Solutions. In Proceedings of the International Scientific Conference. Intelligent Ambience and Well-Being. AMBIENCE 05. 19-20 September 2005 Tampere, Finland, 47-56.
- Mattila M.A.K., Lintu N., Holopainen J., Seppälä S. & Hänninen O. 2003. Smart protection of trauma patients against weather influences in prehospital care. *Acta Anaest Scand.* 2003: 47; Suppl 116, 57.
- Mattila, H., Talvenmaa, P., & Mäkinen, M. 2006. WearCare – usability of intelligent materials in workwear. In Mattila, H. (ed.), *Intelligent textiles and clothing* (ss. 359-368). Cambridge: Woodhead Publishing.
- Mäyrä, J. 2004. End User Knowledge and the Meaning of Design in Context Exceeding Solutions. In Proceedings of The Proactive Workshop PROW 2004. 25-26 November 2004, Helsinki, Finland, Lindén. G. (ed.), 1-3.
- Mäyrä, J., Matala, R., Mäkinen, M., Talvenmaa, P. & Lintu, N. 2005. Puettavan älykkyyden tutkimusmenetelmät ja mallit: poikkitieteellinen lähestyminen tuotteiden käytettävyyteen. *Tekstiililehti. Tekstiili- ja ompelevan teollisuuden ammattilehti* 2/2005, 16 – 17.
- Mäyrä, J., Matala, R. & Falin, P. 2005. Utilizing End User Knowledge in the Designing of Intelligent Workwear. In *Digital Proceedings of the In the Making. First Nordic Design Research Conference.* 29–31 May, 2005 Copenhagen, Denmark. Mazé R. (ed.).

- Pursiainen, M. & Falin, P. 2005. Perspectives on the roles of a web-based environment in collaborative designing. In Proceedings of the 12th International NBE 2005 Conference. Teaching-Studying-Learning (TSL) Processes and Mobile Technologies: Multi-, Inter- and Transdisciplinary (MIT) Research Approaches. i Ruokamo, H., Hyvönen, P., Lehtonen, M. & Tella, S. (ed. by). September 14-17, 2005, Rovaniemi, Finland.
- Pursiainen, M. & Matala, R. 2005. The virtual prototype as an evaluation tool in the intelligent-clothing design process. In Digital proceedings of the Joining Forces Conference 22.-24.9.2005, Media Centre Lume UIAH, Helsinki, Finland. Referenced 22 February 2014. <http://www2.uiah.fi/joiningforces/papers.html>.
- Pursiainen, M., Matala, R., Mäyrä, J., Latva, M., Pohjapelto, K., Pyykkönen, M., Janhila, L., Falin, P., Juurikka, M. & Uotila, M. 2006. HardWorkers - Intelligent Clothing Concept for Heavy-industry Workers. Multimedia presentation produced for evaluating usability of Intelligent Clothing Concepts. University of Lapland, Faculty of Art and Design C 32. Rovaniemi, 2006. CD-Rom.
- Rytilahti, P., Falin, P., Uotila, M. & Aula, P. 2006. Uutta luksusta etsimässä. In Hildén, M. (ed. by) Ryijyistä kyborgeihin – tekstiili- ja vaatetusalan muotoilututkimusta luomassa. Taiteiden tiedekunnan julkaisuja B: Tutkimusraportteja ja selvityksiä 7. Lapin yliopisto, Rovaniemi. Cd-rom/ Available: <http://www.ulapland.fi/?deptid=17194>.
- Rytilahti, P., Uotila, M. & Narbrough, M. 2007. Understanding the essence of environmentally sound products: some Insights into ecoluxury design. In Digital Proceedings of the Nordic Design Research Conference, 27-30 May 2007. Konstfack, University College of Art, Craft and Design, Stockholm, Sweden.
- Talvenmaa, P. 2005. Proceedings of International Scientific Conference “Intelligent Ambience and Well-being”, 19-20 September, 2005, Tampere, Finland. CD-Rom.
- Talvenmaa, P. 2006. Introduction to chromic materials. In Mattila, H. (ed.), Intelligent textiles and clothing (ss. 193-204). Cambridge: Woodhead Publishing.
- Uotila, M., Aula, P., Rytilahti, P. & Falin, P. 2006. Understanding Cultural Diversity in Design Consciousness. In Digital Proceedings of the Design & Emotion –conference. 27–29 September 2006. Chalmers University of Technology. Gothenburg, Sweden.
- Uotila, M., Falin, P. & Aula, P. 2005. Experience of Luxury and Pleasure with Products. In. (ed. by Wensveen, S.) Proceedings of the Conference Designing Pleasurable Products and Interfaces, 24–27 October 2005 Technische Universiteit Eindhoven, Department of Industrial Design, Netherlands. p: 91-103.

- Uotila, M., Falin, P., Aula, P. & Varanka, P. 2005. Designing luxury: Understanding the hidden values and pleasure factors of luxury and high level design products, In Digital Proceedings of the International Symposium on Fashion Marketing and Management Research, 27.6.2005, London College of Fashion, University of the Arts, London, UK.
- Uotila, M. & Koskennurmi-Sivonen, R. 2006. Käsityö ja muotoilu – tulevaisuuden luksusta! (Craft and Design – Future Luxury!) Tekstejä ja kangastuksia. Puheen- vuoroja käsityöstä ja sen tulevaisuudesta (Texts and Mirages. Addressing the Future of Craft). (Ed. by Kaukinen, L. & Collanus, M.) Artefakta 17. Hamina: Akatiimi.
- Uotila, M., Koskennurmi-Sivonen, R., Varanka, P., Aula, P. & Falin, P. 2004. Emergence of Luxury: Introduction of the Research Project. In Turpeinen, O. & Vihma, S. (ed. by) Proceedings from the seminar on Signification, Usability, and Interaction in DESIGN, at the University of Art and Design, Helsinki, Finland 1.–2.12.2004. UIAH, Helsinki, Finland. ss: 23-25.
- Uotila, M., Mattila, H., & Hänninen, O. 2006. Methods and models for intelligent garment design. In Mattila, H. (ed. by), Intelligent textiles and clothing (ss. 5-16). Cambridge: Woodhead Publishing.
- Uotila, M., Mäyrä, J., Matala, R., Mattila, H., Mäkinen, M., Talvenmaa, P., Hänninen, O., Holopainen, J. & Lintu, N. 2003. Methods and Models for Intelligent Garment -ference INTEDEC 2003, 22-24 September 2003, Edinburgh, United Kingdom.

»» OVERVIEW

OF THE RDI AND LEARNING
ENVIRONMENTS WITH RELEVANCE
TO COLD-PROTECTIVE CLOTHING
AT THE UNIVERSITY OF LAPLAND
AND THE LAPLAND UNIVERSITY
OF APPLIED SCIENCES

INTRODUCTION

This overview discusses the initial situation of one of the most important goals of the ArcticPro Lapland project. The existing research, development and innovation environments (RDI), learning environments and teaching materials of both universities from the point of view of cold-protective clothing are explored. One of the objectives of the project is to develop learning environments from the perspectives of user-centred arctic clothing design and testing of cold-protective clothing. Overview also aims to identify RDI and learning environments from both universities involved, which could be used in providing comprehensive cold wear related services. This report examines the current state of affairs and aims to identify parties relevant to cold-protective clothing.

From the University of Lapland, staff members from the degree programme of Clothing Design and, more generally, the Faculty of Art and Design were consulted. Experiences and reports gained during past projects and the successful cooperation between fields of study have also been used. The most recent Study Guide of the Faculty of Art and Design, the faculty and university homepages, company interviews and visits to learning environments have been used as sources and inspiration. At the Lapland University of Applied Sciences (Lapland UAS), there is no degree programme in the field of clothing that would be directly connected to the theme of cold-protection. Heads of Education from different fields were interviewed as a part of the project in order to find out if things relevant to using clothing for cold-protection are covered in any of the study programmes. RDI staff was interviewed with regard to learning environments and reports from finished projects were also used as a resource. Based on the interviews and different kinds of project reports, it can be distinguished as to how learning environments are connected to the focus areas of cold climate expertise and conditions management.

COLD-PROTECTIVE CLOTHING IN THE CLOTHING DESIGN DEGREE PROGRAMME

The goal of the Clothing Design degree programme offered at the University of Lapland is to create conditions for product design and development that are based on the principles of high quality and sustainable development. Teaching and research activities focus on the development of expertise in the fields of culture, tourism, well-being and business; applied for example in costume design for the performing arts, adventure travel, clothing design for groups with special needs and business cooperation projects. Students in the Clothing Design degree programme are encouraged to develop their design thinking, apply user research and methods from future studies as part of their design process and always seek new innovations. (Study Guide of the Faculty of Arts and Design, 2013–2014)

These emphases are closely connected to cold-protective clothing and arctic apparel. One of the main purposes of clothes is to protect the body and keep it warm, and to meet these requirements, clothing design is always very much user-oriented. In the north, everything happens at the mercy of the conditions and, as a result, culture, tourism and well-being as well as the business life both draw from the features of the Arctic and have to adapt to them. Here, a dance performance might take place on an arena full of snow, tourists can dip into a hole in a frozen lake and the business life makes use of a building material that will evaporate into air – ice. Services for special needs groups must take into account the winter conditions and make it possible to enjoy them. Designing a cover for a bi-ski sled rider is an example of such design activities. In the University of Lapland, in this arctic context, clothing can be approached in industrial, research-oriented and artistic sense, from cultural, commercial, technical and social perspectives. Combinations of these can produce innovative new openings into the field.

Study modules and courses

The courses in the degree programme of Clothing Design include small scale assignments connected to cold-protective clothing which can also be conducted in cooperation with companies. Examples of courses that developed students' skills on standards, special clothing and materials are *Children's clothing design*, *Materials* and *Material applications*. The minor subject module on *Product development and innovations in the clothing industry* is especially good for improving a student's competence in cold-protective clothing and can serve as a platform for project works. It includes designing specialised clothing for challenging conditions set by the user, activities and environment. The module includes the courses *Innovations in the clothing industry*, *Functionality* and *Well-being*. Students will learn more about the design process of outdoor clothing, clothing physiology and materials. Student work examples connected with cold-protective

clothing include workwear for a snow builder, designing neck and shoulder warmers and, most recently, a winter cape that allows the use of a baby carrier.

The aforementioned courses correspond well with the themes that the staff of the Clothing Design degree programme associated with cold-protective clothing: functionality, interaction with the surroundings, materials, well-being and protection from conditions. Other associated themes were visuality, demanding manufacturing, research orientation and technical applications. (Konola 2014).

Project assignments, Master's theses and Bachelor's theses

At the Bachelor level, a study module entitled *Design project or production* is completed, with changing contents and foci selected among topical themes every year. It is possible to complete projects in multidisciplinary teams or as a collaborative effort with projects or companies. The Master's degree comprises a more extensive, *Advanced project (research and product development)*. It is possible to complete this as a real commission and on a selected topic. Examples of project assignments relevant to cold-protective clothing include a police officer's snowmobiling uniform, designed as a part of the Body-Fit project and the outerwear survey and design project for the Finnish Institute of Occupational Health employees.

Few Master's theses relevant to this theme have been completed at the University of Lapland recently; but they were numerous in the beginning of the 2000s. Eeva-Mari Pyhäjärvi (2012) discussed the traditional clothing of reindeer herders in the Sompio area of Lapland. Laura Seppälä (2010) has studied sustainable development in outdoor clothing with a focus on materials and extreme sports. Päivi Rautajoki (2007) studied the possibilities of use of traditional and local wool in connection to the HoiVi project. Topics in the beginning of the 2000s included women's hiking wear (Hamara 2002), adventure activities clothing for cold climates (Kauppinen 2000) and layer clothing in cold climate conditions (Asamäki & Moisala 2000). Snowmobiling as a challenge for clothing design has also been studied (Niemi 2000). *Case studies have been carried out with companies focusing on winter apparel, for example Halti (Leino 2005) and Rasavil-Tuote Oy (Alaraudanjoki 2008)*; a phenomenological study has been completed on the properties of cold-protective clothing materials (Hildén 1999).

Learning environments, equipment and teaching material

The courses and project possibilities mentioned above are identified as learning environments connected to cold-protective clothing in the degree programme of Clothing Design. There is no separate environment or course that would focus on cold-protective clothing. Teachers of the courses are responsible for the teaching material and

references to any additional literature. When lecturing on clothing physiology for example, teacher often refers to the comprehensive publications by the Finnish Institute of Occupational Health on the topic and recommends further reading for the students.

Virtual learning environments are involved in most design instruction in the Clothing Design degree programme, so they are relevant to cold-protective clothing as well. Cold-protective clothing for the police, completed as a part of the Body-Fit project, was studied and designed with the help of these virtual environments. The degree programme includes a compulsory minor subject study module in Design technology that incorporates the *Digital clothing* course, where the clothing design applications of 2D pattern-making and 3D fitting software are explored. With tools of digital visualisation, the students learn how to visualise new, innovative products and produce flat sketches for production. With the most recent project assignments, connected to children's clothes for example, the students put together portfolios that showed how the piece of clothing was designed and examined utilising all of the design software. All the required elements of the piece of clothing were provided, from material information cards to presentation boards; from flat sketches to digitally drawn patterns and 3D fitting images.

The University of Lapland has a Symcad body scanner from Telmat Industries. The device provides nearly 100 measurements of the scanned person and completes a three-dimensional avatar in just a few seconds. In research conducted in the Body-Fit project, it was noted that a body scanner is useful when measuring large groups of customers and when a size is being determined for a piece of clothing with great looseness, such as outerwear (Kaartinen 2011, 38). The Lectra Modaris 2D pattern-making software and the associated 3D Fit fitting software offer the tools for both making patterns and editing digitalised patterns. The finished patterns can be virtually fitted; so the first prototype of a piece of clothing can be studied without any production costs. At the moment, fitting multi-layered, loose outerwear virtually and their visualisation remain challenging. It is possible to determine the distance of the piece of clothing from the body and simulate quilted pieces for example; however, fitting three layers on top of each other cannot be done (Kaartinen 2011, 87–88).

It is more challenging, with respect to manufacturing, to produce cold-protective clothing and, in general, functional workwear or outdoor clothing than ordinary clothes for the indoors. Just drawing the flat sketches of technical garments requires solid design skills and a command of vector graphics software, not the mention the challenges with virtual fashioning and fitting. At the same time, they make a great learning opportunity. Just as Professor of Fashion and Textile Design, Marjatta Heikkilä-Rastas, states in a newspaper interview: “Everyone should be able to design a winter jacket. It is much easier to design an evening dress than a functional and fantastic winter jacket.” (Laukkanen 2014). Cold-protective clothing, with their challenging features,

could even present an excellent research environment for software designers like Lectra. Company interviews also indicated that the potential uses of body scanning technology and 3D virtual modelling are not fully understood at present; however, larger companies in particular expressed great interest in them. At the moment, a Master's degree student at the University is writing a thesis for a company and studying the possible applications of the software. Creating a convincing and functional learning environment around virtual clothing design would also help in establishing the basis for the creation of a credible RDI environment with regard to business-oriented research projects.

The degree programme also has a laboratory for textile materials, with samples and some testing equipment. This offers the opportunity to study the features of the materials, including water tightness, colour wash fastness, rub fastness and tear resistance and to compare these with industry standards. With protective clothing, important factors include the quality, good materials, and understanding the standards and reference values for materials. The material storage is in need of updating, for example with regard to the technical, ecological and "arctic" materials (Kylmänen 2014). In functional clothing, it is important to understand materials and know how they interact. In the company interviews, some of the companies stated that they would like help with material selections or comparative data on the functionality and ecological aspects of different materials.

Other possibilities

Some other learning environments offered in the Clothing Design degree programme more or less regularly are workshops and cooperation networks in their different forms. The degree programme has a long-standing cooperation with the Japanese Yamaguchi Prefectural University. The most tangible form of cooperation is the Japan–Finland workshop that has been organised annually since 2009. Visits have taken place in both directions and fashion shows have also been arranged. This is connected to Arctic clothing through materials and aesthetics in particular. The objective is to use and combine local materials, both Finnish and Japanese, in the workshops. Denim, hand-woven yanaijima cotton, washi paper, felted wool and reindeer leather from Lapland are some of the materials used in the designs. Extreme weather conditions have been witnessed around the world, including Japan, during the past few years, and the country suffered deadly winter storms in February 2014 (STT/AFP 2014). The topical theme of the 2014 workshop was *East Meets Arctic*, and clothes were designed for special groups in the cold climate, focusing on grandparents and children.

ARCTIC CLIMATIC CONDITIONS EXPERTISE IN THE LEARNING, RESEARCH AND DEVELOPMENT ENVIRONMENTS OF LAPLAND UAS

Clothing for cold-protection is not included in the Lapland University of Applied Sciences' tuition as such. By interviewing the Heads of Education, it was established that the students already know how to dress warmly and protect themselves from the cold. Students learn about cold-protection during a couple of courses in the Sports and Leisure Studies degree programme, with the help of guides by the Finnish Institute of Occupational Health, among other materials, as athletes must often exercise in cold weather conditions (Hannola 2014). In addition, during a course on snow building, the group, which is predominantly made up of exchange students, is given instructions on what to wear for the snow-building that takes place outside. In the other fields, it is the assumption that the students know how to dress warmly, but it is not specified as part of the instruction. Cold-protection is considered a basic skill that everyone studying in northern Finland possesses already. Conditions competence is a part of everyday life, and it is not thought of as a special skill.

Arctic Power

In the cold-protection related projects of Lapland UAS (and previously the Rovaniemi University of Applied Sciences), the topic has been approached from the perspective of arctic climatic conditions expertise. The school has been involved in the realisation of several projects and product development projects that have been connected to clothing. The competence cluster Arctic Power, with its special emphasis on cold and winter technology, is a part of the University of Applied Sciences and takes part in projects requiring cold climate expertise. It offers an optimal learning environment especially for students of Measurement Technology. The core of Arctic Power's expertise lies in the innovative applications of measurement technology, but the competence cluster also carries out versatile, multidisciplinary projects in cooperation with many field and stakeholders. (Lapland UAS – Arctic Power 2014).

Test environment

The Lapland University of Applied Sciences obtained its first measurement and development environment directly relevant to clothing in 2011 as a part of the Body-Fit project, even though the school does not offer instruction in the field of clothing. A research project by the same name was carried out at the University of Lapland at the same time. The thermal insulation measurement system that was developed during the project at Lapland UAS was located in the facilities of Arctic Power. The unit is completed with a measurement environment that offers a controlled environment to carry out testing in accordance with the EN ISO 15831:2004 Standard. A thermal

manikin divided into 15 sections was produced in the project. Manikin was given the name Pena. Each section has its own heating, thermostat and power supply, with constant monitoring of the power supplied. The power used for heating determines the thermal insulation properties of clothing in accordance with the formula determined in the standard. The walking manikin has a mechanism, constructed so that the manikin takes 45 steps a minute while hanging in place.

The cold-protective clothing testing environment at Arctic Power comprises three main elements: conditions management, measurement and data acquisition systems and the manikin itself. The standard defines exactly the conditions for carrying out an approved test. The climate chamber at the Arctic Power laboratory is designed for this purpose. The temperature in the room can be adjusted in the accuracy of 0.5 degrees, air humidity can be controlled within a given range and the air flow directed on the manikin can be controlled. It is possible to clearly exceed the temperature and air flow limits set by the standard in the climate chamber. The manikin can be exposed to rain and freezing rain as well. This kind of an environment is a significant help to product development when working on cold-protective equipment for challenging conditions.

The data acquisition and measurement system of the manikin have been entirely developed at Arctic Power. The centre's own experts and students have been involved in the development process. The system surrounding the manikin can be adjusted according to the needs and improvements can be made on the controls, which will speed up the testing process. The testing environment can be used for testing clothes in the different stages of product development; for example by comparing the number of washes to the thermal insulation properties. Together with the field testing possibilities and thermal camera, it is possible to obtain versatile information of the clothes in connection to the conditions. (Arctic Power 2014). The laboratory, and all the services it provides, is a learning environment for students of Mechanical Engineering, Electrical Engineering and the various well-being related degree programmes. Co-operation has been carried out with the University of Lapland with regards to snow building, industrial design and textile design. (Uusipulkamo 2014).

Development activities

For projects related to nature tourism and its safety, Arctic Power has developed customised measuring tools that are applicable real-time. A test has been prepared together with students that determines the correct protection for a person with physical disabilities on a snowmobile safari. Local companies organising safaris have used this information when arranging safaris for people who have mobility difficulties or whose own temperature regulation or sensory systems are inadequate.

A tourist bus accident in the fell area can be compared to a destructive fire in the centre of a big city. In Lapland, distances to medical care facilities are long and, in the case of an accident in winter, it is essential that patients are kept warm. The Regional Rescue Services of Lapland have placed cold-protection carts around Lapland in locations where they can be utilised. These carts have thermal blankets and thermal bags where an injured person can be placed to wait for transfer. The purpose of the bags is to protect the victim from hypothermia. The thermal bags have been tested and, in part, designed at Arctic Power together with the owner of the business.

Testing cold-protective clothing for police officers in the Body Fit project demonstrates collaboration with and opportunities towards the clothing field. The new outfit designed and the old version were tested both in the climate chamber and in field tests, after which the results were compared. A Bachelor's thesis was completed on the tests at Lapland UAS (see Kouri 2011). Students of physiotherapy have carried out studies in the climate chamber, for example on the effects of cold on the muscles' ability to function and general mobility. Testing clothing in extreme conditions is another possibility offered by the conditions room. It is possible to create wind, water, and freezing rain in the room and the temperature can be adjusted according to need.

COLD PROTECTION RELATED RDI ACTIVITIES AND COOPERATION IN PROJECTS

The research and development activities carried out as part of projects offer invaluable learning environments for researchers, students and businesses involved in them. The Faculty of Art and Design and the Clothing Design degree programme of the University of Lapland have conducted extensive research on the topic of cold-protective clothing and, in recent years, there has been operation with the Lapland UAS and Arctic Power in particular. Arctic Power has brought technical competence into the co-operation in the form of testing and conditions management. The projects have produced a substantial amount of information on different subjects, from the healing properties of wool to virtual clothing. Special emphasis has been given to the research and development of a material that is characteristic to the north and the local conditions – wool. Later, the activities have also focused on using virtual environments and technologies in clothing design.

HOIVI – Healing Wool

The research and development project HoiVi – Healing Wool was carried out in 2006–2007 with the Rovaniemi University of Applied Sciences (in operation at the time) and the University of Lapland. Participants in the project included the degree programmes of Textile Design and Clothing Design from the University of Lapland and Social, Health and

Sports study programmes from the Rovaniemi University of Applied Sciences. The University of Lapland's research and development activities focused on felt as a material, its usability and product design research. At the University of Applied Sciences, the emphasis was on examining the functionality of the woollen prototypes with different patient groups. (Tuovinen 2008). From material and production premises, wool was studied in cooperation with lamb farms and felt-makers. A collection of wool felts was designed and then manufactured with different techniques. From these, healing products were designed. From the perspective of design, the project studied user-oriented co-design that was carried out in cooperation with nursing staff and end users. Usability research on the use of woollen products, worn next to the skin, was conducted both in authentic nursing environments and at the homes of users, with nearly one hundred volunteer testers. The Rovaniemi University of Applied Sciences coordinated the project networks with the partners in the field of social and health care sector and was responsible for the research on the healing properties of the products designed (Tuovinen 2008).

Woollen Innovations (WINNO) projects

Woollen Innovations (WINNO), a research project on the northern sheep wool at the Lapland University of Applied Sciences and the University of Lapland's research and development project on sheep wool and felted materials in Lapland, were both funded by Tekes (the Finnish Funding Agency for Innovation) and took place as a collaborative effort in 2012–2014. The projects continued the work that had been successfully initiated in the HoiVi project with a focus on the local, healing material.

Lapland UAS's project researched the properties of northern sheep wool and wool felt, and the well-being promoting properties of products designed from them. The objective of the project was to produce well researched and easily deployable information on the properties of different felt types and usability of felt in product design. The project, furthermore, studied dyeing and patterning woollen materials with colours derived from Lappish nature and by adding different kinds of extracts from plants to wool. In addition, the project examined the damp proofing and thermal insulation properties and ease of maintenance of a wool felt, and the products made from it. (Sipola 2014). The objective of the University of Applied Sciences' project was to generate new information that could be utilised, on the use possibilities of healing wool material and to study wool in the promotion of well-being in arctic conditions. The project also looked into combining wool with natural products with the intention of discovering new possibilities for use. The multidisciplinary research activities drew from the expertise in several degree programmes, with the goal of promoting the use of raw materials obtained from Lapland and the profitability of production as well as collaboration between the local parties involved. (Sipola 2014).

The project of the University of Lapland focused on the development of the material, and its objective was to discover and create possibilities for manufacturing in local serial production. The design perspective concentrated on sustainable design that would take into account sustainability with its ecological, social and economic dimensions. Research in Textile Design degree programme concentrated on multi-sensory interior design textiles and their well-being promoting properties; with manifestations such as acoustic boards and art textiles. The suitability of felt for outdoors use and in the freezing conditions – such as a door curtain for the snow hotel – was studied. The research activities on the healing qualities of wool with patients suffering from pain were continued; the case concentrated on patients experiencing rheumatic pain. The university's research input focused on the applicability of the material and usability of design; the research on healing properties was carried out by the Health care sector of the Lapland University of Applied Sciences. Student work conducted in the project also included developing a lower limb cover for a Bi-Ski sled, intended for people with physical disabilities, by combining felt and technical sportswear fabrics. (Tuovinen 2014).

BODY-FIT projects

The Body-Fit projects were also carried out as collaborative efforts, funded by Tekes, at the University of Lapland and the Rovaniemi University of Applied Sciences in 2009–2011.

The Body-Fit research project at the University of Lapland was built around body scanning technology, but the ultimate purpose was the research and development of the equipment from the clothing design perspective. The purpose of the project was to explore the uses of virtual measurement and design technology in the virtual design of clothing, and virtual online applications – such as a web shop – and to develop a productisation model for the measuring services. Before this, infrastructure for a virtual measuring, design and fitting environment was constructed as a part of their brief Body scanner project. There was close cooperation with a parallel project managed by the Rovaniemi University of Applied Sciences. Cooperation was also carried out with the Lapland Vocational College in making prototypes. The “Virtual clothing form” work package in the project explored the virtual measuring, design, pattern-making and fitting in many ways with the processes of developing protective clothing for a police officer, outdoor clothing for disabled people and sportswear. (Pursiainen 2011). There was a strong focus on cold-protection especially in developing protective clothing for the police and for physically disabled youth. With the latter, challenges were detected in connection to scanning people with physical disabilities and people in different positions. As a response to this, an improved body scanner chair was designed. All the product development cases that were carried out in cooperation with businesses and organisations had a strong user-oriented focus and, due to

this, it was possible to develop the methodology for user research and feedback and, at the University of Applied Science, also user testing methods.

The University of Applied Sciences' goal in the project was to develop the cold testing services of Arctic Power and the cold-protective clothing for the police. As a result, a testing environment complying with the standard was completed at Arctic Power. The facility makes it possible to carry out tests in accordance with the EN ISO 15831:2004 standard to measure thermal insulation of cold-protective clothing. A thermal manikin was built for the test environment in this project. The testing environment is described above. The project also produced testing plans and test reports about both laboratory and field tests. (Hirvaskari 2012).

OTHER LEARNING ENVIRONMENTS AND DEGREE PROGRAMMES RELEVANT TO THE THEME

University of Lapland and the Faculty of Art and Design

The University of Lapland has decided to profile itself more clearly as an expert in arctic issues and arctic design. This could prove productive for the field of arctic clothing and protection and also from the perspective of the international ArcticPro network. As a concept, arctic design is new, but at the University of Lapland it is connected with strategic, multidisciplinary research, respect for the know-how and culture of the indigenous people, taking into account natural resources and sustainable development, international aspects, new technological solutions, agile design measures and transparent product development. As a learning environment, the Arctic generates applied information, teaches to adapt and, through these features, might offer some answers to the wicked problems of the world. (Miettinen 2014). In 2015, the new master's degree programme on Arctic design – the Arctic Art and Design Master's degree programme – will be initiated at the University of Lapland. It may introduce new openings, in various fields and disciplines, in Arctic clothing and cold-protection as well. At present, the general studies of the design degree programmes aim to develop the students' design thinking and methodical competence in a broader sense. There are no common courses in cold competence, but projects combining several fields and different themes have been made possible, for example, on the Design project and production course. In connection to this, many projects related to the Arctic Design Week are carried out, including the annual exhibition and outdoors fashion show.

Since 2010 Textile Design degree programme at the University of Lapland has profiled itself as Interior and Textile Design. Teaching focuses on space and well-being from a multisensory approach. Well-being and an individual's relationship with his surroundings were also themes that were brought up when the staff of Clothing Design

reflected on Arctic clothing. Materials are essential to cold-protection and, naturally, in the focus in the textile industry. These fields could offer a lot for each other in connection to this theme. There has been collaboration before, for example in the HoiVi and WINNO projects described hereinabove. At the moment, the printing studio and materials are the learning environments that are in common use of the Textile and Clothing Design programmes. The equipment of the Interior and Textile Design degree programme also includes looms and a TC-1 Jacquard weaving machine, but there are unfortunately no examples on the use of these in the Clothing Design programme.

The direct connections of Industrial Design degree programme with cold-protective clothing remain scarce, even though common field of operation could surely be discovered, in winter sports and leisure time activities and service design, for example. Such links could exist in snowmobiling and designing accessories for special needs groups. In helmets, gloves and driving gear, such as backpacks and snowmobiling backs, the emphasis is on combining soft and hard materials, knowledge of physiology and ergonomics, conditions competence and modelling competence. One example of this is designer Hanna Isojärvi, a graduate of the University of Lapland, who works as product manager at Scott Sports in Switzerland, in the category of snowmobiling gloves, equipment, clothes and shoes (Kilpeläinen 2012). In the past Body-Fit project, a student of Industrial Design designed and modelled a body scanner seat for people with physical disabilities.

Service design is one of the strategic leads at the University of Lapland. It is possible to think of cold-protection as a service as well, and clothes are an essential part of travel services here in Lapland. When asking about interest in service design, some of the manufacturing companies designated it as a task for the programme service providers and retailers; others saw it as a valuable tool for developing business operations and brand building. Interest in service design does exist, but more information and examples on its advantages and applications for businesses in the field are needed. The research, development and innovation environment of service design, SINCO (Service Innovation Corner) can be used by the other fields of the faculty as well.

The degree programme in Audiovisual Media Culture focuses on the different forms of AV media in the contexts of arts and communication. From this point of view, it is also linked to clothing. In a broader digital context, with the Laboratory of Interactive Environments, hosted by the degree programme of Audiovisual Media Culture, cooperation has been made in the form of wearable electronics. A student of AV media designed and completed an extensive measuring and feedback system for the outdoor clothing of young people with physical disabilities as a part of the Body-Fit project (Harjuniemi & Kaartinen 2011). Some sort of interest in cooperation in smart textiles or clothing can still be detected.

Different kinds of events and related projects are increasingly popular learning environments. The Faculty of Art and Design has, in cooperation with the City of Rovaniemi and the Rovaniemi Regional Development Agency, organised the world's northernmost Design Week in February. The Design Week continues to grow and develop, but for students it makes one, big learning environment, where programme is organised in a multidisciplinary fashion, together. Linked to arctic clothing, the programme features the annual fashion show. In 2014, this focused on businesses and the spotlight was on cold-protective clothing, with BRP's snowmobile gear, Joutsen down jackets and Halti downhill skiing gear on the catwalk. The Design Week can work as an empirical testing environment where students, users and the business can all learn more. As an example, in 2013, the Rovaniemi-based company Heat-IT, specialising in cold-protection of patients, demonstrated and tested its products in cooperation with Arctic Power and the help of a wind tunnel built from snow. Examples from other learning opportunities can be found from already completed projects. The Faculty of Art and Design and the WDC2012 Helsinki-Rovaniemi project arranged, in 2012, in cooperation with the Arctic Sustainable Art and Design (ASAD), a thematic design network that belongs to the Arctic network, the Arctic Circles summer school. The Art & Design Summer School featured theme groups for service design, sustainable development and art (WDC2012 Helsinki – Rovaniemi 2012). Courses and events with a problem- or workshop-based approaches that bring together students from different fields are a productive environment for any topic.

The University of Lapland seeks to set up a competence centre or an expertise cluster in Arctic Design that could deploy and bring together the competence, research, equipment and software from different fields (Heikkilä-Rastas 2014b). The facilities and equipment for the competence centre remain uncertain, but the degree programme of Clothing Design has hopes for updated equipment for studying the possibilities of virtual clothing. A body scanner that could communicate with the 2D pattern-making and 3D virtual fitting software, and also with other 3D modelling software, would open up new possibilities in clothing design and cooperation in several fields, for example with industrial design and why not even game developers. The virtual aspects could make more resource efficient planning possible together with several levels of customisation, co-design and early stage user testing. By combining these software applications and service design environments, it could be possible to develop more refined user research environments and, possibly, test new product-service systems.

Learning environments connected to clothing testing at Lapland UAS

A common learning environment for the sports and health care studies in Lapland UAS and the Lapland Sports Academy is the Rakka Fitness Testing Station, located at the Santasport Institute. Rakka has been developed to test the functional abilities and performance levels of athletes and sports enthusiasts; it focuses on testing alongside

teaching and research activities (Lapland UAS Study Guide 2013–2014). The Body-Fit project of the University of Applied Sciences studied the applications that the Fitness Testing Station could offer for testing clothing. Pilot studies were conducted with stations' equipment for a police clothing, sports outfits and clothing for people with impaired mobility. As a result, guidelines were created on the possibilities of using the environment in clothes testing and development (Hirvaskari 2012). Haapakangas and Sirviö (2014), who were interviewed about the Fitness Testing Station, considered the equipment applicable for measuring fitness performance with different outfits and the effects of cold. They were interested in studies that would determine what kinds of winter sports clothing could help to achieve optimal performance level. At the moment, the equipment at the Fitness Testing Station is being inventoried and possible updating needs are being investigated. The portability of the equipment and its ability to function in the cold have not been tested. Winter sports have a strong position in Lapland, but there is plenty to do in the design, research and product development and testing for winter sports clothing.

pLAB, the Software Engineering Laboratory at Lapland UAS is located on Viirikangas campus, and its areas of competence cover software and measuring technologies and, especially, real-time, integrated 3D visualisation environments. The software and 3D visualisation competence of pLAB in particular could be put to use in the context of cold-protective clothing. The interviewed companies expressed some interest in 3D modelling, even though its possibilities are not yet known too well. Research in the topic would be needed. By combining the equipment and expertise of the two universities, it could be possible to achieve interesting new openings. pLAB has already made models of different environments and terrains – forests and downhill skiing slopes as well as people wearing clothes – for the ENVI virtual environments. One of the interviewed companies was interested in a modelled arctic urban environment. By modelling the clothes in an authentic environment, it is possible to carry out early stage user testing with clothing concepts, even before prototypes have been made. An example of this is a Master's thesis written on heat-protective clothing and a video animation made for it, picturing users in authentic work situations, wearing the heat-protective clothes designed (Pursiainen 2003). The pLAB staff also has experience of data acquisition with different measuring tools and then processing this data into an understandable, visual form. In the clothing context, this issue can become topical when transferring into systemic thinking. One of the interviewed companies, the business activities of which are primarily rental and maintenance services, is already thinking of the significance of data for users and in the lifecycle management of clothing.

