

GARMENT SILHOUETTE AND ITS RELATIONSHIP WITH SEAM AND STITCH SELECTION: A TIME COST EFFICIENCY ANALYSIS OF FIVE FEMALE DRESS SILHOUETTES

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DOI: <https://doi.org/10.5281/zenodo.21868204>

Received
29 December 2025

Accepted
13 February 2026

Published
28 February 2026

ABSTRACT

Garment silhouette exerts a defining influence on fit, aesthetics, and manufacturability, while seam and stitch selection governs construction efficiency, durability, and cost. This study examines the relationship between five female garment silhouettes—Ballgown, Frock, Pencil, T-shirt, and Shift—and the seam and stitch combinations used in their construction, quantifying the resulting impact on production time and cost. Digital patterns were developed in Gerber AccuMark and used to guide industrial-machine construction; production time was measured using Standard Minute Value (SMV) analysis, and material and labor costs were tracked for each silhouette. Plain, French, overlock, and flat-felled seams were combined with lockstitch, chain stitch, overlock stitch, and zigzag stitch techniques, each selected for structural and aesthetic compatibility with the target design. Results show that simple silhouettes (T-shirt, Shift) required only 1.5–2 hours of construction and achieved 20–25% cost reductions relative to more complex garments, whereas Ballgown and Frock silhouettes, which rely on gathered and princess seams, required 4–6 hours and incurred 10–30% higher production costs. The Pencil silhouette occupied an intermediate position, balancing lapped-seam precision with moderate time and cost. These findings indicate that strategic seam and stitch selection—rather than fabric or silhouette complexity alone is a primary lever for optimizing garment-production efficiency, with direct implications for mass-market and made-to-order manufacturing strategies.

Keywords: garment silhouette; seam type; stitch type; construction time; cost efficiency; apparel manufacturing

1. Introduction

Silhouette the overall outline of a garment as worn on the body has long served as one of the primary vehicles through which fashion communicates cultural, social, and economic change [1]. Historically, the idealized silhouette has tracked the values of its era: the voluminous, corseted forms of the Renaissance and Victorian periods gave way to the loose, androgynous flapper dress of the 1920s and, in turn, to the structured

hourglass of Dior's 1947 "New Look" [2], [3]. Contemporary fashion has since diversified into a plurality of forms, from body-conscious cuts to oversized, avant-garde shapes, reflecting a broader cultural shift toward inclusivity.

Beyond its aesthetic role, silhouette exerts a direct influence on garment manufacturability. Different shapes demand different pattern-making, seam, and stitch strategies: a structured pencil silhouette requires precise tailoring and reinforced seams to

preserve its clean line, while a loosely draped shift silhouette tolerates simpler seam structures and less fitting labor [4], [5]. Seams and stitches are, in this sense, the technical vocabulary through which a designer's silhouette is physically realized governing not only structural integrity and durability but also construction time, material use, and, ultimately, unit cost [6], [7].

Despite an extensive body of research on seam performance [8], [9] and on stitch-type efficiency considered in isolation [10], relatively little work has directly quantified how the interaction between silhouette complexity and seam/stitch selection affects production time and cost across a comparable set of garment types. Manufacturers therefore frequently rely on standardized seam and stitch conventions that are not explicitly optimized for a given silhouette a gap that can translate into inefficiencies in fabric consumption, labor time, and overall production cost.

This study addresses that gap by examining five representative female garment silhouettes Ballgown, Frock, Pencil, T-shirt, and Shift and the seam and stitch combinations employed in their construction. Using digital pattern development, industrial-machine construction, and Standard Minute Value (SMV) time-and-motion analysis, we quantify construction time and production cost

for each silhouette and identify the seam and stitch factors that drive the observed differences. The specific objectives of this research are to: (i) characterize the technical construction requirements of the five silhouettes; (ii) determine the relationship between silhouette type and stitch-type selection; and (iii) determine the relationship between silhouette type and seam-type selection, with particular attention to the resulting time and cost implications for garment manufacturers.

2. Literature Review

Garment silhouette evolution has been extensively documented as an expression of the patternmaking and construction techniques available in each period [1], [2]. Dior's New Look combined a fitted bodice with a voluminous skirt through strategic seam placement and dart manipulation, while Madeleine Vionnet's bias cut relied on minimal seaming and precise stitching to achieve fluid drape—illustrating that seam and stitch choices are inseparable from the silhouette they produce [11]. Seam-placement techniques such as princess seams, empire lines, and paneling remain the principal mechanisms by which contemporary and historical silhouettes alike are shaped [5], as illustrated in Fig. 1.



Fig. 1. Evolution of female garment silhouettes across design eras, illustrating the range of proportions and seam placements referenced in the historical literature.

At the construction level, seam type is a major determinant of both durability and production

efficiency. The plain seam is simple and versatile but prone to fraying and typically requires a

secondary finishing operation such as overlocking [12]. The French seam encloses raw edges for a superior finish and is favored in couture and delicate fabrics, but its double-stitch construction increases labor time [6]. The overlock (serged) seam is preferred for knit and stretch fabrics because it trims and finishes an edge in a single pass, making it efficient for high-volume production [13]. The flat-felled seam offers the greatest tensile strength and is standard in workwear and denim, but its additional folding and reinforcement steps add substantially to construction time [14].

