PROJECT FINAL REPORT
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Development of new technologies for the flexible and eco-efficient production of customized healthy clothing, footwear and orthotics for consumers with highly individualised needs

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1 Publishable summary

1.1 Executive summary

Mass-customization of wearable products are offered as a higher added value to the broad public and had to compete with ready-to-wear offer. However, people with specific requirements are not covered with the current mass-customized products. This is the case of the elderly, disabled, diabetic and obese population groups when wearing textiles, clothing, footwear and textile-based orthotic goods. However, at present, available knowledge and flexibility of production equipment and machinery of SMEs operating in these traditional industries (even those that already offer made-to-measure products to the mass public) is unable to respond to the individual needs among such heterogeneous groups. The FASHION-ABLE project has solved this problem with: User Framework defining and quantifying the relevant user attributes, New Collaborative Product Customization Services, New stretch-leather's manufacturing processes and equipment, New 3D-spacer fabric's flexible manufacturing process and machinery, New textile's finishing operations and equipment, An extended manufacturing order management structure and tools, Life-Cycle Analysis instruments, and Interoperable Product Data Management tools.

We use the end-user specifications in order to develop product customization services to be used by end-users and professionals (configurators). These tools manage the consumer characteristics and preferences which are the key to individual customization. A collaborative design environment made possible to define the morphological and functional characteristics of the end-user, to configure product style, and to individually personalize key product functionalities relevant to guarantee comfort and avoid health problems. The configurators are connected with an automatic method for adaptation of product dimensions to (atypical) individual shapes and postures. This method is applied to textile products (e.g. clothes and textile orthotics).

In order to develop comfortable and fashion products (e.g. footwear and clothes) one of the results is the development of a new stretching textile, whose final mechanical properties are among the main added values, along with aesthetical and tactile feeling. The new materials combine stretch leather with 3D fabrics. During the project a new manufacturing machine was developed together with a CAM system. A set of parameters based on past production quality checks control the main mechanical and thermic elements of the process, along with the devices, which verify their behaviour during machine operations by means of appropriate sensors. This approach enables the product developers to elaborate past results and take decision based on their verified quality.

To adapt the pattern of the products to customer measures we have developed a process that uses the customer measures to determine the correlating reference size that matches best to the gathered dimensions. In the next step the determined reference size is adapted depending on the divergence of customer measurements to a defined basis set of measurements that was used to develop the reference sizes. For this made to measure (MtM) actions were developed in a morphotype specific way. This allows to cluster customer groups to morphotypes and to develop for those groups optimised MtM rules.

In addition to the new customization processes, a new tool has been designed to support the constant reuse of environmental studies (Life-Cycle Analysis) particularly for the supply of new technical materials (i.e. nano-materials) and sector-specific components (i.e. footbed) in order to counterbalance the high variability of the fashion product chain. EPD general rules already provide a partial harmonization between the PCRs of the upstream materials (e.g. textiles) and the PCRs which are defined to downstream products containing such materials (e.g. footwear).

Finally, we have evaluated successfully the feasibility of the new customization processes with real costumers in Germany, Italy, Belgium, Poland and Spain. We have delivered real products in 3 demonstration campaigns: shoes, clothes and textile orthotics. The costumers cover 3

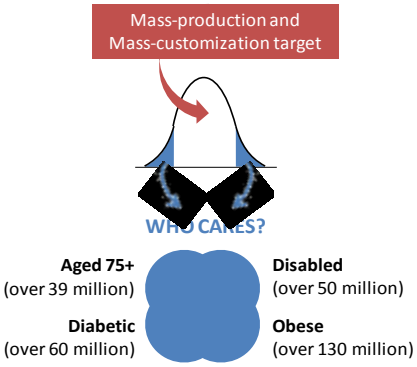
target groups: obese people, wheelchair users, and people with special needs regarding foot shape and physiology (diabetic).

1.2 Summary description of project context and objectives

Until now, mass-customization of wearable products has been offered as a higher added-value to the broad public and had to compete with ready-to-wear offer. However, there are population groups for which personalization IS NOT JUST AN ADDED-VALUE BUT a REAL NEED affecting their HEALTH and QUALITY OF LIFE because off-the-shelf products do not meet their morphological or functional diversity.

This is the case of the elderly, disabled, diabetic and obese population groups when wearing textiles, clothing, footwear and textile-based orthotic goods. But at present, available knowledge and flexibility of production equipment and machinery of SMEs operating in these traditional industries (even those that already offer made-to-measure products to the mass public) is unable to respond to the individual needs among such heterogeneous groups.

Figure 1: Potential market targets for FASHION-ABLE products



FASHION-ABLE project aims at providing the European innovative and customization-concerned SMEs with the technological means that will enable the agile and eco-efficient production of personalised products addressing the complex individualised needs of growing market niches out of the scope of mass-produced goods in terms of health and performance.

In particular, FASHION-ABLE project has implemented and demonstrate the new cross-sectorial technologies developed in industrial contexts in three concrete highly challenging target groups:

Target group addressed	Specific products addressed
Diabetics developing diabetic foot (30 million) among which elderly and obese patients are in higher risk.	**Fashionable footwear for diabetic feet** preventing and mitigating further health complications.
Physically disabled people requiring a wheelchair to move (5 million) among which over 2 million are aged 65+.	**Fashionable clothing for wheelchair users** allowing higher performance and preventing from health complications.
Musculoskeletal disorders (MSDs) sufferers (over 40 million) which prevalence increases with age and weight.	**High performing textile compression therapy bandages** highly reducing the chances of not being adequately used due to discomfort or appearance issues.

1.2.1 Industrial context and strategic importance of the textiles, clothing and footwear

With 2.6 million employees, 230 000 companies (90% SMEs) and a turnover of around €240 billion, the European textile, clothing and footwear sectors accounts for 4% of the overall added value of the European Union's manufacturing industry and for 20% of world's export share [1,2,3]. Total value added produced by the sector is over €65 billion. SMEs dominate these

[1] The future of the textile,clothing and footwear sectors in Europe. European Economic and Social Committee, 2008

[2] European Commission. Enterprise and Industry. Footwear - Statistics (2007)

sectors in the EU-27, accounting for 74.5 % of sectorial value added and 75.3 % of employment. The share of value added generated by SMEs in the textiles, clothing and leather manufacturing sector is also significantly higher than the average 56.9 % across the non-financial business economy [4]. Detailed figures of the specific product niches addressed by the project are described in section 3.1.

Over the last decades the challenges imposed by ongoing economic globalization processes have resulted in a significant reduction of the production-import ratio of goods requiring labour intensive manufacturing processes such as the textile, clothing, footwear and textile-based orthotics industries (sector's added value has fallen by over 40%) [1]. The outcompeting price-pressure imposed by overseas manufacturers has forced European companies to follow different strategies: the bigger players shifted their production to low-labour-countries and focused on distribution, passive SME followers gave in and closed their factories, and the more innovative SMEs survive by adopting flexible manufacturing technologies to proactively respond to the current changing and uncertain customer demand and trying to find profitable premium niches.

The results of the project are addressed to these European innovative SMEs. We expect to set up the technological framework enabling these companies to sustainably produce full-customized products (lot-size-one) based on individual attributes (physical, physiological or functional) and preferences of specific but growing targets (i.e. elderly, disabled diabetic or obese) that cannot be covered by mass-produced goods at comparable costs and delivery times (e.g. comparable to online shopping or to a trouser leg length-arrangement). This target can only be attained in a sustainable and protectable manner by taking advantage of the proximity to customers of EU-based manufacturing sites and revaluing past technological investments (i.e. compatibility with current production equipment, facilities and supportive IT tools).

With regards to technologies, FASHION-ABLE enables on-demand functional properties of wearable products. We have introduced processes to manufacture high performing textiles and stretch leathers. As well as a process that allows functionalising small lots and applied in specific locations of single products according to individual differences and needs defined by users and orthotic technicians. The project has followed two complementary approaches leading to a new generation of full-customised products and manufacturing processes: (a) introduction of new tailored-to-function material structures (spacer fabrics and stretch leathers) and (b) specific location of multi-functional surface properties (on-demand spray finishing).

1.2.2 Special needs market context

As abovementioned, fully-customised high-value added products addressed to the elderly, disabled, diabetics, and obese are key opportunity to European SMEs producers of consumer goods and the service-to-industry SMEs depending on them.

Disabled people represent over 50 million persons in the EU (10% of the population) [5]. In Europe, people aged 65+ represents 17% of society accounting for 89 million in 2008 [6,7]. It is expected to reach 29% by 2050. 80+ represent 4% of total population and it is expected to rise to 11%. There is a high correlation between the ageing process and the increase of body mass index [8], physical limitations or weakness [9], and the development of other degenerative

[3] European Commission. Enterprise and Industry. Clothing and textiles - Statistics (2007)

[4] Eurostat Yearbook 2010

[5] Facts and figures about disability. European Disability Forum

[6] Eurostat – demographics (Access 2010)

[7] Europe' s demographic future: Facts and figures on challenges and opportunities, European Commission, Directorate-General for Employment, Social Affairs and Equal Opportunities, 2007,

[8] Obesity and Overweight. World Health Organisation 2003.

diseases. According to the EC White Paper "*Together for Health: A Strategic Approach for the EU 2008-2013*" the first objective to be pursued is: fostering good health in ageing Europe. Obesity is one the major health challenges in developed countries and has become an epidemic over last decades. Europe has the highest number of overweight and obese people in the world. The number of obese people has in fact tripled over the last 20 years in the Europe, according to the WHO. Today, over 130 million people are obese in Europe [10]. Among favouring the development of other diseases, it is estimated that 55% of obese people develop diabetes. According to the International Diabetes Foundation (IDF), Europe has the highest incidence of diabetes worldwide with 48 million diabetes sufferers [11]. With Europe's ageing society, the number of diabetes cases is expected to increase (at present half of the diabetic are aged 65+). In fact, the IDF expects the occurrence of diabetes to increase to 10.9% of Europe's population by 2025.

These highly overlapped growing potential markets gather millions of European citizens. Their needs can be of temporary or chronic and resulting from congenital or acquired conditions such as illnesses, injuries, habits or the ageing process. Their particularities can be broadly grouped into: reduced mobility or weakness (e.g. physically disabled, lame, musculoskeletal disorders, arthritic); atypical body shapes (e.g. deformities, amputations, very tall/short, obesity, elderly); sensory dysfunctions (e.g. diabetic, neuropathic, or UV-thermal-touch sensitivity alterations) or any combination of them (e.g. cerebral palsy, age, obesity).

The use of unsuitable off-the-shelf clothing, footwear and orthotics by these collectives share a number of inter-related COMFORT, HEALTH and SAFETY problems that often lead to social exclusion and dependent living. These problems are mostly resulting from a lack of functional properties (mechanical or physiological) delivered by materials used in its construction, and from a poor adequacy of product patterns to users atypical body/foot/limb shapes, postures or movements.

These market niches constitute an excellent and protectable business opportunity to European SME producers since within the three sectors addressed, most of these problems could be prevented (or significantly minimised) through the customization of products to individual physical, physiological and functional attributes.

Furthermore, these groups have the same individual needs for fashion than the rest of citizens. However they are restricted either to a much reduced offer of adaptive products (which do not follow fashion trends) or have to pay for craft-made expensive products (especially elderly and disabled people have much reduced incomes than the average [5]). Moreover, functional properties beyond patterns or special design elements are not achieved even at high premium bespoke products since they can only be achieved through especial technical materials or treatments.

[9] D. Van Schaardenburg, K.J. S. Van den Brande, G.J. Ligthart, F.C. Breedveld, J.M.W. Hazes. Musculoskeletal disorders and disability in persons aged 85 and over: a community survey. Annals of the Rheumatic Diseases 1994; 53: 807-811

[10] Health first Europe – Obesity (Access 2010)

[11] Health first Europe – Diabetes (Access 2010)

1.2.3 Main objectives achieved

The main objectives achieved during the project are:

O1. Definition of a user framework that defines the relevant user attributes for each of targets issue of demonstration cases (footwear for neuropathic feet, clothing for wheelchair users and textile-based orthotics for pressure therapy).

O2. Development of New Collaborative Product Customization Services that enable the involvement of users and professionals (i.e. orthotic technicians) in the definition of requirements to tailor the products to individual functional needs and style at the point of sale (i.e. orthopaedic shop). They constitute the interface between the user/professional and the production site enabling to send an accurate product order to manufacture a fully customised product. Three different applications have been developed: footwear, clothing and orthotics.

O3. New stretch-leather's lean manufacturing processes, enabling to control and tailor mechanical (i.e. elasticity, resiliency, surface resistance, and thickness) properties of made-to-order leather components for footwear and leather garments while increasing productivity and eco-efficiency.

O4. New 3D-spacer fabric's flexible manufacturing process, enabling to control and tailor structural (i.e. thickness, stiffness and elasticity) properties of made-to-order textile components while increasing productivity and eco-efficiency.

O5. New process of digital functionalization by airless fine spraying. The new process enables individual application for specific areas of the product components' surface requiring specific functionalisations to improve user product-interaction (i.e. skin friction, skin care, anti-septic, anti-fungi, anti-bacterial, waterproof).

O6. Extended manufacturing order management and Interoperable product data management tools structure and tools, integrating new services with new manufacturing solutions and machinery (pattern marking, cutting and sewing/stitching) used by footwear, orthotics and clothing manufacturers in order to ensure a seamless management and execution of single manufacturing orders for the individually configured product.

O7. Life-Cycle Analysis instruments, enabling to track, monitor and optimize the use of resources and environmental impact of products and along the processes involved. WP3, milestones M9 and M18.

1.3 Description of the main S&T results/foregrounds

The FASHION-ABLE project aims at providing the European innovative and customization-concerned companies with the technological means that will enable the agile and eco-efficient production of personalised products in terms of health and performance, addressing the complex individualised needs of such growing market niches out of the scope of mass-produced goods. In particular, the FASHION-ABLE action implements and demonstrates in industrial contexts innovative cross-sectorial technologies developed for three highly challenging target groups: fashionable footwear for diabetic feet, fashionable clothing for wheelchair users, high-performing textile compression bandages. This section of the report introduces the methodology developed and presents the main S/T results/foregrounds results obtained.

1.3.1 Methodology

The methodology followed during the project is divided in the main phases described below.

1.3.1.1 Definition of the end-user product specifications and SMEs needs

This phase is at the core of the project and sets the knowledge foundations by defining the specifications and requirements of the new customization technologies for the targeted population groups. It is the core around which the development of technology has been built.