ENVI is an interactive, virtual learning environment, primarily intended for the health care sector, at the Viirikangas facilities of Lapland UAS. ENVI simulates actual work situations in the health and social sector, thus contributing to problem-based learning (Lapland UAS – ENVI 2014). ENVI is closely connected to the Software Engi-

neering Laboratory pLAB that produces ENVI's virtual environments. The new ENVI Laboratory hosts training facilities that correspond to different kinds of healthcare facilities; for example, a prenatal and children's healthcare clinic, reception facilities, equipment maintenance facilities, internal ward, ER ward and operating theatre. All facilities are entered from a locker room, just like when going to work and getting changed into a work uniform. There are no possibilities for simulating cold conditions, but there is interest in them, so that the situations could be rehearsed in genuinely cold conditions. The laboratory equipment includes hypothermia equipment, for example cartridges, sleeping bags and the silver space blanket. Patient simulators cannot be used for testing the thermal properties of clothes, and if they were taken to cold conditions, their resistance to cold and dampness should be ensured with the manufacturer first. For testing patient clothing functionality, a sweating, crying, talking, vomiting and bleeding manikin could be used. ENVI could also prove useful for studying and testing the user experiences of nursing staff uniforms.

CONCLUSIONS AND PROPOSITIONS FOR MEASURES

To conclude the report, the current state of the learning environments and teaching materials relevant to cold-protective clothing will be connected to the needs for research and product development that have been identified. The conclusions combine observations from interviews with the manufacturing companies and with UoL and Lapland UAS staff and learning environment visits, and measures for development are proposed. Some of the development measures are very practical and can be carried out as part of the ArcticPro Lapland project; some are more future-oriented.

Developing methods for user-centered clothing design

One of the objectives of the project is to develop user-oriented clothing design at the University of Lapland, as it is essential to know the users and conditions when designing functional clothing for Arctic conditions. Focus group thinking and user orientation are built into the clothing design teaching and students are encouraged to apply user information in their designs (Rajakangas 2014). As stated in the beginning of this overview, plenty of valuable research has been conducted at the University of Lapland at the turn of the millennium in the field of user-oriented, functional and even technology-embedding clothing design, and these could be better utilised or brought forward. There are Master's theses, project assignments and project publications in the archives. The Arctic Centre and the Multidimensional Tourism Institute (MTI) conduct or have conducted research relevant to cold-protection and this data is valuable for using in the clothing design context. We have already explored the possibilities offered by the testing facilities of the Lapland UAS, but many fields are studied at the school, as are at the Lapland Vocational College, where a lot of future users of

cold-protective clothing and workwear will graduate. Within the Lapland University Consortium, there are future experts and professionals of health care and social services, forestry, the mining industry and construction, and they could be involved in cooperation of representing their visions for dream workwear or uniform. At the Lapland Sports Academy, you can find experts of winter leisure activities and sports. This publication is one way of communicating to the students and external interest groups of the universities' possibilities related to the themes of user-orientation and arctic conditions.

Cold climate expertise in sportswear and leisure clothing

One excellent option for building a profile is cold climate expertise in sportswear and leisure clothing in sportswear and leisure clothing for user-oriented clothing design and testing, also when positioning the universities' competence in the ArcticPro network. In contrast to Norway's oil and shipping industries, we don't have a lot of heavy industry - but we do have tourism and winter sports. The different winter sports have a strong position in Lapland, and a preliminary investigation has been completed on the theme of innovation environments in sports. Based on this, a cluster of expertise in physical exercise and sports is planned in Rovaniemi (Lapin AMK – ROIHU 2014). With user research among future top athletes or active snowboarders and examining the usability of designed prototypes with movement analysis and performance levels testing, it could be possible to conduct impressive R&D and, possibly collaborate with businesses. The interviewees at Rakka were extremely interested in the impacts that clothing and cold has on performance and connecting technology that would measure body functions into clothes (for example the Mbody measuring trousers).

Service design pilots

There is a clear demand for service design piloting and developing these methods in the context of clothing design. Some of the interviewed companies expressed interest in the development of services, such as customisation and web shops or helping the overall development of business activities. Service design examples that could be specifically applied in the field of clothing design are needed; otherwise, they are interpreted as programme service providers' or retailers' business. Service design could be connected to projects researching for example the possibilities of virtual clothing, or snowmobile outfits customisation and maintenance services, in cooperation with respective companies. Service design can be thought of in the context of products, or as a product-service system, as well as a more in the general context of developing business activities or co-creation methodology.

Events and workshops as ways of communication and learning

Events and workshops are an agile learning environment, in which it could be easy to develop even company-university cooperation. International workshops between universities in Europe – and why not between the schools in the ArcticPro network – could prove productive learning environments for students in the field of cold-protective and arctic clothing. With this in mind, as a part of the ArcticPro Lapland project, a workshop on the future of Arctic clothing, the ARCTIC WEARS, was organised in February 2015 as a part of the ADW design week. Workshop examined the future requirements that will be placed on clothing in the future and related trends. The Arctic Design Week was a great opportunity to gain visibility for the ArcticPro network and promote its existence. The theme of the 2015 Design Week was Transparency, a fairly topical theme with relevance to production chains in the clothing industry. Arctic clothing requires high competence levels in material technology and design solutions, transparency of which should also be promoted in order to understand it's quality.

Virtual clothing design

Virtual clothing design is likely to become reality in the future, from Arctic work wear to haute couture trends. The University of Lapland is the only member in the ArcticPro network in Finland that is equipped with a body scanner, and it is one of the few universities in clothing design where virtual technology is actively used in the design instruction. This should be invested in, as others will soon follow. Even though the company interviews revealed that although the small companies in the clothing industry do not have any use for CAD software, the larger companies see all the more potential. Not all the possible applications of the body scanner technology and 3D virtual modelling are known yet, but the future vision is that they will reduce the design and product development costs as well as save time, and the visualisations will also be used as marketing material. Customisation opportunities are also an area of interest. Creating a convincing and functional learning environment around virtual clothing design would also help in establishing the basis for the creation of a credible RDI environment with regard to business-oriented research projects. Through the project interviews, one of the companies became interested in a student project on the virtual fitting of work wear. A description of this project can be found in the publication.

Virtual modelling, gamification and digitalization

Virtuality belongs to the present day, both in terms of products, environments and games. Virtual environments for problem-based learning and service prototyping are also on the rise. ENVI and SINCO laboratories are examples of these. New openings

to the world of digital clothing and possibilities of new technologies were surfaced by exploring these learning environments and, in part, company interviews. Themes and questions that were brought up in the company interviews were for example simulating the urban environment, intelligence and technology in connection to maintenance and logistics of clothes, as well as the customisation and web shopping turned into reality by virtual possibilities. All of these are connected to the world of digitisation; a concept not much talked about in the clothing industry yet. With digitalisation one can refer to any electronic technology that stores and processes data, whether it is a chip that conveys information, a scanner that records body measurements, a smart board, a game or an application that makes customisation possible in a web store.

Safety could be one of the surprising applications of clothing digitalisation. The safety of tourism in cold conditions has been widely researched and developed, but still a tourism expert from the Lapland University of Applied Sciences and a researcher from the Arctic Centre pointed out that many tourists experience cold. There is a problem in communication or, simply, inadequate clothing. Problems in communication could be solved with the following idea for a game, for example. The game could test your ability to dress for the changing Arctic conditions and the activities and teach you. The more realistically game could simulate the combination effect of wind, humidity and cold and different activities together with the required layers of clothing and materials, the more interesting it would be. How challenging it is to dress for the arctic urban environment and activities when you constantly need to be putting on more clothing or taking them off as the conditions change. A knit cap manufacturer mentioned as an example how people put on far too much clothes when they go cross-country skiing. If interest is expressed in the game idea, as communication material or a testing demo of the new RDI and learning environments that are brought together, its possibilities for making it happen could be investigated. At ENVI, for example, rehabilitation related games are being developed and different kinds of learning games belong to the larger phenomenon of gamification.

It should be investigated what kind of added value is created by these worlds of virtual design and fitting, modelling and gamification and what more could they bring design, product development or testing of clothing, or alternatively service development, marketing or communication. The benefits of virtual design and product management have been examined (Global Fashion Business seminar, 2012), but research into added value, significance and implications of digitalisation is still at the very beginning.

IN CONCLUSION

Arctic 'design' used to people's daily lives and a matter of life and death. On Arctic Design Week 2014, consultant and blogger Tuija Seipell reminded us of how our consumerist culture has brought us to the point where design is, once again, a necessity. We cannot all wear fur like in the old days, but we can design systems that will both ensure our well-being in everyday life and extreme conditions and take into account environmental, social and economic sustainability and well-being. The clothing industry, too, is currently striving for a systemic change. More ecological and recyclable materials are being developed, new business models introduced by sharing economy, zero-waste design and cradle-to-cradle approaches. New kinds of product-service systems, the new coming of local, yet connected and agile production, as well as software applications and technology that make virtual design and flow of information possible, are connected to many of these developments. It is unlikely that these will go unnoticed in the field of cold-protective clothing, and pioneer companies have already seized many of these themes. This report was the starting point for the many measures in the project, of which you can learn more in this publication. The articles and project descriptions that were created as a part of the measures will provide further details on many of the themes and possibilities brought up in this report.

REFERENCES

- Arctic Power 2014. Vaatteen lämmöneristävyystesti - Arctic Power. Referenced 20 May 2014. <http://www.arcticpower.fi/fi/vaatteen-lammoneristavyystesti/>.
- Global Fashion Business -seminaari 2012. Global Fashion Business – Virtuaalista tuotehallintaa ja kuluttajakommunikointia. Seminar 26 April 2012. Helsinki. <http://videonet.fi/finatex/20120426/>.
- Hannola, H. 2014. Lapland University of Applied Sciences. Principal lecturer's telephone interview 23 April 2014.
- Hirvaskari, M. 2012. RAMK Body Fit – research project. Final report of a European Regional Development Fund -project.
- Haapakangas, T & Sirviö, J. 2014. Visit to Rakka learning environment and interview 23 May 2014. Interviewed by Sanna Konola and Päivi Kähkönen. Lapin Urheilupuisto, Hiihtomajantie 2, Rovaniemi.

- Hagman, H. 2014. Teema: Globaalisti sovellettavaa osaamista arktisesta oppimisympäristöstä. Referenced 20 May 2014. <http://www.ulapland.fi/news/Teema-Globaalisti-sovellettavaa-osaamista-arktisesta-oppimisymparistosta/5youbqgx/c9ed49b6-829e-4c50-b97d-d9dabd33e9ee>.
- Harjuniemi, E. & Kaartinen, H. 2011. Ulkoiluvaatetuksen suunnittelu ja toteutus liikuntarajoitteisille nuorille. In Pursiainen, Mari (ed. by) 2011. Vaatemuotoilu kehoskannauksen valossa. Body Fit –tutkimushankkeen tuloksia. Lapin yliopiston taiteiden tiedekunnan julkaisu Sarja C. Katsauksia ja puheenvuoroja no. 37.
- Laukkanen, M. 2014. Kauneuden muodot ja muodon kauneus. Kide. Lapin yliopiston yhteisölehti 1/2014. Lapin yliopisto.
- Heikkilä-Rastas, M. 2014. VL: arktinen muotoilu _ määritelmää. Email to sanna.konola@ulapland.fi. 11 April 2014.
- Kilpeläinen, V-M. 2012. Opiskelumuuistoja Lapin yliopistosta. Työtarjous vei Rovaniemeltä Sveitsiin. Lapin ylioppilaslehti 5/12.
- Konola, S. 2014. Notes from a co-creation workshop with Clothing design Degree programme staff: ”Toimenpide 3. TKI – ja opetusympäristöjen parantaminen. Yhteiskehittämässä Lapin yliopiston vaatetussuunnittelun opetushenkilökunta 31.3.2014”. University of Lapland, Pöykkölä.
- Konola, S. 2014b. Raportti kylmänsuojavaatetuksen alalla toimivien tuottajayritysten haastatteluista. ArcticPro Lappi -hanke, Lapin yliopisto. Spring 2014.
- Kylmänen, A. 2014. University of Lapland. Interview with University lecturer Kylmänen about materials as a learning environment. Interviewed by Sanna Konola 27 May 2014.
- Lapin AMK – Arctic Power 2014. Arctic Power. Referenced 20 May 2014. <http://www.lapinamk.fi/fi/Tyoelamalle/Kehittamisymparistot/Arctic-Power>.
- Lapin AMK – ENVI 2014. ENVI herättää teorian tiedon henkiin. Referenced 4 May 2014. <http://www.lapinamk.fi/fi/Tyoelamalle/Kehittamisymparistot/ENVI---Rovaniemi>.
- Lapin AMKin OPS 2013-2014. Tulevaisuus pohjoisesta. Opinto-opas 2013-2014. Rovaniemen Ammattikorkeakoulu. Referenced 20 May 2014. https://arkki.ramk.fi/RAMK/arkisto/julkinen/RAMK-opinto-opas%202013-14_paino.pdf.
- Lapin AMK – ROIHU 2014. ROIHU – Rovaniemi liikunnan ja urheilun huipulla 2014-2020 (ERDF). Referenced 17 May 2014. <http://www.lapinamk.fi/fi/Tyoelamalle/Tutkimus-ja-kehitys/Hyvinvointipalveluiden-osaamisala/ROIHU>.

- LAY 2014. Profili ja painoalat - Lapin yliopisto - University of Lapland. Referenced 14 May 2014. <http://www.ulapland.fi/Suomeksi/Tietoa-yliopistosta/Strategia/Profili-ja-painoalat>.
- Miettinen, S. 2014. Arctic Design määritelmä. Attachment in email Heikkilä-Rastas, M. 2014. VL: arktinen muotoilu _ määritelmää. Email to sanna.konola@ulapland.fi. 11 April 2014.
- Pursiainen, M. 2011. Body-Fit tutkimushanke. In Pursiainen, M. (Ed. by) 2011. Vaatetusmuotoilu kehoskannauksen valossa. Body Fit –tutkimushankkeen tuloksia. Lapin yliopiston taiteiden tiedekunnan julkaisu, Sarja C. Katsauksia ja puheenvuoroja no. 37. Lapin yliopistopaino, Rovaniemi 2011.
- Rajakangas, L. 2014. VS: ArcticPro Lappi kyselee. Email sanna.konola@ulapland.fi. 4 June 2014.
- Sipola, R. 2014. Woollen Innovations. Pohjoisen lampaanvillan tutkimusprojekti. Referenced 25 May 2014. <http://www.lapinamk.fi/fi/Tyoelamalle/Tutkimus-ja-kehitys/Teollisuuden-ja-luonnonvarojen-osaamisala/Woollen-Innovations>.
- STT/AFP 2014. Japanin lumimyrsky tappanut jo kaksi - Japani – Ulkomaat. Helsingin Sanomat. 8 February 2014.
- Tuovinen, H. 2008. Raakavillasta hoitotuotteeksi. In Tuovinen, H. (Ed. by) 2008. Lapin lampolasta terveydenhoitotuotteeksi. Hoitava Villa – HoiVi - tutkimus- ja tuotekehityshanke. Lapin yliopiston taiteiden tiedekunnan julkaisuja C. Katsauksia ja puheenvuoroja 33. Lapin yliopisto: Rovaniemi.
- Tuovinen, H. 2014. Woollen Innovations -hanke. Lappilaisen lampaan villa- ja huopamateriaalin tutkimus- ja kehittämishanke 2012 – 2014. Lapin yliopisto. Referenced 20 May 2014. <http://www.ulapland.fi/loader.aspx?id=9e93c119-24d1-45ea-8a27-05754a26de20>.
- Uusipulkamo, M. 2014. University of Applied Sciences. Test engineer's interview during a visit to Arctic Power 25 March 2014. Arctic Power laboratory, Innokaari, Rovaniemi.
- WDC2012 Helsinki-Rovaniemi, 2012. WDC2012 Helsinki-Rovaniemi: Arctic Circles. Referenced 20 May 2014. http://www.wdc2012helsinki-rovaniemi.blogspot.fi/p/arctic-circles_18.html.

THESES

Alaraudanjoki Maaret, 2008. CASE: HALTI OY. *Asiakkaan ja yrityksen näkemykset Halti-brändistä. Lapin yliopisto.*

Asamäki, Päivi ja Moisala, Paula 2000. KERROSPUKEUTUMINEN KYLMÄSSÄ ILMANALASSA. Sovelluskohteena lappilaisten matkailuyritysten naispuoliset työntekijät. Lapin yliopisto.

Hamara, Minna 2002. ERÄVAATE EEVALLE. *Peninkulman Taival, aiheena naisen eräpukeutuminen. Lapin yliopisto.*

Hildén Marjatta, 1999. PÄSSINPÖKKIMÄSTÄ HIGH-TECHIIN. Fenomenologinen tutkimus kylmävaatetusmateriaalien funktionaalisista ominaisuuksista. Lapin yliopisto.

Kauppinen Johanna 2000. KYLMÄN ILMANALAN ELÄMYSVAATE. Lapin yliopisto.

Kouri, Anton 2011. Kylmäsuojavaatteen kenttätestaus ja tulosten analysointi. Rovaniemen ammattikorkeakoulu, Tekniikan ja liikenteen ala, Tietotekniikka. Opinnäytetyö.

Leino, Sari, 2005. SUOMALAINEN LASTENVAATEMERKKI CASE TUTKIMUS: *Rasavil® - tuotemerkin kehitys vuodesta 1979 vuoteen 2004. Lapin yliopisto.*

Pursiainen, Paula Marianne, 2003. VIRTUAALI-PUKEUTUMISKUVA Visuaalisen 3D prototyypin informatiivisuus ja prototypoinnin kommunikatiivisuus vaatetuksen käytettävyyden arvioinnissa. *Lapin yliopisto.*

Pyhäjärvi, Eeva-Mari 2012. Perinteinen vaatetus elinkeinokulttuurin ilmentäjänä Lapin Sompion alueella. Lapin yliopisto.

Rautajoki, Päivi, 2007. VARA ON VILUA VANTTUUSSA JA LÄMMINTÄ SUKASSA. Perinnetiedon kydyssä jalkojen alueen villaiseen tulevaisuuteen. Lapin yliopisto.

Seppälä, Laura 2010. Sustainable responsible outdoor clothing: what every designer should know. Lapin yliopisto.

An aerial photograph of a frozen body of water, possibly a river or lake, with a blue overlay. The water is cracked and textured, and the overall color scheme is monochromatic blue.

ARCTIC, PROTECTIVE CLOTHING AND ARCTICPRO NETWORK

» ABOUT ARCTICPRO NETWORK

INTRODUCTION TO ARCTICPRO NETWORK

Heikki Mattila

The strategic and political importance of the Arctic Area is reflected in national and international policymaking. Finland, as well as other Arctic region countries, has written its Arctic strategies, where large deposits of oil, gas and minerals are identified. Furthermore, climate warming is making the area suitable for tourism, and new shipping routes between Asia and Europe are opening. More and more people will be engaged in work and free time in this area.

The Nordic countries are well aware of the challenges of the Arctic climate for human well-being and safety. Several Universities and Research Institutes have special facilities for carrying out R&D projects regarding personal protection in these areas. In order to join forces the research network ArcticPro was established in 2013. The core know-how and expertise of the members can be highlighted as follows:

- Tampere University of Technology, The Finnish Institute of Occupational Health, Arctic Power (Lapland University of Applied Sciences), SINTEF of Norway, Lund University, Hohenstein Institute of Germany, SWEREA of Sweden and EMPA of Switzerland all have special laboratories for testing clothing physiology properties with thermal manikins in climate rooms.
- University of Lapland, VTT, School of Textiles of University of Borås and TNO of Netherlands concentrate on design, human factor studies and textile testing.
- Norsk Industri, TEKNO and Finatex are national textile and clothing industry associations which promote the need of such research on behalf of their member companies.

Outdoor apparel, survival suits, specialty work wear for oil, gas, mineral and shipping industry constitute the core products for ArcticPro research. Functionality, wearing comfort and clothing physiology properties, interactivity and high usability and user

acceptance of arctic smart textile systems in such demanding environment will be the key elements of the products.

Tourists and tourism workers in arctic climates, workers in oil & gas fields, mining, shipping, fisheries, cold indoor workers, construction, military, repair and maintenance workers, sports and leisure, agriculture are some of the categories of people which need special protective apparel. By using existing textile materials and by creating new ones, the product constructions are built for enhanced comfort and protection. Functional design and ergonomic requirements are important to be considered already from the outset of the process. Mathematical modelling of heat and moisture transfer in multi-layer constructions contributes to the further understanding of different materials in connection with insulation and wearing comfort. Phase change materials, shape memory materials and conductive materials together with wearable technology solutions will be applied to product applications. Laboratory testing by sweating thermal manikins in climate rooms as well as human physiological testing in authentic environment in arctic climate will ensure the R&D quality and functional results. Laboratory and field studies and performance testing of smart apparel will be carried out. Usability evaluations of the integrated arctic smart textile systems are also required.

The research projects are typically company driven. The R&D results will be commercialised by participating textile, clothing and other PPE companies. Scientific articles and theses will also be produced from the future projects. Guides, such as instruction videos, for protection in arctic conditions can also be considered. The Arctic is a big challenge but also an opportunity. We in the Nordic region should be able to capitalise on this opportunity with top quality research and development.

ARCTICPRO NETWORK ACTIVITIES IN NORWAY

Kari Rømcke

The Norwegian part of the ArcticPro network is a joint initiative between research organisations, industrial companies, user groups and the textile organisation within the Federation of Norwegian Industries. The first ArcticPro-conference under the headline: *Protection of humans, the environment and equipment in the high north* was arranged 13-14 January 2015 in Tromsø. The main goal of the conference was to get an overview of challenges in the high north, to present solutions to some of them and to discuss relevant research activities. The presentations are available at: <http://www.norskindustri.no/Bransjer/Teko/AKTUELLE-SAKER/arctic-pro-2015-presentasjoner/>

There is increased activity in the high north connected to fishery and fish farming, tourism and oil- and gas offshore activity. Within each of these areas there are challenges to be solved in which textile products may be part of the solutions.

In the Arctic Ocean regions north of Norway and Russia there are huge climate challenges as polar low pressure systems, storms that causes ice to build up quickly and remain on structures for long periods, small icebergs (growlers) that are difficult to detect, total darkness for several months, snow flurries for long periods and periods with thick fog in the summer. There are also poor real time communication possibilities in these ocean areas. All of these factors contribute to make activities and industrial operations difficult. Search and rescue is an important issue for these extreme environments and there are a number of projects going on under this headline.

Textile solutions are already in use for a number of purposes in maritime and arctic areas. In addition to clothing there are textile technology and materials for instance in oil brooms, rescue rafts, survival suits, tents, tarpaulin solutions to protect ships, fish farming and other industrial structures. Textile materials and processes are flexible and adaptable and there are numerous possibilities for innovative solutions.

Keywords for new solutions are multidisciplinary research and development, material technology, communication technology and interdisciplinary expertise. One major challenge is to develop materials that prevent ice from fastening on the surface. Further activities in the Norwegian part of the ArcticPro-network will be discussed in the months to come.

FOCUS ON WOOL AND CONSUMER RESEARCH

Ingun Grimstad Klepp

SIFO the National Institute for Consumer Research (Norway) is a non-biased governmental institute conducting consumer research. SIFO's projects are organised into three categories: Technology and Environment, Consumption and Economy, and Culture of consumption. SIFO is the only institute in Norway solely concerned with consumer research, and as such is responsible for developing expertise on the relevant fields. SIFO is known for their work on textiles and sustainability and how this links the concrete textile material with social aspects, in relation to theory as well as methodology, product lifespan, use, system changes within production and use of textiles have particularly been focus-areas. Another focus of SIFO's work has been the dissemination of research results to the general public. Examples of dissemination activities used are exhibits in museums, articles in popular journals, lectures and books.

Research professor Ingun Grimstad Klepp wrote her MA and PhD on leisure time and outdoor life at the University of Oslo. She works at the National Institute for Consumer Research in Oslo with research on wool, sustainable textiles, clothing, laundry and leisure consumption. She has written numerous articles and books of these themes. She currently works with wool, both in regard to consumption, environment and questions regarding the value chain. The relationship between textiles, social and physical characteristics and how these are woven together is at the core of her interest.

Clothes do not provide warmth when they are not in use. Good clothing can also be used incorrectly. In addition to a very good knowledge about wool, it is this use aspect of clothing that is Klepp's contributions into the network. This is a topic SIFO has worked with both in projects related to work and leisure. What clothes we use is governed by norms and subconscious practices, which change slowly. To understand the present relies on understanding why things have changed over time. A historical perspective on dress-systems and dress standards can thus also help in understanding and changing the way apparel is used today.

ARCTIC INTEREST IN THE NETHERLANDS

H.A.M. Daanen

The Arctic region is of special interest to the Dutch for several reasons. First, leading oil industry companies like Shell are located in The Netherlands and have an interest in the oil and gas reserves available in the Arctic regions. Several companies linked to Shell, like Allseas, taking care of the pipelines, are also linked to this economic activity. Second, the opening of the Arctic waterways is important for The Netherlands, with Rotterdam as a major port in the world. Third, our military train in the cold of Norway and Sweden and rely on expertise how to function and survive in the cold. Fourth, the Arctic area is an area for touristic exploration.

TNO has expertise on work in the cold and shares this expertise in NATO, conferences, ISO standardisation committees and the ArcticPro network. TNO is a company dedicated to applied scientific research with about 3,000 employees (www.tno.nl). TNO specialised in manual dexterity in the cold, prevention of cold injuries, sea sickness and evaluation of cold weather equipment. Publications are available on request. Point of contact is Prof. Dr. H.A.M. Daanen (hein.daanen@tno.nl).

»»OVERVIEW

ON THE RESEARCH AND
DEVELOPMENT NEEDS OF
MANUFACTURERS IN THE FIELD
OF COLD-PROTECTIVE CLOTHING

INTRODUCTION

This article reports the findings from interviews conducted with mostly Lapland-based manufacturing companies in the field of cold-protective clothing. The interviews are connected to one of the most central goals and measures of the project: updating the research, development and innovation environments, learning environments and training materials to meet the needs of working life and the labour market. We have investigated the research and product development needs of companies in the field and, at the same time, surveyed interest in the activities of the international ArcticPro network. This report compiles the most important observations on the needs for research, product development and areas of interest from a few different-sized companies that operate in the field.

METHODS OF INQUIRY

Survey conducted on Nordic manufacturing companies in the field of cold-protective clothing, carried out in 2013 via the ArcticPro network serves as a background and instigator for this inquiry. Our goal was to continue gathering information especially from the perspective of Finland and Lapland. The ArcticPro network's survey investigated the companies' field of operation in the Arctic or their interest in the area, the most important properties of cold-protective clothing, accessories and textiles and the companies' own research and product development activities. We reviewed the material one more time with a focus on the project goals and, on that basis, prepared a framework of questions for the interview, combined with questions concerning research and product development services that are currently offered by the Lapland University of Applied Sciences and the University of Lapland. Our intention was to find out about the companies' areas of interest and needs in a wider scope and looking to the future. The questions for the companies are appended (Appendix 1). As there are few companies in Lapland that can be considered to operate in the field of cold-protective clothing, we also interviewed a few other Finnish companies that have previously collaborated with one of the universities.

A total of seven companies were interviewed, five of which operate in Northern Finland and two in Southern Finland. Of the respondent companies, four are classified as small, two as small or medium-sized, and one is a large company. The companies manufacture cold-protective clothing for both work and leisure purposes, more specifically for snowmobiling, hiking, winter sports, patients' cold-protection and different kinds of workwear. Depending on the company, we interviewed the Managing Director, Design Manager, Designer or Sales Coordinator; whomever the company considered to be the right person. With the companies located in Northern Finland, we carried out the interviews on the company premises and had the opportunity to visit any production facilities. The other companies were interviewed using Skype. During the interviews, written notes were taken and defining questions asked. The materials were not analysed in-depth, but classified into themes and interpreted from there. This method made it possible for other activities in the project to take advantage of the observations.

INTERVIEW RESULTS

Research and product development measures at the companies

Only at the largest of the interviewed companies, product development is carried out systematically and, in fact, they have one of the largest R&D teams in Finland. The other companies' typical product development activities include testing new models with users or groups representing the users. Materials are an important aspect of product development, but the companies rely on information provided by the suppliers of materials and follow their product development process. This was also indicated in the ArcticPro network survey. Suppliers and subcontractors were considered one of the most crucial partners in R&D. Biggest one of the interviewed companies carries out comprehensive market research when moving into global markets. They also perform a thorough needs assessment regarding workwear with each client company when a customer relationship begins.

At smaller companies, product development is not necessarily carried out systematically and in the long term, but it still exists to some degree in the form of prototype testing, customer feedback and new collections. In clothing design in particular, this is partially due to the fact that workwear and outdoors clothing designs are traditional and the attitude is that they do not need that much development. Prototypes are tested in-house or by a test group made up of active users. It is typical to take advantage of active users or professionals, who wear the clothes as much in just a few weeks as an ordinary user does during an entire season. Examples of such users are the test group for snowmobiling gear and Finland's national alpine skiing team, which helps test downhill skiing outfits. Customer feedback is very important and taken into account.

However, customer surveys are carried out irregularly; it is more often about trying to listen to the markets and new trends.

The cold-protective features of clothes or accessories have been tested by two of the interviewed companies, in both cases the workwear, and they use product-specific EN 342 standards. Water resistance and breathability are the two most common fabric qualities indicated. The thermal resistance values of materials are not usually given, but the thickness of the lining is often indicated in grams. The thermal comfort of the piece of clothing is influenced by the entire set of clothes, the combined effect of materials and layers of air.

User research and climate conditions expertise as research and product development needs

Clearly discernible needs for research and product development and points of interest included user research and protective qualities of clothes or apparel against the cold, rain and wind, in changing conditions. The companies that operate in the specific field of cold-protective clothing have already tested their products with the Finnish Institute of Occupational Health, the instance granting the standard that proves the thermal resistance qualities of a piece of clothing. An explicit distinction is made between workwear and leisure clothing, but companies are also interested in gaining measurable and comparable data on leisure clothing. The overall functionality of materials and material combinations in clothes is another area of interest.

There is interest in user research because the smaller companies in particular do not possess systematic resources for this kind of product development. It is considered important to obtain information that can be used directly and quickly in the design process. Especially research and testing with authentic user groups and in real-life conditions would be appreciated. There is also interest in investigating user conceptions, both in terms of the clothing and the company brand. Single mentions on interesting topics for research and testing included how workwear suffices in the changing conditions at opencast mines, material preferences of customers, customers' willingness to pay for Finnish work and interest in Finnish brands.

There was some interest in product development carried out using the equipment and learning environments of the Lapland University of Applied Sciences and the University of Lapland. As stated above, those who need a standard are already having their products tested elsewhere. However, there is interest in testing cold-protective qualities with Arctic Power's thermal manikins or testing finished products in the Cold Chamber conditions or in the field from the product development perspective, also from some manufacturers of leisure clothes. Interest in cold-protective qualities in particular was expressed in the context of measuring an entire snowmobiling gear set, testing down

jackets, the differences between clothes made of wool or synthetic materials, and adding technological features to clothes and their functionality in cold temperatures (such as temperature sensors, GPS locators).

The interviewees found it hard to find uses for body scanning services and, in part, for 2D pattern-making and 3D fitting software with regard to the activities of their company – that is, all interviewees except the largest company. At the large company's workwear service, there would be plenty of use for portable body scanners, as the customer companies' employees are always measured, and sometimes measurement charts have to be made for countries where they do not exist. There is need for examples of body scanning – the companies saw potential in scanning in developing new products or planning and sizing competition sportswear, for example. None of the companies used virtual fitting software; one used pattern-making and PLM (Product Lifecycle Management) software. As is typical to the clothing industry, most of the operations from pattern-making onwards have been outsourced to sub-contractors or final suppliers of the clothes. Technical information packages of the designs, with the required images and information, are provided for the suppliers. One of the small businesses takes advantage of its solid, classical-style pattern family and makes any changes that are needed manually.

Due to the outsourcing of operations and, at the other end of the spectrum, the traditional working methods, there is felt to be no real need for 3D fitting software. However, the larger companies are interested in the opportunities of virtual modelling. Once again, the largest company actively follows the field and has visions of a virtual chain covering pattern-making, customisation and fitting, effectively reducing costs. Virtual modelling is considered a potential tool for testing and communicating something brand new, but also – when it works – a booster for product development. It is considered to still be in a state of flux, and not all potential or possibilities for use have been discovered. References of these new technologies and software applications are needed, along with examples of the ways they can be utilised in product design, testing or marketing. Two of the interviewees mentioned that Nike already sells nearly half of its products based on modelling only. However, one of these interviewees assessed that the material and fit qualities of a piece of clothing are so important to the consumer that this can be more challenging with clothes.

Sustainable development, services and wearable technology as other targets of interest

Other areas of interest and targets for research and product development were brought up in the interviews, some of them through the questions and some were introduced by the companies. Examples include taking into account environmental friendliness, services development, co-design and wearable technology. The opportunities offered

by virtual worlds were also brought up again. Many companies have their own quality assurance systems, which rely on the feedback from customers and users.

The interest in the environmental friendliness of the products varies between companies and slightly correlates with the size of the company. Those who regard it as an important feature of contemporary clothing design are willing to invest in it. Some need external help and reliable indicators, and one company is already taking environmental matters into account in accordance with the ISO 14001 standard. The activities of others who expressed interest focus on material selections and durability. Sympatex, which is advertised as a breathable, waterproof and recyclable membrane, was brought up by several companies in this context during the interviews. The membrane is recyclable, but no recycling system exists at the moment. One of the interviewed companies did a pilot project with Sympatex on a jacket made entirely of a mono-material (polyester) – the same material the membrane is made of – in order to make the entire product recyclable. The jacket did not go beyond the test phase, however, due to the lack of extensive recycling systems and logistics.

There is interest in developing services, but more information and real-life examples are needed of the advantages of service design. The largest of the interviewed companies, however, is a real-life example of service-oriented thinking at the core of business operations. The company markets itself as a textile service company and rents out products for its customers. Service design is understood as a method for comprehensive business development and aid to productisation and brand creation, and it is considered interesting in these respects in particular. However, rental and other product-related services were associated with retailers and programme service providers, for example. As an example of existing services, some of the companies offered workwear customisation on three levels, and one of the small companies offers the aforementioned warranty for mending clothes. There is also interest in observing the service environment (shops, etc.) from the consumer perspective and consumers' conceptions of the brand. One of the companies had visited University of Lapland's SINCO (Service Innovation Corner) environment, which is used in service prototyping. The possibilities of co-design were considered interesting, possibly in the context of services. One of the companies brought up the concept in conjunction with online sales and customisation possibilities. There is not much experience with the applications and benefits of co-design in general.

