



TALLINN UNIVERSITY OF TECHNOLOGY
SCHOOL OF ENGINEERING
Department of Materials and Environmental Technology

**CAD/CAM PROGRAMS IN THE GARMENT
PRODUCT DEVELOPMENT PROCESS
CAD/CAM PROGRAMMID RÕIVASTE TOOTEARENDUSE
PROTSESSIS
MASTER THESIS**

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(On the reverse side of title page)

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PREFACE

This thesis is about using CAD/CAM programs in the garment product development process. The topic was suggested by my supervisor Piret Mellik, who also assisted me in data collecting. The majority of the work was done in the laboratory of polymers and textile of the school of engineering.

I would like to thank my supervisor Piret Mellik for her help in the process of writing this thesis. I would also like to thank Tiia Plamus and Kersti Merimaa.

The topics covered in this thesis describe different software used in the garment product development process. Gerber Accumark, Lectra Modaris and CLO are compared in constructing patterns and also creating 3D models. All these programs allow companies to increase productivity and to shorten the time needed to create new products. CLO is also used to create a 3D collection for this thesis.

Creating garment technical drawings is also discussed and software used for this is compared. This includes Kaledo Style and Adobe Illustrator.

Keywords: textile, garment, product development, CAD/CAM, master thesis.

INTRODUCTION

Product development plays an important role in the garment industry. It is necessary for developing new products and enhancing existing ones. It depends on the size of the company; how many people are involved in product development and what kind of technology is used. People working with product development are technical designers, technologists and fashion designers. Product development consists of the following stages: creating technical drawings, creating technical descriptions, creating patterns, creating textures for the patterns, making a prototype.

CAD/CAM software is often used in modern garment industry. CAD means computer aided design and CAM means computer aided manufacturing. Using CAD/CAM can be a great way to enhance the technical capabilities of the company, to develop new products and to increase production capabilities. The programs can be used to construct and grade patterns and to derive new pieces from existing base constructions, also to create technical drawings, make textures for the patterns and create a virtual prototype. The software used in this thesis are Gerber Accumark, Lectra Modaris, CLO, Adobe Illustrator and Kaledo Style.

The main aim of this thesis is to demonstrate and analyse ways that CAD/CAM software is used in garment product development, then choose the best software for creating a collection of dresses with ethno patterns. Print files are also created from patterns. The patterns along with the textures are printed on fabric and a single model from the collection is also sewn as a final product. This thesis also analyses the possibility to replace real samples with virtual samples. The collection features ethno patterns from Estonian folk costumes. Ethno patterns were selected, because some additional knowledge of ethno patterns was gained after taking a course at Estonian Academy of Arts.

1 Garment product development

In the garment industry product development is necessary to create new models and enhance the existing ones. The role of product development and the amount of people involved in it is dependant on the size of the company and the nature of the company. In larger companies where production volumes are also larger more people are involved with product development but its role is also important in the case of small companies. Garment product development is described step-by-step in figure 1, the steps are also analyzed separately in chapter 1 and the following chapters.

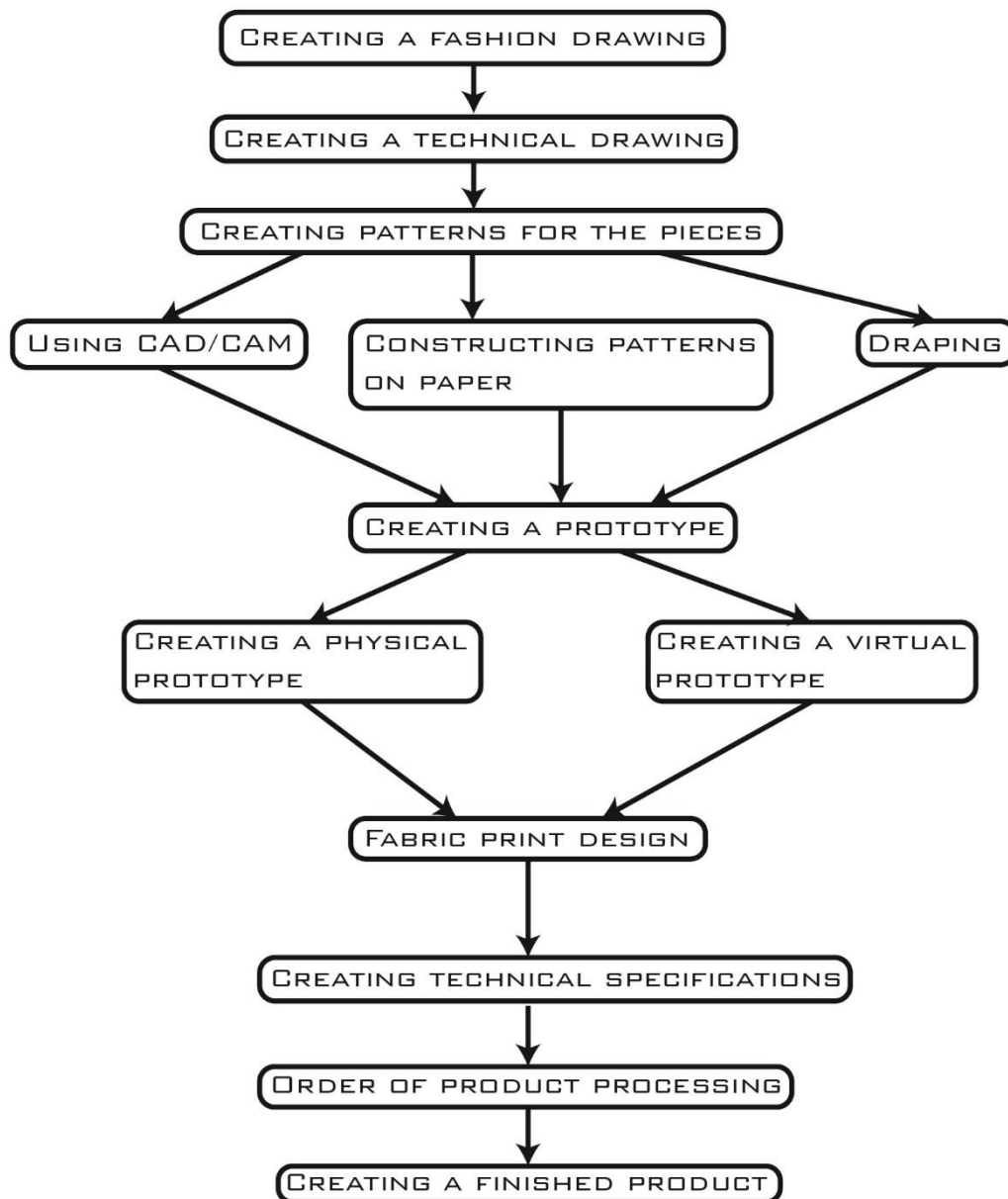


Figure 1 Garment product development steps

Garment product development starts with the idea for a new product. Creating a fashion drawing is the first step in garment product development. This can either be a freehand sketch or drawn with stencils and a ruler. You can use a pen or pencil or other methods like watercolor, gouache or Chinese ink. You can also draw on a mannequin silhouette found in books [20]. or [21]. these books feature pages with mannequin silhouettes meant for drawing fashion sketches. The silhouettes are 9 heads tall, meaning that their body parts are in proportion and the fashion drawings can be used to create technical drawings. Using a book as a sketchpad is also a great way to work since all of your sketches are in one place, not on loose sheets. You can bring the sketchpad with you to

continue your work whenever you have free time. These books [20]. and [21]. also feature silhouettes of body parts for designing accessories like jewelry or shoes. Designing accessories is also a part of fashion design and these can enhance your collection and give you a bigger variety of products to sell. Designing and manufacturing accessories is a separate subject from garment design and these accessories are manufactured using different techniques, therefore they are not covered in this thesis.

Creating a technical drawing is the next step in garment product development. The technical drawing goes on the product sheet and it is used by the technical team and seamstress when sewing garments. Technical drawings give an accurate and detailed representation of the garment.

Creating technical specifications is an important part of product development. Technical specifications or product sheets contain the necessary info for the seamstress to sew the final product. This includes seam allowances, seam type, furniture and all the necessary technical details required to manufacture the final product. A product sheet is shown in figure 25.

Order of product processing is also an important technical part of product development. This shows all the undividable sewing operations step-by-step and in the correct order to manufacture the final product. The order of product processing along with the product sheet go to the seamstress along with the final patterns or pre-cut pieces. When all the previous steps shown in figure 1 are complete, you are now ready to manufacture your final product.

Garment product development steps can differ depending on the type of production and the size of the company. A tailors workshop is individual production. In the tailors workshop product development starts with measuring the clients body and then suitable patterns are selected. The patterns are adjusted according to the clients dimensions to get a well fitted product. Then a first model is sewn and a fitting check is done that reveals what and how much needs to be changed on the patterns. After doing the changes and a new fitting check the main model is sewn.

Product development is done similarly in small and medium size batch production. The process consists of: designing a garment, choosing base size, mapping measurements to design – pattern design, sewing a garment. [16]. If the product is not custom fitted to the client (like in the case of the tailor's workshop) it has to be made to a certain body size. There are type figures and size tables that match certain sizes. When selling to the home market it is wise to select a size table that is most used in that country so that potential customers can select a suitable size from the table. If the size table is

selected you have to select a range of what sizes your product is going to be, for example sizes 36 to 42. If the size range is fixed you have to select a size for the base model, for example 38 and find a fitting model whose body dimensions match that size so that you can do the fitting checks. It is also possible to use mannequins that have body dimensions that match the type figure but they do not give feedback how well the product fits a person. Differently from the mannequin a model can also take dynamic poses that give feedback how well the product fits when wearing. In serial production the first thing to do is to make patterns for the prototype, then sew a first prototype and do a fitting check. According to the feedback it is decided what changes have to be made and if it is necessary to produce another sample model. Technical drawings need to be accurate, because they are used by more than one person and everyone needs to understand them the same way.

1.1 Garment technical drawings

Garment technical drawings are accurate representations of garments, they are used on the product sheet. Technical drawings are made by a technical designer. In technical drawings all details of the garment visible in the front or rear view must be shown. This includes darts, seams, quilts as well as furniture, for example zippers, buttons or snap-fasteners and their location on the product. Technical drawings are black and white.

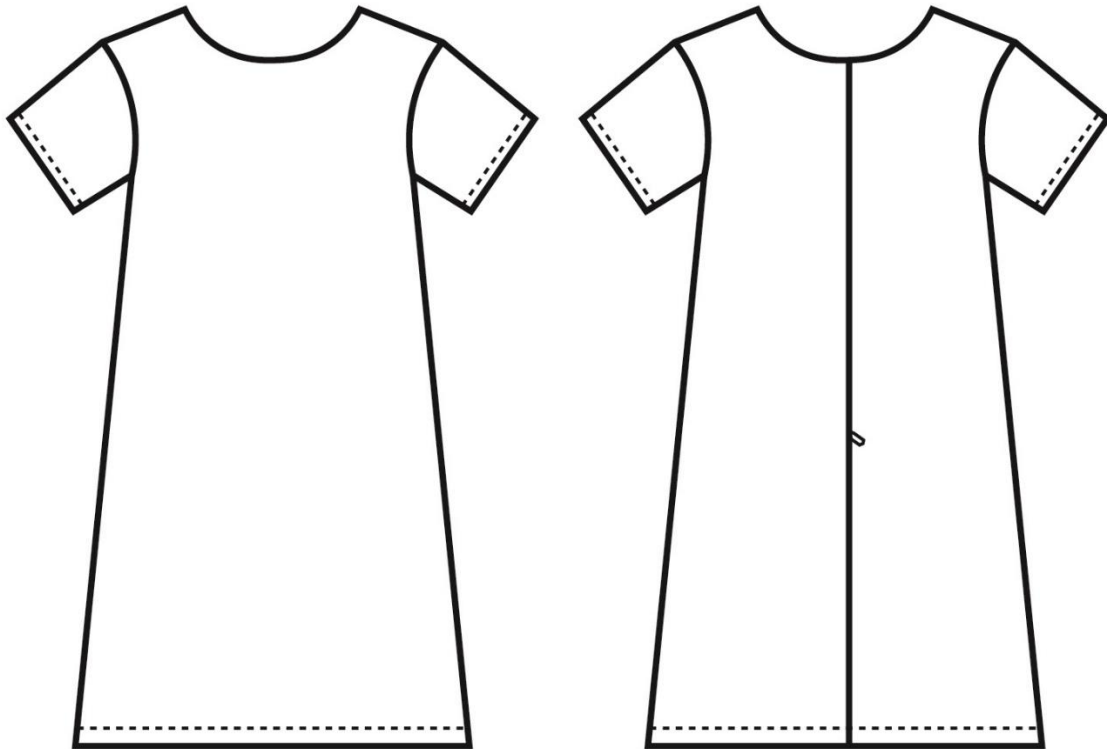


Figure 2 Garment technical drawing

A garment technical drawing is shown in figure 2. In technical drawings proportions need to match with the finished product. The front view of a product represents the finished product laid out on a flat table and viewed from the top down perpendicular to the surface. Basically the front view in technical drawings is a projection of the finished product. The finished product dimensions table helps to make technical drawings so that their proportions fit the finished product. You can also use patterns by taking the necessary measurements. Garment technical drawings can also be created by using the dimensions table of a finished product if a sample of the product has been created.