Specifically, information from health professionals and users has been gathered in two main dimensions, which are:

- User needs and requirements (from a professional´s and from a user´s point of view). For this, semi-structured interviews to gather information from doctors and orthotists as well as from focus groups were used to gather information from both, medically trained specialists and the “end-users”. We did 4 focus groups with end-users, 1 focus group with experts (doctors and orthotists).
- Anthropometric information. The anthropometrical dimensions are related with fitting problems using fitting tests developed during the project. We applied two different approaches:
    - Clothes and textile orthotics. We relate morphotypes and anthropometric dimensions with product dimensions using regression logistic models.
    - Footwear. We deal with feet with amputations and big deformations. In this case the morphotype approach is not possible. For this reason, the correct approach is to design the last using a 3D model of the foot.

While the user requirements were used to develop the configuration space of the individualized products, the anthropometric information was used to select those measures relevant to influence the shape (and thus the pattern) of individualized products.

In the following we describe in detail the methodology applied to textile orthotics in order to select the more relevant anthropometric measures.

(1) The pre-selection of measures to be included in the statistical models is based on previous research and the opinion of the experts.

  (a) Selection of current products and sizes in the market with the help of the experts. We selected 3 types x 5 sizes = 20 lumbosacral orthoses

(2) Selection of subjects: 8 women and 8 men, in order to cover 4 factors:

  (a) Height: short and tall

  (b) BMI (Body Mass Index): less than 25, more than 31

  (c) Age: Middle-aged (40 to 55) and elderly (more than 65.)

Table 1: Distribution of subjects

Sex	Age	Age group	Height(cm)	BMI
M	68	Elderly	158	29.6
M	70	Elderly	159	25.3
M	66	Elderly	166	26.4
M	71	Elderly	174	33.6
M	42	Middle	167	22.2
M	50	Middle	170	29.4
M	48	Middle	180	26.0
M	53	Middle	181	34.1
W	71	Elderly	155	19.9
W	82	Elderly	156	23.0
W	69	Elderly	166	36.2
W	43	Middle	154	18.5
W	55	Middle	162	34.2
W	43	Middle	171	20.5

(3) After the wearing the products, the subjects answer a questionnaire about the dimensions. The question is: Do you want smaller, as it is, or bigger? We consider that the dimension is wrong when the subject prefers smaller o bigger.

(4) Multinomial logistic regression to predict the probability of a small, big or right fitting of the garment sizes. The independent variables are the tight, right and loose fitting of specific product dimensions. The logistic model predicts the probability of tight, right and loose fitting. The anthropometric measures that predict the fitting are selected with a stepwise process.

The hypothesis for our logistic model is that it is possible to estimate the fitting preference if we now the anthropometric measurement and the orthosis dimensions. This allows generating a linear model of the preference variables. Therefore, it is considered that the preference variables are the dependent ones and it is needed to search independent variables correlated and statistically significant with the dependent ones. In our case this independent variables are anthropometrical and orthosis dimensions.

The fitting preference is a categorical variable with three different possibilities. For this reason we use a multinomial logistic regression. This regression type is used when the dependent variable has more than two different categories for instance shorter, good and longer. In the multinomial-logit model one of the response categories (in our case good) is selected as a baseline, and then they are fitted logistic regressions models comparing each of the remaining categories (shorter/tighter and longer/wider) with that baseline.

Therefore, the multinomial logistic regression generates two equations. In our case the probability of failure 1 is the probability that the user assess the fitting as shorter/tighter (eq 1), the probability of failure 2 is the probability that the user assess the fitting as longer/looser and the probability of success is the probability that the user assess the fitting as good (eq 2).

$$\log_e\left(\frac{Probability.of.failure.1}{Probability.of.success}\right) = c_0 + c_1x_1 + \cdots + c_kx_k \qquad \text{(Eq. 1)}$$

$$\log_e\left(\frac{Probability.of.failure.2}{Probability.of.success}\right) = c_0 + c_1x_1 + \cdots + c_kx_k \qquad \text{(Eq. 2)}$$

The stepwise process for selecting the anthropometric variables has two main steps:

(1) Correlation test between variables. If two variables are much correlated (>97.5%), we select the variable that experts (doctors or orthotists) consider more relevant an easier to measure.

(2) Eliminate the variables without statistical significance (ANOVA test, $p<0.05$).

Finally, we use the receiver operating characteristic (ROC curve) for choose the value that choose the probability of success.

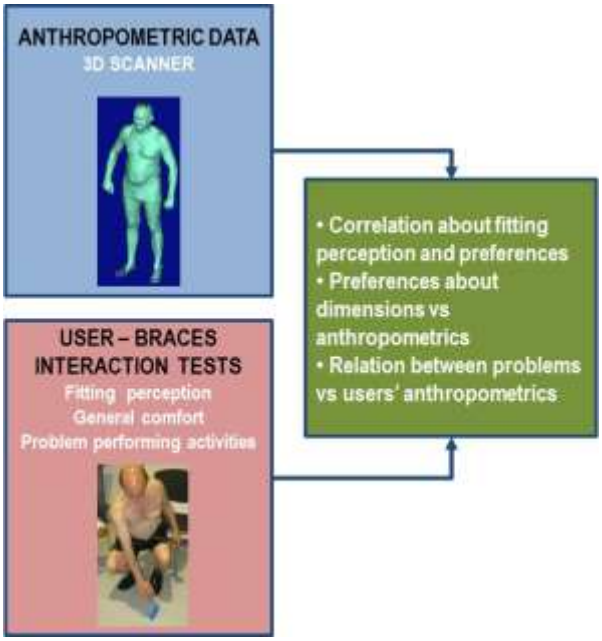


Figure 2. Example of fitting tests.

A similar procedure was applied to the clothes case.

1.3.1.2 Definition of a new customised product development framework.

During this phase, we used the end-user specifications in order to develop product customisation services to be used by end-users and professionals (configurators). These tools manage the consumer characteristics and preferences which are the key to individual customisation. A collaborative design environment made possible to define the morphological and functional characteristics of the end-user, to configure product style, and to individually personalise key product functionalities relevant to guarantee comfort and avoid health problems.

1.3.1.3 Linking of the end-user needs with the new production technologies.

This phase includes all the supportive developments to effectively link and integrate the new collaborative design framework (i.e. professionals and users) to the new production processes at manufacturing sites (from materials suppliers to final product assembly). The supportive developments are:

Development of an automatic method for adaptation of product dimensions to (atypical) individual shapes and postures.

The commonly practiced procedure to find best fitting sizes of orthotics is based on the gathering of characteristic circumferences. These circumferences are compared to underlying measures of reference sizes out of which the best fitting option is chosen. Regarding this, the described process barely covers the determining factors of personalization. In the case of orthotics these should consider individual measures, body shapes, postures and material and construction specific requirements that are derived from indications Regarding back braces people with the same waist may differ with respect to shape of the body and thus the

distribution of proportions, body height and adipose tissue. These individual characteristics of distribution of measures require adaption actions of product dimensions that take the individual body shape, and posture – the so called morphotype – and measures into account. It has been shown that adjustment problems increase with the amount of adipose tissue.

To determine the customers' measures that form the basis for the customisation process there are two different processes to gather these data. The traditional approach relies on manual interaction. Taking lumbar orthotics as an example the orthotist manually measures length, circumference, mediolateral, and anteroposterior dimensions of the body. The second approach relies on 3D scanning of customers, which is a contactless measuring method. By this a virtual representation of the customer is generated which allows to seamlessly process data and characteristics in a digital way. Through this development time can be reduced as well as production times decreased through the enabling of automated order processing.

Our morphotype based MtM approaches consider:

- The relation of the anthropometric dimensions with the product dimensions (see logistic regression models)
- Material and configuration specific parameters that form the functional basis to apply customer specific pattern adaption.
- The friction interaction of the fabric with the skin, which also varies with the age of the person and shear forces. This can be reduced by equally distributed compression

The developed methodology uses customer specific 3D scans to determine relevant measures for pattern adaption. These are combined with the configuration of the orthotic for individualised adaption of dimensions and production. Therefore, based on the relation of the anthropometric dimensions with the product dimensions (see logistic regression models), which determines the relevant measurement paths of the customer; the customer specific measures for pattern adaption can be determined.

Advanced CAM functions for the new production processes of stretching leather

The stretching leather is an important material to improve the shoe comfort for people with diabetes. This material provides the aesthetical function of the normal leather, but with better elasticity properties. A stretch-leather can be customized through a continuous bounding, thermal treatment and chemical treatment. The leather is an organic material, it is a highly inhomogeneous and characterized by a main direction, according to which limited stretching takes place, beside typical aesthetic properties such as reflection, pattern, etc. Furthermore, depending on the animal hide, it is more or less thick, flexible etc.

For these reasons, advanced CAM functionalities are necessary to obtain more homogenous results to guarantee a controlled elasticity range (varying from 50 to 60%). The traditional meaning of CAM is associated to the programming of an operating machine, where the programming of tool path is the central task to be addressed and automated. Very specialized systems exist, in fact, which are able to calculate the optimal path of different tools, in order to effectively and efficiently realize artefacts based on a proper CAD model in which all the geometrical and functional information are designed and represented. The same is true for different specialized process, where the notion of "tool path" is not that relevant, while the calculation of the optimal machine setup assumes a central role in the process design.

The application of CAM techniques in the context of an extended and cooperative enterprise moves instead the focus on different technical aspects, more related to the interaction between various partners, with the aim of integrating the expertise owned by each of the actors in the supply chain. This is certainly true when the involved actors are technical and managerial figures in the process, but it could even be extended to final users or to machine and tool suppliers. This is indeed typical in the context of customized production.

The traditional approach followed by typical CAM systems is based on a clear definition of the input materials and the desired results. Such an approach needs to be revised in favour of a

less deterministic one, due to the high variability of results and the difficulty to foresee the actual behaviour of the materials (from various mechanical and physical points of view). A statistical approach is preferable, since it is based on experiences and documentation of the obtained results. In order to pass from product specifications to required machine configuration, necessary for the production, it is fundamental to identify the most important parameters, which are significant for the manufacturing process, and their related correlations. Once this information is available, it is then possible to link the values and typologies of parameters (or factors) to the quality of results considered as variable and somehow controllable.

For this reason, a Design of Experiments (DOE 2^k factorial design) approach has been implemented in order to identify some qualitative and quantitative correlations between factors and responses, meant as qualitative results which are controllable by the manufacturing process. In details, a factorial experiment plan has been used in order to manage the discrete possible values or "levels" of the parameters. These factors can be divided in two categories: Machine Parameters and Process Parameters. In the first category, only the most significant parameters related to the machine configuration are taken into account: Air Break, Cylinder pressure, Carpet Pressure and Cylinder Temperature. In the second category, only the variable parameters of the joining process are here considered: Joining Path, Winding Pull and Velocity.

This approach allows to take in account all possible combinations of the levels across all such factors/parameters, consequently such experiment allows the investigation and study of the related effects by each factor on the response variable, as well as the effects of interactions among the factors.

The main important properties which can affect the final perceivable quality of stretch leather are: Thickness of the final product, Stretch anisotropy, Elasticity, Wrinkles and Delamination.

Development of innovative Lice Cycle Analysis (LCA) instruments for addressed processes and products.

The application of LCA in the context of customized manufactured products poses a number of issues. From one side the possibility to introduce further sustainability features like reduction of unsold product in stock, efficiency in supply chain management and increased duration of traditional products. On the other hand different barriers can seriously affect the implementation of sustainable policies when the efficiency is not properly monitored. Redundancies in the factory waste and the shift of the stock surplus problem from product selling to product manufacturing can in fact nullify the foreground benefits. Then as primary issue a proper characterization of real effects seems necessary. LCA can represent a proper methodology to assess product sustainability cause to the intrinsic tendency to spot mass and energy balances along the whole product life cycle. Furthermore, being based on the ISO standard, such methodology can produce reliable certification framework. The proper adoption of traditional LCA to the manufacturing context and particularly within a customized environment can produce general and specific issues as reported hereafter.

- General issues are related to the company processes adaptation to the life-cycle inventory and assessment. In particular it can be complex to adapt the business perspective especially within the small and medium enterprises, together with the view of the entire life cycle. When assessments are performed internally the limited view on life cycle produce the use of literature and general purpose database, the main effect is then the limitation of the result reliability. In addition a misalignment can be still registered between company environmental assessments and product design; this misalignment affects both the temporal progression regarding changes on the final product and the type of required data to provide these changes. In fact the design of a product can imply a limited set of parameters which can be reusable for environmental impact assessments.
- Specific issues are related to the LC data reusability within complex reconfigurable supply chains. Once a LCA study is performed it can be hardly reused for other. Furthermore product comparison implies a different set of LCA rules, while changes in the functional unit or in the single processes can nullify the study reliability. In addition, when benchmark data are available the quantitative results are commonly referred to entire life cycles. A different

focus on product composition or on a single life-cycle phase can be then inhibited. Finally the limited use of quantitative framework in the eco-labelling context for shoes and textiles implies a limited awareness both of end user and stakeholders.

To sum up both these barriers types contribute to limit the rapid generation of data. The support to a concurrent design and assessment of sustainable customized tools seem then require a different procedure to properly adopt LCA in the fashion area.

In the Fashionable project a tool for the rapid and reliable tool to assess the environmental impact of new materials has been developed. In particular a modular approach has been followed in order both to rapidly introduce new environmental assessment in design tools and to merge product-design, PDM and eco-labelling processes for footwear and fashion products.

Development of new production technologies for new customised functional materials and finishings.

State-of-the-art textile finishing production concepts, either chemical or physical, are typically based on homogeneous wet treatments of textile fabrics from roll to roll (and post-treatment like drying, consuming a lot of energy), the so called foularding. Specific textile functions like liquid repellence, antistatic behaviour or antimicrobial activity are typically given to a textile along its complete length (e. g. 500 m) and width (e. g. 1.60 m). These processes lack of flexibility and are not suited for small lot size customized functionalization of textiles, which is necessary for individualised clothing, footwear and orthotics for target groups.

Four approaches are tested to decide the best one for suited for small lot size customized functionalization:

- Airless spraying by rotor plates (ROT): This spraying method with rotating plates is a technique near to an industrial finishing process. It is the best method to apply one agent on the whole width of a roll to roll process.
- Air driven jet-spraying (JET): This process variant is characterized by an air driven two phase spraying with an open mechanic valve and the dosage by an external pump system printing with a micro dosing system.
- Three-dimensional spray finishing (3DSF). A multi axial robot adapted with air-driven spraying in a two-phase spray jet.
- Digital functionalization (DF). Digital applying of finishing agents with a modified printing system. It is a one phase jet spraying with valves in the nozzle. The agent is set under pressure and if the valve opened the nozzle the jet begins to spray.