Smart clothes, wearable technology and virtual modelling raised discussion with some of the companies, but in a very contemplative manner. One of the companies was ready to start testing the functionality of thermal sensors and design them into the clothes, while another was a little more skeptical regarding whether this kind of technology is needed in clothing. However, an interesting notion was expressed in regard to linking intelligence and technology to the maintenance and logistics of a product in addition to a person's movement. When asked about virtual modelling,

one of the interviewees independently mentioned pLAB, the Software Engineering Laboratory at the Lapland University of Applied Sciences, and wondered whether this kind of matters could be taken there. With one interviewee, discussion about virtual modelling and virtual worlds led to thoughts about creating a simulated arctic urban environment and exploring the functionality of clothes there, for example when constantly going indoors and outdoors. More detailed thought is still needed regarding what modelling seeks to achieve and where it could be of use.

Future prospects

We asked the companies about their views on future prospects of the Arctic and, on the other hand, their needs for forecasts of future prospects and trends. Some companies expressed interest in this. Some companies consider trend forecasts useful and others do not, but a multi-disciplinary take on world phenomena and the future is considered to be of interest. There might be a demand for forecasts to support the planning of business operations. It is also important to be able to draw conclusions from the information or forecasts that will benefit the company

The Arctic region is considered a growing market area, and especially those who have their eyes set on Russia see potential there. The operations of one of the companies have clearly been affected by the current challenging market situation in Russia. The growing utilisation of natural resources increases traffic and industry in many fields, such as mining, which also creates growth in the market for products and clothes made for these fields.

Climate change is considered a threat, but not everyone spares a thought for it or considers it to influence their own operations. Others understand that global warming will decrease the market, and the poor winters have already clearly reflected in the sales figures of one of the companies. The weather fluctuations and the lack of proper winters are a cause of such concern for the company in question that they are already considering the need to change their product portfolio. One entrepreneur expressed a slightly different view from the majority on the direction of climate change; he sees a new Ice Age coming. Even those who were not influenced by global warming mentioned increasing extreme weather events.

CONCLUSIONS AND PROPOSITIONS

User research is an important topic that is worth addressing in the ongoing activities, future projects and method development. Early user research, usability testing and user tests for finished products are all areas that interest companies. There is demand for user-oriented design, product development and testing. However, it is unclear

whether companies are willing to pay for it. The companies were interested in taking advantage of body scanning technology as well as 2D pattern-making and 3D virtual fitting software, but there are virtually no examples of how they could be applied to the companies' own product development process. The added value that they could bring to companies should be examined and clearly represented. If the technology is not compatible with the current business model, concept models of possible business models should be prepared. For example, a student at the University of Lapland is currently writing a thesis for one of the interviewed companies regarding how these software applications could be used in the company's business operations and design process.

The businesses and universities conducting research and product development should work in closer collaboration, and communication about projects and research results should be improved. A representative of one of the companies described how, a few years ago, they were looking for information, research and involved parties in cold-protective clothing, but could not find anything. There should be more visible and open communication about the services related to research and product development, and there should be more active contact with companies. Networking opportunities and benefits between research organisations and companies are also worth looking into. There was also general interest in the operations of the international ArcticPro network. The companies had difficulties in determining their own needs for research, but they were interested in new phenomena, which speaks in favour of future-oriented research and product development activities.

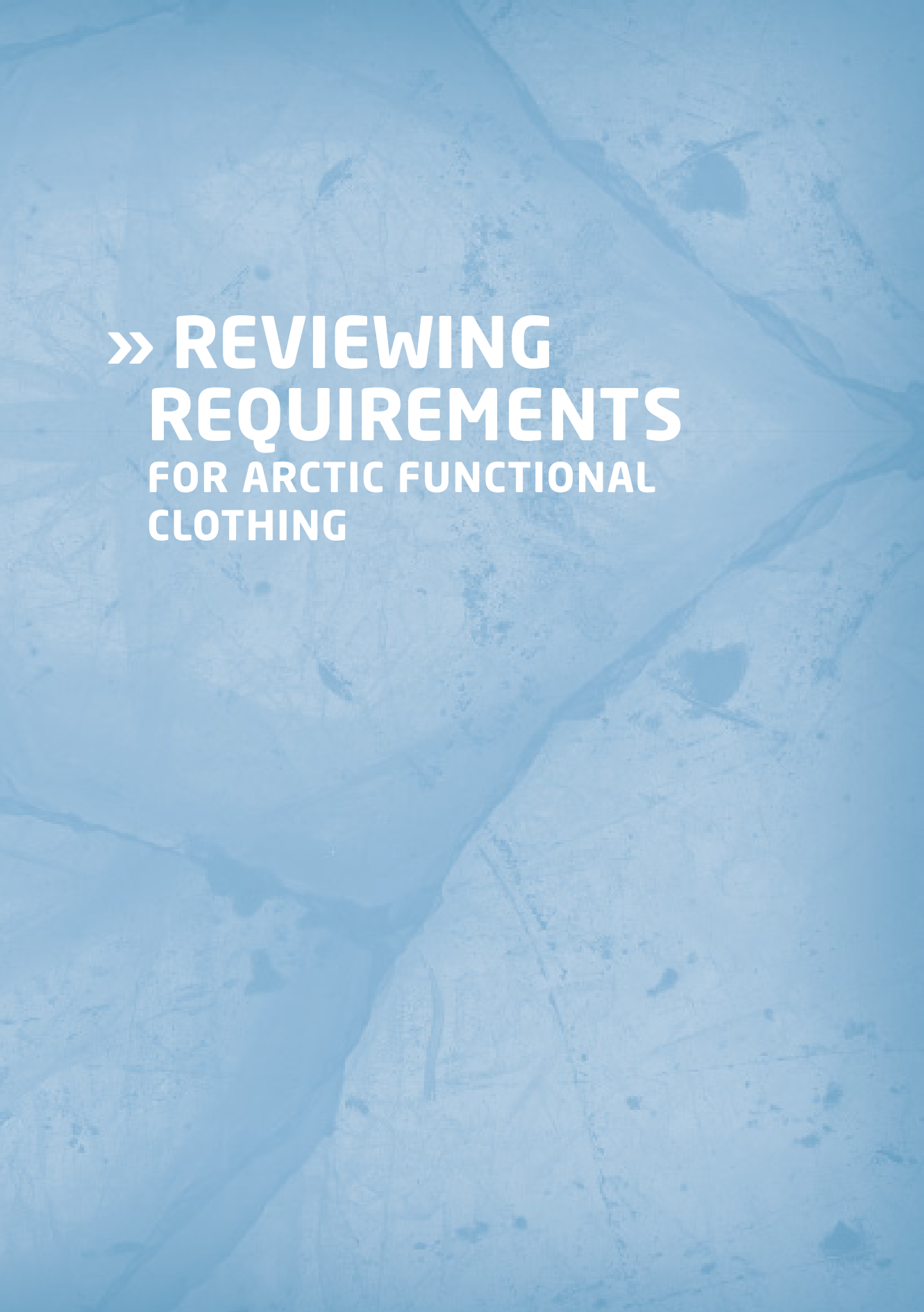
APPENDIX 1. QUESTIONS FOR MANUFACTURING COMPANIES

1. First, please describe the operations and strategy of the company on a general level; how are these reflected in the work and goals of your team?
2. What is the target audience of the company? Are there intentions to expand the target audience?
3. What does the company produce? Are there intentions to expand the product portfolio?
4. How much resources does your company invest in research or product development at the moment?
5. Is there need for user research in your company? If so, what types of things would you like to find out from users?
6. Are you interested in participating in projects?
7. Are you interested in the activities of the ArcticPro network? If so, what kind of information/activities of the network would interest you and how would you like to participate? As a business member of the network or, for example, take part in the research and product development projects together with members of the network?
8. Do you have need for testing in product development or for end products? For example, testing cold-protective qualities with thermal manikins or testing end products in climate chamber conditions or in the field?
9. Does your company need body scanning services? (See the information brief at the end of the document.)
10. Does your company use 2D pattern-making or 3D fitting software? If not, is there a need for such 3D modelling services?
11. Does your company need support for research or product development in any of the following:
 - Design and style of the products?
 - The products' protective qualities against the cold, rain and wind?
 - Environmental friendliness and ecological aspects?
 - Quality, durability, reparability?
 - Possibility to reuse/recycle the materials at the end of the life cycle?

- Developing services?
- Future foreshadowing?
- Other things, please specify?

12. How do you see the future prospects of the company in relation to the future scenarios of the Arctic regions? Preventing and slowing down climate change by saving energy, efficient use of resources and reducing consumption? The Arctic as a growing market area and traffic route? The impact, threats and opportunities of these to your own activities?

*With body scanning technology and new 3D modelling software applications, it is possible to manufacture products with detailed, user-oriented design, better fit with exact measurements and in the right volume, decreasing unnecessary production. This is a way of practicing sustainability in fashion design and manufacturing. With the body scanner of the University of Lapland, you can take a person's measurements in a few seconds; so measuring even large numbers of people goes quickly. Using the scanner you can take over 100 measurements of a person and create a three-dimensional, digital model of the figure. With the virtual pattern-making and fitting software, you can make the pattern and try on the piece of clothing first before making the actual prototype. This both helps prevent unnecessary production and facilitates early-stage user testing.

An aerial photograph of a snowy, mountainous landscape, possibly a glacier or a high-altitude region, with a blue overlay. The terrain is rugged and covered in snow, with some darker patches visible. The blue overlay is semi-transparent and covers the entire image.

**»» REVIEWING
REQUIREMENTS
FOR ARCTIC FUNCTIONAL
CLOTHING**

INTRODUCTION

One of the main goals of the ArcticPro Lapland project has been to update and improve existing research, development and innovation facilities at the University of Lapland and Lapland University of Applied Sciences. To do this, we sought to find out what is needed now and in the future in the field of cold and arctic wear. The International ArcticPro network had already in 2013 conducted a short survey for end-users and suppliers about cold and protective wear. We decided to take a more in-depth look into what issues especially interest or concern users, also in leisure time clothing. This article concentrates on the insights of user research conducted with representatives of different users of functional clothing. User needs for arctic functional wear are discussed as well as focus points for future research and development projects surfaced.

METHODS AND RESEARCH QUESTIONS

The purpose of collecting this user knowledge was to uncover immediate and emerging needs, as well as research and development topics from the field of arctic functional wear. Main research question was: What are the current user needs with regards to functional clothing? This is divided into a few subquestions. What kinds of requirements are posed for functional clothing? Are users happy with the current products on the market? What kind of research and development needs arise with regards to functional clothing? This research is not user research for any specific industry or field of activity to find out user requirements for a specific type of clothing. User research serves the interests of this project first and foremost but may also offer or strengthen new openings to the discussion on functional clothing.

During autumn 2014, interviews of individual users of various types of functional clothing were conducted by a group of student from the University of Lapland as a part of their Functional Clothing course and design process. Hobbies and occupations of the interviewees included wilderness guide, a hunter, skier, skater, a chef, motorcyclist, a pilot, a white-water paddler and a street dancer. All interviews were conducted as thematic, semi-structured interviews and were based on the same question form prepared by project personnel. Themes and questions for the interviews were chosen combining theoretical frameworks introduced later on, as well as practical considerations (see Attachment 1). Interviews conducted by students were recorded or conducted via e-mail, transcribed and then analysed. Data was analysed with a thematic, qualitative analysis. A loose quantitative analysis accompanied this, transforming key concepts, and those closely related, into frequencies.

THEORETICAL FRAMEWORK

As we are examining what kind of research and development topics stem from the users' perspective and what properties are generally considered important in functional wear, we also need to take a look at the literature in the field and examine what kind of functions are understood as relevant in functional clothing. Lists of functional requirements vary somewhat depending on whether clothing is approached from the perspective of physiology, ergonomics, design, fibre and textile research and so on. These will not be dwelled on further here. For the purposes of this research, we have chosen three different frameworks from the design perspective (Figure 1). When embarking on a journey of designing functional clothing, understanding what kind of information is relevant and what needs to be examined to establish the relevant design criteria, is important. v.

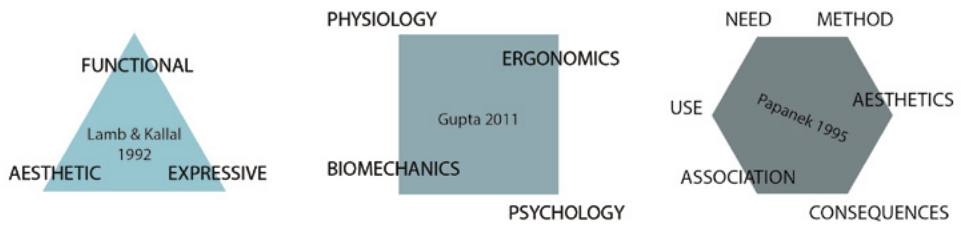


Figure 1. Frameworks for functionality requirements. (Konola 2015 according to Lamb & Kallal 1992, Gupta 2011, Papanek 1995).

Lamb & Kallal's (1992) FEA Consumer Needs Model has been widely used in functional clothing research and education. Their model incorporates functional, expressive and aesthetic considerations and is intended as a basis for developing design criteria for functional as well as normal clothing. To Lamb & Kallal functionality means protection, thermal comfort, fit and mobility. Expressive needs, like the need for identity and individuality, relate to communicative and symbolic aspects that are interpreted through culture and a variety of meanings. According to the authors, aesthetic needs stem from our desire for beauty. Design considerations that arise from this function category are the use of design elements like line, colour, form, texture and pattern. They point out all of these requirements have specific concerns varying according to target users and use-situations and that they are not mutually exclusive (Lamb & Kallal 1992, 42 - 43). Authors report the concept of functional clothing stemming from designing garments for people with special needs or physical disabilities, but now perceived more widely, including classes and subclasses of workwear, sportswear, rainwear, climbing gear and so on (Lamb & Kallal 1992, 42).

Gupta (2011) considers designing functional clothing different from everyday apparel design and calls this process ergonomic clothing design. She defines functional clothing as responding to user specific requirements, which are determined by the user's environment and activities (Gupta 2011, 327). Gupta (2011, 329) lists some properties common to all functional clothes: "*light in weight, thermoregulatory, elastic, antimicrobial, aesthetic and durable*", but doesn't establish the reasoning behind this very list. More convincing is her four categories of functionality: physiological, biomechanical, ergonomic and psychological. According to Gupta, these considerations determine requirements which are common to all users. In Gupta's model, factors like energy metabolism, clothing thermal properties and ambient climatic conditions make up the physiological requirements. Biomechanical requirements address the mechanical characteristics of human body like structure, strength, mobility, postures and movement. (Gupta 2011, 327-328). Ergonomic considerations relate also to mobility and health considerations already presents in physiological and biomechanical requirements. Emphasis, however, is on the mechanical characteristics of the clothing and how they relate to movements, postures and materials handling while working and

workplace layout for example (Gupta 2011, 328-329). In my view, this requirement shifts focus from the person more to the activities, surroundings and other objects and their interaction with clothes. Psychological considerations stem from “*user’s psychological and social behaviour in response to events, people and/or environments*” (Gupta 2011, 329). Clothing aesthetics are subject to social and cultural background, age, sex, activity, peer acceptance and group identification – just to name a few (Gupta 2011, 329).

A product assessment tool of a six-sided function matrix introduced by Victor Papanek in the 1970’s is also included in the theoretical framework to provide fresh approach to examining clothing needs and functions. It doesn’t particularly address clothing design, but has been applied in a few instances especially to functional design considerations (see for example Seppälä 2010 and Risikko & Marttila-Vesalainen 2006 referring to Anttila 1993). Papanek fractions functionality into six different aspects that any design object needs to address. These include method, need, use, association, aesthetics and consequences. Shortly, with method, Papanek refers to the relationship and interaction of tools, processes and materials. He advocates that materials and tools should be used optimally and honestly and most should be made out of materials inherent properties. (Papanek 1984, 8). Objects are evaluated through concepts of need and use. What do we need some object for – for survival or identity formation? Does an object fulfil its purpose in use – does a winter jacket keep you warm? Aesthetics and associations deal with same questions as Gupta’s psychological needs. Very different from other frameworks is the concept of consequences. To Papanek, design is functional only if it takes into account it’s consequences, whether social, environmental, economic and so on. In his updated version of the function matrix, Papanek (1995) replaced teleisis with consequences. This aspect was however already present in the first version, as the future dimension of the whole matrix that needs to be considered. Papanek pointed out that everything we design has far reaching and diverse consequences for example into health, income, biosphere and politics. (Papanek 1984, 23-24).

The FEA model and Papanek’s six-sided function matrix were used as a foundation for the questions of the user research, to cover topics as widely as possible. Later, for the purposes of the analysis, a third framework was selected to accompany these two and act as a background for analysis from the ergonomic and physiological, but still designerly perspective.

REQUIREMENTS FOR FUNCTIONAL CLOTHING

Requirements for functional clothing and user needs are discussed with regards to identified levels of needs and functionalities. Through this, answers are sought for what kind of needs users have in regards to arctic functional clothing, what properties

are valued and are people happy with the current products in the markets. This is done by reflecting the user data to theoretical frameworks and examining them in the light of general requirements, activity specific requirement and user-specific requirements.

Levels of needs and functionalities – from general to user-specific

When talking about functional clothing, there seems to be a division between general functionality and specific functionality that is determined by a person's environment and activities. This division can be a bit artificial, since most functional clothing is designed at least somewhat activity specific. General requirements can be seen as a framework through which activity specific needs are examined and identified through user research: *"Specific concerns within the broad areas of functional, expressive and aesthetic needs vary with the target market. Once these are identified, product assessment determines which concerns have been addressed or neglected"* (Lamb & Kallal 1992, 46). The fuzzy division can also be described via an example. Hunters could be content with basic outdoor functional clothing that allows them to walk in the woods and protects them from basic climatic conditions. But when one is an active hunter, like one of the interviewees was, faults in too generic clothing become apparent, own needs specified and hunting specific clothing is sought. This interviewee even identified specific clothing needs according to which game is hunted. People's activities, the use situation and context as well as climatic conditions create the work and hobby specific functionality requirements for clothing. As the respondents in our user research represent various fields of activities, from their views we can try to infer what properties are generally valued in functional clothing, what observations arise from activity specific clothing and how these appear in the light of our three frameworks.

As people are all unique with personal preferences and experience history, user-specific requirements are an unavoidable point of consideration. User-specific requirements are many times connected to psychological needs described by Gupta, or expressive, aesthetic and associational considerations represented by Lamb and Kallal and Papanek respectively. Gupta (2011, 329) explains that strong feelings are often associated with aesthetics and appearance because *"clothing is an extension of one's persona"* and continues to elaborate that clothing should be in tune with users *"social and cultural background, geographical location, age, sex, activity and work profile"*. All this cannot be denied, but I would argue that perhaps especially aesthetic needs are subservient to personal functionality preferences. These kinds of preferences of for example on material weight and feel and on functional details were voiced by many research participants. In user-centred design, users are considered the experts of their own experience (see for example Sanders & Stappers 2008). So there is a reason to believe that they can identify their personal requirements the best. For these reasons, functionality categories of physiological and ergonomic requirements, psychological and aesthetic requirements and finally sustainable and societal requi-

requirements are examined on three different levels: general requirements, activity specific requirements and user-specific requirements. By going through requirement categories from all the frameworks, we can more closely examine what kind of performance attributes are appreciated by user and whether they are satisfied with current products.

Physiological and ergonomic requirements

Physiological and biomechanical considerations seem to be the primary general requirements for users. Respondents considered mobility, protection from the cold and wind as the most important properties of their functional clothing. Breathability was not on the pre-composed questions list, but as a requirement it was very early on mentioned by some participants. Through a loose quantitative frequency analysis it was discovered that breathability was among the most discussed properties. Use comfort as a property was also high on the requirement list, but as a concept it is a vague one, because it means many things to many different peoples. Some refer to mobility when talking about comfort, some to thermoregulatory properties and breathability and some to the feel of the fabric on their skin. Had we interviewed only outdoor sport hobbyists, protection from the rain and moisture would probably have been highly important. For those it concerned, it was very important, but on average importance was lower. Properties valued in functional materials reflect the appreciated attributes according to activities. Respondents looked for warmth with wool and fleece, mobility with Lycra and college fabrics and moisture management with technical materials. Moisture management, which refers to water repellent properties, breathability and ability to move sweat away from the skin, is an issue that fabric manufacturers have been trying to answer for years, but users still don't seem to be happy with the results – at least in our small sample: *“...perfect water durability...well...moisture durability is good...-...but I would rather appreciate that the clothing breathes than that it would be perfectly water durable.”* Some respondents reported technical materials seizing to function, accumulate frost inside in cold weather or coating membrane pores getting blocked by sweat. When functional properties are lacking or seize to function, clothing is often discarded. Functional stretch fabrics move the moisture away from skin, but accumulate sweat and smells that don't come off in washing anymore. Some users also reported that coating membrane pores of technical textiles get blocked by sweat and that they feel really cold next to the skin.

The complex interaction between activities, use context and climatic conditions create the physiological, biomechanical and ergonomic requirements important to identify for the right clothing performance for specific activities. Functional clothing needs to adapt to different types of climatic and environmental conditions and activity levels rather than different types of activities, as clothing is usually designed activity specific. For example, both hunter and a hiker report to need warm, breathable yet windproof clothes, which one needs outdoors for basic physiological protection. Energy metabolism

and heat production can be similar with walking varying routes in the forest and pausing occasionally. Biomechanics, with what Gupta (2011) means postures and movements, of these activities differ to some extent, as do the ergonomic conditions of how movements, environment and other objects interact with clothing. Hikers have their backpacks, hiking boots and perhaps paved paths. Hunters have their backpacks, guns, ammunition belts - and for bird hunting, need to stay invisible and quiet. Activities, movements and equipment of a wilderness guide or a hunter we can map out, but we can never fully predict the climatic conditions they need to work and function in and the corresponding activity levels. Chef we know works in the kitchen, but temperature and moisture levels can vary depending on how many stoves and devices are on and how busy the work is. This is probably why multi-functionality and transformability were only longed for with regards to temperature and moisture regulation. A comment by one of the research participants describes the situation well: *“Multi-functionality is realised by acquiring good shell clothing, under which one can adjust layers.”*

User can identify very personal needs for physiological and ergonomic attributes of functional clothing. Physiological and biomechanical requirements can even be more personal than ergonomic requirements, referring to thermal regulation, tactile and pressure properties and weight issues. A recent study indicates that there are even six degree differences on how people sense the same temperature. Differences are attributed to at least muscularity, age and gender and it is known that muscle produces heat thousandfold to fat. (Tuomaala 2014). A hunter reports how he produces so much temperature as he walks, that he *“...can't wear any thick clothing”*. Wind, however gets to him and his legs get wet in the thick forest. Thus, according to his needs, he tried to buy a jacket and pants from the same manufacturer, but from different series because of the different properties they possessed - however *“he wouldn't sell me the Gore-Tex pants and windstopper jacket even though I asked...he wouldn't mix the series...”*. A wilderness guide has good experiences with wool next to her skin even though many people think it itches: *“I have sensitive skin and 100% wool doesn't sting on my bare skin.”* A pilot reported rather unusual ergonomic conditions in the pit of a plane that created very special needs for functional details like pockets and Velcro attachments.

Psychological and aesthetic requirements

Appearance and aesthetics are only subsidiary requirements for users, even if they hold a special place in the functionality frameworks. As a function, requirement or need, appearance was rarely the first to be mentioned by user group. However, if appearance is not appealing, or there is something wrong with it, a rejection of the garment can occur – a common phenomenon also pointed out by Gupta (2011, 329) and Papanek (1984, 19). All three theoretical frameworks consider aesthetics, associa-

tions and related psychological factors important part of their function complexes. The FEA model dedicates two thirds of the model to these considerations, but considers aesthetics also as a tool; a tool with which aesthetic needs from the use-context, environment and user are evaluated and transformed into design principles (Lamb & Kallal 1992, 43). In Gupta's model they are only a part of the fourth corner of psychological considerations. Gupta (2011, 329) clearly states that aesthetics is secondary to functional requirements when considering functional clothing. This view is reflected in the user study. To none of the respondents was appearance the dominating factor, but a stylish garment and a functional cut brought value to a piece. Colours were mentioned as the most important aesthetic factor. Answer about the importance of aesthetic factors generally varied from *"they are an essential part of selecting equipment"* to *"to me not really personally"*.

By digging deeper into the expression, interpretation, association continuum and design principles of colour, line, texture and form, we can recognise more profoundly what kind of needs users have. As hobbies and work are centred around specific activities, more emphasis is placed on activity specific practical clothes and group identities – than perhaps just role playing what fashion some consider as (see for example Papanek 1984, 15). Users in the study for example want to express their role as a chef, theme of a figure skating piece and membership of a street dance group. Gupta (2011, 329) describes clothing aesthetics subject to many personal factors, such as social and cultural background, peer acceptance, group identification, events and experiences and so on. Activities, group identification and experiences seemed to be the overriding factors with this user sample. Some respondents could name special groups within their hobbies, based on what practicalities or style they prefer. Our motorcyclist, for example, named *"safety vest drivers"*, *"leathersport motorists"* and *"style conscious technical textile dressers"*, whereas the hunter could name groups favouring army style, technical textiles and outdoorsy styles. Users also reported to favour brands because of having good experiences on functionality and durability of the brand's clothes, not because of looks or status, attributes usually associated with brands. Good experiences included also repair services and warranties promised to clothes, well-fitting clothing and good materials. Colour, right fit, functional cut, as well as style and good appearance as a part of hobbyist or professional identity, were regarded the most important aesthetic features by user respondents. Looking good was also a comfort factor: *"...it is somehow nicer if you perhaps look good too"*. Fashion as a concept was only mentioned by the street dancer.

Even on the very personal level, the functional aspects of aesthetics are emphasised over appearance. Values also step into play when we look at user specific requirements. Interviewed wilderness guide, for example, expresses her ecological values through garment choices. A chef reported he would also do this, if he was provided with the possibility – with the workwear provided for him. Customisation and co-design possibilities one could image having a lot to do with aesthetics and identity; making

the garment look individual and special. Based on this small sample of people, it seems that participation to the design or customisation of the garment in functional clothing would be more focused on the functional properties and details. Some functional details have been added or clothes have been made to fit better. Adjusting the length of pant leg and size of garments were among the few fixes mentioned. Most, however, had selected their gear with such great care, that they had no need for customization. Figure skater and street dancer reported to have customized to the extent on adding embellishment and making performance pieces unique. Over half of the respondents were interesting in co-design possibilities, but again focus was more on testing, providing the user perspective and adding functional details to their own specific needs. Desire to choose colours and have better fitting clothes are important aesthetic properties in this regard.

Sustainable and societal requirements

Conversation about consequences and environmental issues has found its way into the apparel field, but sustainability is still far from being considered a general requirement for clothing. Some pioneer outdoor clothing companies have taken their environmental and social responsibility serious for a few decades now, but others have only been awakened in the 21st century. As a part of her master's thesis *Sustainable responsible outdoor clothing – What every designer should know*, Seppälä (2010) mapped out what outdoor companies have done for sustainable design and manufacturing and found a clear increase in actions even during the two years she conducted her research. A powerful key note in *Ambience14* –conference by Kevin Myette (2014) acknowledged that it is the performance that matters in functional clothing, but advocated for the fact that it is time to start thinking that all inputs and outputs matter just as much. The earlier ArcticPro network survey for users and suppliers didn't include any question concerning environmental issues, but one respondent pleaded this to be included as a core of network activities (ArcticPro Product Supplier Survey 2013). Of the frameworks, Papanek's function matrix is the only one considering consequences and efficient, clean production with his method segment. These are few of the many reasons we wanted to find out how is environmental and ethical performance perceived as a requirement in functional clothing.

Quality and durability can be considered general functional requirements with environmental and economic consequences. These attributes were rated high as important properties of functional clothing by the respondents and this is also reflected on the discussion on clothing lifespans. Lifespan of the respondents' functional garments varied greatly, but some were surprisingly short. Skier, chef, street dancer and paddle estimated the lifespan of their clothing shortest – maximum of two years. These clothes got broken, burned, wore off, started pilling or developed wash resistant odours. More durable clothing is discarded if they no longer function as intended, for example keep

you warm or dry. On the other end there were wilderness guide and a hunter who both had strong cotton fabric outdoor jackets aged 15 and 25 years respectively. Both were dyed once for better colour and were still perfectly usable. Technical clothes, made from technical textiles, users estimated, or hoped to last at least five years. One respondent mentioned how these technical properties no longer work after that time. Pants many regarded to worn more easily because they are more exposed to wearing and tearing and washed more often. Few of the respondents also mentioned to discard clothes when they no longer liked the style. Used clothing either ended up in the dumpster, recycling centres or flea markets. Good quality clothing some resold online.

Ecological concerns seem to be activity and user-specific, depending on whether these issues are discussed or brought up in hobbyist groups or whether users personally hold green values. Generally ecological issues were somewhat on the respondents' minds, but the level of knowledge or actions was not great. Motor sport respondent clearly declared he is not interested in this issue, but others paid some attention or would like to pay more. Hobbyists spending time in nature, like hunter and hiker, seemed most interested. Choices would be made based on ecological considerations if there was more selection and if the prices were the same. This observation is shared by Seppälä (2010) in her interviews with mountaineers and kite snowboarders. What respondents considered as ecological solutions were local production, natural and recycled materials, long lifespan, reuse and manufacturer's take-back and recycling responsibilities. One respondent would like to know about origins and toxicity of the materials. When asked in more detail about the interest in utilising materials at the end of a products lifespan, most of the respondents had not thought about this. Methods for utilisation they could think of, were the same as previously mentioned, recycling or reusing as such. Only the chef thought of his torn jacket as a material for something else: "*Yeah maybe someone could make a carpet out of it if nothing else*", referring to the tradition of making rag rugs.

Moving from ecological to ethical considerations, the requirements became more user-specific as values and awareness play a role in consumption choices. Over ethical issues, respondents seem to favour domesticity. A statement by one of the respondents describes quite well the attitude towards interest in the origins of clothing and ethical issues: "*In principle yes, in practice no.*" Views were polarised as people were either interested or not really interested because they don't think about these things. The idea of domesticity was encouraged, but not everyone was able to distinguish between domestic brands and domestic production. Those who did, favoured Finnish brands because they hoped at least some of the revenues to stay in Finland. Issues people considered important with regards to origins of the clothing were origins of the materials, corporate responsibility especially with regards to repair and warranty questions and paying living wages to garment workers.

METHODS FOR MEETING FUNCTIONALITY REQUIREMENTS

Once expected requirements are established for clothing, methods for fulfilling those needs should be considered in the design phase. Lamb & Kallal (1992, 44) describe this phase as the design refinement phase where priorities are established with regards to identified needs. To Gupta (2011, 328, 329, 331), many different considerations in garment design and garment assembly processes are essential to fulfil requirements – and together these considerations should make up a clothing system. Here, methods for answering identified functionality requirements are discussed in the light of insights from the user data and theoretical frameworks. We follow along the lines of Gupta's performance system model and process of designing clothes where methods for fulfilling needs are material selection, clothing design, assembly and testing, but add our own dimension of thinking further into systems, such as product-system services. This discussion is intended to further identify urgent research and product development needs in the field.

Methods for meeting physiological and ergonomic requirements

Materials are the most obvious choice for answering physiological requirements as new and innovative materials are continuously developed to answer special needs. Textiles are tested for a variety of performance and quality measures, but transferring these results into clothing systems and real life use situations can be challenging. According to Gupta (2011, 331) moisture management and breathability are the dominating factor in material selections today, but as we demonstrated, users still don't seem to be content with the results. According to Gupta, (2011, 329), overall material properties are hard to predict, because there are so many factors in play all the way from fibre construction and yarn properties to weave patterns – not to mention mechanical and chemical finishes and coatings. Technical textiles like water repellent fabrics may be great in appropriate climate, but users report them turning stiff and gathering in frost as weather gets cold. Performance measures like water vapour resistance, thermal resistance and water repellence can be tested according to standardized measures. Skin model test, with which many textiles are tested on, however, are considered the least accurate method (Meinander 2012, referring to Umbach 1981). In many functional clothes, relevant numbers for waterproofness or breathability are presented in tags or info sheets. This is an example of the type of information some of our respondents paid attention to. For some, who reported not needing this information, trust was not high for standards or certificates to guarantee the functionality of a piece. They based their claims on experience: *“A typical example: A cheap riding jacket has materials that fulfil requirements of a waterproof standard, but the seams give up after six months use. Looks good on paper, but doesn't work in real life”*.

Because physiological sensations and ergonomic conditions are created by so many different parameters, thinking in terms of full clothing systems instead of just materials advances requirement fulfilment. Correct sizing, pattern making for a moving body and assembling garments components according to activities can fulfil many functional requirements from mobility to thermal regulation. Factors affecting thermal balance are for example metabolism, level of activity and heat production as well as heat transfer through respiration and skin (Risikko & Marttila-Vesalainen 2006, 23). It is obvious that weather factors like wind and moisture, just as current activity and movements affect this balance, not to mention the looseness of clothing, that allow air flow in and out. Gupta (2011, 332) points out the importance of layering and zoning multiple fabrics like mesh for ventilation, stretch for mobility and padding for insulation on pattern and body areas for answering specific needs. Assembling a number of different fabrics with varying properties into ergonomic patterns in critical locations, increases garment functionality in many respects (Gupta 2011, 333). This is also discovered and wished for by users. Especially outdoor hobbyists could point out very specific materials needs to specific body locations according to their normal activities. A hiker was looking for flexibility in the knees. A hunter also pointed out special locations: *“Of course pants could be like, from the knees down, waterproof and then bottom also so that one could sit down somewhere”*. He also identified the importance of correct fit in thermal regulation. Clothing systems, especially for thermal regulation are many times tested with thermal manikins. The transferability of manikin results to human activities is debatable. A recent study for example points out how *“thermal manikins offer a limited representation of the clothing thermal and evaporative properties”* for sport activities (Redortier et al. 2014).

Activity specific pattern engineering aided with modern 3D technology could offer great advantages for ergonomic clothing design. Garments testing, however, could ultimately be the method that determines overall functionality. Gupta (2011, 332) emphasises how ergonomic design requires *“3D anthropometric data captured in multiple realistic postures.”* To speed this up, body scanners that measure in dynamic mode and capture shape, size and posture data, can be used. Gupta continues that independent size charts should be developed for each type of activity or clothing. This is clearly not done for some chefs’ clothing, since our respondent reported his pants tearing apart from the crotch often. Mobility and free range of motion was among the most highly rated properties among respondents. Functional fit and different body types and sizes were a topic of discussion. When asked about interest to take part in the clothing design process, enabling better fit and sizing for different body types was among the reasons mentioned. Body scanners can produce the data to develop better fitting and even individual clothing. Dutch army scans their soldiers to find the appropriate size for clothing (Daanen et al. 2014) and scanning is also examined as a way to develop more accurate and versatile size charts and better wearing comfort (De Raeye et al. 2014). Because of the interaction of materials, garment construction, assembly and the interaction of garments with user activities, weather conditions and environ-

ment are so complex, Gupta (2011, 333) calls for holistic test procedures which test various performance parameters under actual conditions, on field tests with real humans. She acknowledges that human subjectivity can raise many issues, but thus advocates accompanying field tests with objective measurements and further development of this kind of test procedures.