In production technical drawings are used on the product sheet, detail views of seam cross sections can also be represented in them. In the seam cross sections there is important info for the seamstress for example the right side of the product, seam

allowances, stitch type. The cross section seam allowances have to be proportional in the drawing and their values represented in the technology field of the product sheet. The cross section views can be created with special software like Kaledo Style for example, you can also use other software however it is important that the info is technically correct. In the case of simpler seams for example double hem, a cross section view is not necessary however it is important that the seam allowance is marked on the product sheet. In the case of more complex seams cross section views should be added to the product sheet to help simplify the work of the seamstress. The seamstress has to be able to sew the product according to the product sheet and for them it is important that the technical drawings are correctly done.

1.2 Garment pattern construction

Garment pattern construction means drawing the patterns point by point following the instructions found in books concerning pattern construction. You can construct with measurements taken from the clients body or with measurements taken from size tables. Constructing patterns usually means using base constructions found in books concerning pattern construction [7]. and [19]. These base constructions are modified by using modelling techniques to get new patterns. Modelling is done similarly in CAD/CAM or when constructing on paper. Using CAD/CAM can be a great way to save time and ensure that you get accurate and reproducible results. Using CAD/CAM to construct patterns is explained in subchapters 2.3.2 and 2.4.2 of this thesis.

Constructing patterns on paper is the traditional method. This is most common in smaller companies as CAD/CAM software can be expensive and requires special training. Constructing patterns on paper is accurate enough and the results are reproducible with tracing paper. The patterns do however experience some wear and tear and it is not possible to use patterns made from tracing paper for a large number of times. You can however reproduce the patterns by tracing them again. When you use CAD/CAM programs to construct you simply can plot out the pattern pieces again if they are worn out. Constructing patterns is done on 1:1 scale so you would need an A1 sheet of paper and a large table for constructing patterns. A ruler and stencils are also required.

Draping is a different technique for constructing patterns. You pin pieces of fabric on to a dress form and then start to cut away excess fabric to get the desired form. Draping does not necessarily need a fashion sketch or a technical drawing to develop new styles. You can use your imagination and design new garments directly on the dress form. This is a technique used by fashion designers and pattern makers. It is less accurate than CAD/CAM or constructing patterns on paper, but less limited in creative freedom.

Draping is usually done with muslin fabric since it is cheap and has the desired characteristics of a fabric suitable for designing garments.

1.3 Fabric print design

Fabric print design can be a great way to enhance your products and give them a special look. Fabric print design means drawing or vectorizing your textures with special software. The textures along with the patterns are printed directly on the fabric. This is an artistic and creative process which can be enhanced with virtual prototyping. You can draw directly on the patterns and simulate the result in 3D. You can also use 3D to visualize your products. Using 3D helps to match the textures together at the seam lines. You can move and rotate the pieces and put the seam lines together in 2D also which means you can draw continuous textures directly on the patterns. The collection in this thesis uses printed fabrics with Ethno patterns found in Estonian folk culture. An additional course „Ethno collection“ was taken at the Estonian Academy of Arts. This course provided the writer of this thesis with additional knowledge of Estonian folk costumes, the symbols used in them, how to design your own collection and also use fabric print design to manufacture your prototypes. Fabric print design is further explained in subchapter 2.1.2.

1.4 Garment prototyping

Garment prototyping means sewing a physical or virtual prototype of the desired product. Making prototypes ensures that the garments you create will fit the customers. Sometimes several prototypes of the garments are created to ensure the correct fit and appearance of the final product. Prototypes are usually made from cheaper fabric than the final product, this helps to cut down the costs of prototyping. Virtual prototyping helps to reduce product costs even further and enables the company to produce a large number of prototypes to choose from.

1.4.1 Physical prototyping

Physical prototyping is the traditional and most common method of prototyping at the moment. Physical prototyping means that you sew an actual product. Physical prototyping ensures that the garments are wearable by the fitting model or fit the dress form. Physical prototyping is also the only method to use when using draping for pattern construction. Physical prototyping can be costly and time consuming but it is the most common and widely used method to produce wearable garments. Physical prototyping alongside virtual prototyping were used for creating the dress in this thesis. It is further explained in subchapter 4.1.

1.4.2 Virtual prototyping

A virtual prototype is a 3D representation of the desired product, no fabric or furniture is needed to produce virtual prototypes. Virtual prototyping can be a great way to cut-down product costs and also to produce a large number of prototypes to choose from. Virtual prototyping means that you digitally sew a product and visualize it in 3D. Virtual prototyping was also used to create the collection of dresses used in this thesis as it would have been too costly and time consuming to produce physical prototypes of the models. The collection features 10 garments and it would have cost roughly around 2000 Euros to produce physical prototypes. Virtual prototyping can also be a great way to save space since you do not need a large table for constructing on paper or a sewing machine to make the physical prototypes and you do not need additional space to store the prototypes or a dress form or fitting model to try them on. You only need a laptop computer and special software along with the skills to use it. Virtual prototyping is further explained in chapters 2 and 4. All figures in this thesis are connected to products that have been created using various software, the figures describe the work process step-by-step.

2. Software used in garment product development

In the garment industry CAD/CAM software is used to construct new products and to check the wearability of ready products by 3D simulation with graded mannequins. Constructing patterns is usually done in a 2D environment and wearability check in a 3D environment. Different 3D simulations help to save time and money and also help to reduce to amount of samples needed to produce a wearable garment. Software that enables to construct patterns and simulate them in a 3D environment can have different level of detail, it depends on the software and how much time and resources have been used to develop the software. It is a new and developing field of technology that utilizes the potential of modern computers, 20 years ago this kind of technology was not available. Some programs used in the garment industry like Optitex or Lectra Modaris enable users to create detailed 3D models of finished products and add visualizations to present your ideas without having to produce a sample product.

However it is a technically complex and demanding field of technology and using a computer does not enable the user to get the full picture. Even though modern technology is advanced it is not possible to simulate everything in 3D. To get best results samples need to be produced and tried on real people.

In the garment industry there are tasks which are simplified by using a computer, like grading for example. There are grade rules to apply and a technical designer has to know exactly how much needs to be added at certain points. However there are certain size increments to apply grade rules. In the case of garments body proportions also change with size changes. This means that starting from certain sizes the body proportions do not match the body type used to construct the original pattern. Using a computer also enables you to create and save base-constructions for different product groups. These can be used to create new styles of products. Grade rules applied to base-constructions also apply to derived patterns, this means that using a computer you can construct in several sizes at-once for example sizes 36 to 42.

CAD/CAM software used in the garment industry is also cross-compatible and the pieces can be converted from one format to the other. This means that you can use created patterns with different software. It is also possible to create a database of reoccurring small details like pockets, collars, cuffs and use them in different products. Digitizing patterns enables you to create a database of products created by the company and derive new products from them. Because different file formats can be converted it is possible to keep your database when you start to use a new software. Before computers were used patterns were on paper and in the case of many companies in Estonia the

problem is that their archive is not complete. If there is a wish to recreate a nostalgic product familiar to Estonians you will have to find it physically if it is available somewhere and construct by using a ready product. Digitizing helps to resolve issues with archiving and also to save space because a paper stencil archive for different size products takes up a lot of space. It is also time-consuming to find something from a paper stencil archive.

This chapter demonstrates and analyses different software used in garment product development. All the figures are related to creating the virtual collection for this thesis.

2.1 Adobe Illustrator

Adobe Illustrator is a vector graphics program. It enables the user to create graphics, drawings, vector images and .pdf and .dxf files. Adobe Illustrator is intuitive and easy to learn and tutorials and training videos are also available. Adobe Illustrator is used by graphic designers, fashion designers, technical designers, artists and students. The graphics and garment technical drawings used in this thesis are designed in Adobe Illustrator.

2.1.1 Creating garment technical drawings in Adobe Illustrator

In the Adobe Illustrator software there are a lot of useful tools for making garment technical drawings. The program is intuitive and easily learnable and training videos are also available. Vector graphics is the strong side of Adobe Illustrator and from this the whole logic of drawing is derived. Vectors are lines drawn through anchor points that you can scale without losses. When scaling regular images with a high zoom level you can see pixels and the images have their resolution. In the case of vector graphics the images do not have a resolution and you can view .pdf files created in Adobe Illustrator with 1000 times magnification and the computer draws smooth curves. Vector graphics can also be scaled by using the printer driver.

The process of creating a garment technical drawing is simplified by using a special mannequin. A special mannequin is a silhouette that has proportions that match the type figure. [6]. There are different type figures for different markets, in this work a western type figure is used that enables to create technical drawings in the front-, rear- and side view. The figure front and side view are projected which means you can project points from the front view to the side view. This mannequin is scanned from the book „Technical drawing for fashion“ [6]. , after scanning the figure it has to be made sure that it is straightly positioned related to the page. It can be done by drawing a vertical line in Adobe Illustrator that becomes the front center line and also the axis of symmetry. After this the horizontal lines can be drawn: the bust line, waist line, hip line.

If the type figure is correctly scanned and converted into vector format you can use its contours as guide lines. For example, you can draw using the shoulder line as a guide. Adobe Illustrator also enables to put the mannequin vectors on a separate layer and

lock this layer. This enables to use the figure contours without having to worry about something getting misplaced.

Adobe Illustrator enables to use guide lines as orientation lines, it recognizes the tangent of a line and creates a perpendicular line with it. If the ease of the product is known it is possible to draw to a certain distance from the figure. In the garment industry a lot of the clothes are produced symmetrically, meaning that the right and left flap of the product are mirror images. When creating technical drawings Adobe Illustrator enables you to draw one half of the product and then mirror it across the symmetry axis to get a finished product this can be very useful to save time, because you do not need to draw the entire product.

When the front view of the product is created you can use its contours to draw the rear view. First you have to draw the outer contour of the product, then add decorative/constructive lines, furniture, visible seams. Seam lines are represented by dashed lines. A garment technical drawing is shown in figure 2.

2.1.2 Creating a fabric print design in Adobe Illustrator

Creating digiprint files is necessary when you need to print a pattern on fabric. To prepare a digiprint file you first need to digitize the patterns or construct them with CAD software. You can create textures for fabrics by using the Image Trace function to vectorize the pattern. This is important if you wish to copy a pattern on a photo or a part of it. Image trace recognizes the outlines of the pattern and transforms them into vector format. You can also change the vector lines by using anchor points.

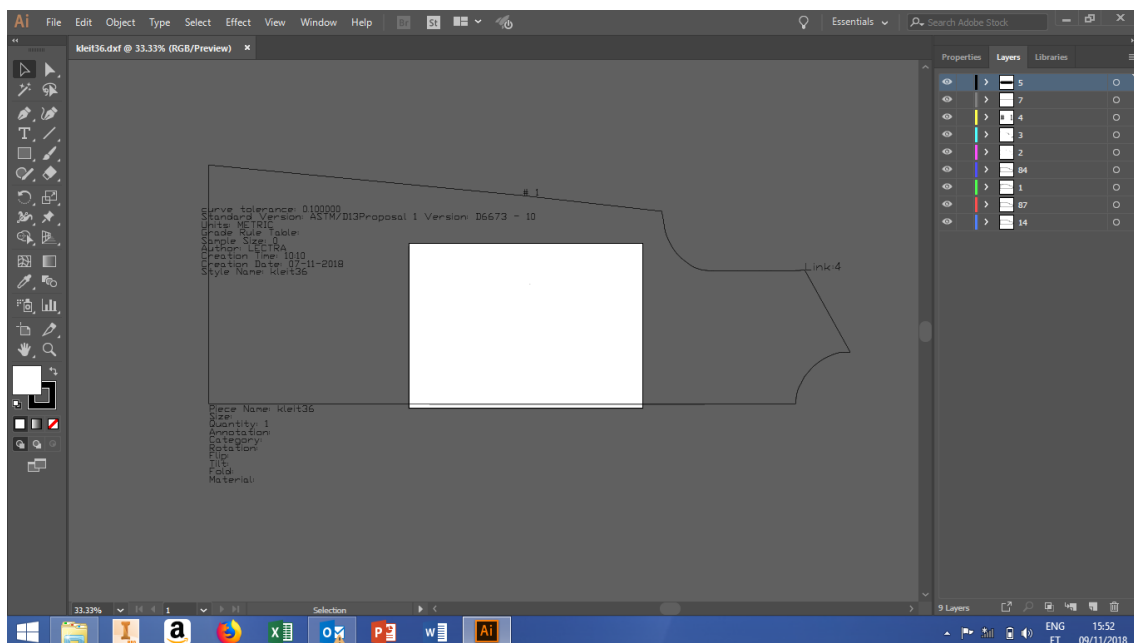


Figure 3 Opening a DXF file in Adobe Illustrator

To prepare the print you first need to find a suitable texture that you wish to print on the fabric. The patterns for the garment can be opened in Adobe Illustrator as .dxf files, this is shown in figure 3. Finding the texture is a creative task that can be fulfilled in different ways. You can draw the texture yourself by using the drawing tools in Adobe Illustrator. You can also scan a drawing and convert it to vector format. Another possibility is to use the stencil method. To use this method you need to draw your garment technical drawing on a mannequin silhouette. Then you cut out the garment part and you are left with a window in the paper representing the garment.