1.3.1.4 Demonstration campaigns

The feasibility of all the results has been demonstrated by means of user-product functional evaluations of prototypes. We have done three campaigns: footwear campaign, clothing campaign and orthotics campaign.

The user-product evaluation is based on fitting tests and analysis of questionnaires. Patients and costumers from Germany, Italy, Belgium, Poland and Spain have participated in the campaigns and tested the different prototypes.

The orthotic campaign is based on customized back braces for users presenting our target group of obese people. And includes the application of new materials and digital functional spray finishings.

Twenty-eight Spanish and German subjects (14 males and 14 females; age: 5.82±9.80 yr; weight: 93.79±20.78; height: 1.70±0.12 m; BMI: 32.29±5.42) volunteered to participate in this study. To get the body measurements, it was used a 3D human body scanner.

Figure 3: 3D human body scanner.

The clothing campaign is based on customized shirts and blouses for wheelchair users. New materials and finishings were integrated in the manufacturing process. Before having the final version of the configurator available, it was developed a pre-campaign in three countries: Spain, Belgium and Poland (19 users). The aim of the pre-campaign was to obtain preliminary information of the suitability of the Made to Measurement process. The measurements were collected with a measurement tape in all subjects.

After this phase, the clothing campaign has been developed in the same three countries: Spain, Belgium and Poland (15 users). However, depending on the country, there are two options to obtain the users´ measurements. In Spain, a 3D human body scanner was used to capture body measurements with a ±1 mm level of accuracy. Clothing is made according to individual body dimensions.

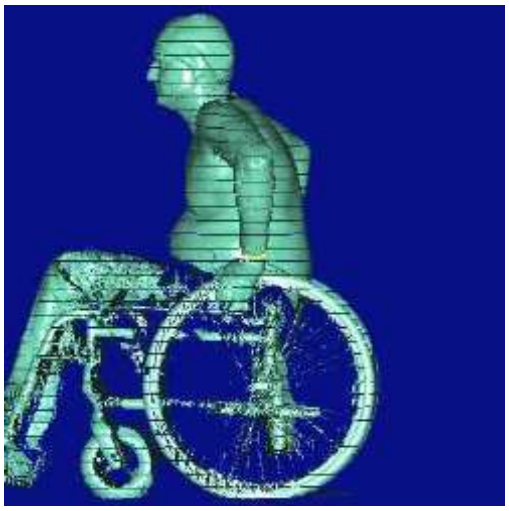
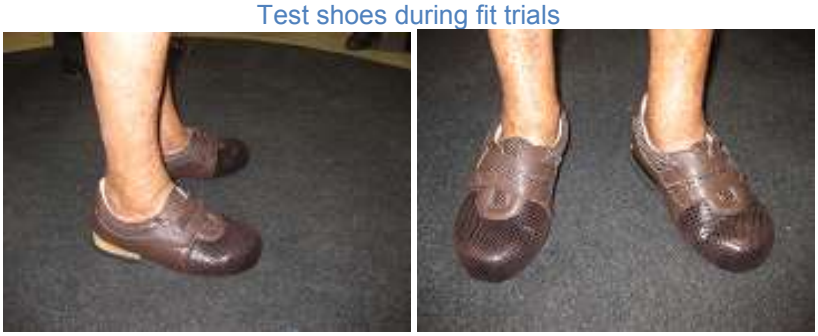


Figure 4: 3D scan of wheelchair user

The shoe campaign is based on customized shoes for patients with special needs regarding foot shape and physiology (diabetic). New materials (3D fabrics and stretch leather) are combined with finishings in order to adapt the product to the specific necessities of the patients. 19 patients from Italy, Germany and Spain participated in the campaign. Specific information related to orthotic aspects of the patient needs was and implemented in the configurator 2. The new materials and functional spray finishings were involved in the production of footwear prototypes.

Patients' feet & foot scans

Test shoes during fit trials



Final pair of shoes vs original shoe (catalogue)

Figure 5: Example of the footwear campaign

Furthermore, we have carried out the evaluation of technical properties that requires specific testing machines: mechanical and durability tests.

Figure 6: Picture of the leather coated side of one sample during stress strain measurement. The new material can be stretched up to 40 - 50%.

1.3.2 S/T Results

1.3.2.1 Needs and requirements of the targeted population

The next tables are a summary of the main requirements for the 3 products.

Table 2: End-user requirements for footwear

Plantar pressure	Avoid excess pressure point (lack of sensitivity in the plant)
Dorsal pressure	Avoid high pressures over the foot dorsum. The inner surface must be soft and smooth.
Fitting	Footwear fitting has to be right since the beginning, without period of adaptation. The toe room must assure they are not press and allow its movement.
Perspiration	Avoid moisture (infections, blisters and ulcerations).
Thermal isolation	Protect feet against hot and cold environments (lack of thermal feeling)
Flexibility	Minimum effort to flex footwear (arthritis, degenerative osteoarthritis)
Foot-shoe friction	Avoid foot-shoe friction. Foot displacement inside the footwear (rubbing or ulcerations)
Shoe-ground friction	Improve shoe-floor friction (slipping during the heel contact and the take-off)
Shock absorption	Cushioning to prevent the joint degeneration (arthropathy)
Ground insulation	Footwear must isolate the foot from the irregularities of the ground (propioception).
Weight	Light footwear to facilitate gait (elderly people).
Stability	Provide foot support to avoid balance problems.
Easy the put and take off	Mainly to elderly people or mobility problems in the hands.
Aesthetics	Footwear must be fashionable and trendy footwear.

Table 3: End-user requirements for orthotic back braces

Correct fitting	Orthosis adapted to the different body shapes depending on the users' anthropometrics. Women are more affected of these fitting problems due to the fact that the orthotics are not adapted to their hip's shape.
Perspiration	Avoid moisture between the user and the orthosis (discomfort, chafing).
Control	Control undesirable motions and permit motion where normal function can occur.
Flexibility	Design flexible areas to avoid discomfort without losing necessary rigidity.
Fastening	Adjustable fastening system to avoid oppression feeling. Elderly and people with osteoarthritis are the users that have more problems in order to adjust and fasten the back braces. They do not have enough strength or mobility
Usability	Orthosis adaptable to different situations: Working, sports, wearing tight clothes... Orthotics easier to wash with the washing machine. Easy the put and take off controlling the force of the closure system, (elderly, osteoarthritis).
Aesthetics	Make the orthosis undetectable under the clothes to improve users' social acceptance. Use attractive colours and avoid the use of the flesh colour.

Table 4: End-user requirements for footwear

Plantar pressure	Avoid excess pressure point (lack of sensitivity in the plant)
Dorsal pressure	Avoid high pressures over the foot dorsum. The inner surface must be soft and smooth.

Fitting	Footwear fitting has to be right since the beginning, without period of adaptation. The toe room must assure they are not press and allow its movement.
Perspiration	Avoid moisture (infections, blisters and ulcerations).
Thermal isolation	Protect feet against hot and cold environments (lack of thermal feeling)
Flexibility	Minimum effort to flex footwear (arthritis, degenerative osteoarthritis)
Foot-shoe friction	Avoid foot-shoe friction. Foot displacement inside the footwear (rubbing or ulcerations)
Shoe-ground friction	Improve shoe-floor friction (slipping during the heel contact and the take-off)
Shock absorption	Cushioning to prevent the joint degeneration (arthropathy)
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Weight	Light footwear to facilitate gait (elderly people).
Stability	Provide foot support to avoid balance problems.
Easy the put and take off	Mainly to elderly people with mobility problems in the hands.
Aesthetics	Footwear must be fashionable and trendy footwear.

In what follows, we show the model that relates the front length of the back braces with anthropometric measures.

$$\ln \frac{Probability.of.failure.1}{Probability.of.success} = 15.89 - 0.32 * \text{Th11.width} - 1.82 \frac{Distance.C7.ASIS}{Fron.length} \quad \text{(Eq. 3)}$$

Where:

- Distance.C7.EIAS is the vertical distance between the C7 vertebra and anterior superior iliac spine (ASIS)
- Th11.width is the width of the trunk at the height of the TH11 vertebra.

Then, we can calculate the front length value with the next equation. Where $\frac{Probability.of.failure.1}{Probability.of.success}$ is the threshold.

$$Front.Lenght == \frac{-1.82*Distance.C7.ASIS}{-15.89+032*Th11.width+\ln(\frac{Probability.of.failure.1}{Probability.of.success})} \quad \text{(Eq. 4)}$$

The ROC curve (see Figure 7) is created by plotting the fraction of true positives out of the positives (TPR = true positive rate) vs. the fraction of false positives out of the negatives (FPR = false positive rate), at various threshold settings. TPR is also known as sensitivity, and FPR is one minus the specificity or true negative rate

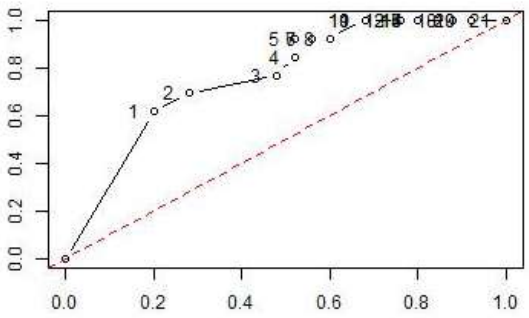

Figure 7: ROC curve

Similar models where obtained for all the relevant dimensions that the manufacturers need to design the patterns. Therefore, the methodology proposed is able to provide the needed rules for pattern design.

1.3.2.2 New customised product development framework

The new customized product framework consists of product configurators for the costumers and knowledge repositories for the manufacturers.

The configurators help the customer in order to select the best options considering the capacities of the customer (Figure 8).

Figure 8: Clothing configurator for wheelchair users (© Bivolino)

The configurators also include visualisation and an annotation tool for 3D scan. This tool is useful for the manufacturers and the customers. The list of annotations is stored along the customized order, for subsequent retrieval (Figure 9).

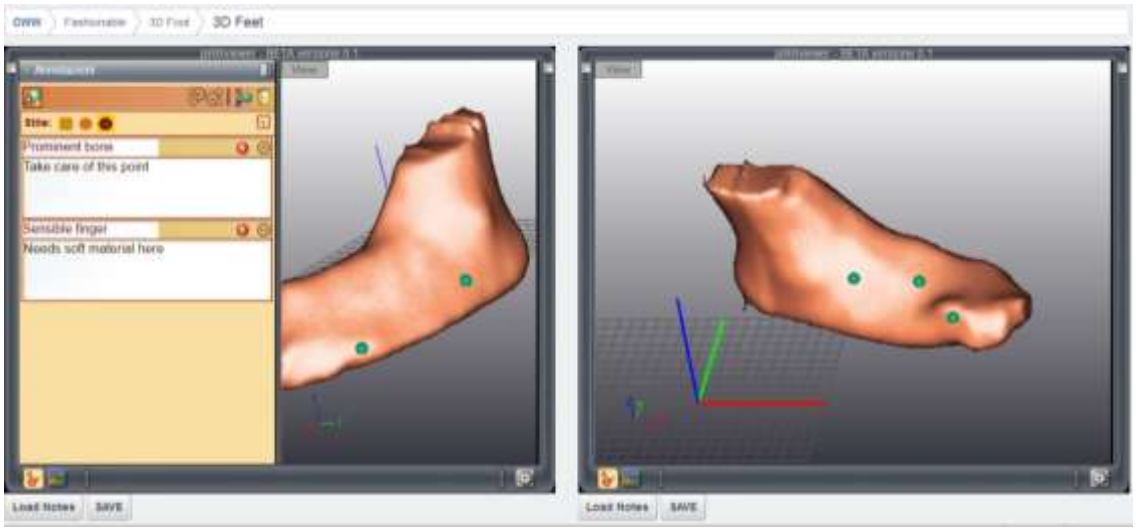

Figure 9: Footwear configurator. Screenshot of the 3D visualization, navigation and commenting tool (© SYNESIS).

The knowledge repositories relate the healthy problems of the end-user with the materials. For example, the material has a score according to:

$$\text{Score}(MAT_k) = \sum_i \sum_j P_i(MAT_k) \times R(P_i, NH_j) \times I(NH_j) \qquad \text{(Eq. 5)}$$

Where:

- $P_i(MAT_k)$ is the property of the material (e.g. rigidity)
- NHj is the health problem of the end-user (e.g. skin ulcer).

- I(NHj) is a level assigned to the health problem. (e.g. the end-user assigns the value 0 to 5)
- $R(P_i,NH_j)$ indicates the level of relation between Need and Property. Relation can be positive or negative.

This way the knowledge repository recommends a specific material according the end-user needs.

1.3.2.3 Advanced CAM functions for the new production processes of stretching leather

The design of a new textile product, especially when both aesthetical values and functional qualities must be considered, involves the expertise of several actors, each contributing to the project with a specific piece of information and ideas.

This is the case for the development of a new stretching textile, whose final mechanical properties are among the main added values, along with aesthetical and tactile feeling.

Such a development process spans between stylistic, design and industrialization aspects, which must all be controlled and checked from the very beginning, following an incremental and improving approach.

The central technology adopted by the Fashion-Able project for stretching leather is represented by the calendering process, applied to the component materials that compose the final product. Such a process is based on a deep analysis of the required machine behaviour that, in turn, depends on the proper choice of reciprocally interacting parameters and the methods applied for the material feeding.

The various experts are often involved in a non-strictly sequential order, overlapping technical checks with the introduction of new ideas. Moreover, the experts have to participate in the process suffering an irregular planning, often limited by geographical distances or even the impossibility to meet physically.

This is a typical case for manufacturer involved in the project to develop the calendering machine and the process plan, whose manufacturing workforce is scattered between various external and independent collaborators, located in distant areas. The involvement of the customers, often requested in case of customized development, and the technical support by machines and tools builders extends even more the needs for an effective cooperation.

Given such a scenario, the Fashion-Able CAM system has been developed taking as central requirements the ability to manage an agile cooperation between partners and an incremental development process.

The system is therefore based on blend of harmonically integrated modules, including a web application to support remote communication between technical actors and a SCADA/Machine control system that provides a clear guide line to the relevant machine parameters which are relevant for the fulfilment of the best product quality.

The final set of parameters control the main mechanical and thermic elements of the process, along with the devices, which verify their behaviour during machine operations by means of appropriate sensors.

Based on the need to collect and to exploit expertise on the process setup, the information have been organized in order to associate the past production quality checks to each of the developed textile products. This approach enables the product developers to elaborate past results and take decision based on their verified quality.

The machine configurations are therefore organized in so-called “recipes”, each one characterized by specific parameter values, material paths around the calendering cylinders and reporting of the verified results. Several tested recipes are available to be reused in any new production, with a reference to the optimal one for the specific product variant.