Answering functionality requirements with technology is an ongoing discussion, but from the user perspective there might not be a great demand for it. Embedded or wearable technology that combines ICT components with textiles has already expanded into commercial applications. Smart textiles, like phase change materials that react to environmental conditions, can already be found in bed linen and sock threads, in addition to functional clothing. These innovations are expected to play an increasing role in the field of functional clothing (Gupta 2011, 330) and a few of respondents also mentioned these developments perhaps to be part of the future *“perhaps some of that smart technology then at some point..”*. Use or need for intelligent solutions, e-textiles or smart materials, however, was not great among the respondents. One user mentioned Outlast, the phase changing material and that he has read about it, but is a bit sceptical of its functionality. Most could not think of any examples, nor imagine solutions that they would need. A few of the respondents hoped clothing to facilitate carrying and using already existing technology like mobile phones, GPS- devices or mp3s. What these users rather envisioned or hoped for future clothing in terms of materials, were quality and durability, solution for the breathability versus water durability dilemma and rise of ecological and natural materials next to technical ones.

Methods for meeting psychological and aesthetic requirements

Developing modularity in garment manufacturing, assembling components according to specified needs and combining this with participatory design, could fulfil not only functional requirements, but also psychological needs of individuality and aesthetics. In addition to customised water proofing, breathability and pocket layout solutions, some respondents were hoping for customised colour and fabric options and individual fit for functional garments: *“Sure it would be great if the design was just right for your own body.”* Colours were the one aesthetic property that everyone regarded as highly important. Colour preferences at the same time are very individualistic. Respondent who hoped for customised pockets continues, and sums up many of the discussed reason for participating in the design or manufacturing customised clothing: *“Colours and effect colours as well and possibly also materials. Also especially in my body type often pants are way too long, so the sizing should be flexible.”* Over half of the respondents would like to take part in designing clothing, two of them specified that as a part of the testing team, but others hoped to express their ideas and views as users, develop better sizing and fit and be able to customise pieces and add features according to specified needs. Methods for user involvement beyond traditional user

research methods and mass-customisation options are currently being discussed and researched in the field (see for example McCann 2014, Konola 2014).

By designing new kind of product service systems, one could perhaps find novel solutions for psychological and aesthetic requirements. Better measuring and sizing with 3D body scans and computer aided designing and manufacturing with pattern engineering and fitting software, as well as rapid manufacturing techniques are predicted to revolutionise the industry and provide people with on-demand produced unique clothing. Gupta (2011, 334) sees a lot of research still needed in these areas and growth a bit slow, but potential is clearly identified. Building infrastructure, technology and user friendly product service systems around this, could aid in fulfilling personal aesthetic and functional needs. Especially offering pro-amateurs a chance for participatory design, customisation or production-on-demand could be a vital business plan. They usually know what they want and are ready to pay for it. As it became clear in the interviews, they are not so interested in rental services, but rather quality clothes just right for them. Hunter for example makes carefully considered decisions, expects his clothing to last a long time and had calculated how much one use instance of a quality gear will approximately cost him. Connecting production on demand facilities with repair and customization services would serve these needs well. Performers, like figure skaters, on the other hand have needs of very limited lifespan. Costumes must also always correlate with the theme. Instead of making new unique costumes every time, activity specific rental and customisation services could be set up. Renting performance pieces from another figure skating team in another city is what our respondent's figure skating team had once tried. Identifying potential activities and user groups for developing product-service systems is an acute research and development topic.

Methods for meeting sustainable and societal requirements

Materials as a starting point for sustainability is the very basic, and perhaps most understood and developed level at this point. More sustainable materials and recycling methods are developed and brought into the markets as we speak. Ambience '14 –conference for example heard promising research results on the recyclability of cellulose fibres (Ma et al. 2014). Durable, non-toxic and recycled materials also interested user respondents. Quality, health and safety at the moment, however, seem to be overshadowed by the striving for fulfilling and exceeding performance parameters. A change in priorities, I believe, is just waiting around the corner. Environmental certificates like Oeko-Tex and Bluesign are already responding to the need for safer and more sustainable textiles. Myette, director at Bluesign Technologies, points out the fact that performance today is created by chemicals – at least 40 000 different chemicals identified by REACH, some more harmful to the people and the environment than others – and many with unknown consequences (Myette 2014). From the

perspective of chemicals, REACH (see for example Tukes 2014) is an example of minimum EU and national regulation that is required to achieve improvements. However, when the responsibility of identifying and regulating harmful substances is left to the industry, results are not impressive (see for example Greenpeace 2012). Government decrees can speed up the development of more sustainable solutions. From 2016 onwards textile waste is no longer allowed in landfills in the EU and this regulation is spurring up new innovations in material recycling. The above mentioned cellulose recycling methods could even be applied to dirty textiles (VTT 2014).

Methods for clothing design as an answer to sustainability or societal requirements are emerging, but strategies especially suitable for functional clothing need further examination. Research on apparel sustainability has already produced a huge variety of methods and strategies how clothing companies and designers can start reducing their environmental impacts. Based on phases in the haute couture design process, Gwilt (2011, 68) for example had identified sustainable strategies like design for end-of-life strategies, design for disassembly, design for waste minimization, design for slower consumption, user participation and product-service systems. Approaches like cradle-to-cradle, slow design or zero waste design are becoming household concepts, but strategies like open-source design, understanding patterns and rhythms of use, updatable clothing or participatory design that Flechter (2008) adds to the growing list of sustainable strategies, are perhaps less known. As Gupta (2011, 331) puts it, the activity of clothing design involves many iterative and parallel steps beyond material selection and it is these steps of determining garments components, size and fit, drawing form, lines and patterns that determine many of the important functionality parameters. They also determine a lot of the environmental impact. Here, we shall examine methods perhaps especially suitable for functional clothing design based on reflections and insights from the user interviews.

Users might not be that good in identifying or expressing their specific needs and thus developing methods to help with this, can already be a solution in getting the right needs and functions meet. When respondents were asked to describe the clothing, gear and conditions related to the activity, the length and depth of answers varied greatly. Some of the differences can be contributed to e-mail answers being generally shorter, but another contributing factor was the respondents' age and experience. Those who could identify and describe conditions and performance requirements in detail can be described as pro-amateurs, a term coined by Eric von Hippel (2005). These were the ones who reported to going to great lengths in finding the right clothing and gear: *"Again we come to this that, there is this conservative guy who doesn't think about these things. They just go and buy something and then amaze how uncomfortable a piece is. They don't go through the trouble of trying out. I am such a fool that when I go to the store to buy a riding jacket (for downhill skiing) I even have my helmet with me. So that I can try the hood on with my own helmet."* True-amateurs, who are perhaps starting their hobby, are less experienced and thus less apt in explicating what

are all the factors placing demands on the clothing. Thus they easily make bad purchase choices. A few users told examples where their less experienced friends bought cheap gear that simply broke after short use. Services like clothing coaching could help people to find their real needs and better clothing. Rental services where beginners could familiarise themselves with truly quality functional clothing, could result in wiser long-term purchases. Rental services also answer for short term, specific needs and trying out new activities. Respondents who were active hobbyists were not really interested in renting their clothes, because they use them so often, but a few identified the need to rent activity specific clothing for trying out new things.

Life-cycles should be considered in the fullest sense of the cycle word and turned into design strategies. Combining lifecycles and rhythms thinking with circular economy efficiency, the industry could develop very functional clothing systems. Functional clothes often serve real needs and they are bought for a purpose. Most respondents expressed a hope their clothing would last a long time. Many items were reported to have rather short lifetime, even as short as just six months. Pieces that only have short lifetimes, should be identified and manufactured so that material can be put back into circulation in closed – loop systems. The idea of circular economy, biological and technical closed-loop systems where materials circulate was introduced by McDonough and Braungart (2002). Through this kind of lifetimes and rhythms thinking and accumulating understanding on patterns of use and maintenance, Flechter (2008, 169) suggests for we can develop “*resource-efficient rhythms and speeds of consumption*”. As an example, she suggests biodegradable underwear and on the slow end, a durable quality wool jacket with an updatable design and immaculate maintenance instructions (Flechter 2008, 178, 182). Quality functional clothing represents this kind of slow jacket – two of the users had jackets aged 15 years and over. Patagonia currently has a campaign for promoting longer use of their quality garments, backed up with online repair guides and sewing kits (Worn Wear 2015 & Ifixit 2015). The monopoly of high-tech materials in the functional clothing industry, what Gupta (2011, 334) refers to as a challenge for smaller players to come into the market, makes also users input challenging. It is difficult to repair a waterproof jacket with a friend’s sewing machine because the needle makes extra holes into the coating. If DIY repair is made difficult, companies should provide guarantee repair services like one the respondents mentioned, to ensure longer lifetimes for their products. Also if users are unable to think of and demand cradle-to-cradle solutions, as it seemed with this small sample, it is the industries or governments responsibility to develop them. One user remembered an example where he could return his old jacket to the manufacturer and get a discount for purchasing a new one. This jacket was collected to be sent to developing countries, but full recycling of for example polyester clothing has been possible for years. Many outdoor companies collaborate with a Japanese company called Teijin on their closed-loop recycling system for polyester (Teijin 2015). The Finnish Innovation Fund Sitra and The Federation of Finnish Textile and Clothing Industries FINATEX are launching a project concerning circular economies of textiles (Finatex 2014).

CONCLUSIONS AND RECOMMENDATIONS

Design criteria for functional clothing should be established based on the general requirements of physiology and ergonomics, aesthetic and psychological needs as well as sustainable and societal considerations. These dimension need to be considered also on the activity and user specific levels. The most important requirements and pressing needs from the user interviews also revealed topics where further research and development is needed.

Thermal regulation, moisture management, correct fit and mobility are what people look for and are still lacking. Varying arctic condition pose a challenge for technical textiles, so development is still needed on materials. These issues, however, are perhaps more effectively dealt with thinking in terms of clothing systems; layering and zoning appropriate materials accordingly. Poor quality clothing out in the markets is also a reason for bad experiences. Rental services and coaching could help users identify their own needs and good quality clothing just for them and avoid bad purchases.

With aesthetics, a basic level of acceptability is a default, but since aesthetics is a subsidiary requirement when it comes to functional clothing, other psychological needs should be emphasised. Design principles of fit, form and even functional accessories, as well as group or professional identity are valued over fashionability, textures or brands. For functional clothing brands, it would pay off to invest in detail and fit customisation possibilities as well as repair and guarantee services rather than just brand marketing or producing new collections every season. Rental services are again an option for those who regularly need new aesthetics, like performers.

Even though technological development might not be what users need in terms of wearable technology, technological solutions like body scanning, computer aided design and manufacturing could help answer user needs more efficiently. Body scanning in realistic postures could help develop activity specific size chart. Developing modularity and customization options in design and manufacturing can answer to both functional and psychological requirements. Manufacturing for demand would produce only for real and individual needs. Development of product-service systems and business models is also necessary to make this kind of technology affordable and viable to both, producer companies and users.

Finally, I advocate a shift into a dimension of systemic and circular thinking, where needs are answered with resource efficient product-service systems. The world is full of functional clothing, many of them world class, high performance gear, developed for different kinds of sports and activities in different conditions. World is full of users, in different conditions busy with different activities and use-related specific needs. New sports and activities are also developed along the way and thus new needs are generated. Then there is earth, our biosphere with limited resources and need for

human species to sustain its existence and wellbeing on this planet. Whose needs should we answer? What kind of requirements should we place first? Instead of debating on hierarchies, we need to start implementing and developing multiple strategies for overall wellbeing. We need a paradigm shift in the overall goals and aims of the apparel industry, that Flechter (2008) for example advocates and we need to rethink our inputs, outputs and supply chains, as Myette (2014) suggests. Also, instead of products we need to start thinking in terms of systems and services. There are multiple ways of fulfilling people's needs and it might not be a new fabric, coating or technological development – it might be services through which people can find the right existing product for their current needs and from which used products continue on to next cycles.

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REFERENCES

ArcticPro Product Supplier Survey 2013. Unpublished.

Daanen, H.A.M., Woering, A., Ter Haar, F.B., Kuijpers, A.A.M., Haker, J.F., & Reulink, H.G.B., 2014. Optimization of Military Garment Fit. Proceedings of Ambience '14 –conference. Ambience'14&1013m, 7-9 Sept 2014 Tampere, Finland.

De Raeve, A., Van Ransbeeck, P., Cools, J., Vandersmissen, B., Vasile, S., & Vermeulen, M., 2014. Towards Virtual Engineering of Clothing Comfort. Proceedings of Ambience '14 –conference. Ambience'14&1013m, 7-9 Sept 2014 Tampere, Finland.

- Finatex 2014. Sitran hankkeella uudenlaista liiketoimintaa tekstiilialalle. News 5.12.2014. Referenced 10 December 2014. www.finatex.fi/uutiset/sitran-hankkeella-uudenlaista-liiketoimintaa-tekstiilialalle.html.
- Fletcher, K. 2008. *Sustainable Fashion and Textiles: Design Journeys*. London: Earthscan.
- Greenpeace 2012. Chemicals for any weather. Greenpeace tests outdoor clothes for perfluorinated toxins. Referenced 13 January 2015. www.greenpeace.org/romania/Global/romania/Chemistry%20for%20any%20weather.pdf.
- Gupta, D. 2011. Design and Engineering of Functional Clothing. *Indian Journal of Fibre & Textile Research*. Vol. 36, December 2011, pp. 327-335.
- Gwilt, A. 2011. Shaping sustainable fashion: The Points for Positive Intervention by the Fashion Designer. In Gwilt, A. & Rissanen, T. 2011. *Shaping Sustainable Fashion: Changing the way we make and use clothes*. London: Earthscan.
- Von Hippel, E. 2005. *Democratizing innovation*. Cambridge: MIT Press.
- Ifixit 2015. Patagonia Care & Repair. Repair your Patagonia gear. Referenced 20 January 2015. www.ifixit.com/Patagonia.
- Konola, S. 2014. From Co-design to Convivial Design. Insights from engaging users in a participatory clothing design process. Pro Gradu Thesis. University of Lapland.
- Lamb, J. M. & Kallal, J. M. 1992. A Conceptual Framework for Apparel Design. *Clothing and Textiles Research Journal* January 1992 vol. 10 no. 2 pp. 42-47.
- McCann, J. 2014. Co-design development: design direction for the clothing layering system as a wearable technology platform. In McCann, J. & Bryson, David (ed.) 2014. *Textile-led Design for the Active Ageing Population*. Woodhead Publishing.
- McDonough, W. & Braungart, M. 2002. *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press.
- Meinander, H. 2012. Vaatteiden toimivuus ja tekninen vaatetutkimus. In Koskennurmi-Sivonen, R. (ed.) 2012. *Johdatuksia pukeutumisen tutkimukseen*. Publications of the Association for Textile Culture 6/2012. Helsinki: Tekstiilikulttuuriseura.
- Ma, Y., Määttänen, M., Särkilahti, A., Harlin, A., Hummel, M. & Sixten H. 2014. TEXTILE FIBERS FROM RECYCLED MATERIALS. Proceedings of Ambience '14 - conference. Ambience '14&1013m, 7-9 Sept 2014 Tampere, Finland.

Myette, K. 2014. Doing well or looking good? A systems approach to transformative change in product and supply chain sustainability. Keynote in Ambience '14 –conference in Tampere Tuesday, 9 September 2014.

Papanek, V. 1984. Design for the Real World: human ecology and social change. London: Thames and Hudson.

Papanek, V. 1995. The Green Imperative. London: Thames and Hudson.

Redortier, B., Voelcker, T. & Jacob, B. 2014. Manikin vs Human for Sports. Proceeding of Ambience '14 –conference. Ambience'14&1013m, 7-9 Sept 2014 Tampere, Finland.

Risikko, T. & Marttila-Vesalainen, R. 2006. Vaatteet ja haasteet. Helsinki: WSOY.

Sanders, E. & Stappers, P. J. 2008. Co-creation and the new landscapes of design. CoDesign, Vol 4, No 1, pp. 5-17.

Seppälä, L. 2010. Sustainable and responsible outdoor clothing: What every designer should know. Pro gradu Thesis. University of Lapland.

Teijin 2015. TEIJIN | Solutions | Closed-loop Recycling System: ECO CIRCLE. Referenced 13 January 2015. <http://www.teijin.com/solutions/ecocircle/>.

Tukes 2014. REACH-asetus. Referenced 16 December 2014. <http://www.tukes.fi/fi/Toimialat/Kemikaalit-biosidit-ja-kasvinsuojeluaineet/Teollisuus-ja-kuluttajakemikaalit/REACH---asetus/>.

Tuomaala, P. 2014. ”HTM-malli osoittaa: Ihmisten lämpöaistimuksissa on huimia eroja”. Referenced 19 December 2014. <http://rym.fi/fi/htm-malli-osoittaa-ihmisten-lampo-aistimuksissa-on-huimia-eroja/>.

VTT 2014. VTT: Jätetekstiilistä voi valmistaa jopa alkuperäistä parempaa kangasta. News 15.6.2014. Referenced 16 December 2014. <http://www.vtt.fi/medialle/uutiset/vtt-j%C3%A4tetekstiilist%C3%A4-voi-valmistaa-jopa-alkuper%C3%A4ist%C3%A4-parempaa-kangasta>.

Wornwear 2015. The Stories We Wear. Referenced 20 January 2015. <http://wornwear.patagonia.com>.

ATTACHMENT 1. INTERVIEW QUESTIONNAIRE

A. Background information

1. Name & Age
2. Profession
3. Tell something about your work/hobby where functional clothing is needed

A. Use context and needs

4. What kind of clothing or gear you need for your hobby/work? Where do you get them from?
5. In what kind of conditions clothing is used?
6. What do you consider as their primary function (for example protection, communication, identity)
7. What kinds of properties are important for you in clothing and gear?
 - Protection from the cold
 - Protection from the wind
 - Protection from rain and moisture
 - Use comfort
 - Mobility
 - Ease of maintenance
 - Visibility
 - Quality and durability
 - Transformability and multi-functionality
8. What is especially good and especially bad in the current clothing you have?

B. Aesthetics and associations

9. Are the design and style of clothing important to you? What properties particularly?
10. Do you favour clothing from particular manufacturers or brands? If so, why?
11. What type of clothing is favoured in your field of activities?

C. Materials, production, product and service solutions

12. What do materials mean to you in clothing? What materials do you favour and why?
13. Clothes maintenance – how and how often it is done?
14. Do you customise your clothing? Why?
15. Would you like to influence or take part in designing clothing? How?
16. Do your work/hobbyist clothing have any technology or intelligence embedded in them? If so, what kind and why? If not, would you need any?
17. Do you ask for tested information on clothing properties? Pay attention to certificates or standards?

18. Would you be interested in using a clothing service, where you for example rent the clothes you need for a certain period of time and this service would also take care of maintenance and disposal?

D. Consequences

19. What is the average lifetime of your work/hobby clothing?
20. For what reasons are the clothes disposed? Where do they end up?
21. Is environmental friendliness something you pay attention to in clothing?
22. Is transparency in production processes important to you (for example who makes the materials or who make the clothes and where)?
23. Are there domestic options to the types of clothing you wear? Would you like there to be and would you be willing to pay for domestic production?
24. Are you interested in materials utilisation at the end of life cycle?

E. Future and visions

25. What type of clothing do you think is needed in your field of activities in the future?
26. How do you think products or services in your field should be developed?



»» PERSPECTIVES
ON ARCTIC WORK AND
PROTECTIVE WEAR REQUIRE-
MENTS AND SOLUTIONS

INTRODUCTION

One of the main goals of the ArcticPro Lapland project has been to update and improve existing research, development and innovation facilities regarding arctic protective wear at the University of Lapland and Lapland University of Applied Sciences. To do this, we sought to find out what is needed now and in the future in the field of cold and arctic wear. To continue the work started in ArcticPro network survey conducted in 2013, we decided to examine what themes or issues especially interest or concern suppliers and users and where they see research is needed. This article concentrates on the insights of user research conducted with representatives of different companies and organisations using work and protective wear in arctic conditions. User needs for arctic work and protective wear are discussed as well as focus points for future research and development projects surfaced.

METHODS AND RESEARCH QUESTIONS

The purpose of this user research is to uncover immediate and emerging needs and research and development topics from the field of arctic work and protective clothing. The main research question is: What are the current user needs with regards to work and protective wear? This is divided into a few subquestions. What kinds of requirements are posed for workwear today? Are users happy with the current products in the markets? What kind of research and development needs arise with regards to the products and services in focus? This research is not user research for any specific industry or field of activity. User research serves the interests of this project first and foremost but may also offer or strengthen new openings to the discussion on work and protective clothing used in our climatic conditions.

During autumn and winter 2014, interviews of individuals from different companies and organisations using work and protective clothing were conducted. The positions of the interviewees ranged from head of security managers to different types of managers and workers. Fields that were interviewed in this sample, were construction,

forestry and forest research, power-, telecommunications and ICT network building and maintenance, snow research and tourist safari services. All interviews were conducted by the project personnel as thematic, semi-structured interviews and were based on the same question form prepared by project personnel (Attachment 1). Themes and questions for the interviews were chosen combining theoretical frameworks introduced later on, as well as practical considerations. Interviews were recorded on audiotape, all but one conducted via e-mail, transcribed and then analysed. Data was analysed with a thematic, qualitative analysis. A loose quantitative analysis accompanied this, transforming key concepts, and those closely related, into frequencies.

THEORETICAL FRAMEWORK

As we are examining what kind of research and development topics stem from the users and what properties are generally considered important in work and protective wear, we also need to take a look at the literature in the field and examine what kind of requirements are considered relevant. The field of work and especially protective wear is very different from the field on functional clothing in the sense that it falls under many legislative frameworks starting from European safety and health legislation, national laws and can also be affected by field specific collective labour agreements. Thus, as one of my frameworks, I will use The Directive on Personal Protective Equipment (PPE) 89/686/EEC which defines the basic requirements to be satisfied by personal protective equipment and the accompanying SFS-EN ISO 13688:2013 harmonised European standard drafted to facilitate proof of conformity with the requirements. To my understanding, similar basic requirements for non-protective workwear issued by a directive don't exist, but employers do have the responsibility to guarantee their workers' health and safety at work (Työturvallisuuslaki 23.8.2002/738). Only a few theoretical models on the design processes of protective clothing design have been presented (Black, Kapsali, Bougourg, & Geesign 2005, 64). However, Black et al. (2005) have put together a tree of functional design requirements (adapted from McCann 1999) that demonstrates primary and secondary considerations for protective wear and divides it into more detailed sub-choices. Thirdly, as a framework for identifying product requirements and establishing design criteria, I will use a product assessment tool of a six-sided function matrix introduced by Victor Papanek in 1970's. It doesn't particularly address clothing design, but has been applied in a few instances especially to functional design considerations (see for Risikko & Marttila-Vesalainen 2006 referring to Anttila 1993).

The PPE directive lays down basic requirements for all PPE. First and foremost “*PPE must provide adequate protection against all risks encountered*” (89/686/EEC, Annex II). Directive then states general design principles to be taken into account; ergonomics and levels and classes of protection and risks. Harmlessness, or innocuousness of PPE refers to minimising any obstructions to movements, postures or sensory perception,

as well as avoiding adverse effect of materials or their decomposition residue, PPE parts or their surfaces, to the user. Comfort and efficiency are highlighted in their own clause and include requirements of adaptation of PPE to user morphology “*by all appropriate means*” and PPE being as light and strong as possible with regards to adequate protection. Finally, PPE must be accompanied with use instruction that includes, for example, instruction on the proper use, maintenance and storage instruction, fitting, dressing and undressing instructions if applicable, possible use limitation instruction and so on. ISO 13688:2013 standard for the general requirements of protective clothing provides more hands on means to conform to the requirements presented in the directive. To determine the innocuousness of materials for example, the standard directs towards familiarising oneself “*with information on the classification and identification of harmful substances*” provided in the REACH regulation, but provides also a flowchart of questions for determining acceptability of materials (ISO 13688:2013, 4.2). It must be noted that the standard on general requirements is always used together with specific standard for specific protection.

The tree of requirements in the design development of protective clothing by Black and Kapsali identify five primary requirements that design must consider (Figure 1). These include identification of user needs, overall clothing system, protective function, form and style and finally performance and cost (Black et al. 2005, 69-70). There is perhaps some overlap between ergonomic considerations of user need and needs of the body mentioned in the context of protective requirements, but on the other hand this model includes considerations not voiced in any legislative framework.

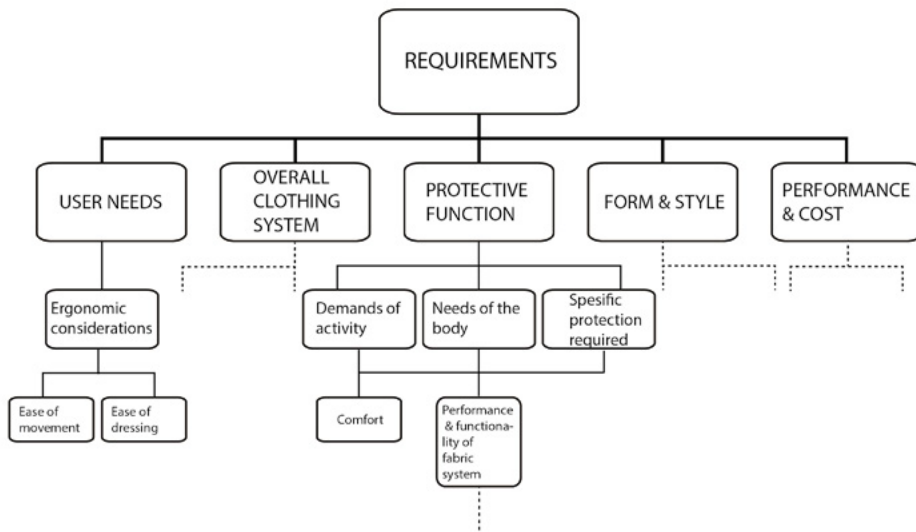


Figure 1. Main requirements and a few branches of the tree of requirements in the design and development of protective clothing (Konola 2015 after Black & Kapsali in Black et al. 2005, 70). Alkuperäinen tiedosto nimellä APW requirements.

For example form and style refer to considerations of culture of activity and contemporary aesthetics, which can influence the acceptance of workwear, as authors suggest (Black et al 2005, 61). Black et al. (2005, 65,70) do acknowledge a review on legislation and standards as a part of the process of apparel product development, more specifically the problem exploration phase, but have included standards only as a small sub stick of their performance and cost branch.

Papanek fractions functionality into six different aspects that any design object needs to address. These include method, need, use, association, aesthetics and consequences. Shortly, with method, Papanek refers to the relationship and interaction of tools, processes and materials. He advocates that materials and tool should be used optimally and honestly and most should be made out of materials inherent properties. (Papanek 1984, 8). Objects are evaluated through concepts of need and use. We need protective clothing for protection and they can be evaluated through whether they function as intended in use. Or are there perhaps more diverse needs and who dictates what needs are taken into account? Aesthetics and associations deal somewhat with same questions as Black et al.'s form and style, as Papanek's associations as cultural preconditionings can also be understood as cultures of activities. Different from other frameworks is the concept of consequences. To Papanek design is functional only if it takes into account it's consequences, whether social, environmental, economic and so on. PPE directive, however, presents some echoes of this as it calls for harmlessness of the materials. ISO standard specifying this acknowledges environmental impact of product in all life-cycle stages, but only includes suggestions to minimise environmental impact and an informative Annex F regarding environmental aspects such as material selection, recycling and packaging to name a few (ISO 13688:2013).

REQUIREMENTS FOR WORK AND PROTECTIVE CLOTHING

Through introducing the frameworks we have established that lists of requirements vary depending on where clothing is approached from; a legislative, design focused or environmentally considerate point of view. These frameworks will be further discussed next to insights from the user research conducted. It is worth pointing out that work and protective wear requirements will only be discussed in the context of the above mentioned industries and fields of work. Possible dangers or hazards presented here include only mechanical, temperature and electricity hazards as opposed to for example chemical or biological hazards that can present themselves in other kinds of work.

Levels of requirements – from legislation to work and user specific requirements

When we are talking about Finnish work and protective wear, requirements posed by national and EU wide legislation are the first level of requirements to be taken into account. If the risk assessment that is required to be carried out in all workplaces shows that PPE is needed, then this dictates that acquired and designed clothing also needs to conform to 89/686/EEC directive. As already presented, this directive states some general design principles to be taken into account when designing PPE. Even though no protective wear is needed, according to the Finnish work legislation, the employer has an obligation to take care of the employee's safety at work. The employer must be provided with appropriate equipment when working conditions or nature of the work so require (Työturvallisuuslaki 23.8.2002/738). Two research institutes from our respondents serve as a good example where no special protective clothing is needed, but where the employer provides the workers with appropriate clothing for outdoor work they must regularly conduct. The keywords here are safety and clothing appropriate for work.

When talking about work and protective wear, there are at least two kinds of users that pose their own requirements for the clothing: the employer organisation, and the worker. In Finland, trade unions may have also defined requirements for workwear into the collective labour agreements. For example, in the food industry employee is obliged to provide workwear, but also because of the hygiene requirements, take care of the maintenance (Toimiva työ- ja suojavaatetus 1996). PAM, a trade union for people working in the private service sector has negotiated that employees in the retail sector must provide their permanent workers with appropriate workwear, but this is not always complied with (ESS 2012). From our interviews we discovered that in organisations where special PPE is not required and organisations don't have a nationwide unified image, workers can influence the acquired clothing a lot; decisions were done as a team while working conditions, individual and general requirements were discussed and negotiated. With bigger firms we interviewed people locally responsible for work security or workwear acquisition. They knew the working conditions, job requirements and PPE needed well, but they didn't know much about the company procurement criteria. It can be inferred that needs vary according to organisation and user levels.

Legislative and protective requirements

To both user representatives, protection can be considered as the basic requirement workwear. Employees are required by law to protect the workers and workers, at least in our small sample, consider protection as the most important attribute for work and protective clothing. What protection is needed from depends on the activity. Risk assessment determines what kinds of hazards are likely to be encountered at a workplace. These can be anything from mechanical, biological, heat and fire to

radiation. At a construction site, for example, mechanical protection is needed from head to toe with added visibility. PPE is always designed to protect from one or more types of hazards. There are specific standards for most commonly identified hazards such *Protection against heat and flame* (ISO 7000-2417) or *Protection against cut and stabs* (ISO 7000-2483), just to name a few. Black et al. (2005, 69) address protection requirements as any specific protection required, but also speak in more general terms of protective functions arising from needs of the body and demands of the activity. This can be seen as a more determining perspective for normal workwear.

As we are talking about arctic wear, respondents first and foremost required protection from the cold and moisture or rain. Cold or foul weather, however, are not considered a serious hazard if conditions are not “*of a neither exceptional nor extreme nature*” (89/686/EEC). There are three classes of PPE with regards to the risk and protection level, but the first level equipment doesn’t need EC –type examination. It is interpreted that “*user can himself assess the level of protection provided against the minimal risk concerned the effects of which, when they are gradual, can be safely identified by the user in good time*” (89/686/EEC: Article 8). In Finland it is expected that workers dress according to the weather conditions and protective clothing as PPE is only needed with exceptional conditions that would intensify adverse effects of the weather (Työsuojeluhallinto 2010, 6). Probably due to the broad interpretation possibilities, protection from the cold is not followed by the directive book and standards, but by common sense. Cold is often not assessed a hazard requiring EC –type examined PPE, but workers are protected from the cold by providing appropriate winter clothing, in some instances also mid-layer.

Physiological and ergonomic requirements

Physiological and ergonomic requirements of comfort and ergonomics, as examples, can be considered the very basic general requirements for any work and protective clothing. European Directive 89/686/EEC also considers ergonomics in addition to protection as the primary design principle. As a summary, clothing should be designed and manufactures so, that activities can be normally performed while enjoying highest protection possible, so that correct positioning of PPE is facilitated with regards to movements and postures and so that it is as light, strong and efficient as possible. In our user research, thermal comfort and protection from the cold, moisture management and overall functionality of workwear with regards to mobility, correct fit and thus operational capability were the properties most highly regarded. In Black et al.’s (2005) tree of requirements comfort arises from the needs of the body and ergonomic requirements refer to ease of movement and ease of dressing and undressing. In the ISO 13688:2013, comfort is one of the basic health and ergonomic requirements and refers to correct fit, allowing proper movements, avoiding heat stress and injuring

or irritating surfaces (ISO 13688:2013, 4.4). Our respondents mostly discussed comfort in terms of thermal comfort, mobility, sizing and performance.

Perhaps a distinct feature of arctic work and protective wear is that thermal comfort and protection from the cold climb high in the requirement priorities. These features are considered most important features of any workwear during the winter, fall and early spring by the respondents. Quantitative analysis also revealed this as the most discussed topic right after protection and safety. In many jobs people are out there no matter rain or shine, freezing cold or wet sleet. Construction sites usually have cold limits somewhere around -20°C and snow researchers can choose to stay indoors on the worst days, but for example electricity grid repair men can work “in extreme conditions” as broken power lines need to be repaired as fast as possible. Interestingly, even though this is considered very important, only two of the respondents had heard about the existence of a standard on protection against cold environment (EN 342). One respondent had not heard about this, but suspected that their clothing has it, because “...*there are those standards there in our (ordering system)...but I have never really read them...*”. One respondent knew this standard very well but didn’t see it compulsory or relevant because “*the results chart (about thermal insulation and level of performance) is only directional, because for example wind and air moisture affect thermal comfort so much.*” Rather than standards, organisations and workers seem to trust common sense and experience. Generally work and protective wear was considered warm by the respondents. Problems and cold are experienced with extremities like hand and feet. Especially cut resistant gloves were mentioned to be cold as well as protective boots. Protective boots were also mentioned very slippery.

Adverse health effects of the cold are well known and Finnish employers and employees probably consider and take care of appropriate protection quite well, but it can be asked, should more attention be paid to this issue. The EN 342 standard for protection against cold environment characterises cold environment as “*combination of humidity and wind at air temperature below -5°C* ” (SFS-EN 342:2005). This technical specification implies that EC marked clothing should be worn below these conditions. Also discomfort due to cold starts to appear already in 10°C (Työsuojeluhallinto 2015). Also garments certified by the EN 342 standard, are tested with two layers of undergarments. The provision of mid-layers or undergarments, however, seems to be optional. In our small respondent group, most employees only provide workers with the outer layer. The rest are workers’ own responsibility. Two respondents report of a mid-layer shirt provided for the workers, but all know and speak about the importance of layering. According to Black et al. (2005, 74 referring to Renbourn 1971), functional properties of textiles or features may be lost within the complexities of clothing systems if they are not designed “*to work in an integrated manner*”. In addition, a distinct feature of arctic work is to be able to move about in the snow and in the forests – and most often this is done with snowmobiles. All but one of our respondents rode a snowmobile as some part of their work. Snowmobiles are also a common vehicle for the police, army

and for example reindeer herders in Lapland and other Arctic areas. Thus one needs to consider not only requirements of the job, but the conditions of moving in between the tasks with the snowmobile. Those who didn't have a special snow mobile outfits added an extra layer, an overall or jacket to their normal clothing to ride when necessary. Wearing a snow mobile outfit to work is balancing between thermal regulation and extra windy conditions when riding. Riding conditions can also be physically demanding and then internal moisture accumulates. A special heat dress is considered necessary when riding a snowmobile because the cold wind enhances the effect of weather conditions (Työsuojeluhallinto 2010, 6).

