ENHANCED CONSTRUCTION TECHNOLOGY FOR ERGONOMIC CLOTHING: A NEW APPROXIMATION OF THE BODY AND SYSTEM FOR GARMENT CONSTRUCTION.

R. Lindqvist and C. Thornquist

1Rickard Lindqvist, Swedish School of Textiles, University of Borås, Sweden
2Dr. Clemens Thornquist, Swedish School of Textiles, University of Borås, Sweden
rickard.lindqvist@hb.se

Abstract
This paper explores the ergonomic and functional possibilities of a recently developed new principle of construction technology for garments based on a new approximation of the human body in garment development.

Although there are several different principles of pattern construction, the far majority are derived from the same approximation of the body based on horizontal and vertical measurements. Based on Lindqvist’s[1] model for enhance pattern technology, building on a number of key biomechanical point and balance lines instead of horizontal and vertical measurements of the body, this paper demonstrates the potential of the proposed technology in two garments for a specific function.

The relevance of this new garment construction technology is significance because it presents a previously unknown model to construct garments with significantly increased ergonomics and agility as well as presenting a new theory of approximation of the body from which further construction principles could be developed.

Keywords: qualitative approximation, pattern cutting, draping, ergonomics, design model

1. Introduction
Putting the body at the centre of attention may sound obvious when talking about and working with the creation of garments. However, most of the methods of and techniques in pattern cutting presented in the educational literature merely deals with the shapes of patterns, how to alter patterns in order to achieve a certain familiar garment [cf. 2,3,4,5], or how various two-dimensional shapes can be turned into three-dimensional ones, which may then be used to create garments [cf. 6,7]. Others clarify methods for draping garments on tailor’s dummies and how to turn these creations into reproducible patterns [cf. 8,9,10,11]. In common for all these works are that they originate from the same approximation of the body based on horizontal and vertical measurement.

Several research works has recently proposed developments within this prevalent pattern making theory discourse. McKinney [12] points out how “theory can ground the practice and lead to a better understanding of body-pattern relationships” and aims to develop the theoretical understanding of the body and fitting issues within available theories of flat pattern cutting. The quantitative approximation of the body i.e. the tailoring matrix and the manner of cutting from block patterns based on a static upright position of the body is however disputed and several improvements of it has been suggested. Wang [13] and Simoes [14] both presents alternative ways of construction foundational patterns based on different studies of bodies in motion. Wang by altering tight fitted block after studies of runners in motion and Simoes by tracing distorted forms of tight fitted costumes with plastic qualities worn by six different women. Both methods are intended to support the biomechanical functions of the body better and while questioning the prevalent approximation of the body they are both still developments within the prevalent theory of pattern cutting.
Also the developments in pattern construction through 3D body scanning build on and stays within the prevalent constructions systems. For example, research may be focused on changes in body measurements for various active body positions, comparing a standing posture, a 120° knee bend posture, a one pace stepping posture [15]; the role of quantitative data on the intra- and inter-observer land marking errors in measurements for garment constructions [16] or the precision and definition of the waist in relation to the current ISO waist definition because of the waist’s significance for several garment construction technologies [17].

2. Materials and Methods
Through different reconstructive studies of the pattern works by costume designer Geneviève Sevin-Doering, a hypothesis for an alternative model for pattern construction took form. Considering the way the fabric in the different constructions interacted with the human body while creating the dress, dressing and wearing them, an alternative relationship between body and dress appeared. The aim of my research endeavour was to develop new models for garment construction that enabled new artistic expressions and design functions for dress. [cf. 18].

The first part of the work, to understand the problem of research and to form the hypothesis of an alternative pattern cutting system, was framed through reverse engineering and design recovery of Geneviève Sevin-Doering’s work and methods. As Chikofsky [19] explains, reverse engineering is a process of analysing a system to create representations of the system at a higher level of abstraction, aiming to bring about new development. Design-recovery may then be understood as a subset to reverse engineering where recovery means reproducing all of the information required for a person to fully understand what a system (or a design program) does, how it does it, why it does it, and so forth, as is explained by Biggerstaff [20]. By quoting principal parts of Sevin-Doering’s work, different representative types of dress was recreated on a live body using the same working method she had utilised. In this way, I managed to abstract and understand the key principles of her work that formed the initial hypothesis.

By looking upon the body this way and through draping experiments with a single piece of fabric upon it guidelines and directions has been defined. Guidelines and directions on the body where the fabric plausibly falls and may to be draped in order not to fall off the body and not to restrain the movements of the body. These lines are not suggestions for where to place seams neither guides for where to measure the body but guidelines for how the fabric may be draped around the body. The way the fabric falls and where it “breaks” or folds also highlights certain points toward which the transformative cuts is supposed to be directed. The principle difference between conventional
draping and this model of working, is that the “break-lines” that occur in traditional draping are here not just beautiful lines which exist because of how a fabric hangs when it is draped based on the traditional grid. Instead, these marginalised, “beautiful” break-lines are in themselves part of defining the fundamental structure – grid – of this dynamic approximation of the body. (fig. 1)

There are two categories of points within this theory. The first category, the foundational (structural) points, coincides with the direction lines at the start of the lines (centre back neck and centre back waist) or at the “bodily break point” at front and back of the armpit and at front and back of the crotch. These points relate to the structure and biodynamical function of the body and are as a fundamental part of the proposed theory as the direction lines. The points at the start of the lines are where to direct cuts into the fabric in order to let it hang unrestrained from the shoulders or from the waist, while the armpit and crotch points are crucial when directing cuts in order to create garments with functional arms and legs.