Each recipe documents, besides documenting all the relevant process details and machine configuration parameters, is associated to the production order that originated the machine run,

so maintaining a reference to the actual result and the corresponding material quality checks, including customer satisfaction.

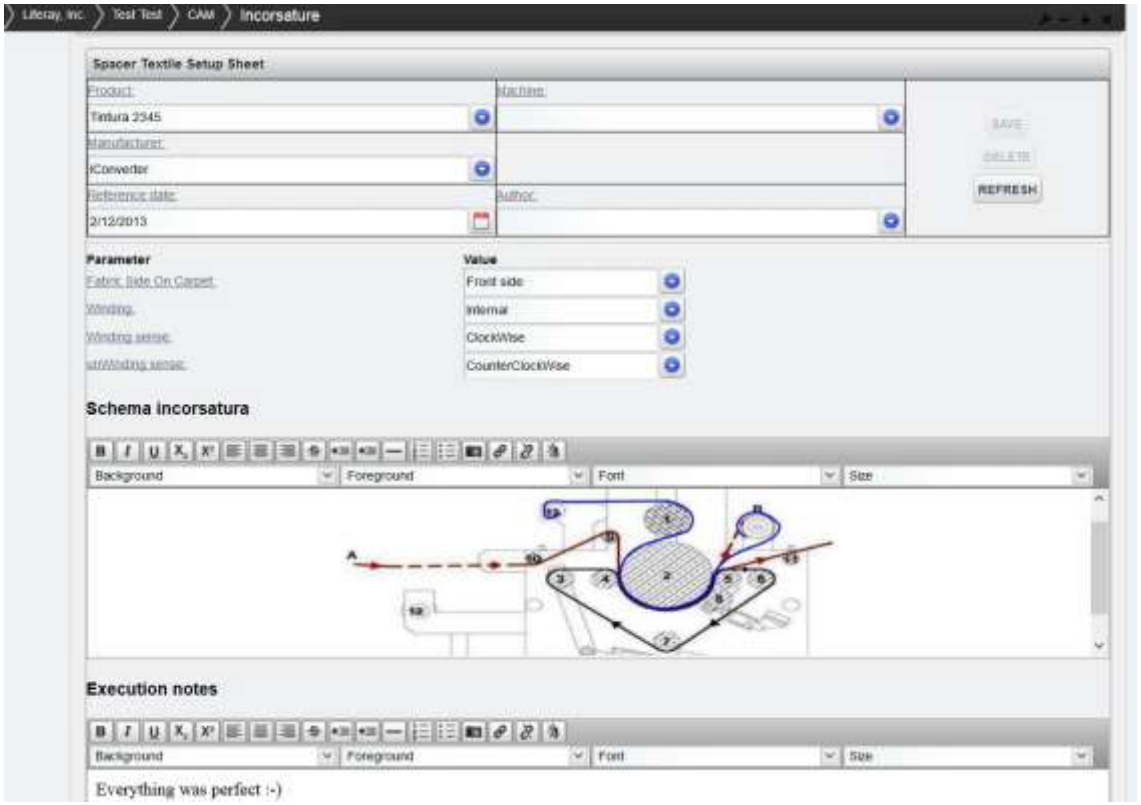

Figure 10: Details for calendering configuration

In addition to the cooperative and shared programming of the machine optimal configuration, the system offers the possibility to select the desired material paths by mean of an interaction over a web-based 3D environment.

This functionality is integrated in the overall architecture of the system, offering a coherent user interface that helps to uniform, hence to harmonize, the user experience of operators in various departments of the company (e.g. design, process planning, plant). Other partners along the supply chain, which are usually residing in geographically distant locations, are also allowed to access to this functionality, which greatly helps the user interaction especially in presence of linguistic barriers.

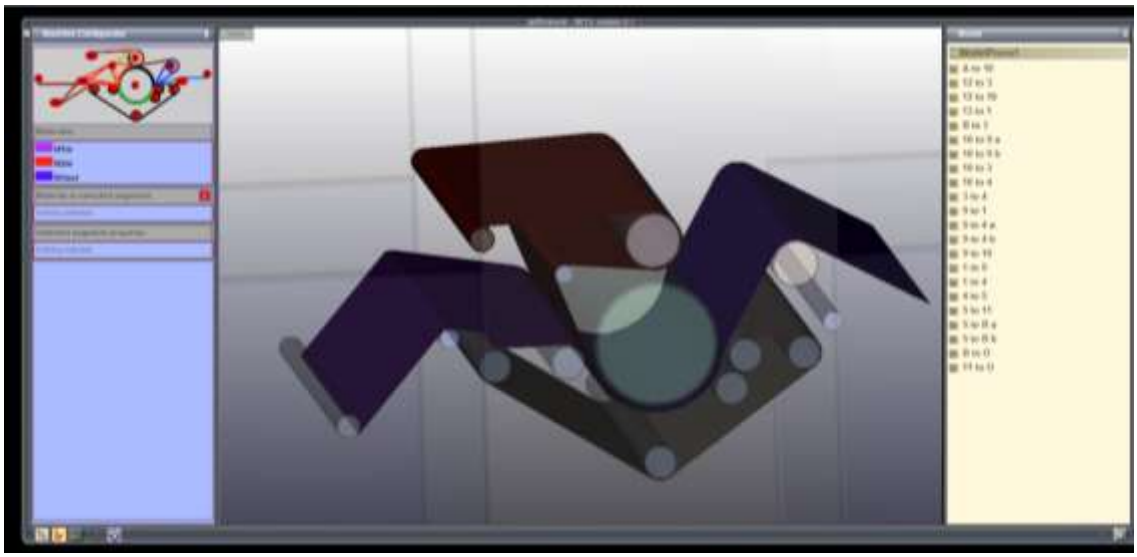

Figure 11: The calendering machine online 3d cooperative configurator

The web 3D cooperative CAM application supports the involved operators in the interactive definition of the optimal materials paths and the machine configuration parameters. In addition, it supports the online real time modification of the CAM model, the exchange of immediate comments, possibly stored for future documentation.

The new CAM system has contributed to develop a new family of stretch-leathers with customized properties through a continuous bounding, thermal treatment and chemical treatment. Flexibility is exploited in terms of customizable textile materials and fabrics to be bound with leather (substitution of traditional Lycra and latex for bounding process), changing of mechanical stretch and enlargement of the working area. The control of such parameters enables the customization of mechanical properties (elasticity, resiliency, surface resistance, thickness) and functional properties (breathability, adsorption, softness, thermal regulation).

The achieved objectives are:

- Homogeneous results: capability to guarantee a controlled elasticity range varying from 50 to 60%
- Capability to replicate performances over a working area of 2400 mm width (length is hide dependent)
- As for customization aspects on material, main features addressed are:
    - Supporting textile capable of orienting the stretch effect in specific directions (mono, bi-stretch)
    - Wider range of thickness which can be processed, considering leather split from 0,3mm to 2 mm (e.g. targeting also spacer)
    - Colour customization

1.3.2.4 Automatic method for adaptation of product dimensions to (atypical) individual shapes and postures (MtM)

To adapt the pattern to customer measures a process is set up that uses the customer measures to determine the correlating reference size that matches best to the gathered dimensions. In the next step the determined reference size is adapted depending on the divergence of customer measurements to a defined basis set of measurements that was used to develop the reference sizes. For this made to measure (MtM) actions were developed in a morphotype specific way. This allows to cluster customer groups to morphotypes and to develop for those groups optimised MtM rules. Depending on the shape of the human body, for example for a body with a hip circumference that is much smaller than the waist circumference the orthoses needs a different curvature to fit and support the back. Cases like this can be cover through automated, morphotype dependent adaption of pattern in an automated way. For this three basic alterations had been developed:

- HW-N: Normal distribution of alteration values, balancing additional width between front and back equally.
- HW-A: Abdominal distribution of alteration values, considering body shapes with hollow back or strong buttocks.
- HW-B: Belly distribution of alteration values, considering body shapes with strong bellies.

The next example shows principle actions that are performed within the developed MtM approach, if a customer can be assigned to type A, and has deviations of +, or -5 centimetres to a dedicated measure of the basis set. Also the general influence of fabric and additional materials within the configuration as pelotte, pressure pad, or stays is taken into account within this approach.

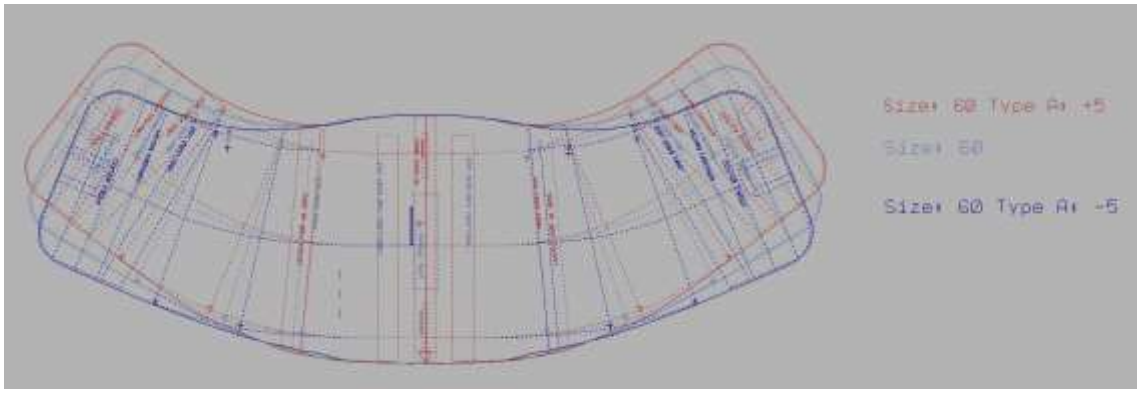

Figure 12: Example for MtM actions with reduction and enlarging of dimension

1.3.2.5 LCA tool to ensure environmentally sustainable development and production

The new tool has been designed to support the constant reuse of environmental studies particularly for the supply of new technical materials (i.e. nano-materials) and sector-specific components (i.e. footbed) in order to counterbalance the high variability of the fashion product chain. EPD general rules already provide a partial harmonization between the PCRs of the upstream materials (e.g. textiles) and the PCRs which are defined to downstream products containing such materials (e.g. footwear).

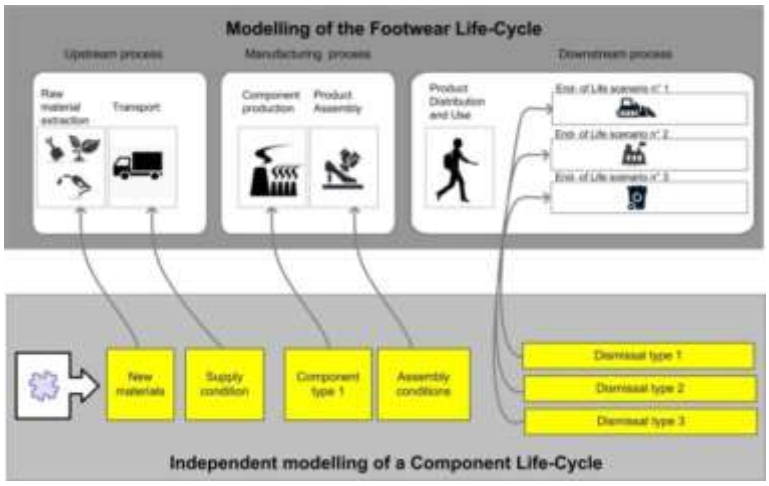

Figure 13: Integration of LCA studies for new components within existing LCAs studies for footwear

Modular structure of the life cycle aims to encourage the creation of a specific sectorial database at international level to integrate data in existing LCAs (Figure 13). Such modular structure can produce the transformation of the entire life-cycle assessment in terms of combination of different gate-to-gate assessments which are referred to single components rather than to the entire product. The same standardized partial studies are thought to be managed even by non-expert analysts by keeping at the same time an adequate level of precision.

In particular the development of independent information modules could facilitate the implementation of the different LCA studies for a wide variety of footwear models rather than limiting the EPD registration to few cases. Methodology description is summarized in equation 6, 7 and 8 and described in Table 5.

$$\boldsymbol{E}_{\mathrm{f}} = \sum_{\mathrm{i}=1}^{\mathrm{N}} \boldsymbol{p}_{\mathrm{ij}} \mathrm{m}_{\mathrm{i}} \qquad \text{(Eq. 6))}$$

$$\boldsymbol{p}_{\mathrm{i}} = \sum_{\mathrm{j}=1}^{\mathrm{L}} \boldsymbol{p}_{\mathrm{ij}} \qquad \text{(Eq. 7)}$$

$$\boldsymbol{M}_{\mathrm{f}} = \sum_{\mathrm{i}=1}^{\mathrm{N}} \mathrm{m}_{\mathrm{i}} \qquad \text{(Eq. 8)}$$

Table 5: Variables in equations (6), (7) and (8)

E_f	Environmental profile of a customized fashion product
M_f	Weight of a product model
m_i	Weight of a single component
p_i	Unitary Environmental profile for unit mass referred to a single component life cycle
N	Total Number of product components in the bill of material
L	Total number of standardized life cycle phases for a single component
p_{ij}	Incremental environmental impact for single life cycle phase

In order to make reusable the individual assessment specific actions have been adopted:

- Use of a consistent terminology and LCA data inventory has been produced with reference to the EPD framework (PCR 2933 - Leather based footwear ; 2952 safety footwear ; 27922 - Nonwovens for clothing, protective clothing and upholstery, Nonwovens for other purposes than clothing; 27190 - Floor-cloths, dish-cloths, dusters and similar cleaning cloths).
- Result comparability with reference to the same physical units independently from the functional unit definition (accounting LCA)
- Modularization with reference to realistic life cycle phases for the reference product
- Use of terminology and methods consistent with the technical standards in the textile and footwear area.

As far as the final tool algorithm a basic description is provided hereafter (Figure 14).