By using this window, a suitable texture from a book or pattern sheet that has proportions suiting the garment can be found. Then this texture can be photographed through the window on the paper. Using this photo, the texture can be drawn in vector

format by using the tools in Adobe Illustrator. The textures can be quite complex and have several layers. When creating the textures it is necessary to mind the order of details. Adobe Illustrator enables to draw shapes on top of each other and also change the order of details, meaning what is in front and what is in the back. Placing details in Adobe Illustrator is shown in figure 4.

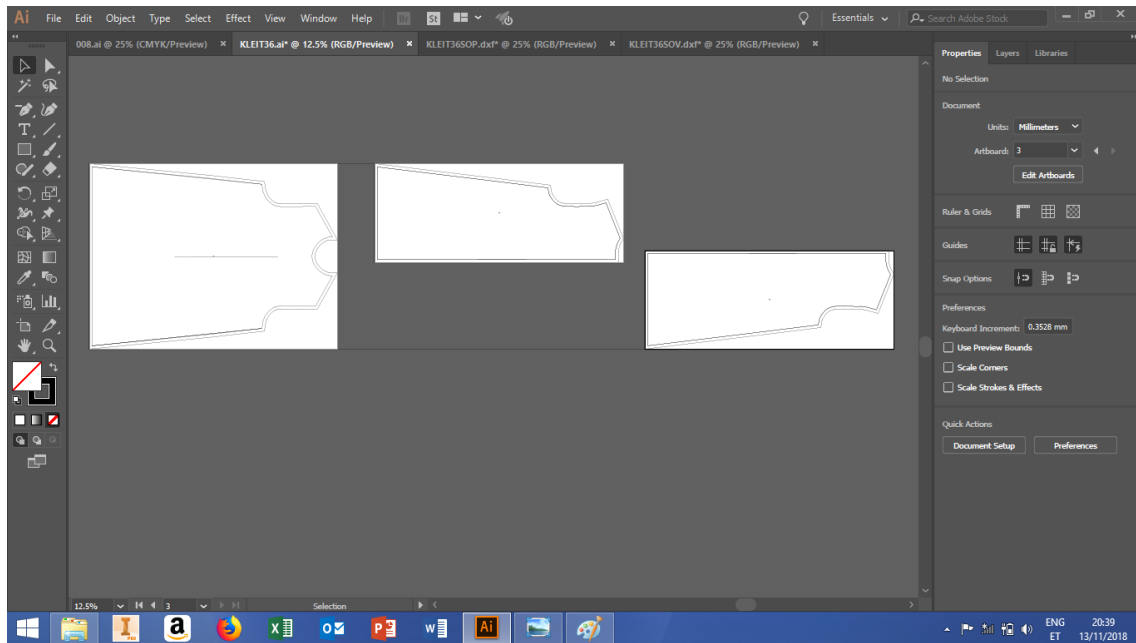


Figure 4 Placing details

To achieve successful results when using digiprint it is important that the texture stretches over the external contours so that you can cut out the textures from the pattern. In the technical drawing front view textures on the side of the garment are also represented, but you cannot directly transfer the textures. Because patterns represent the layout of the fabric they also contain the side parts. One opportunity is to put the texture contours on the stencil and move the side parts so that they cover the whole stencil. In this case the middle part proportions are unchanged and the side part is expanded because it curves around the body. Using this method you can achieve a result similar to the front view by minimally changing the proportions. Digiprint pattern details are shown in figure 5.

Adobe Illustrator software enables you to open .dxf files. Dxf is a common file format used by CAD software in the garment industry.

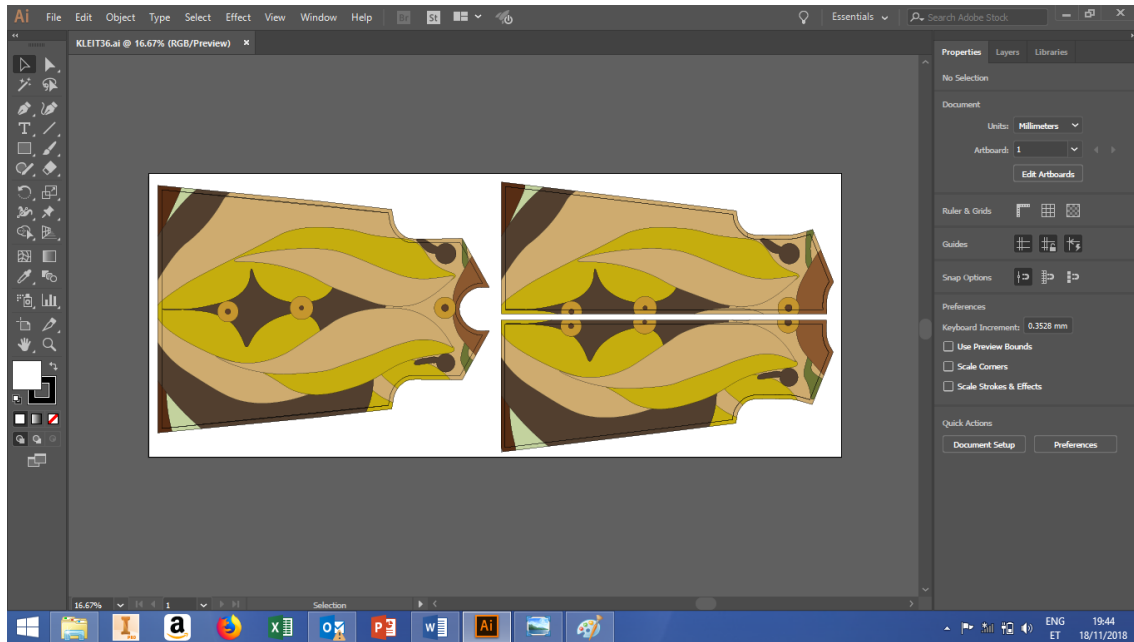


Figure 5 Digiprint pattern details

Dxf enables you to import a model created in Gerber Accumark or Lectra Modaris. Using dxf every detail of the garment is saved in a separate file. When opening .dxf files in Adobe Illustrator it is important that the correct scale is selected. The scale is created when creating the file and in the case of Gerber Accumark for example 1 unit is 1 cm. You can check the scale by drawing a line on a line with a known length, if the length of the line matches the known length, the scale is correct.

Dxf file format is also used in other industries, for example woodworking and furniture industry. In the furniture industry .dxf is used to create toolpaths for a CNC cutting machine. The file can also contain 3D info, meaning a model. Dxf is also used to represent geometry of irregularly shaped details so that these details could be produced by outsourcing. Dxf files used in the garment industry only contain 2D info.

If you wish to create a dress in Adobe Illustrator that has the same pattern on the front and rear parts, first you have to place the patterns on top of each other before copying the texture. You can place the details on separate layers to keep them from mixing up. Because the back part consists of two separate details you have to consider that the back centre line is on the seam line not the edge of the stencil. When placing details you can draw the front centre line on a separate layer and then move the back parts so that the seam line matches the front centre line. When placing details like this the pattern matches in the side seams between the front and back parts. Then you have to

cut out the texture from the patterns by using the pathfinder tool. If the pattern is placed on the details you can place the details next to each other. Besides the seam allowances you have to consider the print allowances.

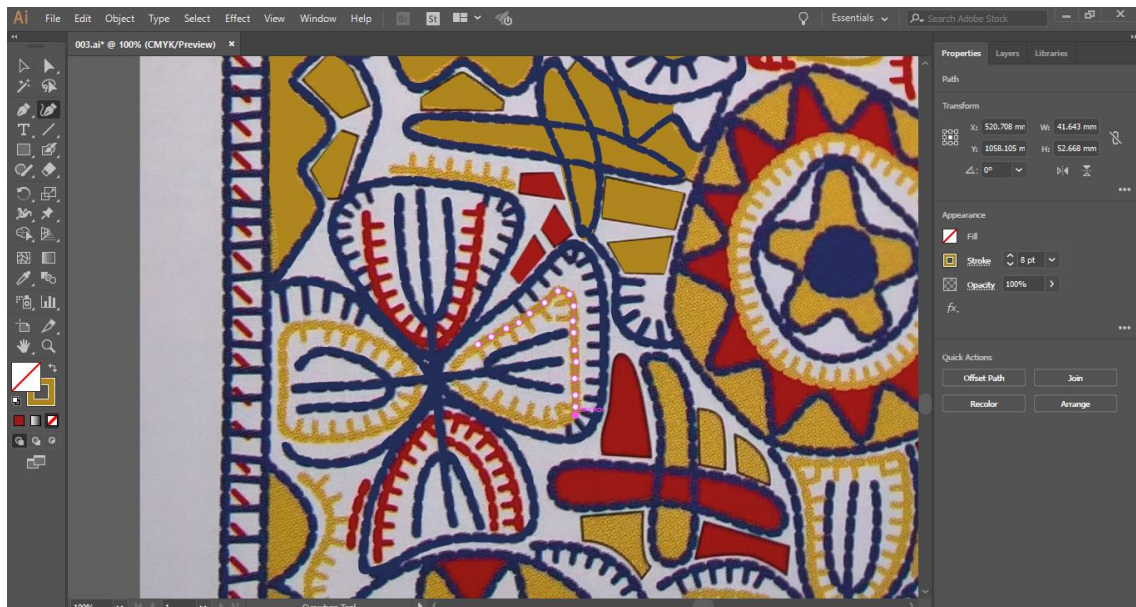


Figure 6 Drawing more complex patterns into vector format

When recreating more complex patterns it might be necessary to draw them in as vectors. Drawing more complex patterns into vector format is shown in figure 6. You can draw directly on the photo. The patterns you draw can be placed on the external contours of the product and then cut off the parts that exceed the contour. Using vector graphics enables you to get large format prints of the technical drawings. Using vector graphics is also important when using the digiprint technology to print your pattern on the fabric. To print the pattern, you need to construct patterns using a special CAD software and then open the .dxf file in Adobe Illustrator and put your texture on the patterns that are printed directly on the fabric along with the contours of the textures.

2.2 Kaledo Style

Kaledo Style is Lectras graphic design program. It enables the user to create garment technical drawings and other graphics. It is used by technical designers and fashion designers. Although not so easy to learn than Adobe Illustrator, Kaledo Style is also used in garment product development.

2.2.1 Creating a garment technical drawing in Kaledo Style

Kaledo Style is another option to choose when creating garment technical drawings.

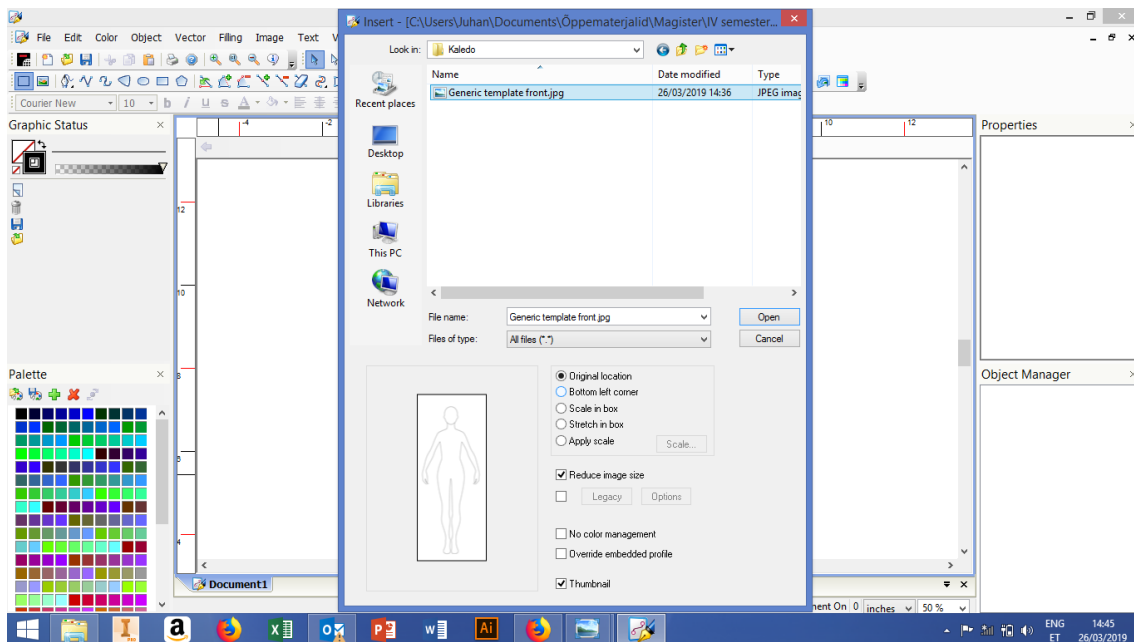


Figure 7 Placing a background image

The command interface consists of a workspace in the middle of the screen and command buttons above the workspace. There are two main types of lines to be created. The first is a linear point type of line that can be used to create sharp edges. The points are added one by one by using the left mouse button, using the right mouse button finishes the line. Lines can be continued from endpoints, but anchor points are not visible. Another type of line is the Bezier line, this can be used to create curved lines. Adobe Illustrator is different from Kaledo Style in that Adobe Illustrator has only one line type which can have either linear or curve points. Anchor points are also visible in Adobe Illustrator and you can change their location. Kaledo Style does not have guide lines when drawing, Adobe Illustrator draws line extensions from tangent points to help with drawing. In Kaledo Style you use the two main line types to create your drawings. Using a special mannequin is also recommended. The special mannequin can be loaded up as a .jpg background image. Placing a background image in Kaledo Style is shown in

figure 7. This greatly simplifies creating garment technical drawings and ensures that they are in proportion.