The secondary category of points, the derived (form) points, relate to the form of the body and the desired form of the garment. They are derived from where the fabric “breaks” or creases when being draped upon the body, this appearance may differ between different body types, different types of fabric and also depending on how the grain line of the fabric is placed. By either cutting through such a point or leaving it uncut one can either eliminate this crease or keep it. For example, on top of the shoulder three break points emerges, if one leaves all three of them and only cuts through the fundamental armpit points one gets a sleeve shape similar to the one of a square cut chemise while if one on the other hand places a cut going through all three of these break points one gets a sleeve shape similar to the one of a tailored jacket. In the same manner the points at elbow and knees are where to direct the cuts if cutting a bend sleeve or leg. The direction lines and the fundamental points is supposed to be valid for all body types while a greater number of derived points might be added on a more curved body. Hence, the number of derived points is the only principal difference between a male and a female body within the theory. For female bodies typically additional derived points may be added on the bust and at the hips. (fig. 2)

![Figure 2](image)

**Figure 2**, Example of breaking point at shoulder (figure with calico draped over shoulders), foundational points (in blue and green) and derived points (in yellow and lilac) on a male respectively a female body together with pattern of blue shell jacket with points at centre back neck, foundational points at armpit and derived points at shoulder marked.

### 2.1 Design examples for function wear

In order to investigate the potential for the proposed model for sports and function wear two hard shell jackets were designed and prototyped in Gore Tex Pro shell fabrics. The jackets were modelled out of a single piece of fabric placed upon as living model in the same manner as visualised by
Lindqvist[1]. The working order for the yellow jacket was as outlined bellow (fig. 3) with each new cut addressing the various points and lines as visualised in fig. 1 and 2.

![Figure 3](image1.png)

**Figure 3**, Step by step making of hard shell jacket while being draped upon a body. Green lines indicates new cuts and points and arrows shows relation to direction and points in model (compare fig. 1&2)

![Figure 4](image2.png)

**Figure 4**, Design example, 3 layer hard shell jacket with shaped sleeves together with pattern marked with direction lines and points.

![Figure 5](image3.png)

**Figure 5**, Design example, 3 layer hard shell jacket with ventilation opening under sleeve together with pattern marked with direction lines and points.

### 2.2 Grading of pattern and comparison to prevalent discourse

In order to demonstrate the generality of the suggested system the yellow jacket was graded in three sizes in order to visualize how the length and angels of the directions changed and how the points changed position (fig. 6). Further traditional block patterns where placed upon the grading principals extracted from the yellow jacket aiming to show the generality of the system and that the foundational points follows the same axis regardless of theoretical framework.
Figure 6, Graded pattern for yellow shell jacket with direction lines and points marked in three sizes (left). Grading principals derived from yellow shell jacket pattern with direction lines and points marked in three sizes (right).

Figure 7, Traditional block patterns, placed upon direction and points from shell jacket (left), in three sizes upon graded direction and points (middle), and in the sizes placed upon foundational points only (right).

3. Results and Discussion

The “transformative cutting” builds on an alternative qualitative and biomechanical approximation of the body in contrast to the traditional quantitative logic based on the horizontal and vertical measurement grid. In conclusions this new construction system opens up for new expressions in dress as well as functional possibilities for wearing. This paper demonstrates and validates the function of this alternative theory of pattern making for new possible expressions and functions of body and dress through two example garments.

As one can see it is not a system for creating one-piece garments. The one-piece block may be split and adjusted into different forms and then consist of any number of pattern pieces. Moreover, the system is not a system of draping in the traditional sense, even though draping may seem as the starting point for the system. The system can be based on any human body, particular or general – to sizing system or cultural deviations. However, and more importantly, it is the actual body as such that is the point of departure for the development of the system and its applied construction, which is an essential different compared to a point of departure from measurements of a body.

Though the main function of the garment technology is defined and validated through these examples, some more distinct qualities of this system may still be analysed to understand the difference in result between this technology and prevalent systems based on traditional measurements of the body. For discussion purposes three climbers were therefore asked to analyses the garments through some simple climbing exercises while comparing the jacket (yellow) with an Arcteryx (Alpha SV) jacket in the same size. Some possible features (hypotheses) recognized in this exercise was for example: less fabric (bulk) under the arms for same movement in the arms; despite tighter fits in the yellow and blue jacket it provides the same or better movement as the Arcteryx jacket, there is a different and “lighter” sensation over the shoulder/around the neck and the fact that the absence of seams at for example the shoulders means fewer areas of potential leakage.
Apart from the direct qualities of the suggested system, another interesting perspective is the usually higher degree of fabric consumption commonly associated to one piece patterns and pattern pieces placed on bias cut. However, in a one to one comparison, both the blue jacket (196cm) and the yellow jacket (190cm) challenge the (206cm) fabric consumption by the Arcteryx jacket, proving enough evidence for this assumption to be further researched.

4. Conclusion
Body movement and balance in direct connection with garment during the design process opens up for improved biomechanical functions. As such this is a general theory and can form, just as the traditional tailoring matrix does, the foundation for any kind of dress, standardized or customized to a certain body. Like any other system, this framework is assumed to hold possibilities for creating any kind of shapes for garments. The grading visuals demonstrate the generality of the system; it is adoptable for any body types or sizes in the same manner as the prevalent pattern cutting systems.

To further validate the hypotheses and discussion points highlighted in the discussion a more rigorous and systematic testing and analyses is needed. Additional research may focus on refining the theoretical model; further develop grading principals, looking into 3-D modulation possibilities etc.

References