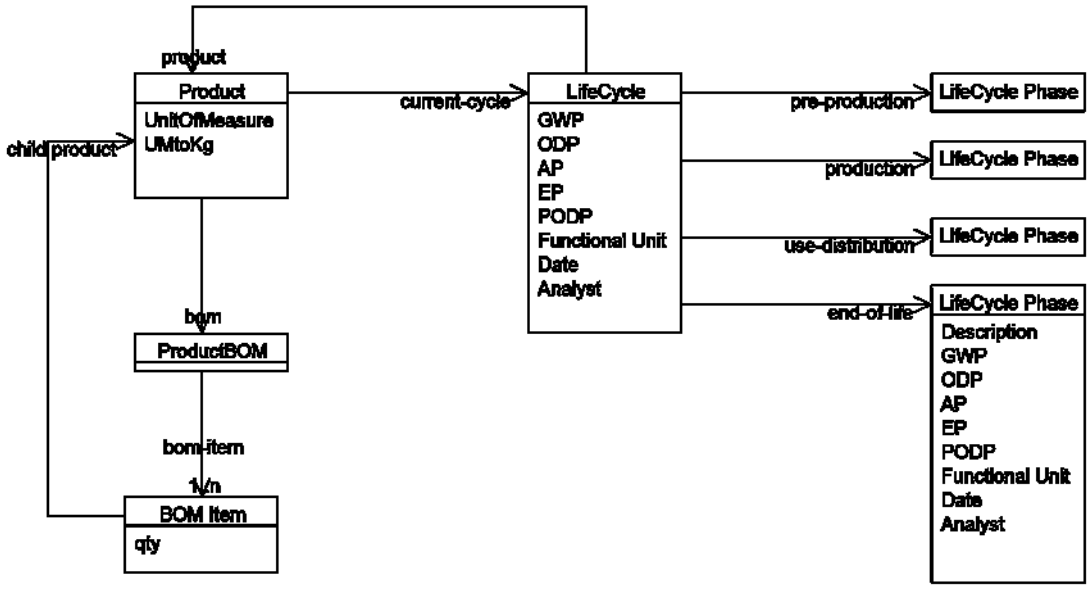

Figure 14: LCA algorithm a basic description

The methodology to modularize data, integrated into a computational tool based on the following features: The final product is analysed as a set of different component life cycles, then multiple partial information are created for the same type of material. Once the material is associated to a component, its life cycle is assembled through the selections of life cycle standard phases. Once all the life cycle stages have been selected, the environmental profile of

the final product is calculated. Finally a database for a list of materials used within the project FASHION-ABLE has been produced.

More in detail the following steps can be identified by the user perspective.

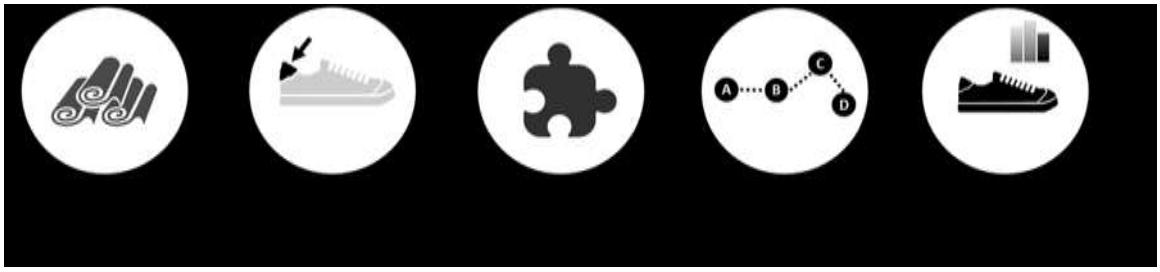

Figure 15: LCA steps

(3) Material identification:	A specific material is selected to be added to the Fashionable database or to a specific new product
(4) Component identification:	The specific use of the material within the product is specified. An inventory for a new component integrating the new material is created
(5) Modules Inventory:	Independent information modules are added with reference to specific component life cycle phases
(6) Life cycle identification:	Impact on different life cycle phases are calculated
(7) Product LCA:	On the basis of a proper aggregation from congruent life component life cycle a standardized Product LCA is structured.

The preliminary results on product LCA seem comparable with traditional static LCA for the same product category.

A particular feature has been added in order to introduce a categorization of the final environmental performance. Common environmental profiles are in fact expressed as ODP - Ozone Depletion Potential (in kilograms of CFC equivalent), GWP - Global warming potential (in kilograms of CO2 equivalent), POCP - Photochemical Oxidant Creation Potent (in kg ethene-equivalent), EP - Eutrophication Potential in kg PO4-equivalent, and AP - Acidification Potential in kg of SO2 equivalent. In order to introduce a benchmark value each environmental profile is clustered in performance classes according to negative or positive closeness to an average environmental profile within the same component category. In the fashionable tool the performance class is reported close to the environmental parameter for each resulting value.

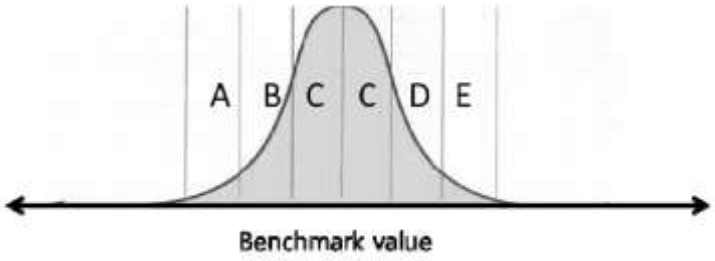

Figure 16: Classes

The classes A and B refer to a positive shift compared with the benchmark, classes D and E, instead, refer to a negative value.

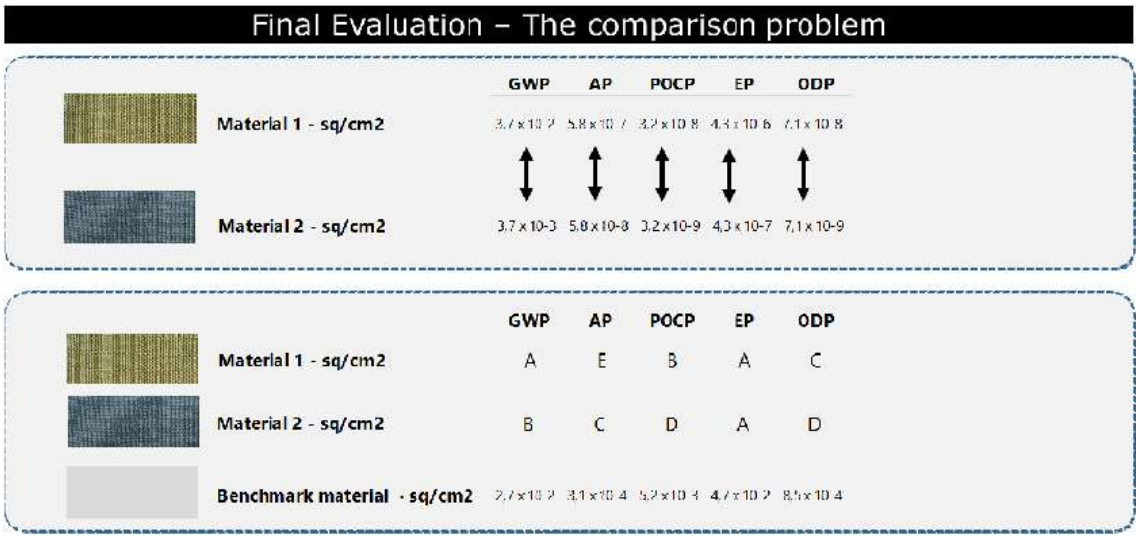

Figure 17: Screenshot of the LCA tool

When a comparison between the two materials occurs, therefore the profile of a third type of "benchmark" material is used in order to reproduce the average impact of all possible materials present in the database. In this way the relative comparison of two different materials is less important than the whole environmental performance. The presence of this type of evaluation allows eco-designers to understand the environmental performance of the material in an immediate way without further extrapolations.

1.3.2.6 New flexible finishing processes

Air driven jet-spraying (JET)

This process variant is characterized by an air driven two phase spraying with an open mechanic valve and the dosage by an external pump system. It has the following advantages compared to the rotating plate spraying:

- No moved parts are used.
- The droplets are sprayed in a cone.
- The distance between textile and spray nozzle can be varied.
- The shear forces can be varied by air pressure and nozzle size.
- High viscose agents can be dispersed.
- The spraying system can be moved by a computer controlled manipulator.

Disadvantages of the air driven jet system are:

- The system generates an overspray.
- The agent is changed between the moment when the droplets are formed and the moment when the droplet hits the surface of textile, because the volatile parts of agent are absorbed by the high volume of used air. The agent droplets have high surface and low volume and they dry during the "flight".
- The used air has to be exhausted and purified because the agents can be harmful.
- The exhausting system is in geometrical conflict with the mobility of system.
- With only one 2D/3D moved spray nozzle much less agent can be applied.

- Exploitation of this process variant is difficult, because no technology provider is (already) working in this direction.

The advantages of the Digital functionalization with a magnetic valve system are:

- Strong increased resolution compared to the spraying system.
- Automated dosage system.
- Easy upgrade of combinable finishing agents.
- Multi-functionality is easy to realize by using several jet systems.
- No air stream is needed to transport the liquor droplets.
- No change in the composition by air-drying.
- No failures because of overlap of spray cones or gaps between sprayed splines.
- Less shear forces in the applying process.
- Fewer problems with foaming and flocking.
- A purging is integrated.
- Easy data transfer and no calculation of splines necessary

Three-dimensional spray finishing (3DSF)

The 3D spraying tests showed that with air jet the handling was very complex. Problems of an air jet based 3D treatment are:

- Overspray and aerosols in the ambient air are harmful form people and robots.
- In order to achieve a defined degree of functionalization quality, the object has to be also in a well-defined state, e.g. related to fabric shape (= distance) and tension, requesting a controlled strain.
- An exhausting chamber is needed with a laminar air flow.
- The thermal fixing of agent is needed because of skin irritations, washing permanence and effect height.
- The thermal treatment without mechanical stretching can change the size and make wrinkles, and can also lead to unforeseen effects of the quality of the function.
- For different object sizes different or adjustable molds / dummies have to be developed and operated.
- Mounting, positioning and dismounting of wearable objects causes high effort.
- The scale up nearly impossible because one robot can´t carry many jets.

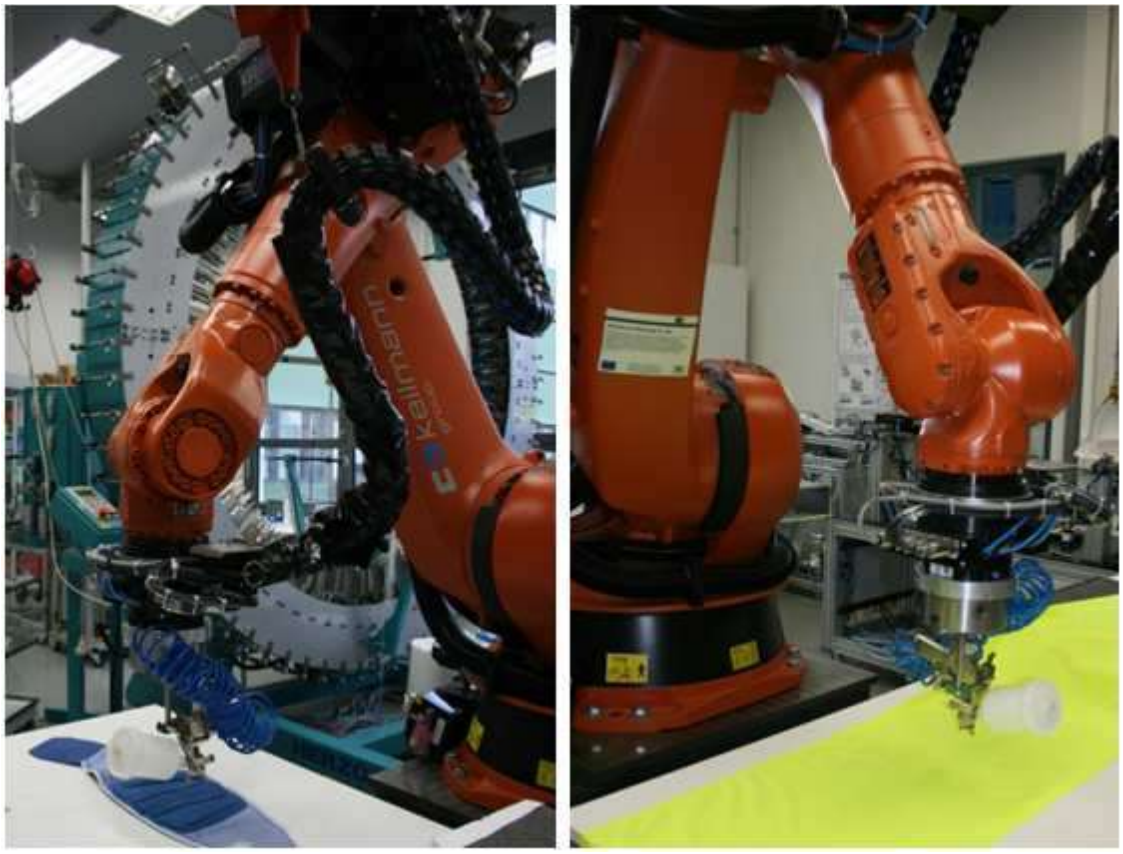

Figure 18: Finishing approach with a multi axial robot

Digital functionalization (DF)

The digital functionalization by airless fine spraying is a one phase jet spraying with valves in the nozzle. The agent is set under pressure and if the valve opened the nozzle the jet begins to spray. The new part of the system is the fast operating valve. Because of the possible high switching frequency the jet has not to be moved in a continuous line, which is a significant advantage. The CAM system has not to find a fitting spline, which covers the whole area with the lowest possible switching events. The fast switching gives a new flexibility, so that several jets can work together at the same area. A second advantage of this system is the one phase spraying. The agent forms the droplets without the help of pressured air. In order of the absence of dispersing air the problem of change of the composition of droplets is solved and the problem of dilution of ambient air is solved too.

Figure 19: Digital Functionalization. Experiment printing a checked pattern with finishing agent

The localized digital print-finishing was demonstrated with Knopf´s Sohn and Bivolino fabrics. Water repellent finishing agents were applied with high local resolution of the digital finishing process displaying the Fashionable-logo (Figure 20).

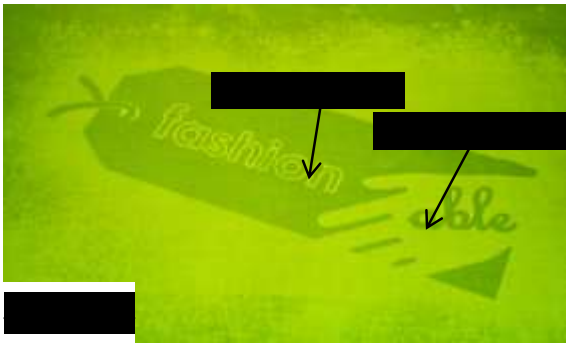

Figure 20: Demonstration of localized digital finishing with hydrophobic fashionable label. Brighter regions: wetted by water spray, darker regions: hydrophobic or dry.

The advantages of the digital functionalisation system are:

- Airless process:
  - No drying of agent between generation and applying
  - No problems with exhaustion
  - No dilution of ambient air, no purification is necessary
  - Much more energetic efficiency because it is not necessary to generate compressed air in high volumes, which is energetic costly
- The system is more flexible:
  - The system can work like a printer with many printing heads.