Adobe Illustrator offers better options when using the

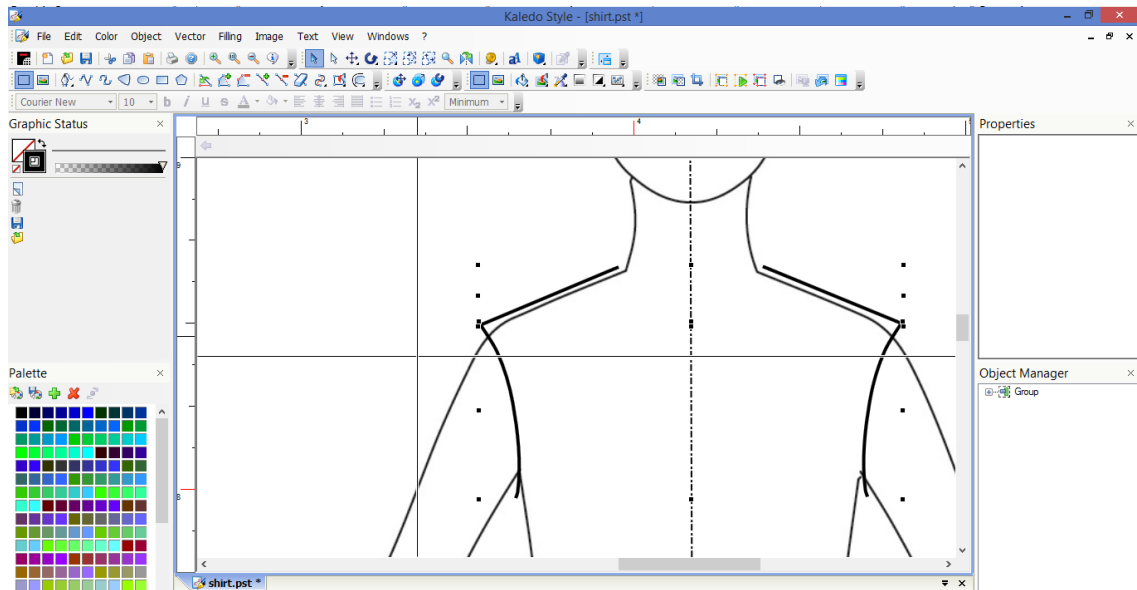


Figure 8 Creating garment technical drawings

special mannequin because you can use guide lines and also snap to the mannequin lines. Garment technical drawings can also be symmetrized in Kaledo Style. This means drawing one half of the garment and then mirroring it across the symmetry axis to produce the other half. This ensures that the garments are symmetrical and also helps to save time because you only have to draw one half of the garment. Creating garment technical drawings in Kaledo Style is shown in figures 8 and 9.

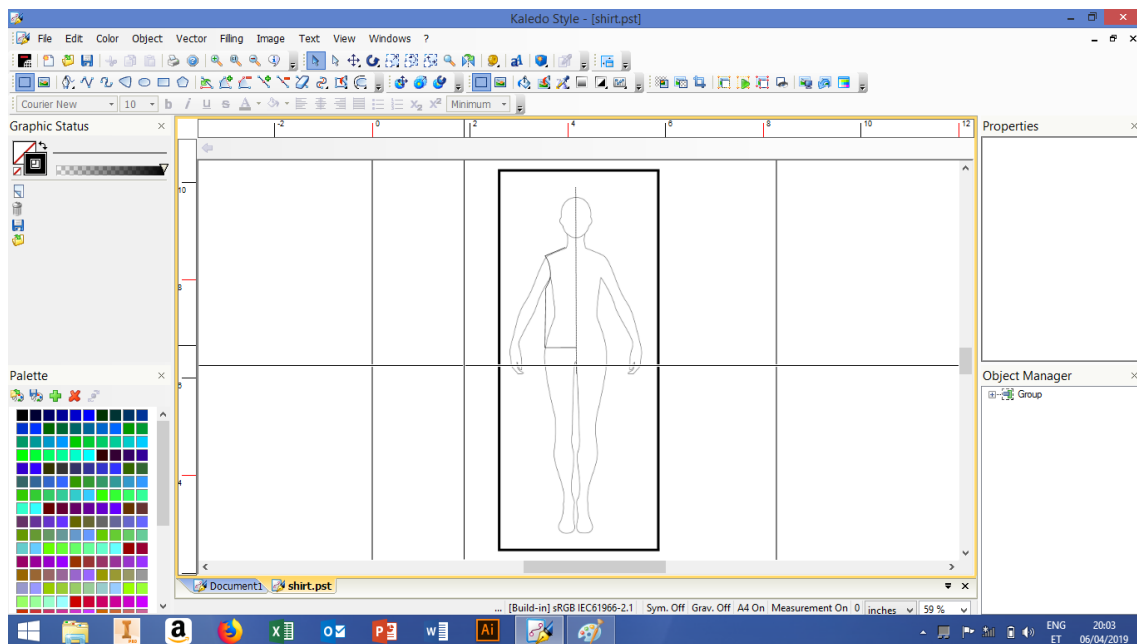


Figure 9 Creating garment technical drawings

2.3 Gerber Accumark

Gerber Accumark is a CAD/CAM program used in the garment industry to create garment pattern pieces and virtual prototypes. It is intuitive and easy to learn. Gerber Accumark is used by technical designers and pattern makers. It also features parametric 3D mannequins, that can be adjusted to custom measurements taken from clients.

2.3.1 Gerber Accumark user interface

The user interface of the Gerber Accumark program is quite intuitive and user friendly. Different commands are divided into categories according to similar activities. The categories are divided into smaller groups that have commands for different functions. For example, a larger category is the Create menu that has commands that enable you to create new base-constructions, patterns, lines or points. The category is divided into groups that have similar commands for example there is a group for commands that create different lines. The commands interface is located above the workspace and one category is active at once. Gerber Accumark user interface is shown in figure 10.

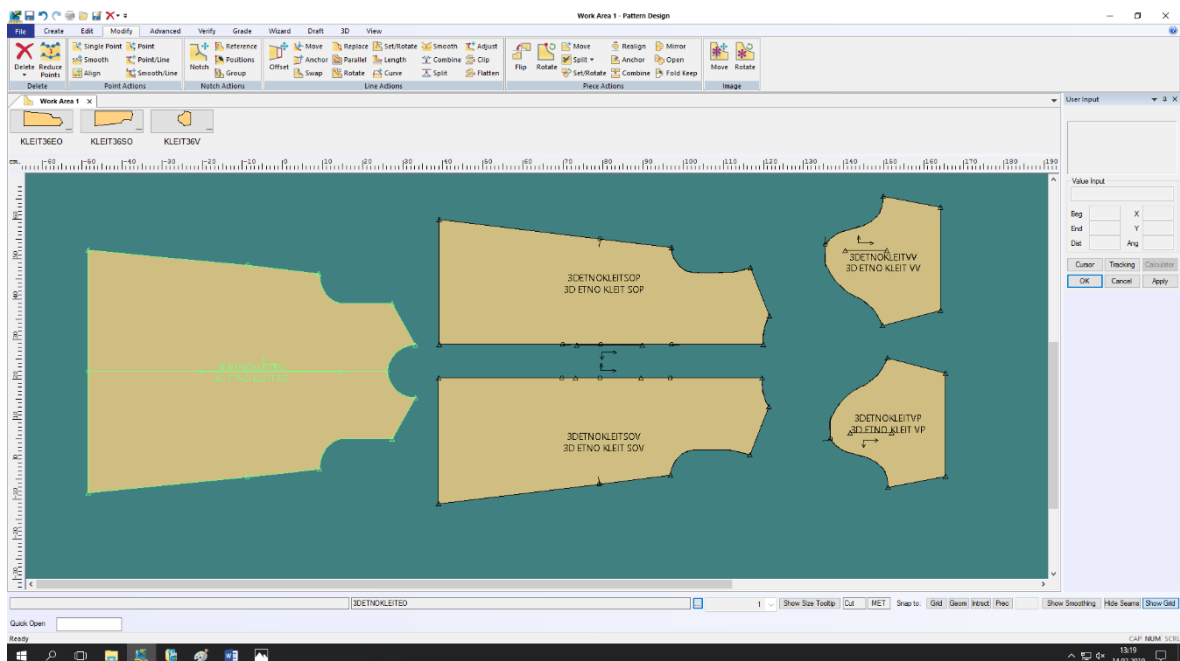


Figure 10 Gerber Accumark user interface

The command buttons contain a name of the command and an icon. Selecting commands is done by the mouse and commands can be fulfilled step-by-step or at once. To the right of the workspace is the coordinates window where parameters can be inserted to fulfill commands. The coordinates window also contains a description of the current command and what parameters have to be inserted next. If the step-by-step mode is active, the program does not automatically move on to the next step of the

command, you have to confirm. This enables you to select individual points or lines and then move on to the next step.

2.3.2 Constructing patterns in Gerber Accumark.

To create pieces in Gerber Accumark software first you have to create a draft piece. Pieces are created by selecting closed contours, it is also possible to add internal lines from base constructions for example the hip line, waist line, bust line. Internal lines help to construct the pieces because distances are measured from them. Internal lines can also divide the piece into segments for example the front centre line. When constructing patterns internal lines are marked with notches and the lines are deleted.

In the Gerber Accumark software there are quite practical options for entering X and Y coordinates. It is also possible to use percentages when entering coordinates and to mark a distance starting from the start or finish of a line. X and Y coordinates can be defined by different types of data, for example you can enter the X value as 20% from the start of the line and the Y coordinate to be +1 cm above that point. In the program there is no global coordinate system and coordinates are given inside pieces, that means you can move and rotate the pieces without messing up the coordinate system. Because coordinates are given inside the pieces it is necessary to create a draft piece, this can be a straight line that distances are measured from. When creating a draft piece, it would be wise to create first a straight horizontal line that has a direction that matches the grain direction, this can be the front centre line or back centre line. Next it is reasonable to draw the perpendicular internal lines for example the hip line, waist line, bust line. Completed base constructions and the derived pieces can be used repeatedly.

Gerber Accumark also enables to apply grading rules to base constructions. The grading rules also apply to derived pieces. Because base constructions are created by type figures it is possible to use them for a long time and also convert between different software. Deriving new pieces from base constructions is called modelling. It means adjusting the base constructions to the style of product needed. If the product appearance is significantly different from the base construction, the grade rules will also need to be changed. Repeating small details, for example collars, pockets, cuffs should be archived to be used in several products and to apply your own rules for using them. For example the pocket size does not change with the pieces but pockets of the smallest size of garments can have different dimensions from the largest size of garments.

2.3.3 Creating a 3D model in Gerber Accumark

Creating a 3D model in Gerber Accumark is a several-step process. The first step is to create a draft piece to construct patterns for the other pieces.

Measurements for the garments can be taken from size tables, this ensures that the garment is constructed to a certain size. Size tables vary by country, it is important to select the correct size table for constructing. The size table corresponds to the country whose constructing system we are using. Different brands can also have different size tables.

When the draft piece is ready the other pieces can be made by selecting the external and internal lines on closed contours. When constructing the pieces, construction lines can be replaced with notches, this helps to clean up the model and ensure that you have a correct piece. It is necessary to remove unnecessary lines and unused points as these can create confusion when creating the 3D model. It is also necessary to make sure the pieces do not have overlapping lines, otherwise you might accidentally select the line with the long length.

Gerber Accumark enables you to have images on the pieces as either a trim or fabric image. A fabric image is a repeated pattern that is placed on all the pieces that have that fabric. Placing images on patterns is shown in figures 11 and 12.