Moisture management is an important part of thermal comfort and very much also connected to cold protection. Respondents rated protection from moisture, rain and wind right next to protection from cold and if quantity analysis results are combined with discussions on breathability, they exceed cold. Accumulating moisture either from inside when sweating or outside from sleet or snow, adds to the experience of cold. If this is combined with windy conditions or a snowmobile ride, "*conditions can get severe*". Snow can wet fabric easily and getting wet in a snowy forest is reported a common problem: "*When you have to deal with snow and it starts to wet there from the front fast...it is not very nice...when your knees start to get wet. You sure are gonna miss your mother.*" Many mentioned to prefer Gore-Tex as a material to protect from the outside moisture, but at the same time it was regarded not breathable enough. Because wet feet and hands are such a common problem, many carry extra socks and gloves with them, some even extra shirts. Many times changing weather and working conditions even during one day are especially challenging for moisture management and thermal comfort. Especially during the spring it can be very cold in the morning, sunny and warm during the day and again freeze towards the evening. In between, one might have to ride a snowmobile, do precise rather immobile measurement or maintenance work as well as walk in heavy snow or perhaps clean up thicket or snow from power lines. Construction workers can alternate between moist and warm indoors and windy and freezing outdoors. Transformability and multi-functionality were not regarded as very important properties, as respondents replied clothing is meant for a specific job, but the importance of layering and possibility for thermal regulation according to conditions was widely discussed.

The overall functionality of workwear with regards to mobility, correct fit and thus operational capability is essential in getting work done efficiently. Mobility and use comfort were rated high in importance by all of the respondents and if combined with numbers from the quantitative analysis regarding correct fit and sizing, they are the next most discussed features. One of the respondents stated keeping workers operational as the primary task for work and protective clothing. This view is also reflected in the ergonomics, comfort and efficiency requirements presented in 89/686/ECC directive. Directive emphasizes the importance of correct fit and mobility in stating that "*it must be possible to optimise PPE adaptation to user morphology by all*

appropriate means, such as adequate adjustment and attachment systems or the provision of an adequate size range". This requirement doesn't seem to be realised in some of current work clothing. The majority of the respondents complained about the lack of correct sizing in clothing and some also in shoes. One respondent reported that their trousers tear from the crotch because they are too big and thus don't allow wide mobility. The crotch is even mentioned as a specific point for consideration for appropriate proportioning and positioning in the general standard (ISO 13688:2013, Annex C). Failures in sizing can lead to loss of protective abilities: *"We get feedback very easily if clothes are such that you cannot work in them. If for example knee pads are in the wrong spot, we will get comments."* If you want better fit from the waist, pants are often too long from the leg and crotch. Body type size variety is too narrow – even though *"there are many sorts of bodies"*. Women in one organisation had trouble finding clothing small enough. Extra protection also seems to reduce wearing comfort. The warmer the clothing, the heavier it tends to get. Also the warmest boots with felt lining were reported good for standing, not walking. Flame retardant or electrical protection clothing is reported stiff and even more so if it gets cold and wet. Cut resistant trousers and overalls are also considered stiff and heavy. Comments like *"straitjacket"* and *"tin plate outfit"* were mentioned in this context. A comment from one respondent sums up this discussion quite well: *"Work clothing that would keep wet and cold away, would be visible, comfortable and flame retardant, that hasn't been invented yet."*

Aesthetic and associational requirements

When it comes to work and protective clothing, aesthetics is subsidiary to functional design elements such as sizing and fit. In many cases of protective wear the aesthetics is very much dictated by protective requirements. For example, the standard on high visibility clothing dictates, according to the protection class, the minimum surface area of fluorescent and reflective materials in square metres (EN 471:2003+A1:2007). Chainsaw protective clothing also has design requirements on where protective areas need to be located (EN 381-5:1995). These requirements can make work clothing look rather similar, differences being in the details and colours. Associations that aesthetics create, however, matter to some extent. Respondents only required that workers look clean and good, not *"wearing rags"*. Sizing and fit, however, are a great subject of concern, not only for physical performance, but also because of looks: *"...a few years ago, especially management complained that these clothes are such that one doesn't really care to walk about around the town in them."* To Black et al (2005, 70, 76) form and style of one of the basic requirements and they claim that aesthetics contributes to the success or failure of a clothing system *"through the way it makes the user feel, allows for personal expression..."* even though they acknowledge that little research is done in this area. An example of the influence of *"contemporary aesthetics"* (Black et al. 2005, 70) especially in cut, style, proportion and fabrics trends in the acceptance of occupational wear, however, was clear in the recent uniform reform of Finnish Border

Guard, at least according to the designer in question. The new, sporty collection with functional materials and innovative solutions was well received by the staff (Kuusisto 2014).

Image, recognition and differentiation can be attributed as aesthetic requirements more from the organisation side. For the workers, this is mostly taken as given. How important brand, differentiation or unified looks is, depends on the organisation. Some mentioned these as essential while others reported organisation not having any unified looks. Big organisations often, together with manufacturers develop a company specific collection for their individual needs and looks. Two of our respondent organisations operated like this. Few of the respondents from bigger organisations mentioned looks as an image issue, especially safari firm which works in the service field. Colour can be a tool for differentiation and branding. Company building infranets uses orange high visibility colour to go with their brand and logo even this colour is more expensive to make than yellow. Generally, colours don't really concern the workers, but are probably accepted as a part of what Black et al. (2005, 70) refer to as "*culture of activity*". Only favourite colours in work and protective clothing seem to be high visibility colours that are required in many jobs. Recognition and differentiation are mostly created in through colour and printing or embroidering logos or company names on jackets.

Product-service system level requirements

Thinking about work and protective wear provision as a service might not be a state of mind for everyone yet and customers might not demand it as such, but many service level requirements arouse from the interviews, where improvements can be made and added value created. These include ordering and feedback system or software, instructions of proper use and maintenance, maintenance and repair services as well as customisation possibilities. Clothing services already exist in the workwear field, but there are many factors that arouse scepticism about the functionality of these services. Over half of the respondents had not even heard about them. One company had had a pilot test with a system where they had two sets of clothes, maintained and repaired by laundromats, but this service had not been adopted. Biggest reasons for rejecting the idea were imagined costs, but some mentioned they would like to see some calculations and comparisons of the costs between this and the purchase model. Short lifecycle was also seen as an obstacle: "*...I don't think maintenance could prolong the lifecycle of these clothes so much (that it would be worth it).*" Workwear and maintenance habits were also perceived so personal that service model was hard to imagine for the smaller organisations: "*these have been so personal...everyone takes care of their own outfits...-...some keep their clothes here at their own lockers, but some have them at home...*" Two of the organisations were very positive about the idea and other respondent imagined this a well working systems for their other department: "*...for these laboratory activities that we have here...for their*

protective clothing it could very well be in use even today. Could always get clean outfits and other ones would be in maintenance”.

Maintenance and repair services, or those providing guidance and instructions for proper maintenance are clearly required. Services were not widely used in our small sample; in half of the organisations workers are responsible for washing the clothing themselves. A few have their own maintenance facilities. It is well known that washing decreases protective properties of flame retardant and cold protective clothing for example. Company that is compelled to count the washing cycles of their flame retardant clothing was the only one regularly using laundromats. Those who wash clothing themselves request ease of maintenance and dirt repellent properties, but at the same time suspect that workers probably don't wash their clothing correctly to sustain those properties: *“And if there are some coatings and such...then they anyway wash them themselves so it probably doesn't always go by the book...”* Only one small organisation reported occasionally using local services to repair broken zippers of sleeves, as they found it beneficial to continue the lifetime of otherwise perfectly good garment. 89/686/EEC directive requires the following maintenance related information to be supplied by the manufacturer: instructions on storage, use, cleaning, maintenance, servicing and disinfection, as well as obsolescence deadline. The ISO 13688:2013 standards details these even further down to for example instruction on fitting, suitability for industrial or domestic washing, instruction concerning repair and so on. Many textile service companies take these into account, but when left to the users themselves, nothing is guaranteed. One of the respondents describes differences between maintenance habits of individual workers: *“...then you person by person see how someone take care of the clothing very diligently and others have clothing like they've gone through a bombing when they have worn them a week...”* Black et al. (2005) see user beliefs and behaviour directly affecting the success of clothing system functionality. It has been found that if functionality of a garment is not transparent to the users, they might reject it (Black et al. 2005, 75 referring to Perkins et al. 1992). Transparency requires instructions and a chance to follow those instructions. Mistreatments, if not rejection, were reported by our respondents who suspected functionality properties fading due to improper care.

Many issues surfaced by discussions on ergonomic and aesthetic requirements also give rise to customisation or collaborative product development services. On a user level, being part of the product development process is not really important, but on the level of organisations, company specific workwear collections are wanted services. On the user level, a need for feedback methods, as well as some customization services is voiced. Big organisations often, together with manufacturers develop a company specific collection for their individual needs. Many workwear manufacturers offer this service. Workers can many times also choose whether they like an overall or separate jacket and pants from the collection. This quality in the ordering system was commended because there clearly are individual preferences and people like different

combinations: *“There are pants and then there are hanging pockets pants and there are separately also vests. There is variation, so that you can combine them as you wish. Because some people insist on hanging pockets and to some those would never do.”* Two of our respondents reported of a collection developed for them and a third company otherwise close communication with the manufacturer. Ready-to-wear clothes were customised with organisation specific embroidery. Those dealing with manufacturers also give feedback and some report of user experiences being collected by the procurement representatives. Feedback takes time to take effect, it seems, as collections are slowly renewed and some problems are reported never to be fixed, like bad quality zippers. Only specific customisation option that users hoped for, in addition to the placement of pockets, were better fit and sizing options.

Cost efficiency and a functional, quick and reliable ordering and delivery system are what are appreciated in workwear procurement today. This is a special requirement of work and protective clothing because the field deals with organisations, usually competitive for-profit companies where expenses are optimised and every purchase put out to tender. Bigger organisations have nationally centralised procurement that decides on acquisition criteria and purchases. Average worker has no say in this and reclamations can be sent through same procurement system as ordering is done. Fast delivery through the system is appreciated, but a clear fault is that people easily pick the wrong size, because sizing is so different with every company and there is no opportunity for fitting. Small teams acquiring their own clothing were happier with the clothing fit and quality, because they were able to try them on and deliberate between choices: *“We have noticed that if we buy a bit more expensive outfit, then it will usually last, at least that two years.”* Others live with the current realities: *“There are all sorts of pieces of equipment, meaning that some could be more practical, but it is that euro that haunts all operations”*. To Black et al. (2005, 70) performance and function are an important branch of the requirement tree where value for purpose, manufacturing methods, commercial considerations and relevant standards meet. Thinking about improvements to the current systems, in the form of better fit through body scanning or acquiring workwear through services, not purchase for example, always leads to questions on the costs. Before someone can show the monetary benefits of more durable clothing, better maintenance and workwear services – not to mention the increased work efficiency and reduced sick leaves through better fitting and more protective clothing, changes are slow. One of the respondents found the possible connection between wellbeing and workwear very interesting as *“we should lift our productivity and keep people healthy to the end of their career. It is a big issue today...-...if people retire at fifty, it cost a whole lot of money for our house...-...it is a good thing (to think about)... these things, that this workwear could keep rheumatisms and such away.”*

Sustainability requirements

Quality and durability can, or should, be considered general requirements for any clothing. User respondents regard these two as important properties in clothing, but this doesn't manifest itself in the average life of workwear. Respondents request for durable textiles that would not wear or tear easily, but report of trousers lasting only two to three months due to breaking knee reinforcements and too soon discarded vests when zippers give up. Shortness of the average lifecycle seems comparable to the harshness of conditions and physical exertion of the work. Companies working with construction, network building and maintenance and forestry, report the shortest lifecycles – between under and over six months. In less consuming work that researchers do, clothes are estimated to last from two to five years and with tourist safaris three to four years. Directive in **89/686/EEC** deals with these only with regards to aging and in stating that *“If it is known that the design performances of new PPE may be significantly affected by ageing, the date of manufacture and/or, if possible, the date of obsolescence, must be indelibly inscribed on every PPE item”*. This mainly refers to diminishing protective properties or dimensional changes through cleaning, as specified in ISO 13688:2013. Subclause on colour fastness has been removed from this new standard. Perception and expectations of general quality vary. One respondent reports of pieces from a few decades ago that would not break even if you tried and to another respondent today, it is normal that a new set of clothing arrives every spring and fall. To Black et al. (2005), quality and durability seems to be subjects relational to performance and cost, since these are mentioned primary requirements, but the two concepts in question are not mentioned in the tree.

Minimal environmental impact and health effects are hoped for, but perhaps not actualised. Basic health and safety requirements in 89/686/EEC directive states that no PPE materials, or their decomposition products, should adversely affect user health. Accompanying the ISO 13688:2013 standard continues that materials should be chosen so, that the environmental effects of production and disposal are minimised. A quick look through some of the catalogues of Finnish work and protective wear producers does not reveal any environmental certificates or proof of the non-toxicity of materials. That is not to say materials are somehow harmful, but this information just isn't disclosed to the public or clients. This is probably due to the tendency that clients are not really interested in sustainability. To none of the respondents was environmental friendliness or ethics a criterion in tendering. Some of the respondents knew that even though their company holds *“green values somewhat important”* or that environmental consequences are a matter of concern, in clothing and protective gear, this is not an issue. Some of the respondents had no idea about the procurement criteria, but were sceptical about *“how these kinds of requisites would exist”*. Small organisations making their own procurements could perhaps consider these as *“this environmental friendliness could tip over the scale to some choice”*, but *“it is more important that the clothing works, than it would be somehow more environmentally*

friendly". In all of the respondents' organisation, discarded clothing ends up in landfills. In most organisations disposal is left to the workers. Thus, there is no way of ensuring proper disposal.

Ethics of production or knowledge on production countries is not really topic for concern. This view present in the user interviews is also depicted in Finnwatch report on public workwear procurement. Most public purveyors don't take production conditions into consideration when making workwear purchases (Finnwatch 2011). There is some interest and support for domestic production and production, however. A third of our respondents are interested in domestic production and would even be willing to pay the extra cost, while second third is a bit sceptical about the business realities and that would current EU competition law even allow this. For the last third, international manufacturing and tendering is an everyday practice that will not change. Directive or standards don't comment on the ethics of production, nor is this present in the tree of requirements presented by Black et al. (2005). For Papanek (1995), consequences, whether social, environmental or economic are an important corner of any product's function. Especially the relationship with materials and processes and the consequences brought about by these choices, Papanek connects with pollution and resources depletion (Papanek 1984, 23-24). Consequences of workwear production, whether social or environmental, are however slowly paid attention to by some of producers and users or buyers. Finnwatch (2011, 4) discovered in their inquest that at least in 2011, a third of the public procurement respondents posed some ethical criteria to their purchases, when four years earlier it was none. Some kind of ethical codes of conduct were found from all the producing companies manufacturing in or purchasing from Asia, but only two of Finnwatch respondents required conforming to ILO Fundamental Principles and Rights at Work³. Environmental issues were only one small part of a longer list and demanded by half the companies. (Finnwatch 2011, 7, 30). There is a growing demand to extend the idea of clothing services to include clothing collection and disposal at the end of workwear lifecycle. Idea of clothing services raised much more interest among the respondents when it was connected with the idea of life cycle services. Even those who had never considered using clothing services, expressed interest to know more. Recycling clothes or materials at the end of their lifecycle is not a topic respondents have been actively thinking about. Only two respondents mention a second life for the clothes before the bin; as maintenance clothing and as spare clothing in the guest storage. When presented with ideas of recycling systems that would collect and utilise discarded materials, most would be happy to adopt them. When the interviewee presented a vision of a circular economy to one of the respondents and suggested a service that would collect discarded clothing and see them to recycling, this was happily received: *"That would be easy!...-...I imagine they are not much joy out there in the cottages. So perfectly well there could be*

3 These include freedom of association and right to collective bargaining, elimination of forced or compulsory labour, child labour and elimination of discrimination in respect of employment and occupation (ILO 2015).

a recycling system for them.” One of the respondents mentioned especially rubber boots as a problem he would like to see answered: “...*these rubber boots. They are one of these problems, that when there comes a hole, they are bygones*”. Organising collection bins, or specific times for collection were suggested as an easy system for redundant clothing and gear, accumulation of which now is seen as a problem. One of the respondents was aware of the 2016 EU directive concerning textile disposal to landfills, but continues that recycling for them “*is not very current*”.

METHODS FOR MEETING REQUIREMENTS

Methods for meeting legislative and protective requirements

Standards are a method for meeting legislative requirements that The Directive on Personal Protective Equipment (PPE) 89/686/EEC lays down. Experts and stakeholders taking part in the standardisation work have established criteria for adequate levels of protection for types of hazards identified. To get the CE mark for protective gear and clothing needed to be selling them in the EU, following the standards is a way to make sure products fulfil the requirements and pass the inspection. Manufacturers can also use “*other technical specifications*” to document and prove compliance with the basic requirements (89/686/EEC). Standards are a safe choice in the sense that they dictate many design solutions from ergonomics to material, measurements and maintenance, just to name a few. Standards, however, don’t always represent the best possible protection. The ArcticPro network survey for suppliers reveals that over 70% of the respondents prefer to go beyond the requirements of the law when it comes to developing PPE (ArcticPro Product Supplier Survey 2013).

Advances in textile technologies have made it possible to engineer materials to protect from specific hazards - and materials are usually the method to start with when meeting legislative and protective requirements. Even if we don’t talk about biological and chemical hazards where the textile properties are critical, many hazards most encountered with arctic protective clothing are also first and foremost answered with textiles. When working with a chainsaw, for example, forestry workers need to wear chainsaw protective suits. The respective standard for leg protection defines minimum cut resistance for the fabric and appropriate standardised test methods to verify this (EN 381-5:1995). High visibility protective clothing is also very much materially defined. Standard defines for example colour coordinates and luminance, colour fastness, tear properties and water vapour permeability (EN 471:2003+A1:2007). Shaw (2005, 113) has compiled a model for selecting textiles for protective clothing. While identifying standards according to the hazards and listing fabrics that meet them are the primary steps, he lists other essential factors like comfort, performance, cost and cultural factors to be considered so that garments are not rejected. A perfect example for this is cut resistant gloves that are becoming common in construction work for example.

One of our respondents reported that they are too cold for working outside. Performance is deteriorated. For Black et al. (2005, 71-72) fabrics are the place to start when hoping to meet the protective requirements, but it is the compatibility of components of the overall clothing systems she advocates as the ultimate solution.

Information and instructions on proper use, that also reach end-users, are perhaps an overlooked method in meeting protective requirements. Workers need instructions on how to use the clothing and gear correctly so that they protect as intended. This is identified in the PPE directive. It has a clause on information supplied by the manufacturer that states that relevant information for example on use, maintenance and performance must be supplied (89/686/EEC Annex II, 1.4). ISO 13688:2013 details use instructions to include for example fitting and dressing instructions, limitations on use, details of additional items needed to be used to achieve protection intended and instruction on how to recognise loss of performance (Clause 8). It should be noted that, for example construction is a field with a growing number of foreign workers who might not be accustomed to work in such harsh conditions and cannot dress properly without guidance. Safari firms are very aware of the inability of tourists to dress properly and thus provide instructive videos on the Internet, airplanes, buses and finally at the safari dressing rooms. For both of these fields FIOH has drawn up guides: *“Construction worker’s guide to the cold”* as an example (TTL/Kylmättyöohjelma 2000). One of the interviewed companies had been involved in this and instructions established then are still used in the company. Interviewee however admits that workers should be reminded about this again, because *“...there are new men... I can say that it hasn’t been talked about much anymore...we assume that everyone understands this even though this of course is not necessarily the case.”*

Methods for meeting physiological and ergonomic requirements

In meeting complex thermal regulation and moisture management requirements, varying climatic and working conditions speak on behalf of shifting attention to managing clothing systems instead of just materials or an outer layer. Black et al. (2005) consider clothing system a basic requirement and have devised basis of a system anatomy where layers play the key role. Black et al. (2005, 74-76) consider clothing as a system of dynamic relationships between wearer, activities, inner microclimates and environmental conditions. Three layers, where outer one is usually the protective one, form the basis of this system anatomy where layers are adjusted to circumstances and needs. In arctic work and protective wear, layers play a key role in adjusting thermal comfort and managing moisture accumulation. Workers seem to acknowledge this and carry extra layers, spare socks and shirts with them. Inner linings that can be removed, are also mentioned. Right kind of layering is instructed in the above mentioned cold guide for construction workers, where appropriate materials are mentioned. Black et al. (2005, 81) emphasise the coordination of layers because if

“both outer and mid-layer garment have impermeable membranes, then their effectiveness may be cancelled out”. They continue that for these reasons the procurement for protective clothing should be coordinated. In this age of technical textiles, coatings and functional features, the worker can get baffled in selecting appropriate layers themselves. With 30 years of experience, as the workers of one employee had, one probably knows how to dress in any condition, but it remains a question as to how much workers generally are guided in constructing proper clothing systems for their field of activity.

Overall functionality of work and protective clothing with regards to ergonomic, mobility and fit can be improved by applying body scanner data and activity specific information in creating patterns and size charts, but also perhaps with such simple steps as fitting garments before use. Respondents that reported problems with sizing and fit were interested in the possibility of using body scanners to get more personalised clothing. Small organisations that acquired their clothing from local retailers, hardly complained about sizing issues. They were able to ponder options and try them on. Also a bigger organisation that needed special clothing for snowmobiles acquired these locally and tried on a good fit: *“They are sized differently so that there is a possibility for a sturdy, less sturdy and very sturdy. They are like more fitting outfits.”* Instead of scanning just individual workers, some body type analysis could be conducted with larger occupational groups and create appropriate sizing for identified body types. One of the respondents for example mentioned how no matter how physically demanding lumberjacks work is *“...still for some reason extra counterweight is accumulated here in the front side...”*. In scanning and measuring police men in Body Fit-project, distinct body types with broad back and developed shoulder muscles could be distinguished (Kaartinen 2011). Dutch army is optimizing the fit of their soldiers clothing by utilizing body scanner data (Daanen 2014). International companies need data on different nationalities and it is well know that body type changes when people age. It is hard not to agree with Gupta (2011, 332) who advocates for 3D anthropometric data and scanners that measure in dynamic modes and real postures. Data analysed could be then used to develop activity specific clothing and size charts. Even though standards place attention to size designation, markings and adequate size range, not many procurement systems seem to allow fitting garments before ordering. Workers choose the size they are used to wearing with normal clothing and end up with wrong one. Standard ISO 13688:2013 provides an informative Annex for *“Checking the ergonomic features of protective clothing”* that describe some simple performance tests users can do to assess for example ease of dressing and adjustments, freedom of movements and appropriate coverage. If not independent size chart, at least possibility of fitting should be provided and some procedure for assessing the garment functionality before starting work could be adopted.

Many test procedures have been developed to assess clothing functionality with regards to physiological and ergonomic requirements before placing them in the

markets, but it is still debatable what is adequate and what works. Testing with sweating and walking manikins is now widely researched, but human subject tests are still called for. Manikins are generally considered more realistic in evaluating physiological comfort of clothing than sweating guarded hot plates. This is because they demonstrate the effect of a clothing system, not just fabrics, as walking manikins also take into account the pumping and ventilation effects. With sweating manikins, evaporative resistance can also be measured. (Rossi 2005, 238, 246). Manikins, however, have their limitations in reacting to transient conditions as they can't simulate thermal responses of human beings to the same extent (McCullough 2005, 229-230). Human trials are used to validate results obtained with more simple methods mentioned earlier. Whether conducted in the field, or in climatic chamber, they are more expensive, more time consuming and their reproducibility is more difficult as fibres can react differently in different conditions and metabolic rates of the subjects can vary (Rossi 2005, 246-247). Hope I am not too bold in questioning the purposes of precise reproducibility, but results from the user interviews clearly demonstrate that in actual outdoor work, for example, conditions vary constantly as well as the strain of tasks. It has been shown that how people sense temperatures is very individual (Tuomaala 2014). Rossi (2005, 247) also points out how for example different fitness of subjects influences test results. Testing is needed in the development work, but also consistent and long-term recording of user-experiences and learning from actual use conditions, could a beneficial method.

Methods for meeting aesthetic and associational requirements

User-centred design and participatory product development processes can meet not only the functional needs, but also psychological and aesthetic requirements for both user groups, the organisation and end-users. To identify and meet these requirements, designers need to familiarise themselves with the culture of activity, referring to "*traditions and culture of relevant industry or occupation*" to arrive at accepted solutions or to propose well justified changes (Black et al. 2005, 75). Also the skill of designers in being in tune with the contemporary aesthetics and bringing these developments into the working clothes, can perhaps ease the acceptance of work and protective wear. By collaborating with the end-users, Kuusisto (2014) found the right combination of associations, aesthetics and functionality from the world of contemporary outdoor clothing that users were used to wearing in their leisure time and combined this with the traditions of uniform clothing. Users proposed ideas for designs, chose materials and accessories and informed the designer on working conditions and activities. Reciprocally being part of the product development process speeds up the product acceptance and understanding. (Kuusisto 2014). Colour was the main differentiation factor in the uniform reform of Finnish Border Guard, but a designer creates a unified look also through silhouettes, use of materials and details (ibid). It must be noted, that being part of a product development process didn't seem all that important to our

respondents, until discussion turned to better fit and mobility, functional details and customisation options.

Methods for meeting product-service system (PSS) level requirements

Product-service systems already exist, but evaluation as well as proof of cost-effectiveness and benefits to the users in the long run are required. Interviewees seemed to be looking for cost calculations, evidence on the benefits of proper maintenance and repair services and they were also sceptical is it all worth it when thinking about durability and lifetime versus performance and cost. The big organisation that piloted maintenance services suspected that two sets of clothing was so expensive and clothing didn't last longer anyway that it wasn't worth it: *"It tends to be so that our clothes are in such tough use that they won't last longer than half a year, no matter what they are. Conditions are so rough that they break."* Most common reasons for discarding clothes for the respondents are wearing and tearing, depletion of protective properties and non-removable stains. With proper maintenance habits and repair possibilities one could greatly contribute to all of these. Also the fact that textile waste is no longer allowed in the landfills after 2016 might suggest that producer companies could be assigned take back and proper disposal responsibilities – and thus develop corresponding services. What speaks in favour of developing maintenance services is a research result that shows that washing workwear at home can be a risk for employee safety. This is because washing at home does not guarantee dirt removal without jeopardising loss of protective properties, doesn't keep track on wash cycles, nor does it provide inspections on the condition of the garment or chemical retreatments some textiles require (ETSA 2014). ETSA (2009) also suggests some hidden costs of ownerships like managing, maintenance and disposal costs that are often overlooked when compared to service prices. Some objective comparison data on the benefits of workwear PSS is needed.

Perhaps some shift in thinking and practices towards procurement criteria is needed to meet the product-service system related requirements. Problems that were identified in the current systems, such as maintenance, proper instruction for use and maintenance, quality as well as sizing and fit are problems to which textiles services promise answers for. A full textile service would take care of fitting for the right garments, maintenance and repair, service life and condition monitoring as well as managing stocks (ETSA 2009). Most likely the key here is tendering criteria and what is considered most economically advantageous and in what time frame. Dutch government sees PSS as a sustainable approach and suggests there are economic benefits in extending the life of garments. Dutch Ministry of Infrastructure and the Environment (DMIE 2011) has drawn up a point of reference for sustainable workwear procurement to assist in taking concrete steps in more sustainable public procurements. This document contains many points for consideration that support the adopting of PSS options.

Document encourages to avoid unnecessary purchasing and advocates for repair and reuse instead. Also exploring the possibility of a service that would entail supply, maintenance and cleaning is encouraged, because *“this may be beneficial from an environmental perspective, because the supplier will maintain and clean the clothes in such a manner that they last longer, which could help reduce the need for new uniforms in the long run”*. (DMIE 2011). Can environmental or social benefits of services be calculated an economic value?

Utilising service design and co-creation methods in the development of PSSs can perhaps aid in reaching better reception, user-friendly systems and overall economic, social and environmental benefits. The benefits of PSSs are still perhaps hard to grasp and the idea somewhat rejected for various reasons. Service design and co-creation as approaches include all stakeholders in designing and developing products, services and systems. A co-creative approach where, for example, procurement managers, local HSEQ managers and users are brought around the same table could reveal the hidden costs and surface real needs concerning also services, not only products. Including users in the PSS development process could increase user’s knowledge on the system and remove behavioural patterns or habits standing on the way of adopting new systems. Black et al (2005, 75) suggest that workwear users easily reject new developments because they are reliant on their clothing systems and become attached to products. I would imagine this applies to shifting from products to product-service systems as well and comments by some of the interviewees on how personal clothes are, support this interpretation. Kuusisto (2014) interpreted a better reception from the users and increased knowledge on products from her collaborative design process with Finnish Border Guard Uniform reform. In his early work, Papanek (1984, 293-305) advocates on behalf of integrated design that takes place in design team, including multidisciplinary experts, as well the end-user. This later developed into encouraging people’s participation even to *“become their own designers”* to find solutions to the very problems they encounter (Papanek 1995, 59-61). Black et al. (2005, 75) remind about the importance of research into tradition and cultures of any industry, in the design process, and the importance of information provided to the users accompanying any changes. What better way than to start both of these processes at the very beginning collaboratively, with all stakeholders involved.

Methods for meeting sustainability requirements

Sustainability is perhaps not the requirement users pay most attention to, but it is an issue where societal and environmental requirements step into play and welcome multiple answers. Changes in the industry are perhaps best adopted when legislation so demands and economic incentives encourage. Currently, the PPE-directive only refers to protection of user health. Clause about innocuousness on ISO 136688:2013 advocates that environmental impacts of production and disposal should be minimized

when it comes to materials, but provides only informative annex (Annex F) about environmental aspects to be considered. EU bodies have devised a voluntary instrument to encourage more sustainable public procurements, called the Green Public Procurement that has its own textile section (EU GPP criteria for textiles 2012) and there are many environmental initiatives and certificates, voluntary of course, for the private sector. If legislation, taxation or other governmental instruments don't impose clear environmental demands on manufacturing and disposal, I am a bit sceptical on how fast change will happen. Standardised tools, such as Life Cycle Assessment (LCA) methodology exists that could be used in setting agreed limits on environmental impacts of work and protective clothing. Some research around this topic is being made (see, for example, Fatarelli, Parisi, Varheenmaa, Talvenmaa & Pavlidou 2014).

Circular economy is a movement, approach and a method that has potential to answer not only complex sustainability requirements of garment production, but also the economic obstacles perhaps now standing in the way of sustainability. Widely and constantly produced working clothing could be especially fruitful resource for this new model. LCA is characterised as the “*cradle-to-grave*” method (Fatarelli et al. 2014, 2) where approach is linear, but circular economy is based on the cradle-to-cradle thinking, where materials circulate in closed-loop biological or technical cycles (McDonough & Braungart 2002). Textile material flows are currently being researched in Finland and other Nordic countries and it is shown that, for example, in Finland only two per cent of the over 50 million kilos of disposed textiles circulates as materials (Aalto 2014). From 2016 onwards, textile waste is no longer allowed in landfills in EU and this regulation is spurring new innovations in material recycling. The Finnish Innovation Fund Sitra and The Federation of Finnish Textile and Clothing Industries FINATEX are launching a project concerning circular economies of textiles (Finatex 2014). Work and protective clothing that have a relatively short lifetime as well as constant need and production, could provide one of these steady material flows. Companies like Globe Hope have already been utilising this flow in their production, but with new recycling possibilities, broken and worn workwear could perhaps be turned into new fibres. Research conducted on cellulose fibres shows promising results on recycling dirty textile as well as recirculating already once regenerated materials (see, for example, Harlin 2014, VTT 2014). These are indications of the possibilities of truly circular fibre economy. Workwear users are not really interested in developing these services, because work safety and efficiency come first, but as our interviews indicate, they are somewhat interested in end-of-life options and would be more than happy to hand over their used clothes for collection instead of piling them up in summer cottages.

To make circular economy possible and economically viable, a lot of development is needed in all parts of the systems, from material development to establishing collection and sorting bodies, building large scale recycling facilities to innovating services and business models around this. Material development is on the way, but good collection

methods and steady flows of materials are also needed so that those who are interested in utilising it could develop their business (Dahlbo 2014). Life cycle services as circular economy business models are already provided by some of the forerunners in the field. Teijin, Onward Holdings as a designer and manufacturer and Fuji Xerox as the customer have collaborated to develop closed-loop recycling system for uniforms for Fuji Xerox in China. Consumption of natural resources are minimised as polyester fibres cycle in a closed-loop system based on chemical recycling developed by Teijin. (Innovation in Textiles 2013). A Dutch company has developed materials suitable for circular economy and provides its customers with full circular economy services where they take care of garments circulation after use (Dutch aWEARness 2015). Many textile service companies that lease work and protective wear, also already track their material flows and garment ageing; manage the circulation and are more or less aware of average lifetimes. New technologies and IT capacity in our society can facilitate the shift to circular economy, for example with systems that track, trace and manage material flows in the systems (Ellen MacArthur Foundation 2013). Circular Content Management System, utilising barcodes and databases is something Dutch aWEARness has already developed. It has been calculated that one tonne of clothing as a resource can generate a revenue of almost 2000 US dollars (Ellen MacArthur Foundation 2013). With this math, 50 000 tonnes of discarded textiles in Finland is a 100 million dollar business. Business opportunities are out there, they just need seizing.

CONCLUSIONS AND RECOMMENDATIONS

Standards, materials and proper communication in the whole clothing value chain are the first steps when considering and meeting legislative and protective requirements. The worker level might not be so aware of the existing standards, but those doing the risk assessment and requests for tender in organisations must be. It can be asked whether raising workers' awareness on what they are wearing and why would increase the level of proper protection. Some indications of this could be found from user interviews. Increased awareness might also increase feedback inside organisation and towards the manufacturers. Standardisation work itself is a continuous process to which any interested party can contribute their views through platforms provided.

When considering and trying to meet physiological and ergonomic requirements in work and protective clothing, attention should be shifted towards managing clothing systems. When these features are in question, there are no one-size-fits all solutions. Clothing systems in this context means everything from functional layering to adequate size charts, activity specific ergonomic patterns and fitting opportunities. There are immediate needs to be answered, such as better sizing and fit, breathability, thermal and moisture management and better cold protection of extremities. There are questions of who will pay this development work for modular and more individual workwear that is called for and manikin and field tests perhaps required.

Then, there are also more far reaching issues that need collaborative research efforts. Is there a possibility to support longer and healthier careers in demanding jobs with clothing? Is it possible to increase work efficiency with clothing that would not only be safe and protective, but also health promoting?