- The combination of several different agents is easy to do.
- In the demonstration system 8 different agents could be delivered without a risky change of possible incompatible agents.
- The resolution of system is around 50 times better, harder edges can be reproduced.
- Patterns in the millimetre size can be applied.
- The overlap between two adjoining splines is dominated by the wicking of substrate, and not by the functionalisation system.

- Simplified exploitation:
  - The basic technology of digital printing is already well known and well appreciated in textile industry, and therefore the barrier for introducing this process variant for localized functionalisation in industry is much lower.
  - There exists already an industrial "infrastructure" for provision, support and maintenance of this process variant, e.g. related to spray heads/print head, chemistry, mechanical set-up or software and interfacing.

Summary of research about flexible finishing processes

The initially targeted approach for flexible localized functionalization using air spraying (2D and 3D) is technically feasible, but not efficient. The digital functionalization by fine spraying using digital controlled magnetic valves with a very short distance to the material surface, using chemicals without auxiliary air (for diffusion), allowing a more precise functionalization, is easier to apply, needs less resources, and – due to development for digital printing, e.g. on carpets- has a shorter time to market. In particular a precise local, multi-functionalization is possible with the fine spraying technology, because no overspray occurs.

Additionally set-up times are shorter, and scalability/flexibility is higher, using multiple magnetic valve units. The used chemistry is treated more save and smoothly. And finally, the fine spraying allows additional features like e.g. making markers or completely other functionalities.

1.3.2.7 Results of the demonstration campaigns

Considering the results of the 3 campaigns, we can conclude that the result of the prototypes manufactured is very satisfactory. The main conclusions are:

- The majority opinion of the subjects who tested the prototypes is good or very good.
- The orthotics configurator together with 3D body scanning technology has demonstrated to be a useful communication tool between the orthopedic shop and the manufacturer, enabling to increase the data exchange and increased accuracy of subject data.
- The clothing configurator together with 3D body scanning technology has demonstrated to be a useful communication tool between the costumer the manufacturer, enabling to increase the data exchange and increased accuracy of subject data. However, the 3D scanning methodology did not show any influence in the final opinion of the subjects.
- The footwear configurator together with 3D foot scanning technology has demonstrated to be a useful communication tool between the orthopedic workshop and the manufacturer, enabling to increase the data exchange (no need for plaster casts and physical parcel) and increased accuracy of patient data (compared to the list of measurements). The possibility of adding information directly to the 3D shape of the feet offer new possibilities for specific treatments of the lining, otherwise difficult to be located (e.g. compared to photographs and diagrams).
- Regarding the spacer material which provided by Italian Converter and applied to orthotics, the subjects who tested these samples provided a good feedback. Therefore

this material has proved to be suitable in order to be included in future products. And the hard Spacer Fabrics used as insole materials have proved to provide better thermal comfort while keeping good mechanical properties (foot accommodation and pressure distribution in the foot plant) compared to the regular EVA insoles.

- Stretch leathers have proved to provide excellent foot shape accommodation, especially in the forefoot for feet with problems or deformities in the metatarsal and toe area (bunion, bunionette, claw fingers, hammertoe, etc.). The use of this new material provides the users of this kind of shoes (people with severe deformities in the forefoot and toes) with a more FASHIONABLE footwear alternative.
- The new 3D fabric combined with stretch leather combines a lot of advantages of leather and textile. The look and the permeability are the same for new stretch leather and full material leather, the compression and the strain on stress is improved with the new material. This means the fit could be better and small tolerances can be better tolerated.
- Regarding the samples with local functionalization, the subjects provided a good feedback too. The functionalization process has no influence in the mechanical properties, the fitting or opinion about comfort. Therefore the local functionalization process has proved to be a good solution in order to consider individual needs of the subjects. For example as preventive measures for ulcer prevention and mitigation.
- Regarding the opinion about fitting and comfort there are not negative opinions. And the majority opinion of the subjects is that the samples are good or very good.
- In conclusion, all the users were very satisfied with the samples and they would like to take it for their own.

1.3.3 Conclusion

FASHION-ABLE provides to the European innovative and customization-concerned SMEs with the technological means that will enable the agile and eco-efficient production of personalised products addressing the complex individualised needs of growing market niches out of the scope of mass-produced goods in terms of health and performance.

In particular, we have demonstrated that the methodology applied is feasible for developing s the new cross-sectorial technologies for three highly challenging target groups: fashionable footwear for diabetic feet, fashionable clothing for wheelchair users and high-performing textile compression bandages.

The harmonized combination of developed technologies will have a direct impact on health, comfort, safety and quality of life of the targeted populations: diabetics developing diabetic feet; physically disabled people requiring a wheelchair; and sufferers from acute periods of musculoskeletal disorders which prevalence increases with age and weight. Furthermore, the cross-sectorial approach will allow for extending and up-scaling functional customisation with little effort to future unexpected functionalities as well as to be transferred to other products and high demanding markets.

1.4 Potential impact, main dissemination activities and exploitation of results

Knowledge and technologies developed will overcome the common process barriers that currently hinder manufacturing companies from the addressed industries to effectively customise products to individuals:

- Definition of the relations between user requirements depending on individual attributes and its translation into quantified product specifications for orthotics, footwear and clothing.
- True involvement of users and orthotic technicians in the definition of product requirements (both style and function) through effective communication supportive technologies.
- Drastic reduction of current trial and error cycles followed to optimize product performance to individual requirements.
- Flexibility of the production processes of leather and textiles, and integration of eco-friendly materials providing with new tailored-to-function properties into products that will enable to customise garment, footwear and orthotic components to the wider variety of higher performing functions required.
- Introduction of new finishing operations enabling to locate multiple on-demand physiological and tribological properties in specific areas of the product.
- Vertical integration along the supply chain to effectively shorten production cycles and delivery times.
- Tracking, monitoring and optimizing the use of resources and environmental impact of products from a lifecycle perspective (production processes + use).

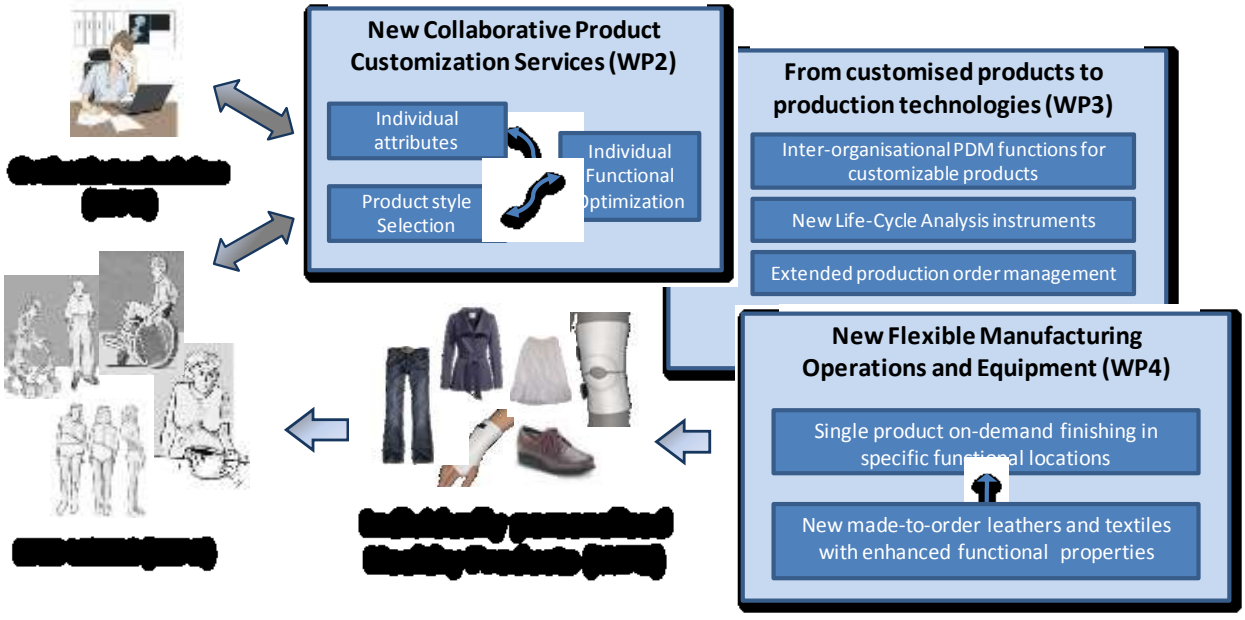

Figure 21: FASHIONABLE concept

Main socioeconomic impacts expected from the implementation of project outcomes will be:

- Raise competitiveness of European SMEs in the textiles, clothing, footwear and orthotics manufacturing industries. The project will provide them with a protectable business opportunity based on their ability to respond the highly individualised needs of currently unaddressed market niches.

- Substantially improve the health, comfort, quality of life, social inclusion and independent living of the targeted population groups by the enlargement of product assortments meeting their needs and substantially improving end-users satisfaction and quality of life.
- Reduce the environmental impact and optimize the use of resources currently made by the European textile, clothing, orthotics and footwear industries in their products and processes.
- Set the technological basis and the industrial framework for extending and up-scaling functional customisation to other high demanding premium niches such as children or sports.

1.4.1 Potential impact on special needs population and society

The harmonised combination of the project results will have a direct impact on health, comfort, safety and quality of life of the targeted populations:

- Diabetics developing diabetic feet (30 million) among which elderly and obese patients are in higher risk.
- Physically disabled people requiring a wheelchair to move (5 million, where over 2 million aged 65+.
- Sufferers of acute periods of musculoskeletal disorders (over 40 million) which prevalence increases with age and weight.

In the particular target groups considered in the project, a significant impact in health is expected due to the functional and morphometric customisation of clothing, footwear and orthotics by: contribution to the reduction of the likelihood of developing pressure ulcers by 5% and the considerable improvement of sweat and moisture accumulation, skin care and hygienic conditions while following fashion trends. This will lead to an increase in product acceptability and comfort by a 40%, contributing directly to the fulfilment of users' individual physical, physiological and functional needs, and filling the current offer-demand gap. There features together with suitable prices will ensure a broad market penetration growing at 5% p.a.

Moreover FASHION-ABLE project aim not only to address the needs of European citizens, which represent a significant social problem in Europe, but also to contribute to reducing Public Health System burden derived from savings on treatments for the health problems avoided.

1.4.2 Main dissemination activities

The main objective of Fashion-able dissemination activities was to outreach to consumer groups with special needs and related research and industrial community across the EU. Thus, after the launch of the project the dissemination strategy and tools were set up to assure efficient communication of all project's developments and results to different audiences both within and outside the Consortium.

During the project a number of national and regional dissemination events were organised by the consortium in different European countries. These events became a strong communication activity of the project (detailed description below). The project has been present in international conferences. For example: ICE 2012, ICE 2014, Manufuture conference 2103 and the European Congress on Innovations in Textiles for Health Care 2013. Moreover, a paper with the main results of the project has been submitted to the Journal of Computer Integrated Manufacturing.

The dissemination largely benefitted from the availability of contents produced during the three demonstration campaigns: shoes, clothes and orthotics. The campaigns delivered the Fashion-able products to real costumers from Belgium, Italy, Germany, Poland and Spain, hence the campaigns proved that the results achieved during the project activities could be used in actual production contexts and ultimately were welcomed by the market. Partners delivered customized products to highly challenging target groups: people that suffer diabetic foot and

deformations, wheelchair users and obese people. The results of the campaign received very positive feedback and most costumers shown full satisfaction with the products delivered. Some wheelchair users confirmed that the shirt is only comfortable and fits well, but this was the first time they could obtain a fashionable and attractive product.

The final dissemination activities took large inspiration from the approach and the results of the demonstration campaign.

1.4.3 IMS-YourGoods event, Valencia (Spain), 27-28 February 2013

The first Fashion-able dissemination event took place in Valencia, Spain on 27-28 February 2013. A two days event was organised and coordinated by the hosting partner and Consortium coordinator IBV, in cooperation with partners and external stakeholders. The Fashion-able specific presentation was focused on the customer needs and product specification. The event offered the opportunity to present early results and discuss synergies concerning the activities of Fashion-able and those of other related projects.

Figure 22: Opening of the event by local policy makers

To maximize the impact of the dissemination event beyond the some 40 participants present as well to allow further dissemination in longer period of time at additional costs all the materials (videos, presentations, photos) have been made available in the IBV web site: *http://indumentaria.ibv.org/yourgoods*.

1.4.4 OFOONR General Assembly, Lublin (Poland), 26-27 October 2013

Another Fashion-able dissemination activity was organised in in October 2013 in Lublin, Poland, in the framework of the General Assembly of OFOONR, the Polish national association representing people with impaired motor functions, one of the target end-users of Fashion-able. The event rolled out based on a three day calendar of activities, the first two days addressed mostly the sport performers with mobility impairment. On the final day, at the OFOONR General assembly Bivolino presented Fashion-able to the delegates of associations-members of OFOONR by using both the general presentation (Fashion-Able goals, partners, etc.) and the detailed presentation on the use of the online wheelchair configurator.

Figure 23: Representatives of Bivolino and OFOONR

1.4.5 EU Open Doors Day, Brussels (Belgium), 17 May 2014

In May 2014, the Fashion-able partners organised a dissemination activity in Brussels, Belgium, within the European Institutions' Open Doors event targeting the broad public raging from decision-makers to the end-users. The Fashion-able partners presented the project in a separate stand placed in a highly visible location inside the Headquarters of the European Commission. At the result of the event, the achievements of Fashion-able project were exhibited for some 15.000 visitors of the Open Doors event, including: fashionable shirts for wheelchairs users, customized shoes for feet shape altered by illness and high-performing textile compression bandages. Features of the on-line tools for consumers to co-design and order 'on demand' wearable goods were demonstrated on a big screen next to the Fashion-able stand. Many guests asked details about the innovative processes and materials used to produce clothes. To strengthen the impact of the event the following articles were published:

- Euratex website: *http://bit.ly/1hJKcrG*
- Fashion-able website: *http://www.fashionable-project.eu/node/670*

Figure 24: FASHION-ABLE stand in the EU Open Doors day

1.4.6 General Assembly of PREDIF, Madrid (Spain), 28 May 2014

The following dissemination activity of Fashion-able project was organised in Madrid, Spain, at the General Assembly of PREDIF – State Representative Platform of the Physically Disabled (Spain). In the framework of this event the aims, achievements and current results of the Fashion-able project were presented. The Spanish members of the Consortium demonstrated the configurator that enables people with disabilities to order personalised wearable goods online. With the help of some volunteers the functioning of the configurator and its features were tested at the stage. Representatives of the organisations of people with physical disabilities (some of them wheelchair users) confirmed their willingness to support Fashion-able project and promote the project's results in the future, so the stakeholders can benefit from the project's results most.