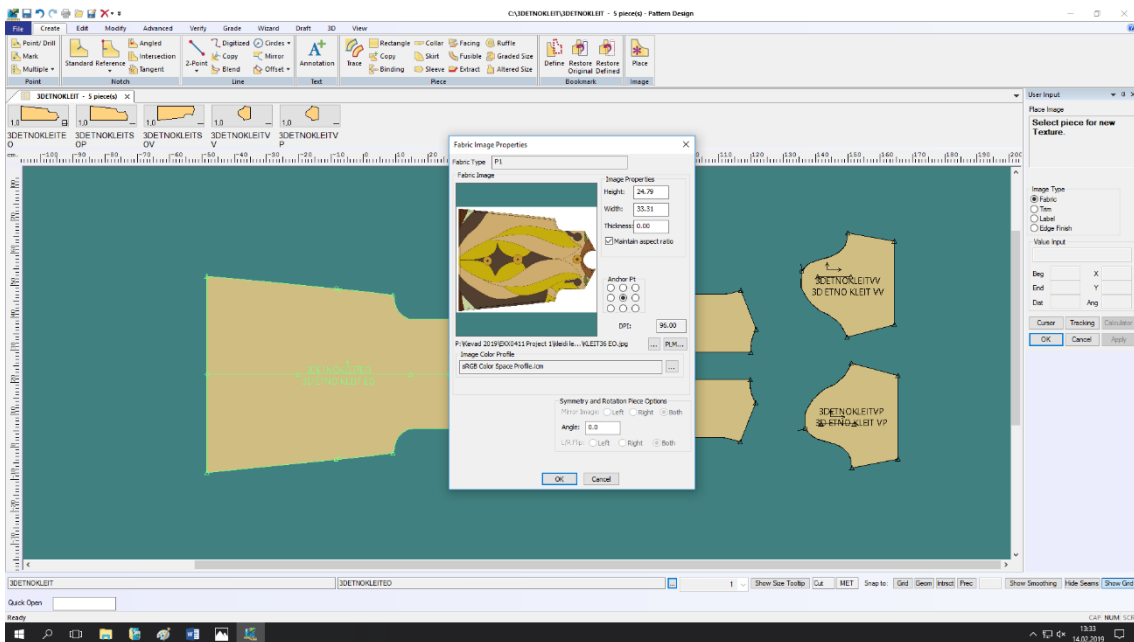


Figure 11 Placing images on patterns

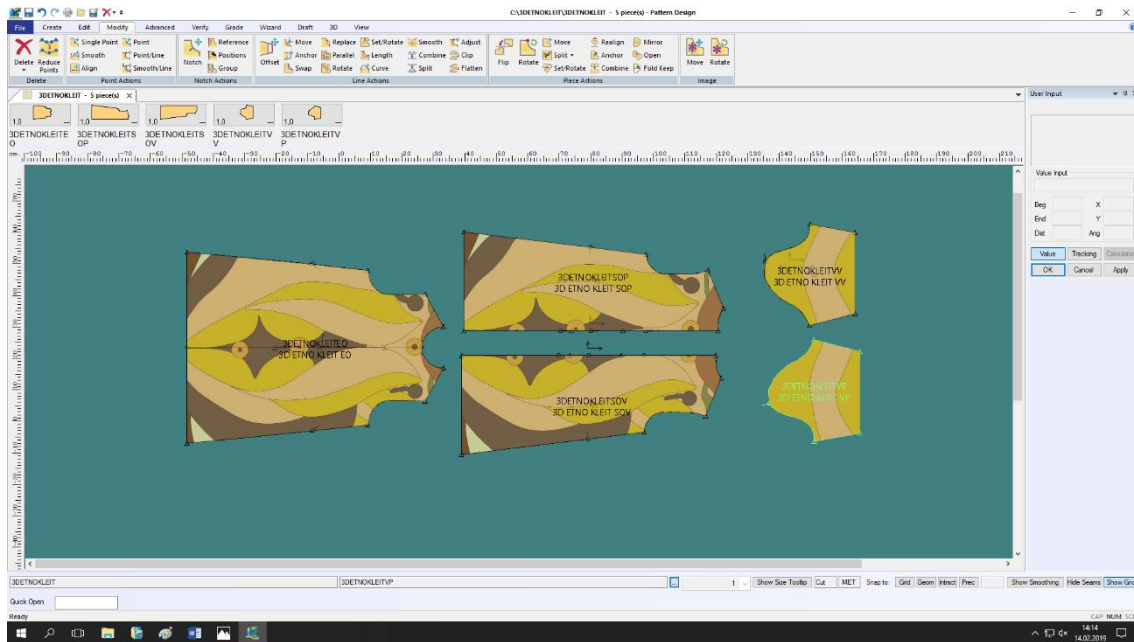


Figure 12 Patterns with textures

If you have several textures you will need to create different fabrics for different pieces. An image trim enables you to place an image on the piece and move and scale it to the right size. Image trims are placed separately for each piece and an image trim is not visible in the bill of materials on the fabric. When you do have printed fabric in the garment you can create a fabric for it to get the material info into the bill of materials and then use image trims to get the textures on the pieces. Gerber AccuMark also contains a library of image trims that you can use for your garments. The library includes buttons and zippers and textures of various seam edges. You can use these to decorate the 3D model, but keep in mind that image trims are not actually printed on the fabric.

To produce a garment with printed textures you have to export the pieces as .dxf files to make sure the patterns are the correct size. The textures can be created by using a graphical design program like Adobe Illustrator for example. The .dxf file format enables you to construct the patterns using Gerber AccuMark and then transfer the texture on the patterns using Adobe Illustrator. You can place the pieces next to each other and then have them printed directly on the fabric. You can then use the printed lines to cut out the pieces. Using 3D can be a great way to match textures at the seam lines and get nice patterns with repeating textures. The process contains a lot of trial and error however and there is not a guaranteed way to get 2D images onto 3D garments. It is necessary to keep in mind the construction of the garment when creating textures with repeating patterns or pictures that continue at the seam lines. Gerber AccuMark has the set/rotate function which you can use to place pieces next to each other, you can then check the continuity of the pattern.

When you have all the pieces for your garment you can move on to the next step which is constructing a model. A model description contains details about the garment. The model description is shown in figure 13.

Avatar: ...

Graded Avatars: ...

Garment Position:

	Piece Name	Piece Image	Piece Category	Fabric	Original	Flips	As Input	Position	Orientation	Body Position	Wrap Type	Fabric Layer Position	Overlap Type
1	3DETNOKLEITEO		3D ETNO KLEIT EO	P1	1	1	Left	Front	Centered	Chest	Cylinder	1	None
2	3DETNOKLEITSOP		3D ETNO KLEIT SOP	P1	1	1	Right	Back	Right Only	Chest	Cylinder	1	None
3	3DETNOKLEITSOV		3D ETNO KLEIT SOV	P1	1	1	Left	Back	Left Only	Chest	Cylinder	1	None
4	3DETNOKLEITVV		3D ETNO KLEIT VV	P1	1	1	Left	Side	Left Only	Shoulder	Cylinder	1	None
5	3DETNOKLEITVP		3D ETNO KLEIT VP	P1	1	1	Right	Side	Right Only	Shoul	Cylinder	1	None
6													

Figure 13 Model description

Included in the model description is the number of pieces or mirrored pieces in the garment. Pieces can be mirrored either horizontally or vertically. When you have pieces with a texture or image printed on them it is necessary to have unfolded mirrored pieces in the model, this enables you to position the image on the pieces and ensures that the texture continues from the right place at the seams. You can move and scale textures that will be placed on the patterns. It is necessary to maintain image proportions when scaling textures to ensure that you do not stretch out the image. You can use stencil corners to aid in positioning the textures and scale them to the correct size to fill the stencil.

The model description also contains info for 3D. For each piece you have to determine its position on the body as well as its orientation related to the mannequin. The pieces can also be moved directly in 3D to position them more accurately. Another parameter in the model description is the wrap type which can be either cylindrical or flat. For details that wrap around the body, cylindrical wrap is used. Also included in the model description is the 3D mannequin and its size, this is called an avatar in Gerber Accumark.

When you have completed the pieces and the model description you can move on to the digital sewing room. Garment pieces have digital sewing relationships, they are created by selecting the first and second group of lines. Digital seams hold the model together.

It is also important to mind the direction of sewing. The 3D window contains a 2D window where you assemble the model and create sewing relationships. You can add comments to the model in 3D and synchronize the changes to 2D. When you have assembled the model, it is time to move on to cloth simulation. This is a more detailed 3D window which you can use to simulate the garment model. Cloth simulation shows how the fabric drapes on the body. When the cloth simulation is complete you can get a better idea of how your garment will look like in real life. Gerber Accumark allows you to make graded 3D mannequins for garments. It is important to select the same size table for the graded mannequin than for constructing the pieces. You can change the mannequin parametrically by inputting values from size tables. This enables you to make a suitable 3D mannequin for the size of garment you are constructing. A 3D model in Gerber Accumark is shown in figure 14.

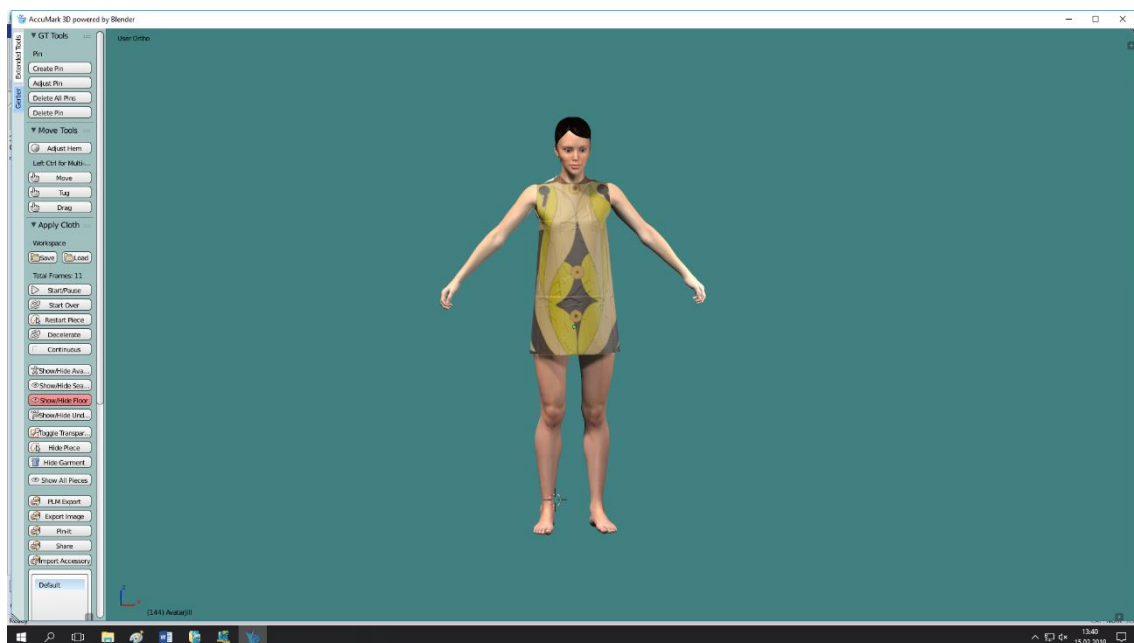


Figure 14 3D model

Gerber Accumark also enables you to make a custom mannequin with measurements taken from a person. This can be used for creating custom-fit garments for clients who have had their measurements taken. But then you have to know how to take measurements from the body to ensure they are taken from the correct places.

Gerber Accumark enables you to check the wearability of a garment by simulating a graphical tension map. These highlights areas of the body where the garment is too tight around the body and enables you to make changes to the patterns to ensure a correct fit.

2.4 Lectra Modaris

Lectra Modaris is a CAD/CAM program used in the garment industry. It is used by technical designers and pattern makers. Lectra Modaris enables the user to construct pattern pieces and virtual prototypes. It also features parametric 3D mannequins, that can be changed to the desired body dimensions.

2.4.1 Lectra Modaris user interface

The user interface of Lectra Modaris can be confusing at first, since it is not made like the other programs like Gerber Accumark, Optitex or Adobe Illustrator which can be easier for people familiar with other windows programs like Word, Excel . It is presumed that the user knows exactly what to do and where to click and there is a lack of help texts. On the other hand, the user interface of Lectra Modaris has remained similar for several years and for the experienced user moving on to a new version of the program is quite easy because the command buttons are in the same place. A negative example for comparison is the Autodesk AutoCad program where the commands and buttons are rearranged every three years. Lectra Modaris user interface is shown in figure 15. In the Lectra Modaris software the commands are divided into larger categories according to similar activities. The categories window is to the right of the workspace and changing categories can be done with the mouse or keyboard, one category is active at once.