Specific aesthetic requirements mainly stem from the organisational level and general ones from the culture of activity. Designers need to get in touch with both and additionally tune in with the end-users to create a product that is easily and happily accepted. Fit and correct sizing are an important part of overall aesthetics and functionality of workwear. It is also important for end user to be able to choose clothing they are more comfortable in, whether an overall or separate pants to set an example. With smaller organisations where greater care was put into the selection of clothing, clothes were also a bit more carefully maintained. There might be then some indication or hope for better maintenance through instructions and well received pieces. It can be asked if aesthetic pleasure and acceptance aid in bringing about better maintenance habits and thus longer lasting clothing.

Product-service system thinking will increase and practices will be developed as cost issues are resolved and benefits demonstrated. PSSs can be an answer in meeting many requirements, such as customisation, better fit and sizing and providing proper maintenance. PPE directive already requires many things concerning maintenance and lifetime monitoring, which are hard to fulfil by individual workers, whose main responsibilities are elsewhere. There are differences between industries and organisation sizes on how services are imagined to suite to their operations. Services should be developed through participatory design approaches to understand what services are perceived beneficial, how they could be accommodated to different operating models and to increase users' understanding of the system.

Sustainability requirements of work and protective wear are multiple; ranging from ethical production, sustainable use and maintenance habits to minimising environmental impacts in all life cycle stages and developing solutions for circular economies of textiles. Research should be done and solutions developed on multiple fronts, whether it is extending clothing lifetimes or developing appropriate rhythm and quality balance to easily recycled materials. Making materials less harmful in terms of chemicals for example, will serve both users and the environment. Responsibility about proper and sustainable maintenance and disposal should be placed upon either companies providing the clothing, or those ordering them for their workers – not the end users. Incentives for adopting more responsible procurement criteria than just the price, could be provided. Getting governmental bodies, textile and clothing producers and user organisations working together on more sustainable work and protective wear is the key.

REFERENCES

- Aalto, K. 2014. Suomen tekstiilivirta vuonna 2012. Työpaperi, Kuluttajatutkimuskeskus. TEXJÄTE-hanke 2013–2014. Referenced 2 March 2015. <http://www.syke.fi/hankkeet/texjate>.
- ArcticPro Product Supplier Survey 2013. Unpublished.
- Black, S., Kapsali, V., Bougourg, J., & Geesign, F., 2005. Fashion and Function – factors affecting the design and use of protective clothing. In Scott, Richard (ed.) 2005. Textiles for protection. Cambridge: Woodhead Publishing
- Council Directive 89/686/EEC of 21 December 1989 on the approximation of the Member States relating to Personal Protective Equipment. Referenced 2 February 2015. <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31989L0686>.
- Daanen, H.A.M., Woering, A., Ter Haar, F.B., Kuijpers, A.A.M., Haker, J.F., & Reulink, H.G.B., 2014. Optimization of Military Garment Fit. Proceedings of Ambience '14 –conference. Ambience`14&10i3m, 7-9 Sept 2014 Tampere, Finland
- Dahlbo, H. 2014. Tekstiilien elinkaaren pidentäminen - askel kestävämpään suuntaan. Referenced 20 February 2015. <http://www.tekstiililehti.fi/fi/puheenvuoro/helena+dahlbo/>.
- DMIE Dutch Ministry of Infrastructure and the Environment, 2011. Sustainability criteria for Sustainable Public Procurement of Workwear version 1.3. Referenced 2 March 2015. <http://english.rvo.nl/sites/default/files/2013/12/Criteriadocument%20Workwear.pdf>.
- Dutch aWEARness 2015. Circular Economy. Referenced 2 March 2015. <http://dutchawearness.com/circulareconomy/>.
- EN 471:2003+A1:2007. Näkyvä varoitusvaatetus ammattikäyttöön. Testausmenetelmät ja vaatimukset. SFS käsikirja 166. Suojavaatteet, suojakäsineet ja ammattijalkineet. Suomen Standardoimisliitto SFS Ry. Helsinki: SFS.
- EN 381-5:1995. Moottorisahan käyttäjän viiltosuojaimet. Osa 5: Jalkojen suojainten vaatimukset. SFS käsikirja 166. Suojavaatteet, suojakäsineet ja ammattijalkineet. Suomen Standardoimisliitto SFS Ry. Helsinki: SFS.
- Ellen MacArthur Foundation 2013. Towards the Circular Economy. Opportunities for the Consumer Goods Sector. Referenced 2 March 2015. <http://www.ellenmacarthurfoundation.org/business/reports/ce2013>.
- ESS 2012. Kaupan työehtosopimusta rikotaan työasuissa

- Kotimaa 10.8.2012, klo 19:20. Referenced 6 February 2015.
<http://www.ess.fi/uutiset/kotimaa/2012/08/10/kaupan-tyoehostosopimusta-rikotaan-tyoasuissa>.
- ETSA 2014. Employers, don't underestimate your responsibility. Home washing can affect your employees' safety as well as your liability. 12 November, 2014. Referenced 2 February 2015. www.textiles-services.eu/news/home-washing.
- Finatex 2014. Sitran hankkeella uudenlaista liiketoimintaa tekstiilialalle. Uutiset 5.12.2014. Referenced 10 December 2014. www.finatex.fi/uutiset/sitran-hankkeella-uudenlaista-liiketoimintaa-tekstiilialalle.html
- Finnwatch 2011. Halvimman markkinat. Julkisten työvaatehankintojen ja -valmistuksen eettisyys. 1/2011. Helsinki: Finnwatch.
- Fatarelli, E., Parisi, L., Varheenmaa, M., Talvenmaa, P., & Pavlidou S. 2014. Life Cycle Assessment on Personal Protective Equipments. Proceedings of Ambience '14 – conference. Ambience'14&10i3m, 7-9 Sept 2014 Tampere, Finland
- Gupta, D. 2011. Design and Engineering of Functional Clothing. Indian Journal of Fibre & Textile Research. Vol. 36, December 2011, pp327-335
- Harlin, A. 2014. Tekstiilijäte raaka-aineena. Tekstiili-lehti 4/2014.
- ILO 2015. ILO Declaration on Fundamental Principles and Rights at Work. Referenced 13 February 2015. <http://www.ilo.org/declaration/lang--en/index.htm>.
- Innovation in textiles 2013. Closed-loop recycling system for uniforms in China. December 19th 2013. Referenced 13 February 2015. <http://www.innovationintextiles.com/protective/closedloop-recycling-system-for-uniforms-in-china/>.
- Kaartinen, H. 2011. Kehoskannaus: Mittausprosessi ja mittojen vertailu. In Pursiainen, Mari (ed.) Vaatemuotoilu kehoskannauksen valossa. Body Fit –tutkimushankkeen tuloksia. Lapin yliopiston taiteiden tiedekunnan julkaisu Sarja C. Katsauksia ja puheenvuoroja no. 37.
- Kuusisto, S. 2014. Rajavartiolaitoksen virkavaatetuksen kehittämishanke. Työ- ja suojavaatetuksen ajankohtaispäivät 2.10.2014 Hämeenlinna.
- McCullough, E.A. 2005. Evaluation of protective clothing systems using manikins. In Scott, Richard (ed.) 2005. Textiles for protection. Cambridge: Woodhead Publishing
- McDonough, W. & Braungart, M. 2002. Cradle to Cradle: Remaking the Way We Make Things. New York: North Point Press.

- Papanek, V. 1984. Design for the Real World. London: Thames and Hudson.
- Papanek, V. 1995. The Green Imperative. London: Thames and Hudson.
- Risikko, T. & Marttila-Vesalainen, R. 2006. Vaatteet ja haasteet. Helsinki: WSOY.
- Rossi, R. 2005. Interactions between protection and thermal comfort. In Scott, Richard (ed.) 2005. Textiles for protection. Cambridge: Woodhead Publishing
- Scott, R. (ed.) 2005. Textiles for protection. Cambridge: Woodhead Publishing
- SFS-EN ISO 13688:2013. Protective clothing. General requirements. English version. Finnish Standards Association. CEN 2013.
- SFS-EN 342:2005. Kylmältä suojaavat vaatekokonaisuudet ja vaatteet. SFS käsikirja 166. Suojavaatteet, suojakäsineet ja ammattijalkineet. Suomen Standardoimisliitto SFS Ry. Helsinki: SFS.
- Shaw, A. 2005. Steps in the selection of protective clothing materials. In Scott, Richard (ed.) 2005. Textiles for protection. Cambridge: Woodhead Publishing
- Toimiva työ- ja suojavaatetus 1996. Helsinki: Työterveyslaitos.
- TTL/Kylmätyöohjelma 2000. Rakentajan kylmätyöopas. Oulu: Työterveyslaitos.
- Tuomaala, P. 2014. HTM-malli osoittaa: Ihmisten lämpöaistimuksissa on huimia eroja. Referenced 19 December 2014. <http://rym.fi/fi/htm-malli-osoittaa-ihmisten-lampo-aistimuksissa-on-huimia-eroja/>
- Työturvallisuuslaki 23.8.2002/738. Referenced 6 February 2015. <https://www.finlex.fi/fi/laki/ajantasa/2002/20020738#L4P20>
- Työsuojeluhallinto 2010. Henkilönsuojainten valinta ja käyttö työpaikalla. Aluehallintovirasto. Työsuojeluoppaita ja -ohjeita 11. Tampere: Työsuojeluhallinto.
- Työsuojeluhallinto 2015. Työsuojeluhallinto / Lämpöolot. Referenced 6 February 2015. <http://www.tyosuojelu.fi/fi/lampoolot>.
- VTT 2014. VTT: Jätetekstiilistä voi valmistaa jopa alkuperäistä parempaa kangasta. Uutiset 15.6.2014. <http://www.vtt.fi/medialle/uutiset/vtt-j%C3%A4tetekstiilist%C3%A4-voi-valmistaa-jopa-alkuper%C3%A4ist%C3%A4-parempaa-kangasta>.

ATTACHMENT 1. INTERVIEW QUESTIONNAIRE

A. Background information

1. Name & Age
2. Profession
3. Tell something about your work where functional clothing is needed

B. Use context and needs

4. What kind of clothing or gear is needed in your line of work?
5. In what kind of conditions clothing is used?
6. What do you consider as their primary function (for example protection, communication, identity)?
7. What kinds of properties are important for you in clothing and gear?
 - Protection from **the** cold
 - Protection from the wind
 - Protection from rain and moisture
 - Use comfort
 - Mobility
 - Ease of maintenance
 - Visibility
 - Quality and durability
 - Transformability and multi-functionality
8. What is especially good and especially bad in the current clothing you have?
9. Are your winter clothing in accordance with the cold protective clothing standard (EN 342)? Why or why not?
10. Would you want more tested information on clothing properties, for example in the form of certificates or standards?

C. Materials, production, product and service solutions

11. Where is your current clothing acquired from? What is the procurement process like?
 - a. Clothing and gear is purchased ready-made?
 - b. Clothing and gear is customised for the company? If so, how?
 - c. Clothing and gear is designed for us and we are part of the product development process?
 - d. Workers themselves have a say in what kind of clothing is acquired?
12. Would you like to influence or take part in designing clothing? How?
13. What do materials mean to you in clothing? What materials do you favour and why?
14. Clothes maintenance – how and how often it is done?
15. Does your current clothing have any technology or intelligence embedded in them? If so, what kind and why? If not, would you need any?

16. Would you be interested in using a clothing service, where you would rent the needed workwear and this service would also take care of maintenance and disposal of the clothing?

D. Consequences

17. What is the average lifetime of your work clothing?
18. For what reasons are the clothes disposed? Where do they end up?
19. Is environmental friendliness something you pay attention to in clothing?
20. Is transparency in production processes important to you (for example who makes the materials or who make the clothes and where)?
21. Are there domestic options to the types of clothing you wear? Would you like there to be and would you be willing to pay for domestic production?
22. Are you interested in materials utilisation at the end of life cycle?

E. Future and visions

23. What type of clothing do you think is needed in your field of activities in the future?
24. How do you think products or services in your field should be developed?
25. Would you be interested in taking part in developing better products or services, for example in research and development projects?



**»» UTILISING
VIRTUAL ENVIRONMENTS IN
A CLOTHING DESIGN PROCESS**

INTRODUCTION

Virtual or digital clothing or clothing design is a concept yet to be defined. Virtual, today, is usually something created with a computer, or existing on the Internet. Digital, or digitalisation usually refers to electronic technology that converts data like text or sound into an electronic form or something that creates or processes data (FDS 2015). Digital watches convert time into electronic form while digital televisions use digital signals. Body scanners today can digitalise human form, create a virtual avatar. Digitalisation can also refer to a phenomena of business activities transitioning to electronic channels and contents (Teknologiateollisuus 2014). The Fashion Digital Studio at the London College of Fashion understands digital fashion as a very all-encompassing concept that that connects to ways we research people and clothing and how we design, manufacture and consume fashion (FDS 2015). Digital technologies create not only avatars and game characters with fancy clothing, but also new product design and management tools, computer aided manufacturing, new shopping and communication possibilities as well as new business models and content. Research has already been conducted on virtual product design and management in Finland, for example in the VIRTUA (Virtuaalinen tuotesuunnittelu ja -hallinta) project in 2013, that was coordinated by Finatex and funded by Tekes (Finatex 2013). It is noteworthy that here I am not even mentioning wearable technology and the Internet of Things that can in a way physically digitise garment pieces and turn them into data processing objects.

At the University of Lapland, we are utilising as well as researching the formation of these new virtual and digital possibilities with the means we have in our possession. Computer aided design is embedded into the curriculum in the form of digital visualisation software programs as well as 2D patternmaking and 3D virtual fitting software. Researching the possibilities of using virtual patternmaking and fitting in clothing design processes is continuous at the University of Lapland. This is done in courses as well as in the context of projects. The Body Fit project, for example, researched virtual patternmaking, fitting and visualisation with protective clothing, sports and outdoor clothing. We have also had a Symcad –bodyscanner in our possession for a few years

now. Bodyscanner related research that has been conducted before, is summarised elsewhere in this publication. As digitalisation connects with any possible field today, a project dealing with artic and protective wear cannot escape it either. In the ArticPro Lapland project it wasn't a special focus area, but since interviewed companies expressed interest in further research and examining possibilities of virtual fitting, it was adopted as one development theme. This article is a brief overview on how virtual learning and innovation environments were developed and utilised in the context of clothing design. A pair of students researched how the 3D virtual fitting software translates into a tool in designing and fitting workwear. The possibilities of utilising the virtual environment of Service Innovation Corner (SINCO) laboratory at the University of Lapland, as a tool or a method in user-centred clothing design have examined. We also examined possibilities to connect clothing design with pLAB, a software engineering laboratory at the Lapland University of Applied Sciences, and their game and virtual environment development know-how.

FITTING WORKWEAR VIRTUALLY

Milka Asikainen and Helena Grönblom

Lindström Award is a workwear design competition for clothing design students organised by Finnish textile service company Lindström Oy. The competition has been held every other year since 2002. In the Lindström Award 2014, there were nearly 250 applicants from 22 countries in Europe and Asia. The task was to design a workwear collection for Estonian department store Kaubamaja. The collection had to include complete outfits for both male and female employees of fashion and food departments. Five finalists were chosen and two outfits from each finalist's collection were produced in an Estonian pattern and garment producer Portex OÜ.



Figure 1. Outfit from Kälkjäjä's Lindström Award competition portfolio.

In our clothing design master's project at the University of Lapland we organised and executed 3D virtual fittings for ten garments from the finalists' collections in the Lindström Award workwear competition 2014. We used Lectra Modaris 3D Fit and

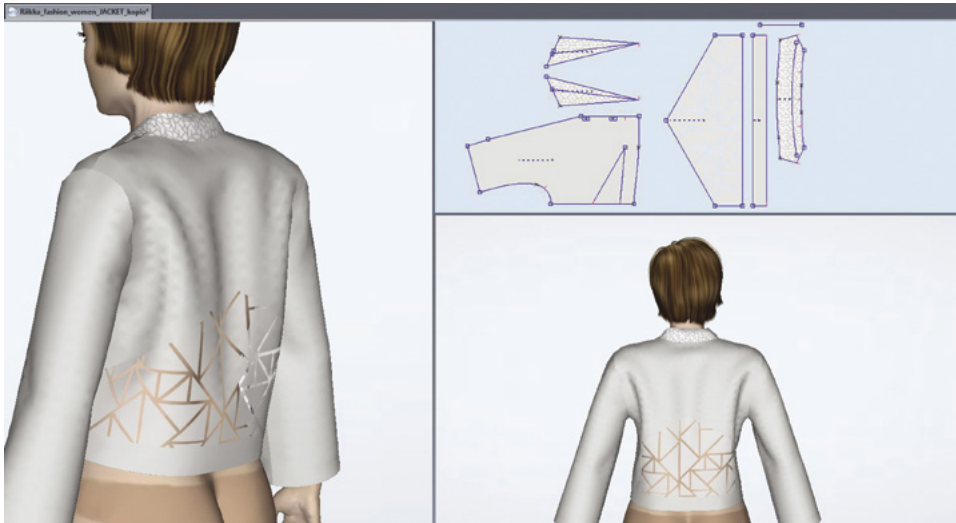


Figure 2. Snapshot from 3D virtual fitting process. (Picture: Asikainen & Grönblom 2015)

Lectra Modaris 2D V7 programmes in the project. Our project consisted of analysing the finalists' patterns, being in contact with finalists in addition to Lindström and Portex staff, executing the 3D fittings for two garments from each finalist, and creating posters out of the completed fittings. In total, the project took us almost three months, starting in late November 2014 and lasting until the 12th of February 2015, when the Lindström Award gala was held in Tallinn. Most of our work was completed during January 2015.

This project was a collaboration between the University of Lapland and Lindström Oy. The aim of the project was to investigate what could be the possibilities of using the 3D virtual fitting programme as a part of the workwear design process. Lindström has been interested in finding out, if the virtual fitting feature could be part of their work in the future. For us students, the benefits of the project were to develop our skills in using virtual fitting software and to get more experience with the garment manufacturing process. We both had previous experience of using the Lectra software and Modaris 2D and 3D programmes in our clothing design studies at the University of Lapland. During our bachelor studies, we had used the programme in a few courses. Now, during this project, we managed to gain very good skills on using the Modaris programmes, which was positive for us.

Fitting process with Lectra Modaris 3D Fit

Before fitting garments virtually with the Lectra Modaris 3D Fit programme, the original patterns were to be modified in the 2D programme. Modification is required because the 3D programme does not identify certain structures and details. We received

patterns of ten garments, two from each finalist's collection, via email from the Lindström Award competition's partner Portex OÜ. Portex made the patterns according to the finalists' collection portfolios using the Modaris 2D programme. This was remarkable for the project because the Modaris 3D and 2D programmes are synchronised and we didn't have to make the patterns from the beginning.

The first step was to analyse the patterns and compare them to the flat drawings and illustrations in the finalists' portfolios. We had a video meeting with Merja Vormisto from Lectra who helped us through the whole fitting process. With her assistance we analysed the patterns to see what sort of modifications were required. We worked on two garments at the time, as we were two students in the project. The same process was repeated with each garment. After the analysis we created a new variant, named it and put only the needed patterns there. For example, linings and other pieces that are not visible on the right side of the garments were not included in the variant. Once all the required patterns were put into the variant, we modified the patterns in required terms. Pleats, for instance, had to be drawn as 3D lines that were to be defined as folds.

When all the required modifications were done, the patterns were ready to be sewn. In case some of the patterns did not work in a proper way in the fitting, we could modify them later and the modifications would appear also in the 3D fitting. To start sewing, we created a phase where we added the pieces to be sewn from the variant. On the sewing phase, we organised the patterns in a way that the edges to be sewn together were facing each other. To create a seam between two pieces we clicked the starting and ending points of the seam in both pieces in a strict order. When all the seams of the garment were sewn, we added slip on points to mark the edges of the garment. After this, we were ready to try dressing the garment on a virtual model in 3D programme, which we opened through the 2D programme.

First, we had to choose the right avatar for the garment from Lectra's virtual mannequin library. In the library, there are two adult male and two adult female mannequins and children from different age groups. As the patterns were made for a standard male (size 50) and female (size 38), we used the avatars called "Alex" and "Julia" whose measurements best corresponded with the clothes to be fitted. After selecting the avatar we could try to dress the garment. In most cases, the dressing did not succeed at the first try because of an error. The programme did not clearly show what caused the error but we had to find and identify it by ourselves. If the error occurred because of a mistake in sewing, the solution was to sew pieces together again. Modifications that were made to the patterns in 2D appeared automatically in 3D when the programmes were synchronised, so we could try the dressing again. When a successful dressing was accomplished, we could see how the garment looked on a virtual mannequin. Even if there were no notified errors, the garment did not always appear correct. We continued modifying the garment as far as possible in 2D to make the fit and shape look like the original design in the finalist's portfolio. The rest of the modifications

and the visualisation were made in 3D. From Lectra's material library we selected a fabric that most resembled the material defined in the portfolio. Details, such as buttons and zippers, we also added from Lectra's library. Pippings and other visual effects we draw with drawing tool in 3D.

Conclusions

When thinking of the 3D fit programme possibilities within the clothing design process, the main prospects would be saving resources and time. If the company, or designer, has both 2D and 3D programmes, it would be an interesting advantage for the designer to see quickly how the garment would fit on a body. Normally in the production, after the patterns are made, the garment prototypes are made from fabrics. When using the 3D fit programme, all the changes for the prototypes are possible to be made virtually, without having to use real materials. And since cutting down materials is environmentally friendly and can bring savings, using 3D fit programme would definitely be an advantage in the whole product development process.

We personally think, with our experience, that a lot of updating would be needed for the Modaris software, before it would be reasonable to be used in working life. Now, we were able to complete the 3D fittings and visualise them quite similar as in the designer's portfolios, but there were problems, for instance, with the material fall. Even if we selected a material with the same properties as the material defined in the finalist's portfolio, the garment wouldn't look different to default material settings.

As said, we had worked with Lectra Modaris programmes before this project, during our bachelor studies. Now when using the programme for a large project, we confronted the same problems in the programme as we had confronted before. From our point of view, the virtual fitting feature could be part of the clothing design and product development process generally, if the Modaris programmes are updated and developed further. We haven't used any other 3D fit software, so it is difficult to compare, but working with Modaris seems to be a bit unreasonable. We had planned, that virtual fitting for one garment would take approximately one working day, but in reality it took us about two to three working days. The programme functions very slowly and goes down all the time, which makes the working to be quite nerve-wracking.

It is difficult to point out the certain problems of using the programme, but in general, working with Modaris 3D fit is slow and complicated. Before transferring to 3D fit programme, the patterns need to be prepared by sewing them virtually in 2D programme. 2D programme lacks several shortcuts, for instance zooming, transferring and rotating the patterns. It is also difficult to find the right features for all functions, because the program mostly has symbol tools, not word tools. There are also several other little things that make working relatively troublesome.

Future prospects of virtual fitting in a workwear design process

During our project, we have put a lot of thinking into the question of what could be the future prospects of virtual fitting in the clothing design field. What we think, based on the experience by using Modaris software, is that virtual 3D fitting feature could be useful, if the programmes would be updated to be working smoothly to meet the expectations of today's rapid work rhythm. If working with the programme would be easy and quick, it would be a great tool in a design process. It would save a lot of real resources, if all the fittings would be possible to be made with avatars. We are looking forward to seeing the development of 3D fitting in the clothing design field in the future.

UTILISING SINCO AS A CO-CREATION ENVIRONMENT AND METHOD IN USER-CENTERED CLOTHING DESIGN

SINCO and service design

SINCO (Service Innovation Corner) is a service innovation laboratory at the University of Lapland, which has mostly been used for the purposes of service design so far. This “*service design prototyping environment*” has been built and developed under the SINCO EAKR-project between 2009 and 2011 (Rontti & Lindström 2013). For clothing design purposes, this innovation environment has only been used a few times. In one Pro Gradu thesis research where Sinco laboratory worked as an interactive space to conduct brand research through consumer involvement (Suhonen 2013) and in one international service design workshop where clothing-related problems were also dealt with. This short article section will not delve into the concepts and practices of service design, but rather describes how Sinco laboratory has been tried out and developed as a tool and method to be utilised in user-centred clothing design. It must be noted, that since we are in such early stages of developing this environment for the purposes of clothing design, try-outs have only been made in the context of one course and a one workshop, both with student groups.

First and foremost, SINCO is an environment for prototyping user experience and it thus can be seen as an interesting method to be utilised in user-centred clothing design to aid in deepening user understanding and innovating new solutions. Buchenau and Suri (2000), who write about experience prototyping, list three critical design activities: understanding existing experiences, exploring design ideas and communicating design concepts. Rontti and Lindström (2013, 7) list three of the most common uses for Sinco in service design, namely analysing and visualising data, defining and concretising the design target and simulating user experience. Sinco also serves as a space for co-creation workshops, enhancing collaboration and brainstorming (ibid). With these design activities in mind, we sought to explore ways to utilise Sinco in

clothing design. By prototyping user experiences of clothing users, we could deepen our user understanding, perhaps surface user needs and critical concerns of a specific target group. In doing this, we could also identify new product or service ideas to answer those needs.

Piloting service design methodology in a clothing design process

Two different kinds of Sinco pilots have been conducted, and in both cases it has been one part of the design process. The first try-out was in an international “*East meets Arctic*” Japan Finland workshop (JFW) in clothing design where the focus was on cold climate clothing for special user groups of grandparents and grandchildren. The second pilot was in the context of course for designing children’s clothing. The first experiment was planned by Hanna-Riina Vuontisjärvi, together with clothing design professor Marjatta Heikkilä-Rastas. Vuontisjärvi is currently a project manager at the University of Lapland who has extensive experience working with and developing Sinco. The second session in the children’s clothing course was planned by project coordinator and researcher at the ArcticPro Lappi project, Sanna Konola, together with course teacher Anu Kylmänen. Methods and tools were derived from literature on service design and Sinco-publications. In prototyping experiences, touchpoints and service, or experience paths, play a central role. Service, or experience path consists of sequences of events that the user faces during a service or experience and touchpoints are the elements, such as people and objects, through which situations are experienced. Saffer (2007), for example, divides touch points into four different categories: spaces, objects, processes and people. (Rontti and Lindström 2013).

East meets Arctic JFW was a four day workshop, where Sinco was utilised on the second day to examine the focus group and conditions more in-depth and create user profiles. The first day was used for design brief, idea creation, research, getting to know the materials in use and finally initial moodboard making. A short visit was also done to a nearby day-care centre where user observation was conducted on children playing outside. On the second day in Sinco, participants walked through a service path that Vuontisjärvi had prepared. This was about grandmother and grandchild visiting the Arctic Circle and Santa Claus. Personas were created with a Hotspot – method and after and during the experience ‘grandmother’ and ‘grandchild’ (who were voluntary students) were presented with questions about the experience. Vuontisjärvi had also prepared profile creation templates where groups could now build their user profiles. Also a quick sketching challenge was presented to the groups after profile creation. The rest of the day participants continued sketching and day three and four they were already making patterns and prototypes for the final pieces. In this process, Sinco served as a co-creation platform where designer students could jointly come to further understand user experience in cold climate conditions and explore design ideas. In a short workshop there is no time for proper user research and

interviews, thus role-playing can be adopted as a method to understand existing conditions.

In the children's clothing course, Sinco as a method was also placed at the beginning of the process to aid in deepening user understanding. Students were also very much involved in building the experience path through their own user research. Here we also used role-playing, because getting real user subject involved in a process yet to be tested could be too incoherent, especially if they are children. The class was divided into two groups, with a focus group of children from 3-6 years old and from 7-11 years old. After the brief on course assignment and Sinco, students set out to conduct research on user groups through observation, interviews and literature. Students were asked to pay special attention to the contact points between children's clothing and their daily activities, people and objects. They were also asked to take photographs to be used later in building the experience paths such as *"A day in eight-year-old's shoes"*. A lecture before the Sinco session was used to share all the knowledge gathered by the group participants on their focus groups, identify relevant touchpoints and build basic structure for the experience path simulation on PowerPoint slides. In Sinco, the basic structure for a 2.5 hour workshop was an introduction to the workshop with instructions and goals, warm-up with all the participants, role creation with the Hotspot method, experience path (Picture 3) sharing observations



Figure 3. Role-playing on the experience path. (Picture: Anu Kylmänen 2015)

(Picture 4), creating user profiles and quick sketching (Picture 5). What was very different from the Sinco-session in the East meets Arctic workshop was the active role of the ‘audience’. This group was presented with sticky notes to write down their observations, and a set of “*Surprising situation*” cards that they could challenge the role-playing group with. After the path, the observing group was also active in disseminating information and pointing out critical things concerning children’s clothing. In the JFW workshop there was no warm-up session and here it was critical in getting to know the props prepared for the session. After the Sinco-sessions, groups continued on their design work in the course, creating moodboards and further sketching.

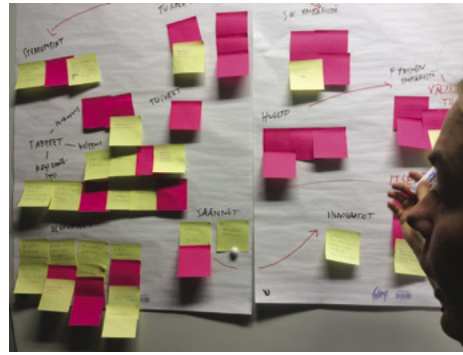


Figure 4. Collaboratively analysing the experience and observations.
(Picture: Anu Kylmänen 2015)

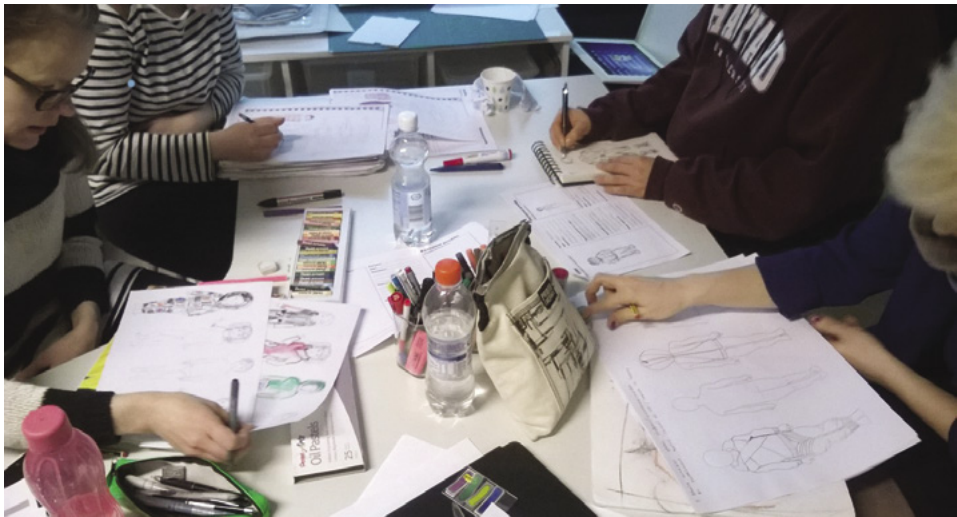


Figure 5. Creating user profiles and quick sketching after analyzing the experience
(Picture: Sanna Konola 2015)

Feedback and insights

From these two pilot sessions, Sinco as a method in user-centred clothing design received both negative and positive feedback from students involved. In JFW, Finnish participants gained further understanding on Sinco and its possibilities, since before this, most had only heard about its existence. Foreign participants from Japan, Russia and the Netherlands found it interesting and especially placing focus on the user and

functionality. For design schools where the emphasis is on fashion design and designers' own expression and creativity, this was reported as an unfamiliar approach. For some of the students in the children's clothing course the Sinco method contributed to their design process and to some it was only "silly play". Participants most liked being on the observing side, the "Surprising situation" cards and sharing the knowledge and experiences after walking the path by grouping the sticky notes into themes because "it helped to perceive the experience as a whole". Sinco is intended for simulating user experience with real users. Even though students got sufficiently involved in their roles, it is clear that involving real users is preferred: "Another option could be that we create environments, but don't act ourselves, because in my opinion, playing a character takes away the focus from the clothing". Students also felt, that user research they did before Sinco was more beneficial: "I got more out of the interviews that are based on real life and real experiences". Some students saw, that perhaps with some development, this could be further utilised in clothing design, but some felt that it is more beneficial in other design fields and some would not like to try it again at all.

Sinco as a method representing co-creative and participatory approaches as well as service design thinking could serve as a platform for developing new tools for user-centred clothing design – it would only need continuous research and development. The clothing design field is gradually waking up to the idea of designing also services or product-service systems (PPS) and here a new kind of design thinking, modes of collaboration and design methods are needed (see for example Niinimäki 2011, Flechter 2008 or von Busch 2009). Wake-up diagnosis, envisioning prototyping and out-of-the box thinking are examples of workshop modes in Sinco, conducted in the context of service design (see Rontti 2013), but these could also suggest approaches for clothing design, in innovating new PPS solutions or simulating and testing concepts. According to the student feedback, Sinco also places special focus on users and functionality. The environment could thus function as a platform for participatory user research or concretising customer understanding, which also are workshop modes identified for Sinco (Rontti 2013). A Sinco type environment has been utilised at Yamaguchi Prefectural University as a part of a process designing new nurse's uniform in collaboration with staff, manufacturers and designers (Mizutani 2014). These kinds of labs can have many roles in design and product or service development processes. It would be important to identify the beneficial functions and ways of working, which would perhaps facilitate co-creativity, make user research more agile or in-depth or serve as a platform for quick prototyping of product, services, concepts or business models. This is what we will turn our focus towards in the future.

UTILISING BODY SCANNER DATA AND 3D VIRTUAL FIT SOFTWARE DATA IN OTHER VIRTUAL ENVIRONMENTS

In a short collaboration with pLAB, a software engineering laboratory at the Lapland University of Applied Sciences (Lapland UAS), we examined possibilities to utilise body scanner data and 3D virtual software data in other 3D modelling software and virtual environments in use at the University of Lapland and Lapland UAS. When dealing with, or more importantly, when acquiring 3D modelling software programs, it is important to know how they work with other software programs in use. Are they compatible with pattern making or virtual fitting software programs, or perhaps product management or some 3D rendering software programs? In educational institutions it is worth knowing whether software could be somehow utilised in another degree programme. The Body Fit project introduced elsewhere in the publication, already examined this issue to some extent, and here we decided to continue a bit further. A project was carried out by a group of four students from the Lapland UAS: Linda Frantsi, Joonas Jänkälä, Kimmo Karjalainen and Jari Strand.

It has been noted that the data derived from a Telmat body scanner does not directly discuss with the Lectra 2D patternmaking and 3D virtual fit software programs that University of Lapland currently has in use, but measurement data is manually typed into avatars in the software. There are however, some methods to translate avatars into virtual fitting mannequins. There are some virtual fitting software programs, into which scanned avatars can be brought, usually in OBJ-file format and also ready and fully integrated systems like between Assyst 3D and Human Solutions body scanners. Maya and Studio Max are examples of 3D animation softwares that are also reported compatible with some systems. (Huhma 2013, 27). Research in Lapland UAS Body Fit showed that data from this scanner needs a lot of post-production to be utilised in any other software, like 3DS Max 2009 that was tested, or taking the avatar to 3D printing (Hirvaskari 2012).