The following articles were published in Spanish media (national outlets and publications specialized on social topics):

- Comodidad para personas con movilidad reducida (once.es)
- Ropa adaptada: moda y comodidad para personas con movilidad reducida (lainformacion.com) - Ropa adaptada: moda y comodidad para personas con movilidad reducida (eleconomista.es) - Se presenta en Madrid el proyecto Fashion-Able (predif.org)
- Predio presenta el catálogo de servicios accesibles a sus federaciones (periodico.laciudadaccesible.com)
- Ropa adaptada: moda y comodidad para personas con movilidad reducida (insercionsocial.com)

Figure 25: Taking measures for shirts (left). Explaining the features of the configurator for on-line customisation and submitting the orders (right)

1.4.7 Large-scale public conference, Brussels (Belgium), 15-16 October 2014

The final Fashion-able conference was organised in Brussels, Belgium and was linked to the 3rd PROsumer.NET conference that is annually bringing together professionals, researchers and policy makers in the consumer goods sector. The Fashion-able partners presented the project results and achievements during a separate panel. They shared the experience of testing the developed products during the demonstration campaigns. The Fashion-able video was a strong dissemination tool along with the other promotional materials distributed during the

conference. The conference audience watched the very first release of video productions specifically realised by the Fashion-able project and coordinated by Euratex.

Some 60 experts from 13 European countries joined the event to attend inspiring presentations on innovative consumer product concepts and prototypes as well as manufacturing and ICT solutions to realise them and bring them to consumers, most of them resulting from collaborative European research projects such as Fashion-able, MyWear, AddFactor and CTC.

The upcoming political support and funding schemes by the European Commission have been presented. The COSME programme with its design-based consumer goods market take-up action was presented by Jean François Aguinaga of DG Enterprise & Industry. Roberta Salonna from DG Research & Innovation presented the HORIZON 2020 Programme with the FoF research topic for "Manufacturing of Custom Made Parts for Personalised Products".

The project's panel attracted much interest among research and business community, as the Fashion-able project received funding from the European Union's Seventh Framework Programme and partners could share their experience in this type of research projects.

The materials from PROsumer.NET and Fashion-able conference are available: *http://prosumernet.eu/*. Fashion-able videos: *http://www.fashionable-project.eu/*

1.4.8 Exploitation of results

The final exploitation plan of the project includes 13 exploitable results.

Table 6: Exploitable Project Results

ER number	Description of exploitable foreground	Owner & Other Beneficiary(s) involved
ER01	User framework and design criteria for customised manufacturing of the targeted products	IBV (owner) BIVOLINO, CALZAMEDI, BSN
ER02	Collaborative Product Development Services	BIVOLINO (owner) ATC (integrator)
ER03	New production technologies and processes for shirts and nightwear for wheelchair users	BIVOLINO
ER04	Innovative LCA DB and Software tools	ITIA-SYNESIS
ER05	New flexible textile finishing processes	DITF (Owner), KnopfSohn
ER06	New/improved functionalisation processes and/or new/improved functionalities of textiles	DITF
ER07	Model of configurable orthotics (configuration space, MTM adaptation	BSN
ER08	Concept for MTM adaptation of dimensions of garment and orthotics	DITF, HS/Assyst, BSN
ER09	Configurable software enabling MTM adaptation of dimensions of garment and orthotics	HS/Assyst
ER10	Software functionalities enabling visualisation of MTM orthotics fit	HS/Assyst
ER11	Extended manufacturing order management framework and tools / Interoperable Product Data Management tools / Extension of Product Data Management software for configurable wearables	HS/Assyst (Owner), DITF
ER12	New stretch leathers lean manufacturing process and equipment	IConverter
ER13	New 3D –spacer fabrics flexible manufacturing process and machinery	IConverter

The result ER01 consists in the design criteria (knowledge and algorithms) to customize footwear, clothing and orthotics for customers with highly individualized needs. This result also included algorithms that relate material properties with health problems. IBV is the owner of this result, but IBV offers free the use of the result to the consortium. CALZAMEDI, BSN and BIVOLINO can use the know-how and algorithms in their e-platforms to customize products and manufacturing processes. The algorithms that relate materials with health are included in the platform developed by ATC that is declared as open source software. IBV will use this knowledge in future research projects. For example IBV is partner of the proposal Smart-Fit-In (call NMP35-2014 Integrated business model solutions for customer-driven supply chain management). This proposal has succeeded in the first evaluation stage.

BIVOLINO has already implemented most of the knowledge in its e-platform for co-design, configuration and ordering of personalized MtM MtO garments for wheelchair consumers.

CALZAMEDI has already implemented this knowledge in the online forms used by the orthopedics to customize shoes. CALZAMEDI is using as well a software tool developed by IBV to correct the errors in the 3D scans uploaded by the shops. This way CALZAMEDI has reduced the devolutions caused by mistake in the customization process. After the project, CALZAMEDI will prepare a strategy in order to introduce the on-line tool that allows the shops to add landmarks in the 3D models and specify the indications for specific areas of the foot.

BSN is the owner of **ER08:** Concept for MTM adaption of dimensions of garment and orthotics. This result uses the knowledge about orthotics contained in ER01, and the knowledge of BSN about how to adapt the patterns of the orthotics.

Five exploitable results are related with the objective of developing ***Collaborative Product Development Services (i.e.FPC and configurators)***:

ER 02: Web-based wheelchair end-user configurator for customized, fashionable and functional garments	BIVOLINO
ER 03: New production technologies and processes for shirts and nightwear for wheelchair users	BIVOLINO
ER 07: Model of configurable orthotics (configuration space, MTM adaptation)	BSN
ER 09: Configurable software enabling MTM adaptation of dimensions of garment and orthotics	HS/Asssyst
ER 10: Software functionalities enabling visualisation of MTM orthotics fit	HS/Asssyst

BIVOLINO is the owner of the result ER02. This result is ready to be launched to the market. BIVOLINO will include this result its own e-platform, and future plans includes the integration with other platforms, e.g. AMAZON. BIVOLINO is also the owner of ER03. ER03 consists in wheelchair clothing manufacturing services and technology (CAD, CAM, BoM, production technology) that will be offered as Software as a Service (saas) to other garment manufacturers.

BSN will launch the result ER03 as a configurable orthotics service based on individual body measurements in sanitary shops and specialized hospitals in 2015. This will be a significant advantage to place customer specific products for customers with uncommon proportions, severe injuries and those that demand exceptional function.

HS/Assytst has developed extensions (result ER09) and visualization functionalities (result ER10) for existing CAD systems. These results are ready for orthoses manufacturers such as BSN. And they could be adapted to other related products. These results have improved the product catalogue of HS/Assyst.

Italian Converter is the owner of the results *ER12: New production technologies, materials and treatments for stretch* and *ER13: New production technologies and machinery for 3D spacers fabrics* appears in the final exploitation plan with the numbers ER12 and ER13. ICONVERTER

has developed during the project a new machine and a new manufacturing process with the help of ITIA and SYNESYS. These developments allow manufacturing stretch leather with more reliable elastic properties form batch to batch. The leather can be coupled with technical spacer elastic fabric in order to provide more breathable and comfortable materials. It can also be coupled with “non-spacer fabric” in order to obtain only elasticity. It was also developed a production process for 3D spacer fabric that allowed obtaining prototypes of this material. The materials have application to footwear and leather goods sector; hospital sector; sporting sector; furniture sector and technical general sector. The manufacturing process is already operating in real manufacturing environment.

The objective of developing *Innovative textile multi-finishing operations and equipment* has generated two exploitable results:

- ER 05: New flexible textile finishing processes
- ER 06: New/improved functionalization processes and/or new/improved functionalities of textiles.

DITF is the owner of these results, and KnopfSohn is the beneficiary of the new flexible textile finishing processes (ER05). KnopfSohn can use this result free and use it in its manufacturing process. DITF will offer this result to all industries involved in textiles. DITF also plans to include the result in 4 collaborative R&D-projects within next 3 years. The result ER06 is complementary with ER05. DITF will use ER06 to offer consultancy to the textile industry.

DITF and HS/Assyst have developed tools to support the whole process chain for configurable orthotics and related products. These partners have decided to join the results in the exploitation plan. It is the exploitable result ER 11. HS/Assyst is the owner of the result and DITF can use it for reference and for future industry/manufacturer consulting. HS/Assyst will integrate these tools in Existing PDM and order management software owned by HS/Assyst. HS/Assyst will exploit this result with license agreements or services to manufacturers of customized and individualized products.

Finally, the result ER04*: Novel Life-Cycle Analysis instruments* consist in a modular LCA database of textile based components to rapidly assess environmental performances of new product since design phase. The main innovation is due to industry based approach which is compliant both with design tools, PDM tools and Certification rules. ITIA and Synesis will own IPR on algorithms and average database, and they plan to exploit this result by consultancy made upon it, selling them to companies

1.5 Project public website, list of beneficiaries and other contents

Website

A comprehensive public Fashion-able website (*http://www.fashionable-project.eu/*) was developed by DITF right after the launch of the project to become a centralised information source about Fashion-able developments, news, and partners. The website managed by Euratex was linked to all partners' websites. After the accomplishment of the project it will keep serving as the reference point for stakeholders and will also contain reference material on all covered research fields and developed products.

Printed materials

In the project initial phase, summer 2012 a first promotional fact-sheet was produced and included in the Prosumer.Net brochure a printed document presenting concisely over 20 projects relevant for the consumer good industry. The brochure benefit of large dissemination as it was widely distributed at partners event, Textile ETP annual events, and activity organized by the 20 project individually.

As more results became available in in 2014 and also to strength the Fashion-able message dispersed during the events, a new phase of material production was coordinated by EURATEX and focused on roll-up, new results-based brochure and leaflet. The brochure of 12 pages and a leaflet of 2 pages were prepared in English. They were printed in the amount of 500 copies each to be distributed during the EU Open Doors Day and at the following regional and national dissemination events. The brochure presents the objectives of the Fashion-able project, it explains the importance of customized goods and provides the practical examples of the project's achievements: made-to-measure sheers for wheelchair users, new technique to produce footwear for feed altered by illness and individualised textiles orthosis.

Figure 26:: Prosumer.Net brochure

Figure 27: Fashion-able brochure presents the objectives and achievements of the project

Video

After thorough considerations the Consortium took decision to boost the communication of the Fashion-able project beyond its duration with the help of the promotional video. The preparation of the video production started at the partners meeting in Hamburg in May 2014 when EURATEX elaborated on the objectives and initiated a joint development of the video story lines. It was decided that three brief videos on how companies and users have benefited of the Fashion-able products should be produced. Following an Annex I amendment, a call for offers to select a subcontracted video-making company and a number of conference call with concerned partners the video production was started in summer 2014.

The final outcome was 3 separate videos with common frames showing the full process of production of customized shirts for wheelchair users, shoes for people with diverse pathologies and orthotics for people with musculoskeletal disorders. Video shooting team visited the production sites of eight project partners, made shooting of all manufacturing process – scanning, application of innovative materials and processes, as well collected testimonials from the companies' professionals. This video will be available for broad public on Fashion-able website and can be used by partners to promote the project's results. Fashion-able videos: *http://www.fashionable-project.eu/*

Figure 28: Shot from Fashion-able video on shirts

Figure 29: Project partner from BSN Mr. Schmeltzpfenning providing his testimonial in the video about orthotics

Figure 30: The scanning process shoved in the video on footwear

Other contents

Demonstration activities are included in a stand-alone project Work Package (WP5). Contents developed as part of such Work Package are technically oriented and exceed the simple transfer of project-related information

Table 7: List of beneficiaries

No.	Short name	Country	Type	Web page
1	IBV	Spain	RTO	*http://www.ibv.org/*
2	IConverter	Italy	SME industrial	*http://www.italianconverter.it*
3	Calzamedi	Spain	SME industrial	*http://www.calzamedi.com*
4	Bivolino	Belgium	SME industrial	*http://www.bivolino.com*
5	BSN	Germany	LE industrial	*http://www.bsnmedical.com*
6	KnopfSohn	Germany	SME industrial	*http://www.knopfsohn.de*
7	Synesis	Italy	SME service-to-industry	
8	ATC	Greece	SME service-to-industry	*http://www.atc.gr*
9	HS	Germany	SME service-to-industry	*http://www.human-solutions.com*
10	EURATEX	Europe	SME Association	*http://www.euratex.eu*
11	DITF	Germany	RTO	*http://www.ditf-denkendorf.de*
12	ITIA	Italy	RTO	*http://www.cnr.it*
13	PREDIF	Spain	End-user Association	*http://www.predif.org*
14	OFOONR	Poland	End-user Association	*http://www.ofoonr.lublin.pl*

2 Use and dissemination of foreground

This section includes the final version of the Plan for Use and Dissemination of Foreground (PUDF), which describes the strategy, plans, measures and concrete actions of the Consortium for the protection, exploitation and dissemination of the results.

Concerning the importance of the exploitation of results, the Consortium participated in an Exploitation Strategy Seminar (ESS) in December 2013, to analyse the exploitable results of the project; the intentions of each partner with regard to the dissemination and use of the results; evaluate the conflicts of interest in the exploitation plans; and the risk and potential obstacles for exploitation these results. The ESS service is funded by the Industrial Technologies programme (NMP) under FP7, and was provided by a business consultant. Following the one-day ESS, partners refined and consolidate the enhancements into this report.

The PUDF is presented in three sections:

- **Section A**. The section provides an overview of the strategy, tools and activities of dissemination that have taken place during the project, including scientific publications relating to foreground, press releases, website, conferences, etc. Dissemination activities are described in detail in two tables:
    - Table A1: List of all scientific (peer reviewed) publications relating to the foreground of the project.
    - Table A2: List of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters).
- **Section B.** This section specifies the exploitable foreground, provides the plans for exploitation and the IPR strategies. A detailed description of each exploitable result (ER) is presented, including their plans of exploitation, and an identification of internal risk associated. The section is divided in two parts:
    - Section B1. Includes a description of the applications for patents, trademarks, registered designs, etc. of the project.
    - Section B2. Includes a detailed description of each project result which has commercial significance and can be exploited, and a risk analysis. The key exploitable results, including owner and other beneficiaries involved, are shown in the following table:
- **Section C**. This part includes a description of the background and foreground of project partners.