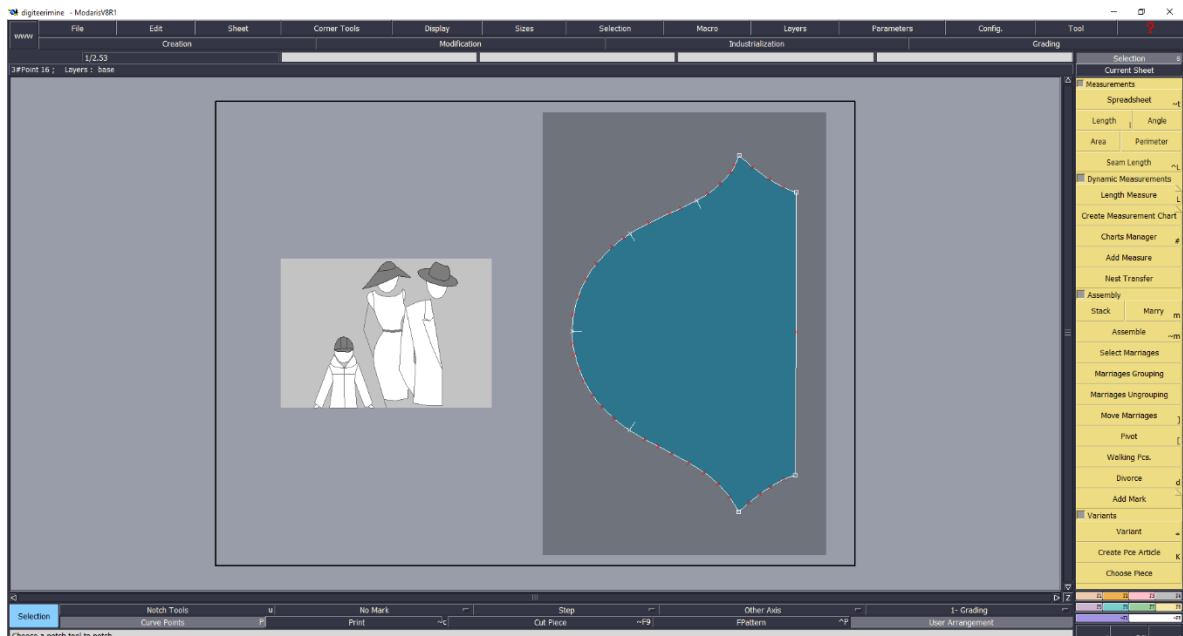


Figure 15 Lectra Modaris user interface

The command buttons are marked by either an icon or a text. Changing from text to icons can be quickly done using the keyboard. The icons are not easily understandable but then again, they are pictograms, if you learn them once the brain recognizes

pictograms easily. In the Lectra Modaris program commands are not fulfilled step-by-step, meaning that the program automatically moves on to the next step of the command when certain parameters are entered. When using the commands, the user has to know what is expected and what to do next. Commands can be selected either by mouse or keyboard. When the command is activated a parameters, window opens where the user can input values.

2.4.2 Constructing patterns in Lectra Modaris

Constructing patterns with Lectra Modaris is quite similar to using Gerber Accumark, however it has certain differences. Constructing patterns in Lectra Modaris is shown in figure 16. Lectra Modaris also enables to digitize patterns using a digitizer and a special mouse. Having a digitizer is a great plus when digitizing paper patterns because the patterns can be digitized on a 1:1 scale and to apply the changes to them that you want or use repeatedly the base construction and change the main material.

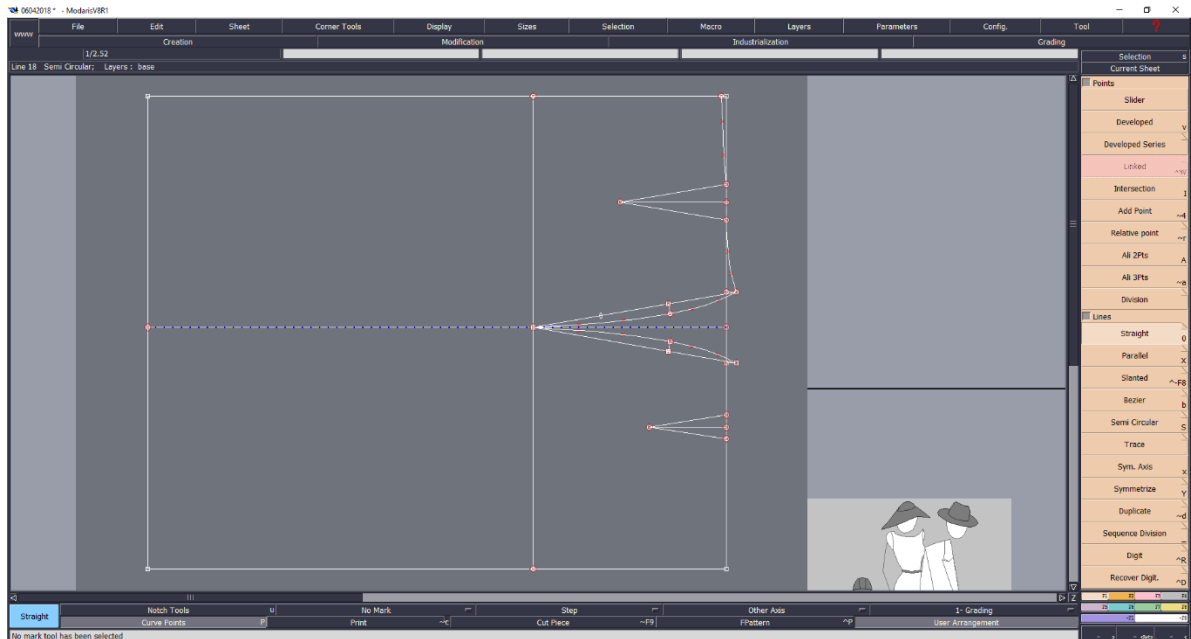


Figure 16 Constructing patterns in Lectra Modaris

Lectra Modaris software is also similar to Gerber Accumark because there is not a global coordinate system and the X and Y coordinates are given inside pieces. In the Lectra Modaris software it is not possible to measure distances by percentages along the lines but you can divide the line into equal parts and measure distances with the help of additional points. There are also special points connected to lines – slider point and developed point. Slider point is proportionally linked to the line and it stays in the same location when the length of the line changes for example in the centre of the line. Developed point always stays the same distance from the starting point of the line, for example 5 cm and its location changes when the line length changes. In Lectra Modaris it is necessary to create base constructions. Closed contours of base constructions are selected to create the pieces.

2.4.3 Digitizing patterns in Lectra Modaris

Digitizing is a way to get the patterns constructed on paper to a digital format. It consists of a certain amount of skill and in the same time it takes time to learn how much points to digitize to get accurate curves. [12].

Digitizing patterns is done on a special digitizer. Before digitizing you have to construct patterns on paper. Digitizing board with patterns is shown in figure 17.

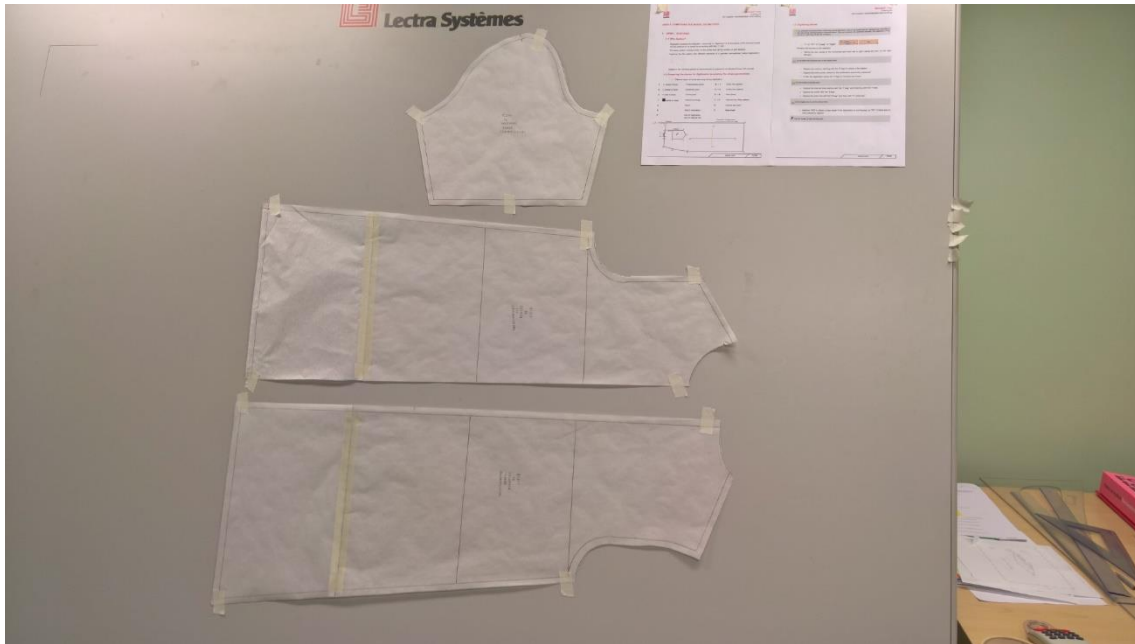


Figure 17 Digitizing patterns

You can digitize patterns on fabric, tracing paper, card or other materials with the digitizer. Already digitized patterns in Lectra Modaris are shown in figure 18.

Digitizing patterns is usually done on the sewing line and seam allowances are later added using a computer and necessary software. To digitize a pattern, you need to fix it to the table, for example with adhesive tape. Then you need to activate the necessary software. In this work we use a Lectra digitizer and Lectra Modaris software. Digitizing a pattern is done counter-clockwise. First you digitize the grain line. When digitizing you first need to select the starting point and then move on along the seam line. There are different types of points used, for example straight points, curve points. When digitizing curves, you need to select the curve points, the distance between them is related to the complexity of the curve. When drawing lines, notches are also used, these are used to mark the bust line, waist line or hip line or other internal lines. After digitizing it is wise to align horizontal and vertical points to keep the lines horizontal or vertical and to keep the notches aligned. In Lectra Modaris software darts are drawn as cutouts. After

successfully digitizing the pattern you can add the seam allowances. Digitized patterns can also be used to derive new pieces by using modelling techniques.

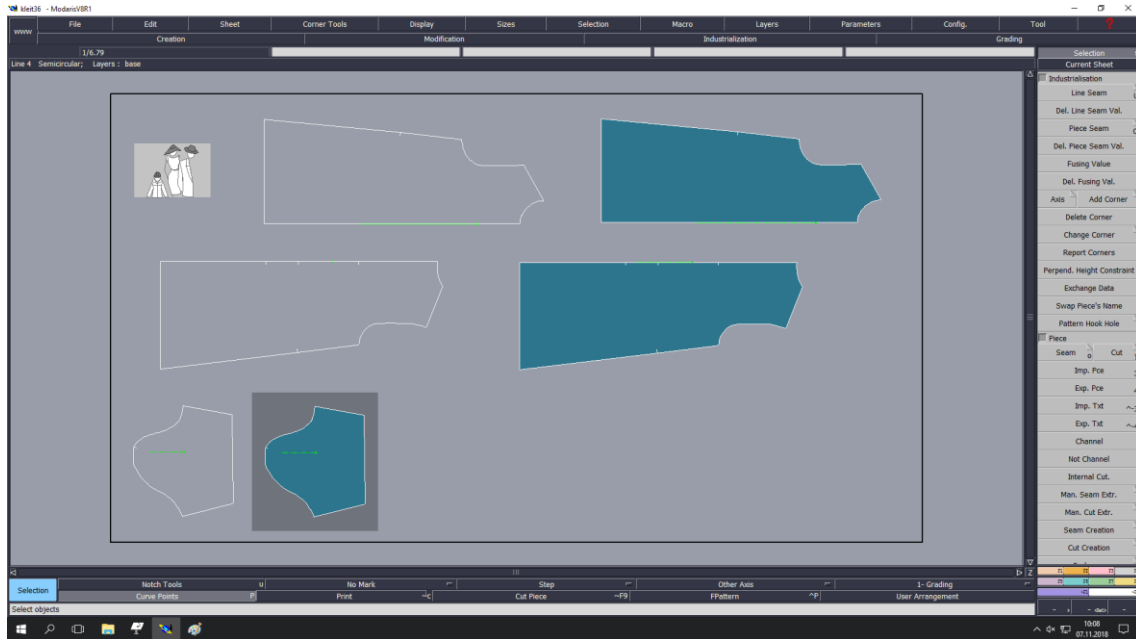


Figure 18 Digitizing patterns

2.4.4 Creating a 3D model in Lectra Modaris

Creating a 3D model in Lectra Modaris is a process which has several steps. First you have to create a base construction which you can use to create the derived pieces. The base construction can be created by drawing in lines and curves or by using a digitizer. You follow the perimeter of the stencil and create points for your pieces using a special mouse. When you have the base construction, it is time to create the pieces by selecting

closed

contours.