Because game development is a current issue in Lapland and gamification was also discussed in interviews with sports- and workwear producers during the spring 2014 interviews, we decided to test the compatibility of our softwares with those used at pLAB and for example industrial design programme at the University of Lapland. Virtually 3D modelled avatars could also be used in early-stage user testing and usability evaluation, where clothed people placed in virtually created environments could perhaps enhance the accuracy of evaluation (Pursiainen 2003). pLAB could create the environments and clothing designers the clothing. We wanted to know whether clothes designed and fitted with Lectra Modaris 3D Fit could be exported to 3D modelling software of 3DS Max (newer version) or game platform software Unity. Also direct exporting of body scan avatars from Telmat body scanner and Artec Eva, a hand-held scanner at the possession of LAO (Lapland Vocational College), was examined. The hardware and software involved in the project were the following:

Symcad ST bodyscanner from Telmat Industries, Arcte Eva hand-held scanner with combined software for object rendering, Modaris 3D Fit virtual fitting software from Lectra, a free trial version of Marvelous Designer – a 3D modelling software for clothing, 3DS Max - a computer graphics program for making 3D modelling and Unity 3D which is a 3D game platform software.

Mostly exporting and importing between softwares was successful. There are many details, however, like excessively large file sizes, changing file formats, or leaving out details like textures somewhere along the way, that make working slow and perhaps difficult for non-computer expert. The following things were accomplished by the student team. Clothed virtual avatar from Modaris 3D Fit can be exported in WRL format to 3DS MAX, but Unity doesn't support any file formats that Modaris offers for export. Clothed avatars from Marvelous designer can also be exported to 3DS Max in OBJ file format, which also works for Unity. Some of the textures, meaning for example skin and fabric colours, can get lost in translation, but they can be retrieved from separate files. Avatars from Modaris can be taken to Unity game platform via 3DS Max where file can transformed to FBX file format. Files from Telmat scanner and Artec Eva hand-held scanner can be exported to 3DS Max in WRL and OBJ formats. File from Artec Eva, however, is so big that it took almost an hour to open it in 3DS Max. Via Max, these scanned avatars can also be taken to the Unity game platform. From these results, we can conclude that work and protective wear virtually fitted in softwares like Lectra Modaris 3D Fit or Marvelous Designer, could be exported and presented in another 3D modelling platform like 3DS Max or a game platform like Unity. What to do with these possibilities, needs further examination. Combining the pLAB student know-how and clothing designer student creativity, one could perhaps create new kinds of virtual clothing possibilities or design clothing into the game world. This kind of work should be continued in another context.

OVERALL CONCLUSIONS

Virtual environments have potential to speed up clothing design processes, create new kind of content and possibilities in clothing design and business and even generate more in-depth knowledge on user needs. All this, however, needs a lot of up-to-date, working technology and people comfortable with that technology. If University of Lapland was to update its bodyscanner and virtual fitting technology, building collaboration with software engineers and other technical experts is worth considering. Lapland University of Applied Sciences should also consider if they can benefit from the same technology in their study programmes. Thus, partnership beneficial for both could be established around these new technologies – their full potential waiting to be discovered.

REFERENCES

- Buchenau, M. and Fulton Suri, J. 2000. Experience Prototyping. Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques, DIS '00. Brooklyn, USA.
- Von Busch, O. 2009. Where are the Fashion Service Systems? Referenced 23 February 2015. <http://www.kulturservern.se/wronsov/selfpassage/XXI/XXI-0905/0905.htm>.
- FDS 2015. What is digital fashion? Referenced 13 February 2015. <http://fashiondigitalstudio.com/about#what-is-digital-fashion>.
- Fletcher, K. 2008. Sustainable Fashion and Textiles: Design Journeys. Earthscan, London.
- Finatex 2013. VIRTU - virtuaalinen tuotesuunnittelu- ja hallinta –projekti. Referenced 17 February 2015. <http://www.finatex.fi/projektit/virta-projekti.html#.VOMooWPQqmM>.
- Hirvaskari, M. 2012. Body-Fit research project. Final report. ERDF Project.
- Huhma, A. 2012. Virtual Fashion Value Chain. Master of Science Thesis. Tampere University of Technology.
- Mizutani, Y. 2014. SPS - Service Design Prototyping System in Designing Nurses' Uniform. Presentation at Service Design Forum. Co-creation of Future City Yamaguchi: Changing City, Life Changes by Service Design. Cable Factory, Yamaguchi. 14 December 2014.
- Niinimäki, K. 2011. From Disposable to Sustainable. The Complex Interplay between Design and Consumption of Textiles and Clothing. Aalto University Publication Series Doctoral Dissertations 84/2011.
- Pursiainen, P. M. 2003. VIRTUAALI-PUKEUTUMISKUVA
- Visuaalisen 3D prototyypin informatiivisuus ja prototyypinnin kommunikatiivisuus vaatetuksen käytettyjen arvioinnissa. Pro gradu tutkielma. Lapin yliopisto
- Rontti, S. & Lindström, A. 2014. Tools and Methods for Technology-Aided Prototyping of User Experience. SINCO Environment as a Pilot. A publication of the University of Lapland, Faculty of Art and Design, 2014, Rovaniemi, Finland. SINCO PLUS Project, 2013 (ESR); Value Through Emotion Project, 2014 (TEKES). PDF retrieved from www.sinco.fi/publications.

Rontti, S. 2013. SINCO-toimintamalli 2013 - kokemuksia ja suosituksia. SINCO PLUS (Palveluprotokolluosaamisen lisääminen ja uudet sovellukset) –hanke. PDF retrieved from www.sinco.fi/publications.

Suhonen, M. 2013. Design management methods in private label brand development. Case Stockmann: Cristelle & Co. Pro Gradu Thesis. University of Lapland.

Teknolohiateollisuus 2014. Teollisen yrityksen digitalisoitumisen käsikirja. Korhonen, S. & Valli, K. (ed.) Teknolohiateollisuus ry. Referenced 20 February 2015. https://teknolohiateollisuus.fi/sites/default/files/file_attachments/teollisenyrityksenksikirja.pdf.

FUTURE OF ARCTIC CLOTHING

**» A NEW GENERATION SWEATING
THERMAL MANIKIN FOR THE
EVALUATION OF THE THERMAL
COMFORT OF PROTECTIVE
CLOTHING IN ARCTIC CONDITIONS**

INTRODUCTION

Working or staying in cold conditions set high demands for the garments to sustain the thermal comfort of the wearer. The high thermal insulation needed in cold conditions, like in Arctic areas, can cause heat stress when working in high intensity and post exercise chill while the remaining moisture in the clothing layers due to sweating increases heat loss. Protective properties of the clothing, like waterproof, windproof and mechanically resistant materials, are traditionally achieved by using dense, thick, stiff or bulky material combinations with low water vapour permeability and which hinder movements thus increasing working load. Novel smart or intelligent materials are constantly developed to find the solution for the dilemma between protection and comfort. Common for all of these material types is to know their thermal comfort properties in different conditions to be able to choose the most appropriate combination for the required end use situation. Ideally, one garment should be adaptable to all kinds of conditions without the necessity to change or alter the layers.

The thermoregulatory properties of textiles from material level to garment level can be determined with a wide selection of test methods. Hot plates, water vapour permeability tests and a sweating thermal cylinder are used for planar textiles to determine thermal comfort properties on material level to be able to select the most suitable candidates for the garments for the required end use conditions. The cylindrical shape of the cylinder simulates the human torso and it allows for the adjustment of the fit. For garment level testing, the non-movable or movable thermal or sweating thermal manikins offer the most sophisticated objective methods. They simulate human body heat and sweat production and body movements in controlled ambient conditions for determining the thermal comfort properties either of a piece of garment or the whole clothing systems. The effect of garment design can be determined in addition to material properties. It is possible to get data of the real physiological responses of the human test subjects in real end use conditions in the field or in a controlled environment in wear trials. All these methods are supplementary to each other but the laboratory equipment offers an objective, less expensive and less time consuming,

repeatable way of determining thermal comfort properties of materials and garments. This paper presents a new generation sweating thermal manikin that has been developed by TUT in cooperation with PT Teknik (figure 1), some of its technical features and the first test results based on this new model (www.safeprotex.org; Varheenmaa 2011; Varheenmaa 2013).



Figure 1. A new generation sweating thermal manikin in a climatic chamber at TUT.

MATERIALS AND METHODS

The new generation sweating thermal manikin COPPELIUS II (male) is based on the same technique as its predecessor COPPELIUS and the new generation sweating thermal cylinder (Meinander 2007; Varheenmaa & Meinander 2012). The electrical control system and software are totally new and the body wall is thinner due to a lack of insulation layer of the composite wall material. Sweating is taken care of by altogether 226 sweating glands (figure 2) which are evenly distributed over 16 body parts. Head, hands and feet are non-sweating body regions. The surface temperature is usually kept at 34°C by heating it electrically. The heat resistors on the manikin surface react immediately to the temperature changes on the skin surface. Sweating water from a water reservoir near the ceiling is supplied to the manikin surface through the skin laminate that spreads the moisture to a larger area. The required amount is dosed by the electronically controlled valves (Varheenmaa & Meinander 2012).

- 1) Cylinder wall
- 2) Electric heating wire
- 3) Insulation of wire
- 4) Water pipe
- 5) Plastic layer
- 6) Laminated material

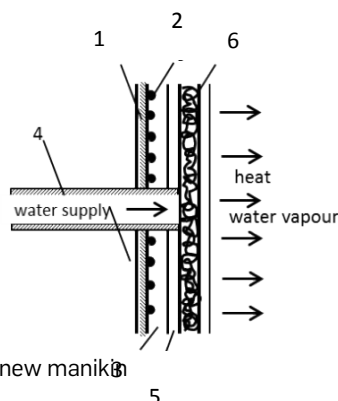


Figure 2. The cross section of one sweat gland in the new manikin (Varheenmaa & Meinander 2012).

The manikin is hanging on a balance and during the test the weight increase of the whole system is recorded. After the test the remained or condensed moisture in the garments can be weighed separately for each layer. Usually the tests are conducted in

set test parameters ^m	measured values ^c	calculated values
surface temperature (°C)	heat supply (W/m ²)	regional and mean heat supply (W/m ²)
sweating level (g/m ² .h)	surface temperature (°C)	thermal resistance or insulation R _{ct} (m ² .K/W) (total and corrected for evaporation)
test time (min)	temperatures at different layers (Pt sensors, °C)	evaporative heat loss H _e (W/m ²)
ambient temperature (°C)	total weight increase during the test (g)	water vapour permeability m _e (%)
ambient humidity (% RH)	weight increase of the separate clothing layers (g)	water vapour permeability m _e (%)

Table 1. The set test parameters, measured and calculated values in manikin tests (Varheenmaa 2011; Varheenmaa & Meinander 2012).

set test parameters	
Ambient conditions	T -50°C...+40°C 0...95% RH (on warm side) air velocity 0.3...0.5 m/s
Manikin or cylinder surface temperature	T _s 34°C
Sweating level	0 (dry)...300 g/m ² h
Manikin	Standing still in measurements, movable joints
Testing time	2h (dry) and 3h (sweat)
Pt-sensors	Pt-sensors can be placed between the selected layers

Table 2. The ambient test conditions in the manikin tests (Varheenmaa 2014a).

static conditions first in dry heat and then with sweating. It determines dry and evaporative heat transfer through clothing material systems in standing, non-movable situation in controlled ambient conditions (T °C and RH %). The thermal part of the manikin conforms to thermal manikin standard SFS-EN ISO 15831 (SFS-EN ISO 15831:2004). Thermal insulation, water vapour permeability and condensed moisture values are determined. The set test parameters, measured and calculated values are presented in table 1 (Meinander 2007; Varheenmaa & Meinander 2012; Varheenmaa 2014a).

The sweating thermal manikin is applicable not only for protective clothing, but also for outdoor clothing, sportswear, medical garments and smart materials to measure dry and evaporative heat transfer through clothing materials and in regard to garment

designs. It is also possible to test a piece of garment, for example socks, using a selected body part (Puolakka et al. 2014). A new generation sweating thermal cylinder can be used for determining thermal comfort properties of materials and it has also been applied for determining the thermoregulation properties of PCM materials in dynamic ambient conditions. The accurately controlled ambient test conditions of the climatic chamber are presented in table 2.

RESULTS AND DISCUSSION ON THERMAL INSULATION R_{ct} AND CONDENSED MOISTURE IN PROTOTYPE UNIFORMS

The three uniform prototypes developed for the rescue team workers for different end use cases within the SAFEPROTEX project were evaluated for their thermal comfort properties using the new sweating thermal manikin for the first time (Varheenmaa 2014a). Prototype 1 (overall with 3D spacer lining) was intended for rescue team workers in extreme weather conditions, prototype 2 (jacket with lining and trousers) for wildfires and prototype 3 (jacket and trousers) for first aid medical personnel. Examples of the results are presented for thermal insulation and moisture condensed in the garment layers. The differences between the prototype designs, the effect of air layers at present and the effect of an addition of an extra middle layer into the clothing system are indicated by thermal insulation results. Examples of the insulation values in the dry test at ambient conditions of $T 10^{\circ}\text{C}$ and $\text{RH } 65\%$ are presented in figure 3 (Varheenmaa 2014b).

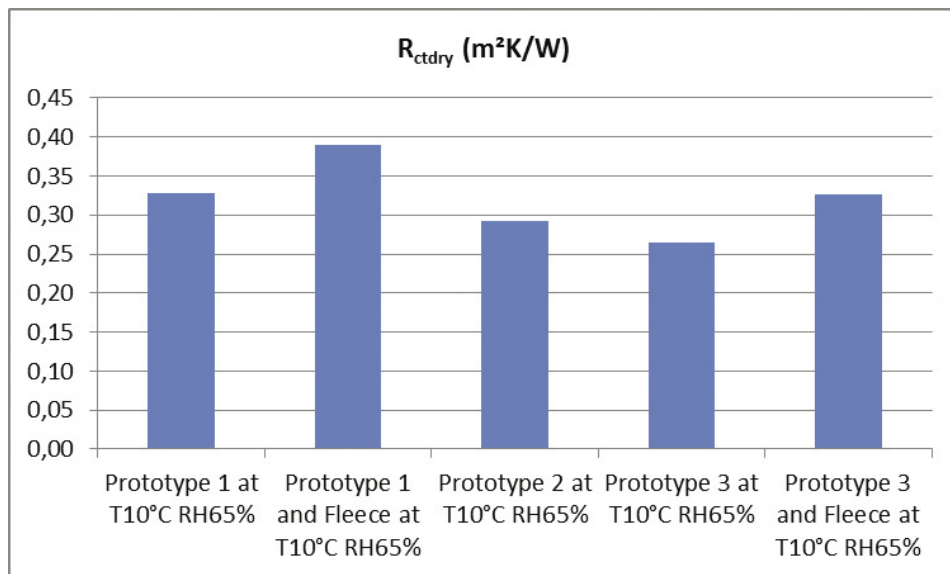


Figure 3. Thermal insulation results for the developed prototype uniforms in the dry test (Varheenmaa 2014b)

Prototype 1 overall garment with 3D-spacer has the highest thermal insulation. The prototype 2 that comprised of the jacket with a knitted lining made of bicomponent polyamide fibres containing PCM (Phase Change Material) and trousers without lining had higher thermal insulation than prototype 3 without lining. When introducing an additional fleece middle layer into the system in both prototypes insulation increases (Varheenmaa 2014a; Varheenmaa 2014b).

A sweating level of 100 g/m²h was used in sweat test and moisture condensed or remained in garments was determined by weighing the samples before and after the tests. Examples of the results are presented in Figure 4.

Mainly due to the laminated waterproof film which has rather low water vapour permeability, the condensation of moisture is the highest for the overall prototype 1 for extreme weather conditions. The amount of the condensed moisture increases in both prototype 1 and prototype 3 when adding a fleece middle layer into the clothing system.

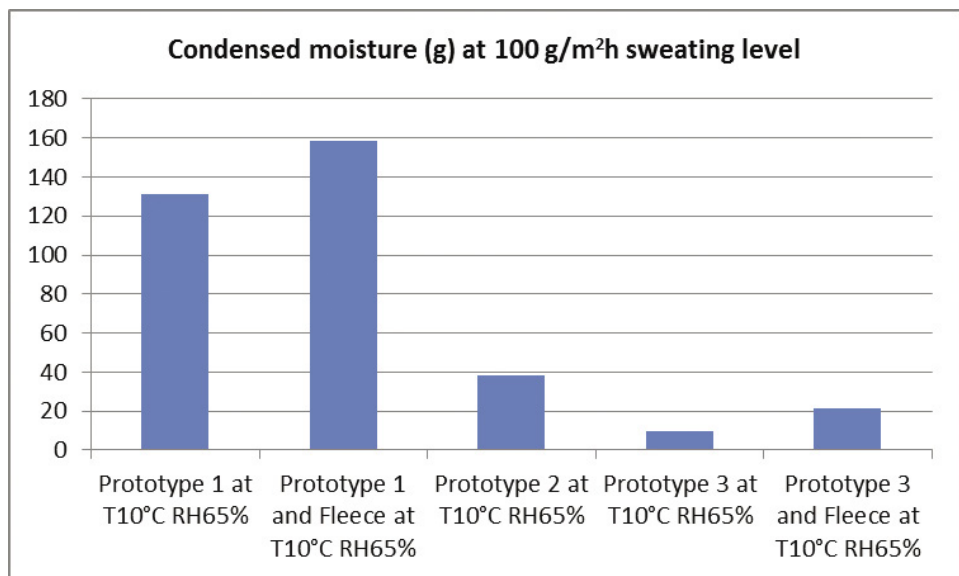


Figure 4. Condensation of moisture in the developed prototype uniforms at T 10°C and RH 65%. (Varheenmaa 2014b.)

CONCLUSIONS

The first results show that it is possible to detect the differences between different clothing material ensembles in thermal insulation and in condensed moisture values with the new sweating thermal manikin in controlled conditions. The tests of different types of garments intended for cold conditions will continue.


REFERENCES

- Meinander, H. 2007. Physical measurements of clothing thermoregulatory properties. Tampere University of Technology, SmartWearLab. 7th Annual Textile Conference by Autex, Tampere, 26-28.6.2007. 5 p.
- Puolakka, A., Hakala, T., Vuorela, T., Nousiainen, P. & Vanhala, J. 2014. Compression stockings with integrated ICT for customized performance. In Varheenmaa, M. et al. (ed. by). Proceedings of Ambience14&10i3m, Scientific Conference for Smart and Functional Textiles, Well-Being, Thermal Comfort in Clothing, Design, Thermal Manikins and Modelling, 7-9 September 2014, Tampere, Finland. Proceedings of Ambience, Scientific Conference for Smart Textiles 1, Tampere, (2014).
- SFS-EN ISO 15831:2004 Clothing. Physiological effects. Measurement of thermal insulation by means of a thermal manikin. Finnish Standards Association. 15 p.
- Varheenmaa, M. 2014a. Evaluation of thermal comfort properties of prototype uniforms for rescue team workers. Tampere University of Technology. In Varheenmaa, M. et al. (ed. by). Proceedings of Ambience14&10i3m, Scientific Conference for Smart and Functional Textiles, Well-Being, Thermal Comfort in Clothing, Design, Thermal Manikins and Modelling, 7-9 September 2014, Tampere, Finland. Proceedings of Ambience, Scientific Conference for Smart Textiles 1, Tampere, (2014).
- Varheenmaa, M. 2014b. A new generation sweating thermal manikin for the evaluation of the thermoregulation properties of protective clothing. Tampere University of Technology. In Varheenmaa, M. et al. (ed. by). Proceedings of Ambience14&10i3m, Scientific Conference for Smart and Functional Textiles, Well-Being, Thermal Comfort in Clothing, Design, Thermal Manikins and Modelling, 7-9 September 2014, Tampere, Finland. Proceedings of Ambience, Scientific Conference for Smart Textiles 1, Tampere, (2014).
- Varheenmaa, M. et al. 2011. Integration of multifunctionality and comfort in personal protective clothing for extreme conditions. Tampere University of Technology. In Talvenmaa, P. et al. (ed. by). Proceedings of FiberMed11, International Conference on Fibrous Products in Medical and Health Care, 28-30 June 2011, Tampere, Finland.

Varheenmaa, M. & Meinander, H. 2012. A new generation sweating thermal cylinder for the evaluation of the thermoregulation properties of protective clothing materials. In the Proceedings of 9th International Meeting for Manikins and Modelling, 21-24 August, 2012, Waseda University, Tokyo. 5 p.

Varheenmaa, M., Peltonen, C. & Meinander, H. 2013. Rescue Team Workers in Cold Climate Areas - Challenges for Multifunctional Protective Clothing. 13th Autex World Textile Conference 2013. Dresden, May 22-24, 2013. Technische Universität Dresden.

www.safeprotex.org. Referenced 30 May 2014.

An aerial photograph of a frozen body of water, possibly a river or lake, with a blue overlay. The ice is cracked and textured, with some darker patches. The text is centered in the upper half of the image.

**»» THE FUTURE
OF ARCTIC CLOTHING**

Ana Nuutinen

Ana Nuutinen, D.A., applies futures research into the theory of product design in order to both broaden it and to develop the practices of design education. In her research the focus is in the future-oriented thinking and the early stages of the design process.

INTRODUCTION

The term 'arctic' has many meanings. Regarding weather, it may refer to weather that feels unusually cold or to the consequences of weather: red cheeks, white frostbite and speech that stammers from the cold. To some, it may recall the taste of blood as a result of sticking your tongue on metal as a child in spite of the warnings. Arctic may also refer to nature and landscape: polar bears, reindeer and fells, long, dark polar nights lit by the northern lights, months of nightless nights teeming with mosquitoes. As for Arctic clothing, it can mean ethnic attire, fur clothes and national Sami dresses as well as the red costumes of Santa and his elves. People's associations are a mix of information about the different Arctic areas and the habitants of the Northern hemisphere. They also include a dose of Arctic exoticism contributed by travel advertisements.

The Arctic is a sparsely populated region geographically located between the North Pole and the Arctic Circle. The boundaries of the area approximately correspond to the limit of the midnight sun and the polar night. The Arctic region includes the vast Arctic Ocean, which is covered by a seasonally varying layer of ice. The Arctic Ocean is surrounded by frosty land that is either bald or stunted in growth and often covered in snow and ice. The Arctic is a small area considering the size of the Earth, as it only covers 6% of the Earth's surface. However, the Arctic corresponds to no less than one third of the area of Finland (see Ylä-Kotola, 2012).

The Arctic is a unique area. The weather and climate of the far north are very different from the lower latitudes where most people live. The characteristics of the Arctic climate include long, cold winters and short, cool summers. Beyond the Arctic Circle, the sun disappears for a long period of time in the winter and shines throughout the day and night in the summer. The Arctic is a challenging, even harsh, environment for the people who live and work there.

This article examines the nature of the Arctic region from the perspective of emerging opportunities. This topic is important because the Arctic is currently of interest to so

many different parties that we might even call the phenomenon ‘Arctic hysteria’. The interest is targeted at, for example, opportunities for new means of livelihood, the utilisation of submarine oil and gas resources and the opening of new shipping lanes. It is important that we study Arctic conditions and prepare for changes in the Arctic. This presents designers with abundant inspiration as well as special challenges. The solid understanding and experience of special needs related to the Arctic region as well as extensive design competence are required to solve such issues. Moreover, the development of Arctic design introduces opportunities for distinguishing oneself in the competitive field of design both nationally and internationally. (Ansala, 2014).

ARCTIC WEARS WORKSHOP

The ARCTIC WEARS future workshop was held on 20 February 2015 in order to identify new design needs and challenges related to the Arctic. The workshop was held in the climate chamber of the Arctic Power test laboratory. The focus was on special expertise in cold protection in terms of professional, sports and protective clothing and winter leisure wear. A total of 20 people participated in the workshop, ranging from different fashion and clothing experts, producers, students and wearers to people generally interested in the topic.



Figure 1. Introduction to the Arctic Wears future workshop. (Picture: Konola 2015)

Arctic conditions are a challenging, if not even a wicked, problem from the design perspective.

In a wicked problem, the problem and solution are interdependent: efforts to understand the problem coincide with analysing solution alternatives. One solution creates new wicked problems, which makes it difficult to ascertain whether all possibilities have been examined and whether the correct or final solution has been found. The solution to a wicked problem does not have a clear beginning or end (Rittel & Webber, 1973).

Arctic as the framework for the workshop introduced many complex and extensive issues into the discussion. Many of the issues are temporally and geographically distant things and phenomena, which are difficult to model for research and testing in, for example, laboratory conditions. The workshop utilised the opportunities provided by the climate chamber in the Arctic Power test laboratory for creating an Arctic approach. The workshop attendants wore cold weather clothing because the room temperature was adjusted to –20 degrees centigrade. At the beginning of group work, the participants tested the wind speed fan in the climate chamber to get an idea of its impact on the temperature (wind chill).

In order to avoid ‘tunnel vision’, i.e. a narrow focus on the development of one’s personal design area (see Aspelund, 2010), the time horizon for the group work was set to 2030. Moreover, an objective was set to steer away from studying trends, i.e. the short-term signals that are characteristic of fashion. In fashion, trend means the first signal of a change (Vejlgaard, 2008). It also means a compilation of trend materials which is based on change signals and serves as a source of inspiration in design, a guiding concept in product development, and a tool for improving cooperation in the different aspects of production. (Nuutinen, 2012).

During the workshop, the year 2030 was examined from the perspective of four megatrends. Megatrends were also used to break away from the short-term signal examination typical of the fashion field, because such an examination allows little room for new, creative thinking. The work methods resembled concept design: they formed a future-oriented, innovative attempt to combine different signals, free from old conventions and familiar thought patterns. (Lahti & Nuutinen, 2014).

A megatrend is a force that changes the future and can only be affected in a limited manner or not at all. Megatrends often evolve from trends that are developing in the same direction – in a way, they are trend clusters (Kamppinen et al., 2002). Even though the fashion industry does not appear to utilise megatrends in the creation of its own trends, it cannot avoid their impact. For example, political (increased oil price), economic (ageing of the population), social (urbanisation), technological (nano-technology) and environmental-related (climate change) megatrends affect the ready-to-wear

and other style industries, such as interior decoration and the automobile industry as an example (Rubin, 2004).

In addition to assessing trends and megatrends, the examination of the year 2030 involved identifying potential wild cards, i.e. surprising events with unpredictable consequences. Wild cards include both natural factors (earthquakes, volcanic eruption, floods) and human activities or failures (wars and revolutions, financial crisis, terrorist attacks, occupational accidents, fires). Wild cards are often ignored because observing them is considered an excessively difficult task. Even though discussing worst-case scenarios may seem like a bleak activity, it also provides opportunities. (Flinkkilä, 2014).

Workshop implementation

The workshop attendants were divided into four groups. Each group was allocated a megatrend theme (population, technology, climate, urbanisation), which they then discussed for approximately three hours based on instructions.

The work was executed with the help of a futures wheel. A futures wheel is a structured brainstorming-like method developed by Jerome Glenn in the 1970s (Glenn, 2003). To help with the working process, flipcharts were used, in the center of which themes under discussion were written down. The groups supplemented the theme as follows:



Figure 2. Starting the futures wheel around a megatrend. (Picture: Konola 2015)

1. First, they brainstormed around the theme (megatrend), i.e., engaged in an extensive, creative discussion, and wrote all the ideas on the flipchart. The discussion was directed using the questions below.

- What different, concrete effects and manifestations can the megatrend cause?
- How can the megatrend generate a positive or negative surprise (wild card)?

2. The second stage involved focusing on the ideas generated and selecting two to three ideas for further consideration. The discussion was directed using the questions below.

- How will the megatrend allocated to your group affect occupational, sports, protective and leisure clothing?
- What requirements does it set on Arctic wear and clothing?
- What future visions, ideas and plans can be derived from it to the clothing industry?

3. In the third stage, the groups presented their ideas and visions and measure proposals for their implementation. The presentations were directed using the questions below.

- How would you go about obtaining (implementing) an optimal future?
- How would you go about avoiding the worst possible future?
- How to prepare for a wild card (surprises)?

4. Stage four was reserved for questions, comments and discussion. Future visions for the clothing industry were briefly discussed at this point.

GROUP WORK RESULTS

The work results were presented orally by elaborating on the flipchart notes. The image below structures the results of the group presentations in two triangular figures as follows: the first triangle shows the three most important ideas derived from the megatrends and the second triangle shows three notable, related ideas concerning wear and clothing.

Demographic change

The group studying the demographic change megatrend presented the following issues: silver industry, healthy lifestyles and social environment. The three notable things concerning wear and clothing were comfort and trendiness, individuality and decency, and safety and technology.

The human lifespan has increased by 2.5 years per decade since 1840. An increased life expectancy and a decreased birth rate are contributing to the percentage of elderly population around the world. Demographic growth exhibits high regional variation. In many Western countries, the so-called baby boom generation is close to retirement age. Demographic change, particularly the growth of the ageing population, affects employment, which, in turn, slows down economic development. A lack of competent labour poses a challenge to solvency, forcing us to create

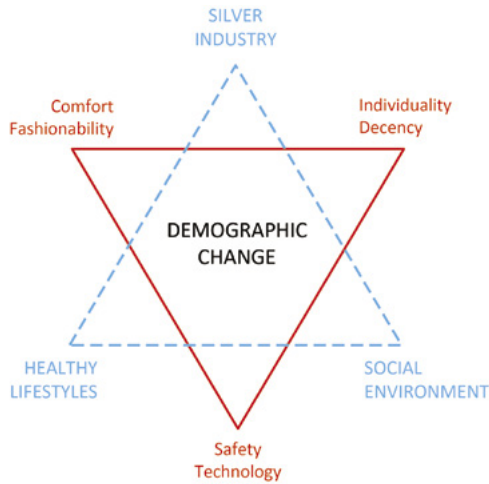


Figure 3. Group work results on demographic change megatrend. (Nuutinen 2015)

new solutions for maintaining well-being and social welfare systems and providing different services (EEA, 2011; Wilkoszewski, 2009). This is undeniably challenging, because the baby boom generation is used to high-quality public services, which the state and municipalities will not be able to provide in the future.

The growth of the ageing population involves new business activities, where demographic development is examined from the crisis perspective. The debate currently revolves strongly around the development of health and sickness care. The well-being of the weak in health and the elderly in need of help are particular concerns, including implementation opportunities and related costs. The debate highlights the fact that products and services are being produced for the elderly without even letting them determine their own needs. It is essential that we reduce or avoid stereotypes based on renouncing ageing or highlighting its negative aspects.

In the future, an increasing number of elderly people will live longer and in good health (Iltanen-Tähkävuori, 2013). We will have an elderly population leading an active life. This population now constitutes a new target group for examination. The target group is wealthier than previous corresponding groups. The group is also used to consumption. Since the target group has additionally received higher education and requires better quality than previously, it offers plenty of prospects for new innovation and product markets (silver market). Some elderly people would like to continue working instead of retiring. However, the competition in the labour market may be tough. Elderly people could be offered alternative opportunities for productive work, which would simultaneously improve their life quality and ensure their physical and psychological health (silver industry).

From the perspective of clothing, elderly consumers form a challenging new target group, since not everybody ages the same way or at the same rate. In some people, ageing causes changes of dimension but does not limit functional ability. Some people's condition deteriorates so that they need more help. One solution is to invest in individuality when innovating for products and services. Another solution would be to develop products and services suitable for everyone regardless of age and condition (universal design) (Kohlbacher, 2013).

The group work brought forth many of the challenges and contradictions listed above. The clothes of an elderly person must be well-fitting and comfortable. For example, materials and seams must not feel uncomfortable against the skin. The clothes and materials must be of high quality in order to prevent unanticipated changes in clothing care. Comfortable and fashionable clothing should include functional, expressive and aesthetic qualities that improve the well-being of the wearer.

The concepts of individuality and decency in the conflicting pressure of personal wishes and social restrictions emerged in the discussion in conjunction with the group work. Ageing consumers are a challenge to designers who often represent several generations and even cultures. One likely challenge is identifying different views of, for example, tolerance or decency related to clothing. According to a study by Iltanen (2007), designers partly consciously and partly unknowingly produce design solutions to cover up the signs of ageing while communicating that elderly women are unfashionable, asexual and wish to express themselves in a very reserved way. According to Iltanen-Tähkävuori (2013), it is essential that designers and the whole industry begin to see elderly people as a new, challenging and exciting target group. This requires training and a quick attitude, information and skill update as well as the courage to discuss difficult matters.

The baby boom generation is both interested in and actively using technology and technical innovations. Technology has already been introduced into people's lives in many ways: information retrieval, communications, diverse services and entertainment offerings. Technology may provide designers with a more rewarding innovation target, separate from deeply rooted attitudes, for producing products and services for elderly people.

Technology solutions that can be applied to clothing and materials are already being developed in abundance. The group work progressed from discussing ideas related to the transportation of smart devices and related radiation protection to ideas concerning the integration of technology, materials and clothes. Smart clothes that monitor the environment and keep the wearer warm or cool depending on temperature changes could facilitate ageing people's clothing problems. The materials would be lighter and more comfortable to wear. The materials would protect themselves from getting dirty, meaning longer washing intervals for clothes and saving precious water – the materials

could also be self-cleaning. The materials could also change visually, e.g., change colour according to lighting in order to, for example, improve visibility in traffic or allow a person to be easily detected in terrain.

Technology

The following were presented as important aspects related to the technology megatrend: social interaction, work and free time. The three notable things concerning wear and clothing were smart materials, the all-in-one and less-is-more ideologies, and internationality and locality (glocal).

As a megatrend, technology means a world that is becoming digital in many ways. In the past 50 years, technology has developed powerfully and communication devices have become an increasingly significant part of life. Nearly everyone has one or more communication devices for contacting each other. In addition to social interaction, the Internet is used to watch television programmes, films and videos. People also often read magazines online. All industries already utilise interconnected devices. Technology is expected to further modify, for example, economic, social and military development worldwide (EEA, 2011).

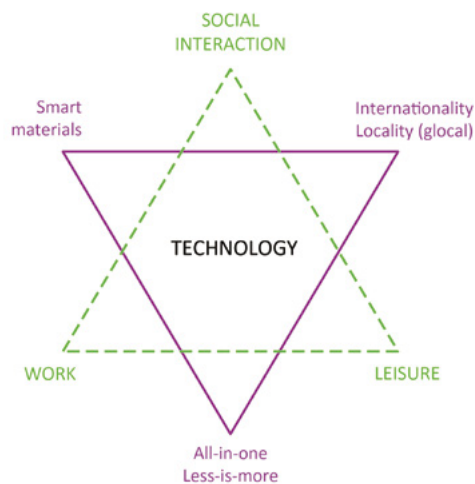


Figure 4. Group work results from technology megatrend. (Nuutinen 2015) (

Approaches to technology are somewhat divided into useful technology and entertainment technology. “Proper” technology is considered to comprise innovations that can help to increase profitability and improve life quality, and manage energy consumption and minimise environmental damage.