2.1 Section A (public)

This section provides an overview of the strategy, tools and activities of dissemination carried out during the FASHION-ABLE project. The aim of the dissemination activities was to:

- Inform to interested organisations outside the Consortium about the project concepts and achievements.
- Support the European Textile, Clothing, Footwear & Orthotics Industries and Research communities in building up a critical mass of knowledge in the domain of flexible production, production of the production of textiles for applications to users with special needs, co-design and processing technologies.
- Support the maximization of results exploitation of partners and of the project as a whole.

These activities have been organized and supervised by the European Apparel and Textile Confederation (EURATEX), which – in collaboration with all partners that cover the three markets targeted in the project – has been in charge of managing information on project activities outside the project consortium, and promote the promising results towards the relevant stakeholders:

- The industrial and research communities of the concerned sectors (the European textile, clothing, orthotics and footwear industry).
- The representative or liaise organization to address the ultimate end-users (social support organizations for people with disabilities or other special needs).
- In particular, the business and research communities operating in market segment addressed by the manufacturing solutions developed.
- In particular, organizations which may support awareness rise and exploitation among the concerned people with disabilities.
- Policy makers at European, national and regional level.
- The relevant media, in particular specialized press of the concerned sectors.

Dissemination activities carried out in the project are described in two tables:

- **Table A1:** List of all scientific (peer reviewed) publications relating to the foreground of the project.
- **Table A2:** List of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters).

2.1.1 Dissemination tools

Dissemination contents include:

- **FASHION-ABLE conferences & printed material.** Consists of documents circulated in printing or electronic format, generally with limited use of technicalities or detailed information with a view to assure overall readability and absorption of information by readers. Releases address a rather heterogeneous audience and for instance journalists, Textile and Clothing, Footwear and Orthotics entrepreneurs and R&D specialists, national T/C organisations, and students.
- **Other releases**. Include Project Updates issued on a medium term time frames, Press Releases following project milestones achievements or events participation, Periodical Short Releases addressing the European Textile and Clothing, Footwear and Orthotics Industry community, proceeding and ad-hoc releases which are set up following national or international events in which the project is presented.
- **FASHION-ABLE Presentations.** Include PowerPoints or other multimedia presentations held by project coordinator, MB members or other project partners and which are held in occasion of national or European events. These presentations are

addressed to professionals with background in one or several of the areas researched in the project.

- **Technical papers.** Include mainly documents highlighting key technical achievements in the project researched area. Produced by R&D partners, authors of such achievements, papers address a more restricted range of audience with higher technical background.
- **Other contents.** Demonstration activities are included in a stand-alone project Work Package (WP5). Contents developed as part of such Work Package are technically oriented and exceed the simple transfer of project-related information.

TABLE A1. LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES

No.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[12] (if available)	Is/Will open access[13] provided to this publication?
1	Evaluating sustainability trade-offs along supply chain	Brondi, C.	ICE 2014 conference proceedings		IEEE		2014		*10.1109/ICE.2014.6871561*	yes
2	New technologies for the flexible and eco-efficient production of customized products for people with special necessities: Results of the FASHION-ABLE project	Durá, JV	ICE 2014 conference proceedings		IEEE		2014		*10.1109/ICE.2014.6871558*	yes
3	Development of a made to measure process for customizing lumbar orthotics for obese people	Kaiser, C.	ICE 2014 conference proceedings		IEEE		2014		*10.1109/ICE.2014.6871602*	yes
4	Case study: mass customization of individualized orthotics - the FASHION-ABLE virtual development and production framework	Kaiser C.	24rd CIRP Design Conference 2014 proceedings		Elsevier		2014		The conference proceedings are not yet available on the internet	The general terms and conditions say yes
5	Mass Customization von Orthesen	Kaiser C.	Konferenz für Wirt-schafts- und Sozial-kybernetik KyWi 2014		Duncker und Humblot		2015			No

[12] Persistent link to the published version (full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).
[13] Open Access is defined as free of charge access for anyone via Internet.

In TABLE A2 the dissemination activities are explained, including:

- Type of dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, etc. and the main leader of the activity.
- Title, date and place of the activity.
- Type and size of audience (scientific community, industry, society, policy makers, media, etc.).

TABLE A2. LIST OF ALL DISSEMINATION ACTIVITIES

No.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
1	Magazine	IBV	FASHION_ABLE	1 June 2011	Revista de Biomecánica 56	Society	1.000-10.000	Spain
2	Press Release	IBV	El IBV lidera una investigación que acerca la moda a poblaciones con necesidades especiales	29 March 2012	Entremayores.es	Media	1.000-10.000	Spain
3	Press Release	IBV	El IBV lidera una investigación que acerca la moda a poblaciones con necesidades especiales	30 March 2012	Gerokon	Media	1.000-10.000	Spain
4	Press Release	IBV	Moda para diabéticos, usuarios de sillas de ruedas y mayores	30 March 2012	Pinker Moda	Media	1.000-10.000	Spain
5	Press Release	IBV	Moda accesible para sectores especiales de la población	2 April 2012	Fashionunited.es	Media	1.000-10.000	Spain
6	Press Release	IBV	El Instituto de Biomecánica de Valencia impulsa el proyecto Fashion-Able	3 April 2012	El noticiero Textil	Media	10.000-100.000	Spain
7	Press Release	IBV	Un 40% de los europeos no pueden acceder a la moda por peso o discapacidad	5 April 2012	Discapnet	Media	10.000-100.000	Spain

No.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
8	Press Release	IBV	Un 40% de los europeos no pueden acceder a la moda por peso o discapacidad	5 April 2012	La Información	Media	10.000-100.000	Spain
9	Press Release	IBV	La moda, una quimera para 200 millones de europeos obesos y discapacitados	5 April 2012	Te Interesa	Media	10.000-100.000	Spain
10	Press Release	IBV	El IBV lidera una investigación que acerca la moda a la población con necesidades especiales	12 April 2012	CPI.UPV.ES	Newsletter	10.000-100.000	Spain
11	Press Release	IBV	Fashion-able, moda accesible	22 May 2012	Revista Perfiles (28 May 2012)	Media	10.000-100.000	Spain
12	Magazine	IBV	FASHION_ABLE	1 June 2012	Revista de Biomecánica 58	Society	1.000-10.000	Spain
13	Magazine	IBV	FASHION_ABLE	1 July 2013	Revista de Biomecánica 58	Society	1.000-10.000	Spain
14	Conference and workshop	IBV	European Technology Platform for the future of Textile and Clothing (ETP): 7th Annual Public Conference, Making European Research & Innovation Programmes Fit for Small and Mid-sized Companies	29-30 March 2012	Brussels, Belgium	Scientific Community Industry	75	Europe
15	Conference and workshop	IBV	18th International Conference on Engineering Technology and Innovation (ICE)	19-20 June 2012	Munich, Germany	Scientific Community FP7 Project partners	200	Europe

No.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
16	Website	PREDIF	El IBV lidera una investigación que acerca la moda a poblaciones con necesidades especiales	June 2012	Internet	Civil Society	-	Spain
17	Conference and workshop	IBV	Word Manufacturing Forum 2012 - Smart Policies for Global Manufacturing Innovation	16-17 October 2012	Stuttgart, Germany	Scientific Community Industry	400	Global
18	Conference and workshop	IBV	IMS YourGoods Day: Public Event on Innovative Technologies for Consumer Goods Industry	27-28 February 2013	Valencia, Spain	Scientific Community Industry Policy Media Civil society	75	Europe
19	Workshop	IBV	EFRA - Impact of the Factories of the Future PPP	11-13 March 2013	Brussels, Belgium	Scientific Community Industry	50	Europe
20	Conference	BIVOLINO	An innovator in customization and consumer co-design of clothing: paper presented at Prosumer.NET conference	28 March 2013	Brussels	Design-based consumer goods industries and related research and technology fields	About 50	Europe
21	Poster presentation	BSN	FASHION-ABLE	29 April 2013	Town hall	Public society	1.000-10.000	Germany
22	Website	PREDIF	FASHION-ABLE, moda accesible	20 May 2013	Internet	Civil Society	-	Spain

No.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
23	Website	OFOONR	Information about Fashion-able activities	May 2013	Internet	Surfers	-	Poland
24	Industry Fair	EURATEX	TechTextile and Texprocess	June 2013	Frankfurt	Industry	>50.000	Worldwide
25	Public exhibition	BSN Medical	City exhibition	June 2013	Hamburg	Civil Society	-	Germany
26	Exhibition event	BIVOLINO	European Championship wheelchair rugby 2013: exhibition of personalized fashionable clothing by the Belgian Paralympic wheelchair rugby team	17 August 2013	Antwerp, Belgium	Players, spectators, sports media	125	Europe
27	Industry Fair	Italian Converter	Anteprima	10-11 September 2013	Milan	Industry	>1000	Italy/ Europe
28	Industry Fair	Italian Converter	Le cuir	17-19 September 2013	Paris	Industry	>1000	France/ Europe
29	Conference	IBV	Manufacture conference 2103	6-8 October 2013	Vilnius, Lithuania	Industry, policy makers	-	Europe
30	Industry Fair	Italian Converter	Linea Pelle	8-10 October 2013	Bologna	Industry	>1000	Italy/ Europe
31	Conferences	IBV	European Congress on Innovations in Textiles for Health Care	10-11 October 2013	Brussels	Scientific Community Industry	85	Europe
32	Conference	EURATEX	Textile Technology Platform event on flagship initiatives Session of Digital Fashion	23-25 October 2013	Brussels	Industry, RTD community, policy makers	150	Europe

No.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
33	Workshop in preparation of an exhibition event	BIVOLINO	Workshop with the Polish disabled national archer team	26 October 2013	Lublin	players	15	Poland
34	General Assembly	OFOONR	Presentation by Bivolino	27 October 2013	Lublin	Delegates of member organizations	30	Poland
35	Article in regional press	OFOONR	Information about co-operation between Bivolino and disabled archers' team	27 October 2013	Lublin	readers and e-readers	-	Poland
36	Poster presentation	BSN	FASHION-ABLE	2 Nov 2013	Town hall	General public	1.000-10.000	Germany
37	Industry Fair- Workshop	DITF	Heimtextil Fair	9 January 2014	Frankfurt, Germany	Industry, Scientific	100	Worldwide
38	Workshop	ITIA	IMS Barcelona Workshop 2014	4-5 February 2014	Barcelona	Industry, RTD community, policy makers	60	Europe
39	Oral Presentation	DITF	2nd Forum of Innovation “Adapted Fashion”	18 February 2014	Elxleben, Gemnay	Industry, Civil society	60	Europe
40	Industry Fair	Italian Converter	Le cuir	February 2014	Paris	Industry	>1000	France/ Europe
41	Workshop	IBV	Impact of the Factories of the Future PPP	24 March 2014	Brussels	Scientific, Industry, Policy makers	60	Europe
42	Conference	EURATEX	Textile Technology Platform annual event	April 2014	Brussels	Industry, RTD community, policy makers	150	Europe

No.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
43	Industry Fair	Italian Converter	Linea Pelle	April 2014	Bologna	Industry	>1000	Italy/ Europe
44	Conference and workshop	IBV	Industrial Technologies 2014	April 2014	Athens	Industry, RTD community, policy makers	1300	Europe
45	Magazine	IBV	Laura Vallejo. (2014). Ropa adaptada. Comodidad para personas con movilidad reucida. Perfiles, (301), 41-43.	May 2014	Spain	Civil Society	n.a	Spain
46	Industry Workshop	DITF	ETP Nachlese	9 May 2014	Denkendorf, Germany	Industry	35	Germany
47	Exhibition	EURATEX	EU Open Day	17 May 2014	Brussels	Civil Society	12000	Europe
48	Website (Online magazine)	IBV	Ropa adaptada. Comodidad para personas con movilidad reducida (El Economista)	18 May 2014	Spain	Civil Society	>20,000	Spain
49	Website	IBV	Ropa adaptada. Comodidad para personas con movilidad reducida (Discapnet)	18 May 2014	Spain	Civil Society	>1,000	Spain
50	Website (Online magazine)	IBV	Ropa adaptada. Comodidad para personas con movilidad reducida (TE INTERESA)	18 May 2014	Spain	Civil Society	>10,000	Spain
51	Press Release	EURATEX	Fashion-able project at the Open Doors Day of the European institutions	20 May 2014	Brussels	General public, policy makers	>10,000	Europe

No.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
52	Oral Presentation	PREDIF	PREDIF Assembly	28 May 2014	Spain	Civil Society	75	Spain
53	Press Release	PREDIF	PREDIF Assembly	28 May 2014	Spain	Civil Society	>10,000	Spain
54	Interview (Radio)	IBV	Candil Radio. Program "Tu y yo Tambiién'	29 May 2014	Spain	Civil Society	n.a.	Spain
55	Website	IBV	Ropa adaptada: moda y comodidad para personas con movilidad reducida Insercion Social	30 May 2014	Spain	Civil Society	>5000	Spain
56	Website	PREDIF	Se presenta en Madrid el proyecto Fashion-Able	3 June 2014	Spain	Civil Society	>5000	Spain
57	Website	PREDIF	PREDIF celebra su Asamblea General	5 June 2014	Internet	Civil Society	-	Spain
58	Social media	EURATEX	Twitter & LinkedIn posts on Euratex accounts	June – October 2014	Internet	Industry, policy maketrs	-	Europe
59	Conference	DITF	KyWi	10-11 June June 2014	Stuttgart, Germany	Scientific, Industry	100	Germany
60	Conference	DITF	CIRP Design 2014	14-16 June 2014	Mailand, Italy	Scientific, Industry	300	Europe
61	Industry Fair	Italian Converter	Linea Pelle	September 2014	Milan	Industry	>1000	Italy/ Europe
62	Industry Fair	Italian Converter	Le Cuir	September 2014	Paris	Industry	>1000	France/ Europe
63	Conference	DITF	Digital Textile Printing Congress	4-5 September 2014	Ghent Belgium	Scientific, Industry	400	Worldwide

No.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
64	Conference – Poster session	ITIA-SYNESIS	Integrated LCA-based Design for fashion and special categories LETS Conference Leading Enabling Technologies for Societal Challenge	29 September - 1 October 2014	Bologna	Scientific, Industry, Policy maketrs	>1000	Europe
65	Conference	EURATEX	Prosumer.Net & Fashion-able Conference	15-16 October 2014	Brussels	Scientific, Industry, Policy makers	60	Europe
66	Website	PREDIF	PREDIF viaja a Bruselas para participar en la última reunión de evaluación del proyecto Fashion-Able	21 October 2014	Internet	Civil Society	-	Spain
67	Video	EURATEX	Three Fashion-able videos	October 2014	Conference presentation, Internet	Scientific, Industry, Policy makers	-	Europe
68	Meetings of member associations	OFOONR	Information about Fashion-able activities	October 2014	different places in Poland	People with physical disabilities	20 - 50	Poland