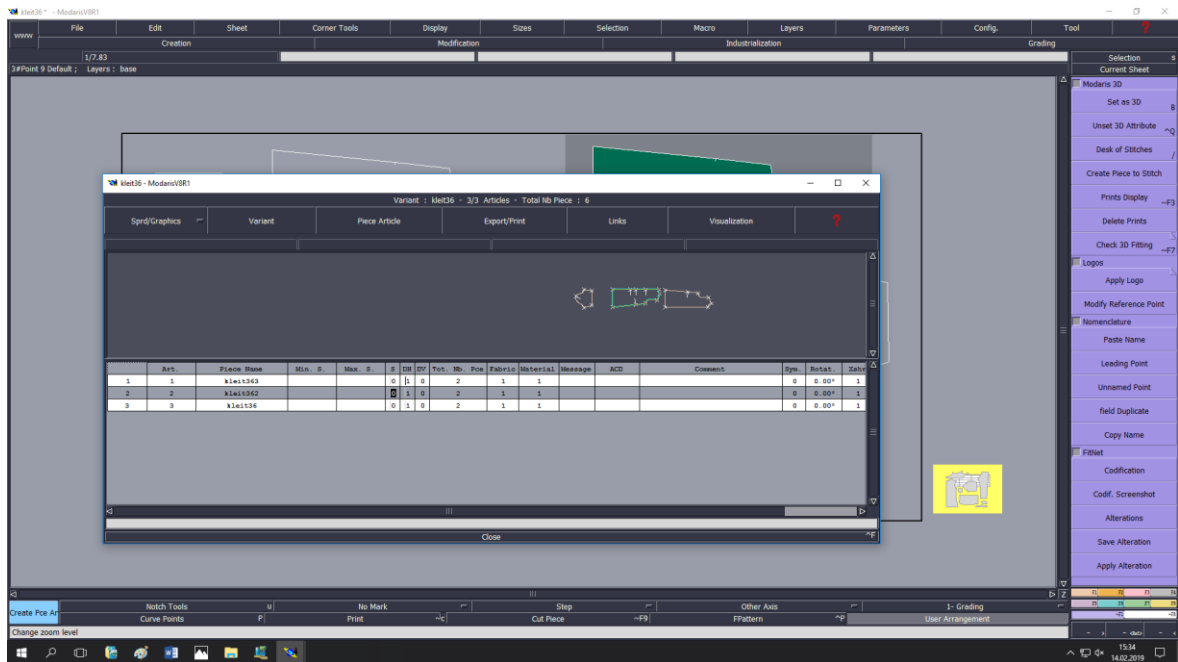


Figure 19 Variant

When you have all the pieces for your model it is time to include them in the variant. A variant is Lectras version of the bill of materials. A variant is shown in figure 19. This includes information about the material of the pieces and the number of single pieces or paired pieces. Pieces can be mirrored either horizontally or vertically. A variant is also necessary to create a 3D model because it contains info about the number of pieces included in the model.

When you have completed the variant, it is time to move on to the desk of stitches. The desk of stitches is shown in figure 20.

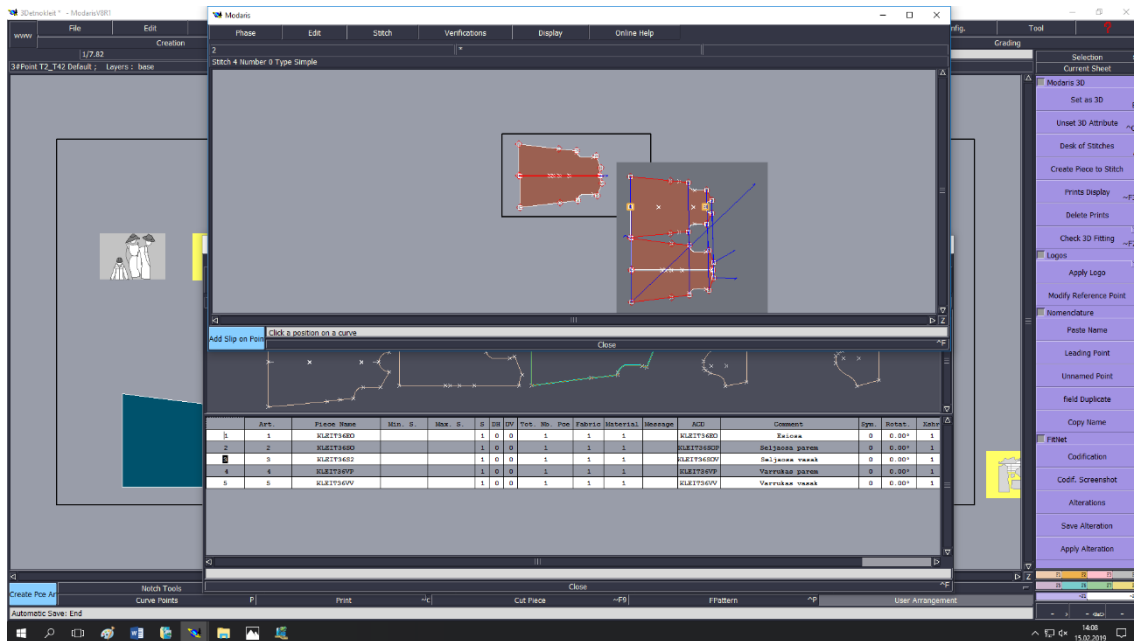


Figure 20 Desk of stitches

The desk of stitches is Lectra's digital sewing room. You can create digital sewing relationships between the pieces by selecting the appropriate sewing lines. It is also important to mind the direction of sewing. Lectra Modaris allows you to make various different sewing relationships, it is also possible to have buttons or zippers in the sewing relationship. A sewing action is related to a phase in the desk of stitches. A phase creates the sewing relationship between the model edges. A single phase can include several seams. Also included in the desk of stitches are the slip-on-points, these are placed at the edges of the garment pieces and they determine the position of the garment piece related to the body. Slip-on-points help you to assemble the model.

Lectra Modaris allows you to create parametric 3D mannequins of various sizes. You input measurements taken from size tables or measurements taken from the body to

create the 3D mannequin.

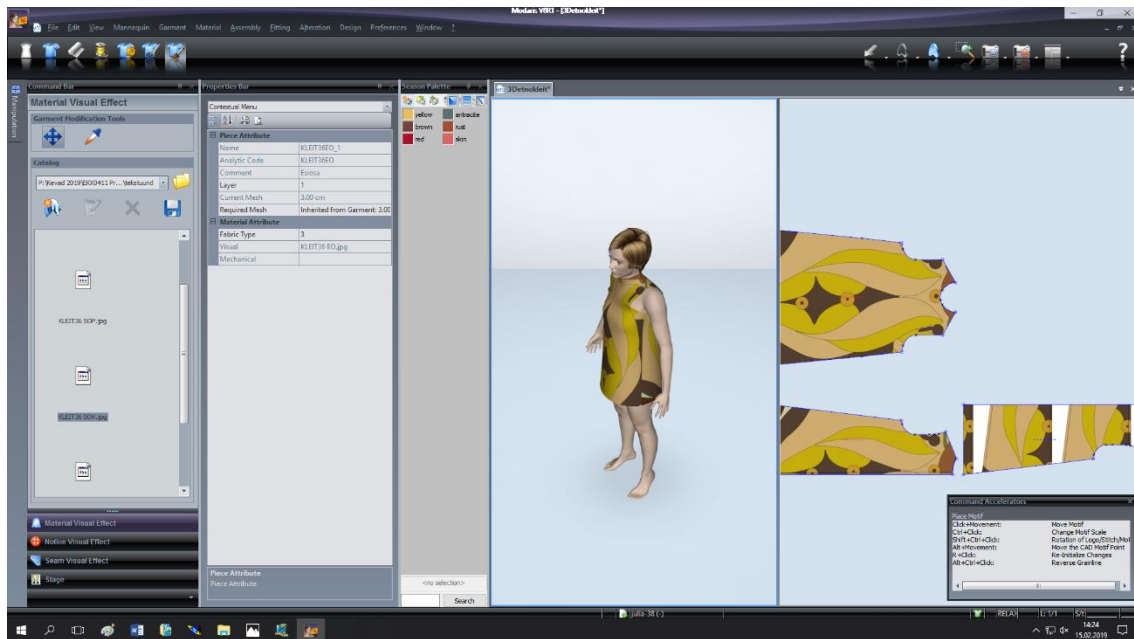


Figure 21 3D model

These mannequins can be used to test the wearability of garments.

Gerber Accumark features more accurate tools for placing images on the patterns. Lectra Modaris also features a library of textures that you can use for your garments, this library includes buttons and zippers. When you have placed the pieces with slip-on-points and created sewing relationships between them you can assemble the model and do a cloth simulation. The cloth simulation gives you an idea of how your garment will look like in real life.

Lectra Modaris can also create a tension map to show the amount of tension of the garment on various areas of the body. Lectra Modaris also features 3D measuring tools, for example you can measure the distance between two points on the mannequin by using a 3D measuring tape. The 3D window also enables you to select the material for your garment. Materials with various physical properties can be selected, these include weight of the fabric and drape. You can also put textures on the materials. This is done by selecting an image and then moving, scaling and rotating it to match the stencil. If you have different textures for different pieces you have to create several different materials. Using textures on the pieces enables you to see how an image continues at the seams of the garment. Using 3D can enable you to create continuous textures however you will have to use a graphical design program to create the images like Adobe Illustrator for example. A 3D model in Lectra Modaris is shown in figure 21.

2.5 Program specific pros and cons

Compared with Lectra Modaris software Gerber Accumark is better suited for the beginner because it is a more user-friendly software that has user interface that is more flexible and intuitive. Lectra Modaris is more complex to use and there is a lack of help texts, but then again, the Lectra Modaris user interface has remained the same for a long time. If you learn it once it is easy to change to a new version of the software.

In Lectra Modaris software patterns are placed on separate work sheets that have a opaque background. It is possible to copy pieces on a single worksheet to place the seam edges together. In Gerber Accumark the patterns have a transparent background. They can be placed on top of each other to check whether the seam lines match. There are also special functions that enable to place patterns next to each other aligning by the edge point for example. In Gerber Accumark there are special functions for darts that Lectra Modaris does not have. In Lectra Modaris darts are drawn as cut-outs on the details. Gerber Accumark features more functions for dart manipulation. When creating digital seams in Lectra Modaris, the user selects both end points of seam lines, but in Gerber Accumark you just select the lines. Lectra Modaris features slip-on-points to determine the position of the pieces in 3D, Gerber Accumark has the piece location in the model description. Both programs contained some graphic errors when making the 3D model even though everything was done in the correct order. These graphic errors can be frustrating, because the programs do not feature any tools to correct them.

3 Creating a 3D collection

Creating a 3D collection is one of the aims of this thesis. Virtual prototyping is used to create 3D models for the collection and render them for presentation. Gerber Accumark, Lectra Modaris and CLO are compared for making 3D models, then the best program for making the collection is selected.

3.1.1 Gerber Accumark

Gerber Accumark gave the poorest results in creating a 3D model. The program had several graphic errors which caused the model to look distorted. Even when everything was done correctly, sleeves could not be attached to the model. On the second try sleeves were attached, but then the program failed to recognize the textures. The model also had some graphic errors and was distorted. Gerber Accumark does not enable you to save 3D models, so every time a problem occurs, you need to start from the beginning. The program does not feature any tools to fix the graphic errors that occur. While Gerber Accumark is good for constructing patterns and working in 2D, it is not recommended for working in 3D. The 3D models for this thesis were done on a previous version of Gerber Accumark, now a new version is available that could possibly fix these bugs.

3.1.2 Lectra Modaris

Lectra Modaris is better for working in 3D than Gerber Accumark. It is also possible to save your models, meaning that you do not have to start from the beginning every time a problem occurs. The program also had some distortion of the model when working in 3D. It was also not possible to attach sleeves to the model as they caused graphic distortion. When the sleeves were removed, there was less distortion and it was possible to construct a model. The program successfully recognised the textures and it was possible to place them on the patterns. The tools for placing textures on the patterns are not as accurate as in Gerber Accumark. The 3D simulation has different results every time and it might be necessary to run the simulation several times to get satisfactory results. Using different fabrics for the simulation might also help. Lectra Modaris is better suited for 3D than Gerber Accumark, but some problems also occur when creating the models. Gerber Accumark is easier to learn for the novice user and it features more commands to change the patterns.

3.1.3 CLO

CLO gave the best results when working with 3D models. Although some graphic errors occurred on the first model, the second try gave satisfactory results. A complete 3D

model with sleeves was constructed. CLO also enables you to save 3D models when the simulation is complete, meaning that you do not have to start over every time. It is also possible to make changes to the simulated models and add new details, you can also change existing details, like the dress length or construction. CLO also features several different mannequins that you can use. These mannequins can also take different poses and you can render animations. Props and scenery can also be used to achieve more realistic visualizations, CLO can also be used to construct custom props like belt buckles or buttons for example. It is also possible to input custom dimensions for the rendered images to get large images, that you can use in prints for example. The patterns for the 3D model were imported as a .dxf file.

CLO is the best program to use when visualizing 3D models, compared to Gerber Accumark and Lectra Modaris. A comparison of 3D models created in Gerber Accumark, Lectra Modaris and CLO is shown in figure 22.



Gerber Accumark

Lectra Modaris

CLO

Figure 22 Comparison of 3D models

3.2 Creating a 3D collection in CLO

The 3D collection was created in CLO as a part of this master thesis. Creating this collection helped me to check the wearability of garments that I constructed in 2D. Visualizing is also an important part. Using 3D helped to simulate the garments and to present them to the potential customer. CLO enables the user to render large resolution images of garments on the mannequin. These can be used in prints, websites, social media or presentations to help advertise your products without the need to produce actual samples. Using 3D can also be used to advertise a base model to the potential customer, you can then produce a custom-fit model according to the client's body dimensions. CLO also enables the user to create parametric 3D mannequins with custom body dimensions. Automatic grading of patterns is also possible. Since CLO is the best program to use for creating the 3D models, the rest of the collection was created in CLO.