Health technology and medical innovations that improve life quality and well-being contribute to an increase in the population’s life expectancy and thereby to balancing the negative effects of demographic growth. Technology innovations serve the needs of both energy and food production, such as renewable energy production, precision farming or irrigation techniques, partially compensating for the problems ensuing from environmental and climate change.

New production techniques and automation, such as 3D printing and robotics, increase work and productivity. Work methods, jobs and workplace hierarchies are also changing. Work does not necessarily have to be performed in a specific location or at a specific time. Technology can be used to actively engage in work, but also to break away from work. Laptop nomads are a new type of people who roam around the world without a permanent home. Because of information technology, they are able to perform their work anywhere in the world. In 2004, Mika Mannermaa said that technology provides individuals with the opportunity to maximise personal mobility (maximum mobility), maximise connections, i.e. be constantly connected with everything (universal connectivity), or maximise immobility, i.e. to aim for not having to go anywhere (maximum immobility).

Useful technology solutions include wearable technology, smart clothes, which are becoming less and less conspicuous and closer and closer to the user. Wearable technology can be used, for example, to monitor a physiological state, such as measuring the heart rate or blood pressure. The actual fabric of smart clothing can, for example, change colour or structure according to the surrounding climate or challenging environmental conditions. The objective is to develop wearable technology to supplement the properties of clothing and to improve the wearer's performance. In this connection, the group detected a possible countertrend, a fatigue with constant positioning, measuring and reporting and also protection against these and even escape from them. Even useful technologies are shadowed by suspicions concerning various threats to information security and privacy.

Simplicity and clarity form the foundation of good design in the less-is-more approach. In all-in-one clothing, many different pieces of clothing are put together to form a single piece of clothing; for example, a shirt and a pair of trousers can be combined to make overalls. Using these approaches, the group generated ideas for 'platforms' that serve as alternative clothing solutions, i.e., half-finished clothes or simplified basic clothes, which the wearers can change according to their preferences and individual needs or using their customisation skills and different modules or technology (re-fashion). The objective is to reduce the quantity of clothing and to develop clothes that serve the wearer better.

Technology development has already affected design work in many ways. The information flow and other work required in design have become faster. In conjunction with technology development, consumers can also actively participate in observing, reporting on and producing fashion phenomena (Nuutinen, 2012). Technology is expected to completely change the design-production-marketing process. The user can select a clothing model from a designer collection and produce it using a 3D scanner he/she can walk through. A 3D-printed item of clothing saves natural resources because of its diversity: the clothing can produce heat in cold weather, cool down in hot weather, tolerate dirt and change colour and pattern. Moreover, the same model

could be changed by recycling the material when fashion changes (Alavalkama, 2013; see Niinimäki 2011).

Climate change

The group studying the demographic development megatrend highlighted the following important issues: materials, dressing culture and consumer behaviour. The three notable things concerning wear and clothing were the sizing of clothing, the acquisition of clothing, and clothing and material innovations.

Climate change is mainly caused by an increase in the amount of greenhouse gases, especially carbon dioxide, in the atmosphere (Climate guide, 2015). The temperature will rise in different parts of the world, but not evenly. The biggest increase in temperature will take place in the northern latitudes in the winter. The currently exceptional heat waves will become more common in Europe in the summer. Climate change is predicted to increase the prevalence and intensity of extreme weather phenomena, such as storms, floods and droughts. The occurrence of rain is also expected to change:

while some locations may have a shortage of water, others will suffer from deteriorated water quality as floods become more common.



Figure 5. Group work results from climate change megatrend. (Nuutinen 2015)

Understanding climate change can be difficult. It is often an invisible phenomenon with no immediate health hazards. The temporal and geographic distances between cause and effect can be long. Many early signs of climate change were detected in sparsely populated areas, such as the northern areas of the Arctic, or in areas where people seldom go, such as the mountains and coral reefs. What makes subtle changes in climate more difficult to see is that modern humans are isolated from the climate and the weather because we live in ventilated buildings, travel in ventilated cars and spend only a little time in nature (Moser, 2010).

The Arctic climate is inevitably changing. According to satellite observations, sea ice in the Arctic is constantly diminishing and may even disappear by 2030. The melting of the ice is not just a local problem. It also affects the southern areas of the globe,

where the majority of the people live. While climate change causes crises, it also offers solutions to crises. At a time when critical natural resources – oil, water and minerals – are running out, the melting of the Arctic ice cap is making new oil and gas resources available. An arctic paradox is emerging: the faster the climate warms, the faster people can access the oil and gas resources at the bottom of the ocean and continue to increase climate change.

Nature changes as the Arctic climate changes. The frosty ground that is either bald or stunted in growth and often covered in snow and ice will thaw, improving the growing conditions of more southern plants and the living conditions of animals moving north. Emerging job opportunities also allow for human migration to new areas – temporarily or permanently.

The group discussed the clothing challenges of people moving into new conditions as well as related solutions. Arctic conditions cause clothing problems for people exposed to the weather in their work. As extreme weather phenomena become more common, clothing must both protect against and adapt to weather changes, such as cold, heat, humidity and wind. Clothing can alternatively serve as a sort of tool to support work and improve work performance.

As global warming advances, people will develop new lifestyles to utilise cold winters in the tourism industry to serve both regular and extreme travellers. While regular tourists enjoy, for example, skiing or snow construction, extreme tourists want to roam the unbeaten path and experience unknown, difficult conditions. Travel in extreme conditions requires forethought, vigilance and situational awareness as well as respect for the prevailing facts (Milonoff, 2007) and proper gear.

Climate change has introduced a sustainable development perspective to consumerism to supplement aesthetic objectives. The new approach takes account of the state of the environment, efforts to reduce consumption and waste, and flaws in the working and living conditions of clothing industry employees (Niinimäki, 2011; Aakko, 2012). Informed consumers weigh their acquisitions critically, including source and method, if they actually make an acquisition at all. The group work generated ideas to serve these customers, starting from clothing borrowing stations that offer clothes optimised for Arctic conditions for temporary employees and tourists visiting the location. They might not be able to acquire clothes suitable for Arctic conditions in their home areas or may not have sufficient information on clothing and related material requirements in Arctic conditions. The clothes available for borrowing could utilise material innovations that provide protection against weather and pollution or have properties that can be adjusted to support work or sports performance and maximise the effectiveness of activities.

The group discussed the impact of new residents and new lifestyles on the clothing culture in the Arctic. Immigration will lead to the dominant culture mixing with

traditions of different backgrounds. Changing conditions will also create new traditions. Mixing clothing cultures may cause some traditions to disappear or partially highlight them and even enrich them.

New materials, developed from plant and animal fibres in addition to artificial fibres, offer a perspective into the renovation and diversification of clothing culture. The warming of the climate improves the availability of natural fibres through improving natural growing conditions and habitats, which in turn increase the number of species and diversify agriculture. As agriculture becomes more profitable, farmers can accommodate the environmental perspective while developing local material production. The environmental perspective will also be taken to raw material refinement, product design and production as well as in recycling solutions after the products have been used. Environmentally friendly local material production leaves open the question of whether we should accept the properties and colours of the raw materials as they are or modify them. Other unsolved issues include the possibly uneven quality and asynchronous availability of materials. Information on the origin of the material and the processing methods of local products is always available. Design can be used to perfect the unique appearance of the products.

Urbanisation

The group studying the urbanisation megatrend presented the following important issues: jobs, tourism and 'ordinary people'. The three notable things concerning wear and clothing were clothing services, two user types and modularity, including DIY solutions.

Urbanisation advances simultaneously with demographic change and technology development (O'Sullivan, 2013). In 1950, less than one third of the world's population lived in cities. By 2030, two thirds of the world's population will live in cities, some of which will have merged into megacities. Most of the development towards urbanization is taking place in developing countries.

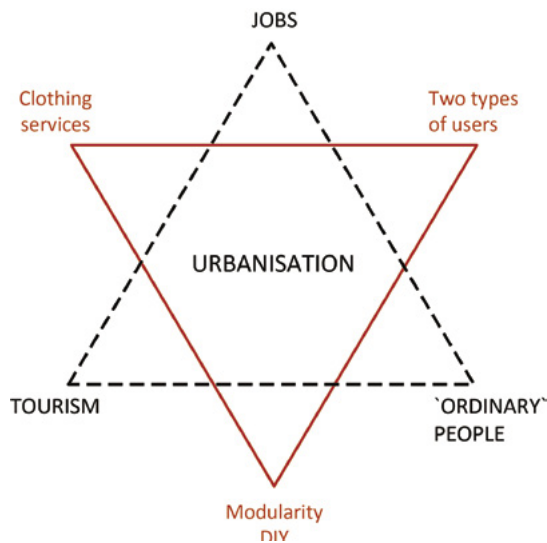


Figure 6. Group work results from urbanisation megatrend. (Nuutinen 2015)

Cities are significant clusters of economic activity and attract people who are seeking a livelihood, prosperity and a better life. Economically attractive cities may benefit

from returnees, people who move away to find work and later return with new competences. Urbanisation promotes social and economic development while presenting challenges to a sustainable way of life by increasing the use of natural resources and expediting environmental decay (EEA, 2011).

The group created a vision where the immigration generated by the new job opportunities in the Arctic requires the development of temporary cities. The cities are built on demand when labour moves into the area, some to become permanent and some to become temporary residents. The residents can be divided into two types in terms of clothing requirements. The residents who work outside the cities in nature or in other challenging conditions need protective clothing. The residents living and working in the cities will not necessarily require so much of their clothing. Tourists present a challenge, as their knowledge of clothing requirements in Arctic conditions may be insufficient.

To solve the problem, the group examined the possibility of clothing service development. The borrowing or rental of clothes is one form of such service. The customers would include temporary workers and tourists, who could rent clothes suitable for the local conditions. This way, they would also not need to worry about clothing care. The group pondered the comfort of the wearer in borrowed clothes. How to convert an item of clothing perceived as ugly into something interesting? Could clothing modularity, i.e. compilations of separate items, promote a feeling of individuality? Or could clothes provide a platform that allows users to personally customise their clothes using technology? Both options would allow the user the chance for personal expression in the spirit of DIY (do-it-yourself), either alone or by sharing personal skills with others.

The group also discussed new opportunities related to clothing production. Co-design emerged as a significant work method, allowing wearers to cooperate with both the designer and the manufacturer. Another option is customisation implemented in cooperation with the wearer, which allows the wearer to modify the product to match personal requirements. The following option is already possible: customers can order, for example, jeans customised according to their measurements online. The third method is personalisation. While mass-customisation means a company producing an item customised according to the requirements of a specific consumer, personalisation means the company allowing the customers to make products that match their needs for themselves. Personalisation is always authorised by the company and performed by the wearer.

ARCTIC WEARS - FUTURE PROSPECTS

The workshop was short but allowed the attendants to explore occupational, sports and protective clothing and winter leisure wear-related requirements from many angles.

The future-oriented approach was an important, conscious choice. The objective was to discuss Arctic clothing and fashion-related issues that allow making solutions and choices today to enable the future vision. This is why four megatrends were chosen to serve as the starting point for the workshop: demographic change and technology are megatrends related to the individual, while climate change and urbanisation are megatrends related to the environment.

All groups shared some discussion topics during the group work, i.e. supporting work or sports performance through material properties or clothes; examining clothes as tools; service activities that highlight sustainable development and limit clothing quantity, but promote availability, and half-ready, modular or platform-like approaches that increase the wearer's opportunities for customisation. The examination of these discussion topics highlights usability and functionality in arctic clothing in relation to the changing climate and environmental conditions in the north.

Arctic clothing may not initially conjure images of fashion or trendiness, if fashion refers to short-term styles that change two or more times a year. Prevalent fashion ideals, however, can be identified in Arctic wear both in ethnic and modern tourist clothing. The user-oriented and practical perspective highlights the concept of clothing, the complex of clothes worn by one person (Koskennurmi-Sivonen, 2003). Another concept emphasized is wearing, the most concrete manifestation of which can simply be deciding how to dress or what clothes to wear when it is cold (Uotila, 1994). What dimensions could arctic clothing entail besides usability and functionality?



Figure 7. Experiencing the effects of wind chill in the climate chamber in arctic outfits. (Picture: Konola 2015)

The Arctic region no longer simply refers to a traditional or protected area, but an actively developing region. For the time being, the term evokes an exotic framework for design and fashion. It also means a unique location close to a real natural environment.

An understanding of the Arctic can be applied to fashion creations that could also be used elsewhere in spite of the starting point.

What would Arctic fashion be like? Expensive, innovative avant-garde couture? Widely accepted mass fashion that complies with the public taste? Global fashion, globally distributed styles of clothing adopted by people around the world? Anti-fashion that opposes the mainstream? Or fashion that reflects environmental consciousness and an artistic arctic reality from the outset and is introduced in a fashion and design capital evolving in the Arctic?

Fashion capitals have long been an important aspect of the development cycle in the fashion industry. Fashion capitals typically feature an extensive range of entertainment, culture and leisure activities in addition to fashion. They are internationally renowned and powerful locations with a strong, unique identity. Great opportunities are available, since “more and more Christmas and winter-related AV productions are being filmed in Rovaniemi. The number of international advertising production has increased. The increase in the number of feature film and television programme productions are also positive signs. AV production initially benefits the tourism and service industries and later the business operations of the AV companies.” (Ansala, 2014)

The currently significant fashion capitals – London, Paris, Milan and New York – have established their status, reputation and significance over a long period of time (Berry, 2012). New fashion capitals are rising to complement them in different parts of the world, such as Africa, Australia and South America. (GLM, 2015). Many fashion capitals are located in areas where the climate is warm. It is not the climate that forms an impediment for the development of a fashion capital in the Arctic, but designers’ ability to innovate and channel artistic energy to interesting products and services. In addition to them, the residents’ lifestyles, street fashion and culture are an important part of fashion capital identity, also contributing to international attraction and recognition (Vejlgaard, 2008).

Obtaining fashion capital status has become an objective to urban designers who wish to expand the tourism supply in the fields of design and fashion. The development of technology has not reduced tourism to fashion capitals, even though fashion week events have developed digital opportunities for participation. Fashion and design tourism can be developed precisely because technology cannot communicate the atmosphere of actual events and products and does not allow people to experience the surrounding local nuances.

REFERENCES

- Aakko, M. 2012. Kestävyys muodissa – Katsaus kestävän muodin kokonaisuuteen. In R. Koskennurmi-Sivonen (ed.) 2012. Johdatuksia pukeutumisen tutkimukseen. Helsinki: A publication of the Finnish Society for Textile Culture 6/2012.
- Alavalkama, S. 2013. Pian vaate on toinen ihosi. *Taloussanomats* 21 September 2013.
- Ansala, L. 2014. Avoin ja arktinen. Referenced 13 March 2015. <http://www.liisaansala.fi/blogi/avoin-ja-arktinen>.
- Aspelund, K. 2010. *The design process*. (2nd ed.) New York. Fairchild.
- Berry, J. (ed.) 2012. *Fashion Capital: Style Economies, Sites and Cultures*. Oxford: Inter-Disciplinary Press.
- EEA, 2011. *The European environment — state and outlook 2010: assessment of global megatrends*. European Environment Agency, Copenhagen. Referenced 13 March 2015. www.eea.europa.eu/soer/europe-and-the-world/megatrends/download.
- Flinkkilä, J. (ed.) 2014. Tee tulevaisuus! Pk-yrityksen ennakkointiopus. Diges ry. Referenced 13 March 2015. http://www.diges.info/pdf/tee_tulevaisuus_pk-yrittajan_ennakkointiopus.pdf.
- Glenn, J. 2003. The Futures Wheel. In Glenn, J. & Gordon, T. (Eds.) *Futures Research Methodology Version 2.0*. The Millennium Project. American Council for the UNU.
- GLM. *The Global Language Monitor*, 2014. New York Takes Top Global Fashion Capital Title from London, edging past Paris. Referenced 11 March 2015. <http://www.languagemonitor.com/fashion/sorry-kate-new-york-edges-paris-and-london-in-top-global-fashion-capital-10th-annual-survey/>.
- Ilmasto-opas, 2015. *Ilmastonmuutos ilmiönä*. Referenced 13 March 2015. <https://ilmasto-opas.fi/en/>.
- Iltanen-Tähkävuori, S. 2013. Vaatteet ja vanheneminen: Katse vaatesuunnittelun nykyhetkeen ja tulevaisuuteen. *Futura* 4/2013. The Finnish Society for Future Studies.
- Iltanen, S. 2007. *From mini-skirts to granny dresses: Industrial fashion design and practices of middle-aged women constructing social age*. Publication series A 80 of the University of Art and Design Helsinki. Helsinki. University of Art and Design Helsinki.

- Kamppinen, M., Malaska, P. & Kuusi, O. 2002. Tulevaisuudentutkimuksen peruskäsitteet. In Kamppinen, M., Kuusi, O. & Söderlund, S. (ed.) Tulevaisuudentutkimus. Perusteet ja sovellukset. Helsinki. SKS. 19–53.
- Kohlbacher, F. 2013. The Business of Aging. Referenced 13 March 2015. http://www.huffingtonpost.com/florian-kohlbacher-phd/the-business-of-aging_b_2784549.html.
- Koskennurmi-Sivonen, R. 2003. Vaatetus, pukeutuminen ja muoti – ero ja erottamattomuus. In Koskennurmi-Sivonen, R. & Raunio, A-M. (ed.) Vaatekirja. Publication series: Kotitalous- ja käsityötieteiden laitoksen julkaisuja 8. University of Helsinki. 1–16.
- Lahti, H. & Nuutinen, A. 2014. Yhteisöllinen konseptisuunnittelu vaatetus suunnittelun lähtökohdista. In Nuutinen, A., Fernström, P., Kokko, S., & Lahti, H. (ed.) (2014). Suunnittelusta käsin: Käsitön tutkimuksen ja opetuksen vuoropuhelua. Publication series: Kotitalous- ja käsityötieteiden julkaisusarja 36. University of Helsinki. University of Helsinki, Department of Teacher Education.
- Mannermaa, M. 2004. Heikoista signaaleista vahva tulevaisuus. Helsinki. WSOY.
- Milonoff, T. 2007. Madventures – Kansainvälisen seikkailijan opas. Porvoo. WS Bookwell Oy.
- Moser, S. C. 2010. Communicating climate change: history, challenges, process and future directions. Referenced 13 March 2015. http://www.susannemoser.com/documents/Moser_WIRE_2010.pdf.
- Niinimäki, K. 2011. From disposable to sustainable: the complex interplay between design and consumption of textiles and clothing. Aalto University Publications series. Doctoral Dissertations 84. Helsinki.
- Nuutinen, A. 2012. Virtauksia suunnittelijalta kuluttajalle ja takaisin – Tulevaisuus-orientaatio muodissa. In Koskennurmi-Sivonen, R. (ed.) (2012). Johdatuksia pukeutumisen tutkimukseen. Helsinki. A publication of the Finnish Society for Textile Culture 6/2012.
- O’Sullivan, M. 2013. Introducing Our New Megatrends Framework. Referenced March 13th 2015. <https://www.credit-suisse.com/media/sites/megatrends/doc/megatrends-usa.pdf>.
- Rittel, H. & Webber, M. 1973. Dilemmas in a General Theory of Planning. Policy Sciences, 4, 155–169. Referenced 13 March 2015. http://www.uctc.net/mwebber/Rittel+Webber+Dilemmas+General_Theory_of_Planning.pdf.

- Rubin, A. 2004. Toimintaympäristön muutosten tarkastelu. TOPI Tulevaisuudentutkimuksen oppimateriaali. Referenced 13 March 2015. http://www.tulevaisuus.fi/topi/topi_vanha/kokohakemistosivut/kokotoimintaymp%C3%A4rist%C3%B6.html.
- Uotila, M. 1994. Pukeutumisen kuva. Fenomenologis-eksistentiaalinen lähestyminen pukeutumiskuvien tekemiseen ja tulkintaan. Helsinki. Yliopistopaino.
- Vejlgaard, H. 2008. Anatomy of a trend. New York. McGrawHill.
- Wilkoszewski, H. 2009. Demographic Change: A Major Political Problem Zone. Referenced 16 February 2015. https://www.mpg.de/798198/Woo1_Viewpoint_010-015.pdf.
- Ylä-Kotola, M. 2012. Arctic Design. In P. Tahkokallio (ed.). Arctic Design. Opening the Discussion. University of Lapland. Series C. Overviews and Discussion 38.



**»» FUTURE
PROSPECTS -
ENABLING BUSINESS MODEL
INNOVATION THROUGH THE
ARCTICPRO NETWORK**

INTRODUCTION

The ArcticPro network combines a vast amount of expertise and facilities for designing and testing cold - and protective wear. The facilities alone within the network consist of climate chambers, test pools, different types of manikins, cleanrooms and textile testing. Additionally, the network has high level expertise in human factor studies, user-centred design and in 3D and digital design of clothing. Such a network is an enabler of various innovations in the clothing industry but it can also enable innovations in the network members' business models.

CREATING VALUE THROUGH INNOVATION IN BUSINESS MODEL

Business is about creating value, which is 'perceived worthiness', to a user of a product or a service (Pitelis, C. 2008, 6). Capturing value, however, is different from creating value. It is a strategy that makes sure that the maximum portion of value is captured (in the form of profits) in a firm (Aspara, J. & Tikkanen, H. 2012, 1.) There are various strategies to capturing value, but it is important to notice that even innovation in its conservative sense is not necessary for firm for doing so. There are companies, such as IBM, Microsoft, Cisco, Intel, Sun and Oracle that are able to capture value without any innovation advantages (Pitelis C. 2008, 25, 27). However, it can be argued that the innovation advantage of these companies lies in their business model innovation.

A business model is a system of interconnected and independent activities in a firm (Amit, R. & Zott, C. 2012, 41). An activity system consists of all activities performed by a focal firm, its partners, vendors or customers, etc. (Amit, R. & Zott, C. 2010, 217). They define the way of making "the business" in a company and it is considered to be a success differentiator for CEOs and it has much stronger correlation with operating growth margin growths than other types of innovation (Amit, R. & Zott, C. 2012, 41; Giesen, E. Berman, S.J. Bell, R. & Blitz, A. 2007, 1.)

The three design elements of *content, structure and governance* characterise a company’s business model and the four major interlinked value drivers of *novelty, lock-in, complementarities and efficiency* can be adopted in assessing the current business model. However, before launching a new business model, the first question is ‘What customer needs will the new business model address?’ (Amit, R. & Zott, C. 2012, 44-45). This question will be further elaborated in later parts of this article.

IBM has identified three types of business model innovations, which are innovation in *industry models, in revenue models and in enterprise models*. The *industry model* is about innovating the whole industry value chain or moving horizontally into new industries, while the *revenue model* focuses on reconfiguring offers and introducing new pricing models. An enterprise model is about altering the structure of an enterprise and its role in the existing value chain. In this model, the company can introduce *specialisation* on high-margin activities or rely on external collaboration through *network plays* (Giesen, E. et al. 2007, 1, 5-6).

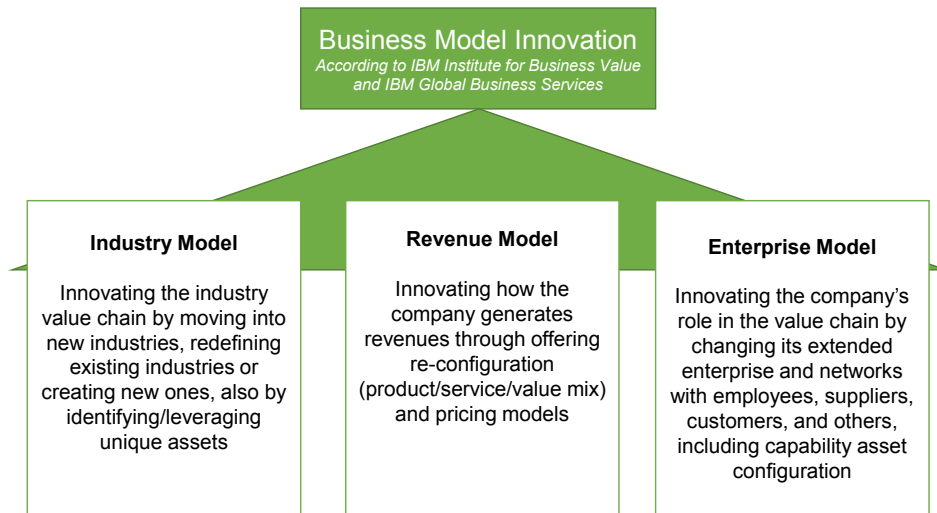


Figure 1. IBM Framework for business model innovation (Giesen, E. et al. 2007, 5)

According to John Hagel, a famous author and consultant in the field of business strategy, companies are an “unnatural bundle” of three different businesses: finding and building customer relations, creating products and managing infrastructure. Hagel points out that a company should have an emphasis on one of those and trust on others to do the other two. Nowadays, it is much easier to assemble a business model such as markets, alliances or distributive network. Digitalisation plays a big role in such models. Seeing business as an ecosystem forces it to consider its relationships and how it interacts with its environment (Allee, V. 2003, 12-13, 211-212).

THE TESTING INDUSTRY AND CHANGES IN THE APPAREL TESTING

Large companies, such as Intertek and TÜV SÜD, are operating in the testing and quality assurance industry. They see that there is an increasing demand for testing as niche products are introduced to larger customer bases through company acquisitions (Intertek. 2013, 6) and companies outsource their non-core activities, such as testing (TÜV SÜD. 2013, 26). Intertek has introduced a business model where the focus is on delivering services through a network of locations and employees. Such network of laboratories can react quickly to changes and deepen its position in the markets (Intertek. 2013, 8).

In apparel testing, it is not enough to solely provide thermal insulation and vapour resistance testing. In fact, measuring thermal insulation in sport and leisure apparel and in protective clothing is decreasing. As an example, companies are more interested about sweat distribution and performance thermal comfort in sportswear and performance heat stress and performance hazard protection in protective clothing (Burke R. 2014). Table 1 below illustrates the state of apparel testing in different fields of clothing. The red colour indicates decline in service demand, the yellow colour stands for stability and green for growth in that area. The exclamation mark highlights the importance in that particular field. It is likely that not all clothing testing service providers possess all the capabilities of conducting such a range of tests.

	Sport and leisure apparel	protective clothing	smart clothing	building ambience	vehicle ambience
Thermal resistance					
Vapour resistance					
Sweat distribution	!				
Performance heat stress		!			
Performance hazard protection		!			
Performance thermal comfort	!			!	!

Table 1. The future of test manikins from a commercial perspective (Burke R. 2014)

THE CURRENT BUSINESS MODEL AT ARCTIC POWER

The Arctic Power research team and Lapland University of Applied Sciences conducts many standardised climatic testing climatic as well as more tailored testing and measurement and sensor data collection systems to its clients. The clients come from different fields and, therefore, Arctic Power needs to work flexibly with various testing setups and industrial areas. One of the offered services is thermal insulation testing for clothing with a moving thermal manikin. The manikin is shown in the Figure 2 below



Figure 2. The moving thermal manikin "Pena" in the Arctic Power laboratory.

Traditionally, Arctic Power has always invested the infrastructure, equipment and expertise to introduce new service products. However, such product innovations are very time consuming and offer uncertain future returns (Amit, R. & Zott, C. 2012, 41). This is true even though the testing industry in general is operating in a networked manner, as in the case of Intertek and TÜV SÜD. At times, Arctic Power is a subcontractor to some testing service companies such as Toptester, which makes it a subcontracting entity as part of existing testing networks.

In apparel testing, the clients need a variety of tests (Burke R. 2014). Arctic Power has also faced situations where it alone cannot provide the customers with all the apparel tests they would like to conduct due to the limited testing facilities and equipment in that particular field. A potentially new business model should target providing a wide array of testing services and facilities to customers to provide effectiveness and efficiency to the customer.

It can be seen that Arctic Power has adopted a *revenue model* (as described by Giesen, E. et al. 2007, 6), where its main innovations are in the configuration of its services. When looking at the whole operations of Arctic Power (R&D projects, testing services), it also has introduced an *industry model* to an extent (as described by Giesen, E. et al. 2007, 6), where it has applied its main expertise of smart ICT and testing to various industries such as tourism, automotive, ITS, energy and buildings.

POSSIBILITIES AND RECOMMENDATIONS

Apple has locked in its customers through iPod/iTunes-combination and they have been able to introduce a novelty-centred business model. In this model, the focus is not on the actual product, but on the business model itself. Apple also offers various complementarities (or “tie-ins”) by offering product knowledge, one-on-one tutorials, workshops and product repairs at the ‘Genius Bar’. The company has also reached substantial efficiency in its supply chain (Montgomerie, J. & Roscoe, S. 2013, 292-293).

Probably there are many micro-, small- or medium-sized companies or units/team, such as Arctic Power, offering testing services, which have very little focus on the actual business model. Introducing *novelty, complementarities, lock-in and supply chain efficiency* in their business model would mean that the testing services are not easily swiped away by superior products by rivals. A good business model offers innovation in areas where the competition does not act (Amit R. & Zott C. 2012, 41-42).

The ArcticPro network could jointly address the customers’ needs of getting a set of testing, modelling and design services from a networked entity. The network, its expertise and facilities, offer a possibility to introduce an *enterprise model* where the focus would be on network plays that relies on external collaboration (as described by Giesen E. et al. 2007, 6.) A novel business model based, for example, on *governance* of an activity system (Amit, R. & Zott, C. 2012, 44) could be established within the ArcticPro network in context of apparel testing.

Introducing governance would require only a little amount of new content in the activity system and it could enable an entity to shift its core from being a service executor to focus on customer and network relations. Finally, the Figure 2 below answers to the six questions (by Amit, R. & Zott, C. 2012, 45) that managers need to ask before launching a new business model. The questions are answered from the viewpoint of the ArcticPro network.

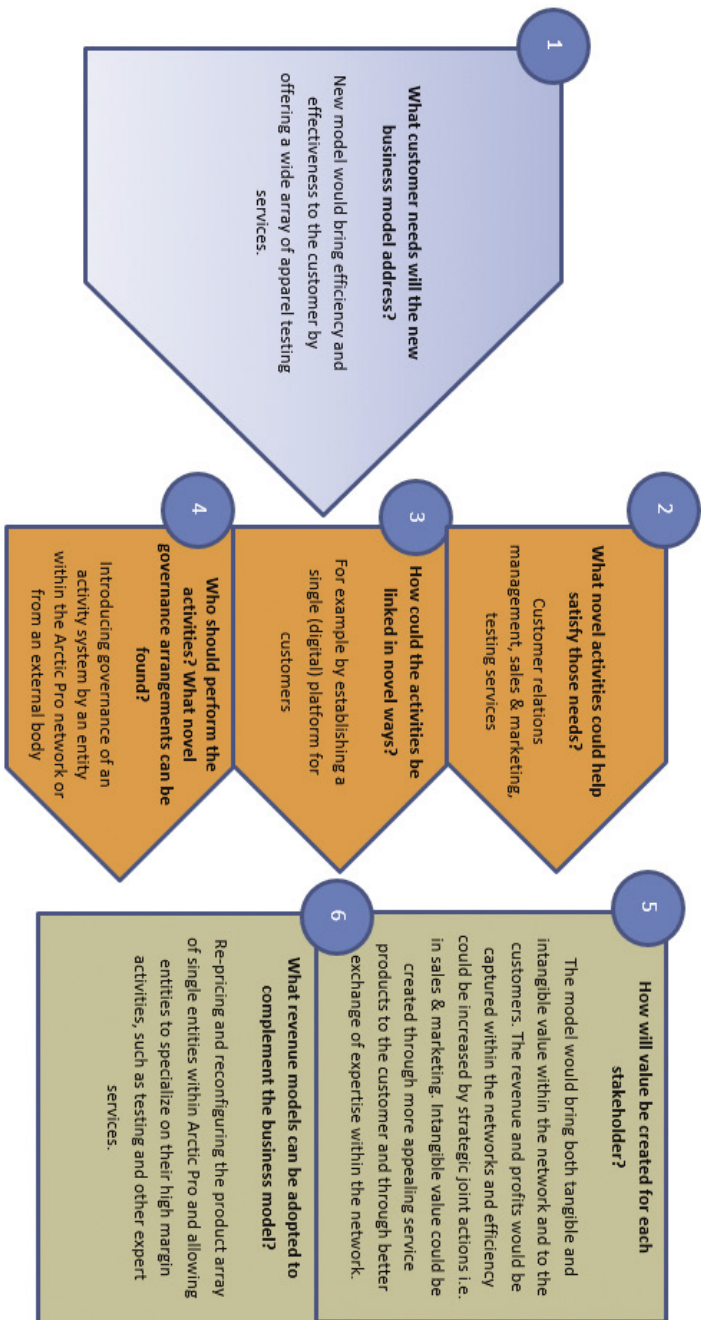


Figure 2. Answers to the six questions managers should ask before launching a new business model, based on the model of Raphael Amit and Cristopher Zott (as described in Amit, R. & Zott, C. 2012, 44)

REFERENCES

- Allee, V. 2003. *The Future of Knowledge – Increasing Prosperity through Value Networks*. Elsevier Science. United States of America.
- Amit, R. & Zott, C. 2010. Business Model Design: An Activity System Perspective. *Journal of Long Range Planning*, vol. 43, issues 2-3, 216-226.
- Amit, R. & Zott, C. 2012. Creating Value through Business Model Innovation. *MIT Sloan Management Review*, vol. 53, no. 3, 41-49.
- Aspara, J. & Tikkanen, H. 2012. Creating novel consumer value vs. capturing value: Strategic emphases and financial performance implications. *Journal of Business Research*, Vol. 66, Issue 5, 593-602.
- Burke R. 2014. Vice-president of Measurement Technologies NW. Verbal source. Presentation in Ambience14 & 10i3m in Tampere. 9 September 2014.
- Giesen, E., Berman, S.J., Bell, R., & Blitz, A. 2007. Paths to success – Three ways to innovate your business model. Referenced 10 March 2015. Address: <http://www-935.ibm.com/services/us/gbs/bus/pdf/g510-6630-01-paths2success.pdf>.
- Intertek 2013. Annual Report 2013. Online document. Referenced 9 March 2015. Address: <http://www.intertek.com/investors/reports/2013-annual/.pdf>.
- Montgomerie, J. & Roscoe, S. 2013. Owning the consumer – Getting to the core of the Apple business model. *Accounting Forum* 37, vol. 37, issue 4, 290-299.
- Pitelis, C. 2008. Value Capture from Organizational Advantages and Sustainable Value Creation. Referenced 18.2.2015. Address: http://www.jbs.cam.ac.uk/fileadmin/user_upload/research/workingpapers/wpo806.pdf.
- TÜV SÜD. 2013. Annual Report 2013. Referenced 10 March 2015. Address: http://issuu.com/tuevsued/docs/2013_tuev_sued_ar_complete?e=3020937/7789475#search.

This publication is produced in the Arctic Pro Lapland project, which was established for enhancing international cooperation and developing the activities of Lapland UAS and University of Lapland in the field of arctic clothing testing and design. The articles reveal what has been carried out in the past, what are the current activities and how the future looks like in the field of arctic clothing. The authors come from various organisations with high-level know-how on the topics presented.



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