The patterns for the garments in my collection were constructed on paper and then digitized on a Lectra digitizer. The model was exported to .dxf format and then imported to CLO. The patterns for the base model were modified in CLO to produce the other models. Then textures were placed on the patterns. The textures were photographed using the stencil method described earlier in this thesis. The textures were found in books concerning Estonian folk costumes. [8]., [9]. The collection uses traditional patterns from Estonian folk costumes transformed to a modern form and made available for the regular customer. One model from the collection was also successfully produced as a real garment. In figures 23,24 and 25 the collection is shown. A technical drawing of the product is on the left, accompanied with a 3D image on the right. The names of the models in the collection start with the name of the parish, that the pattern is from, followed by an Estonian woman's name.

Alutaguse Anu



Alutaguse Heidi



Alutaguse Liisa



Alutaguse Maria



Figure 23 The collection

Halliste Hanna



Järva-Jaani Jane



Kuusalu Keit



Kuusalu Kristiina



Figure 24 The collection

Lääne-Virumaa Liina



Mihkli Marit



Figure 25 The collection

4 Comparison of physical and virtual prototype

This chapter compares and analyses physical and virtual prototypes created for this thesis.

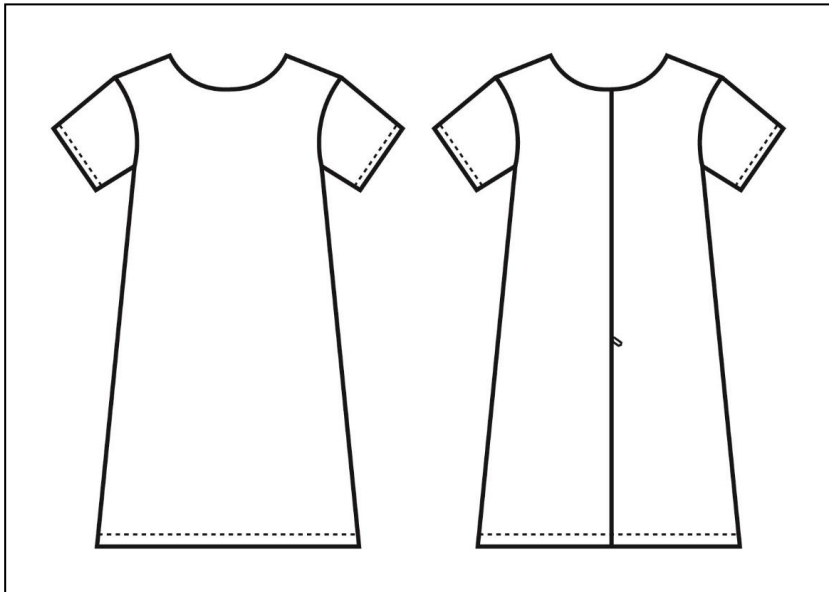
4.1 Creating a physical prototype

For this thesis a real model from the collection was sewn. The model is a short dress with short sleeves and with a digiprint pattern on the fabric. This model was constructed by using a base construction found in a book [7]. A size table was used for constructing the patterns, the size selected is 36. A 3D model was also used to check the fit of the garment on the mannequin. No problems concerning fitting occurred and the model fits the mannequin correctly. A first model was also sewn and minor adjustments to the patterns were done. These concerned the shape of the armhole to achieve a better visual appearance. Using 3D produced realistic results and helped to sew a usable product. A 3D model helps to check the fit of the final product. You can also check how the pattern looks on the final product. Patterns for the model are shown in figure 27. The model is shown in figure 28. A product technical sheet is shown in figure 26. The order of product processing is shown in the appendices.

Product technical sheet

Ordered by	Product	Season	Model nr		
TalTech	Ethno dress	Spring	002		

Fabric art	Thread:	Adhesive fabric:			
P1 (white)	Art. Tkt 120 Color. 09316	Art 060 (white) D			



Stitch frequency 4
stitches/cm, needle nr 90,
needle tip R,

stitch type 301 for connecting
seams, 504 for overlock

Seam allowances:
Facet 0.5, details 1 cm,
Lower edge and sleeve edge
2 cm

Neckline facet outer edges
overlocked

Back zipper 50cm (black), hidden zipper, main fabric
Epoque (P1)

Figure 26 Product technical sheet

4.1.1 Product patterns

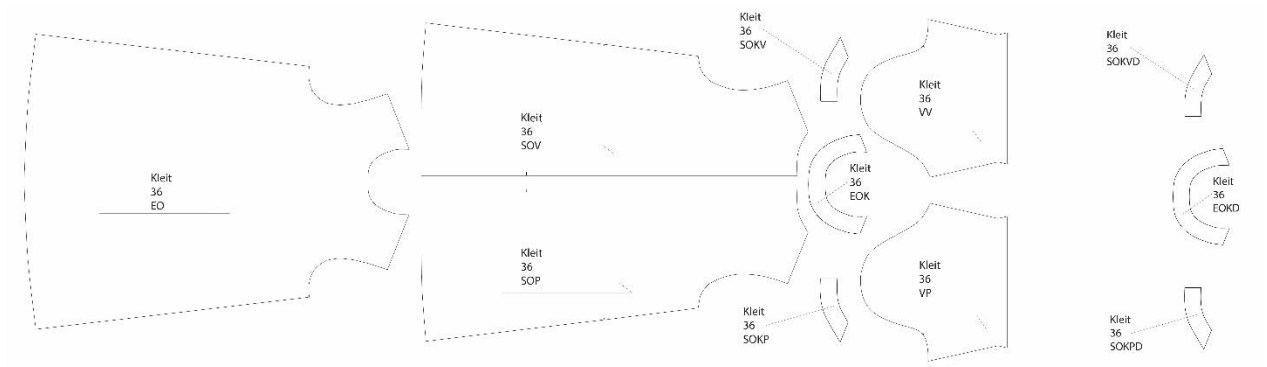


Figure 27 patterns

Table 1 Product pattern specification

Number	Name	Amount	Material
01	EO – front piece	1	P1
02	SOV – back piece left	1	P1
03	SOP – back piece right	1	P1
04	SOKV – back facet left	1	P1
05	SOKP – back facet right	1	P1
06	EOK – front facet	1	P1
07	VV – sleeve left	1	P1
08	VP – sleeve right	1	P1
09	SOKVD – back facet left	1	D
10	SOKPD – back facet right	1	D
11	EOKD – front facet	1	D



Figure 28 Ethno dress

4.2 Analysis of a physical and virtual prototypes



Figure 29 CLO 3D vs photo of physical prototype

A comparison of the physical and virtual prototype is shown in figure 29. For this comparison the physical prototype was worn by a model in a similar pose to the virtual prototype, the expression and hairstyle are also similar. CLO delivers accurate and realistic results in making the virtual prototype. The texture of the dress is shown accurately and is similar to the physical prototype. There is a lack of shadows on the computer rendering, but the model was photographed with a black background so shadows are not visible in the photo either. The fabric drapes more realistically on the photo, in the computer rendering the fabric tends to keep away from the body, this could be fixed by changing fabric properties in CLO, but some experimentation is required. To sum up CLO delivers nice results in making a virtual prototype and the result is comparable to the photo.

SUMMARY

This thesis analysed garment product development steps and the possibilities of CAD/CAM in it.

Garment product development means developing new models and enhancing existing ones. The process consists of: making a fashion drawing, making technical drawings, creating patterns for the pieces, fabric print design, creating technical specifications, order of product processing.

This thesis compared and analysed different software programs used in garment product development. Gerber Accumark and Lectra Modaris were used for creating the patterns. Kaledo Style and Adobe Illustrator were used for creating technical drawings and creating textures for the patterns. Gerber Accumark and Lectra Modaris allow the user to create detailed 3D models of garments and also check the wearability of garments by using parametric 3D mannequins.

Gerber Accumark is a better option for the beginner, because it is more intuitive and easy to learn. Gerber Accumark also features several useful functions that Lectra Modaris does not have. Based on this thesis, it would be wise to choose Gerber Accumark for constructing patterns and CLO for 3D.

Technical drawings are used on the product sheet of the garment and they contain all the necessary technical info for the seamstress like seams and furniture like buttons and zippers. Technical drawings must be accurately produced and technically correct because they are used to sew the final product together. Using a special mannequin can help you to construct technical drawings.

Creating digiprint patterns is also discussed in this thesis. For this Adobe Illustrator was used to create the textures and to transfer them onto the patterns. Adobe Illustrator features many useful functions for this task, like the ability to import .dxf files. This means that patterns can be constructed by using CAD software like Gerber Accumark or Lectra Modaris for example, and then print the texture directly on the patterns. Adobe Illustrator also enables to create garment technical drawings.

A 3D collection was also created as a part of this thesis. Creating the collection helped the writer of this thesis to learn new techniques about virtual prototyping and fabric print design. CLO was selected as the best program for creating virtual prototypes after 3D models in Lectra Modaris and Gerber Accumark were created. This thesis also contains a practical part in which a real model from the collection is sewn. This model

is tested for wearability using an appropriately sized mannequin. Using this model you can determine the success of the collection and the possibility to manufacture garments in this collection. Using different software for garment product development can reduce product costs, create new and exiting products not possible to create with traditional methods for garment product development.

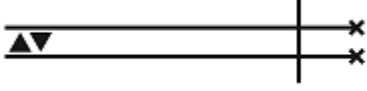
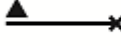
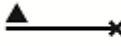
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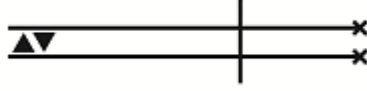
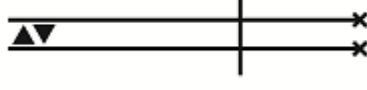
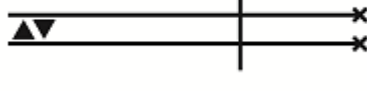
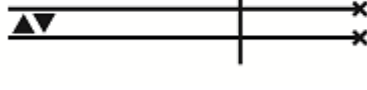
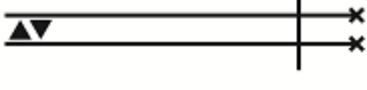
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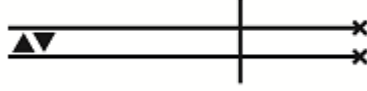
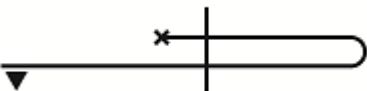
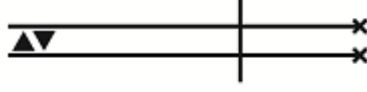

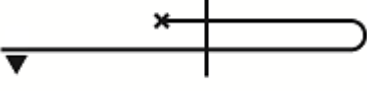
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Appendix 1

Table 2 Order of product processing

Order nr	Undividable operation name and description	Technical conditions	Used machinery	Drawing
1.	Cutting out the pieces		Scissors	
2.	Attaching the adhesive fabric	Temp 130°C, Time 3m/min Pressure 15 N/cm ²	Adhesive fabric press	
3.	Connecting the facet, seam allowances pushed apart	Seam allowance 0.5 cm, stitch frequency 4 stitches/cm	Juki CP-180	
4.	Overlocking the outer edge of the facet	Overlock width 0.5 cm Stitch type 504	Overlock	
5.	Overlocking the pieces	Overlock width 0.5 cm Stitch type 504	Overlock	

6.	Connecting the hidden zipper, seam 3 cm shorter	Seam allowance 1 cm, frequency 4 stitches/cm	Juki CP-180 (hidden zipper presser foot)	
7.	Connecting the back center seam	Seam allowance 1 cm, stitch frequency 4 stitches/cm	Juki CP-180	
8.	Connecting the side seam	Seam allowance 1 cm, stitch frequency 4 stitches/cm	Juki CP-180	
9.	Connecting the shoulder seam	Seam allowance 1 cm, stitch frequency 4 stitches/cm	Juki CP-180	
10.	Iron the seam allowances apart	Temp 150°C	Iron	
11.	Connecting the facet	Seam allowance 0.5 cm, stitch frequency 4 stitches/cm	Juki CP-180	

12.	Sleeve side seam	Seam allowance 1 cm, stitch frequency 4 stitches/cm, seam allowances pushed apart	Juki CP-180	
13.	Sleeve hem	Seam allowance 2 cm, stitch frequency 4 stitches/cm	Juki CP-180 (magnet)	
14.	Connecting the sleeve	Seam allowance 1 cm, stitch frequency 4 stitches/cm	Juki CP-180	
15.	Overlocking the sleeve seam	Overlock width 0.5 cm Stitch type 504	Overlock	
16.	Lower edge hem	Seam allowance 2 cm, stitch frequency 4 stitches/cm	Juki CP-180 (magnet)	
17.	Ironing	Temp 150°C	Iron	