2.5 Stitch-Type Selection and Time–Cost Outcomes

Stitch-type selection interacts with seam choice to further shape time and cost outcomes. The lockstitch offers strength and versatility across woven fabrics, but its two-thread interlocking system is comparatively slow to produce [15]. The chain stitch is faster and more elastic, suiting knitwear, but is more prone to unraveling under tension [10]. The overlock stitch and zigzag stitch are both associated with stretch-fabric applications and rapid edge finishing [7], [16]. Prior comparative work indicates that overlock-based construction can reduce production time by 20–25% relative to lockstitch-heavy construction, while flat-felled seams can add 30–40% more time than simpler seam types [17], [18].

2.6 Automation, Standards, and Documentation

Automation studies suggest that programmable overlock and lockstitch machinery can reduce labor costs by up to 20% in large-scale settings, although the capital cost of such machinery can be prohibitive for smaller manufacturers [19]. Quality control in garment construction has long depended on documented construction standards that specify seam allowance, stitch density, and finishing tolerances [45]; the ISO codes summarized in Table 4 reflect this tradition. Systematic documentation of composite, multi-technique garments, combining several seam and stitch types within a single piece, as in the Ballgown and Frock silhouettes studied here—has been identified as a distinct documentation

challenge relative to single-technique garments [46]. Structured technical documentation practices, including annotated flats and construction specification sheets, support the transfer of construction knowledge of this kind from design to production [47], a practice mirrored in Table 3 of this study. Broader surveys of modern sewing-manufacturing technology confirm that machine-level standardization, rather than technique novelty, remains the primary lever for consistent seam quality across production runs [48]. Taken together, the literature establishes clear, isolated relationships between individual seam types, stitch types, and production efficiency, but stops short of mapping these relationships onto specific, complete garment silhouettes—the gap this study addresses.

2.1 Historical Construction Precedents

Several of the silhouettes examined in this study have documented historical construction precedents that inform current practice. Nineteenth-century ballgown-type dresses relied on multi-panel skirts and reinforced waist seams to support fabric volume, a construction logic that persists in the princess-seam and gathered-seam approach used for the Ballgown silhouette in this study [31]. Decorative and structural stitching has historically served a dual role, simultaneously reinforced seams and signaling craftsmanship or garment value, a relationship still visible in the use of top-stitching and reinforced lock stitching on higher-value silhouettes [32]. Garment modeling from historical fashion sketches has similarly been used to translate two-dimensional design intent into constructable patterns, foreshadowing the flat-pattern methods applied here [33].

2.2 Digital and 3D Pattern-Making Technologies

Digital tools have progressively supplemented, and in some cases replaced, manual pattern drafting. Foundational work on the geometric logic of pattern cutting established the mathematical basis by which flat patterns approximate three-dimensional body form [34], while parametric and size-adjustable patternmaking methods extend this logic to accommodate a range of body types from a single base pattern [35]. Expert-operator studies

of sewing and ironing technique further show that garment appearance depends not only on pattern accuracy but also on operator-level finishing skill, a factor held constant in this study through the use of a single trained construction team [36]. More recent work has explored 3D virtual prototyping for laser-cut and digitally fabricated garments [37] and the use of 3D scanning and prototyping to assess garment fit prior to physical sampling [38], both pointing toward a shift from the two-dimensional, software-assisted pattern development used here (Gerber AccuMark, Adobe Photoshop) toward fully digital design pipelines [39].

2.3 Fit, Sizing, and Decorative Variation

Structural elements such as darts, pleats, and gathers are the primary mechanisms by which flat fabric is shaped to the body, and their placement directly determines both fit and the seam complexity discussed below [40]. This relationship is particularly evident in knitwear, where stitch and seam choices must additionally accommodate fabric stretch and recovery [41], a consideration reflected in the stretch-fabric finishing techniques used for larger-size ranges [44]. Consumer-facing studies of style preference indicate that silhouette choice is also shaped by body-shape-specific fit expectations, suggesting that the time-cost trade-offs identified in this study may interact with sizing strategy in mass production [42]. Decorative

treatments such as trims and applied embellishment introduce a further layer of construction time not captured in the present seam/stitch-only analysis [43].

2.4 Seam Types and Construction Efficiency

3. Methodology

3.1 Research Design

An experimental and analytical research design was adopted to examine how seam and stitch selection affects construction efficiency, seam quality, and durability across contrasting garment silhouettes. Five representative female silhouettes were selected for study—Ballgown, Frock, Pencil, T-shirt, and Shift—chosen to span a range of structural complexity from heavily seamed formal wear to minimally seamed casual wear.

3.2 Silhouette Characteristics

Representative constructed samples of three of the five silhouettes are shown in Fig. 2–Fig. 4. The Ballgown (Fig. 2) combines a fitted, princess-seamed bodice with a voluminous gathered skirt; the Pencil silhouette (Fig. 3) is a close-fitting, dart-shaped form relying on lapped and reinforced seams; and the Shift silhouette (Fig. 4) is a minimally seamed, straight-cut form that drapes loosely from the shoulder. The Frock and T-shirt silhouettes followed comparable pattern-development and construction sequences using plain and overlock seams, respectively.



Fig. 2. Ballgown silhouette, constructed with princess and gathered seams

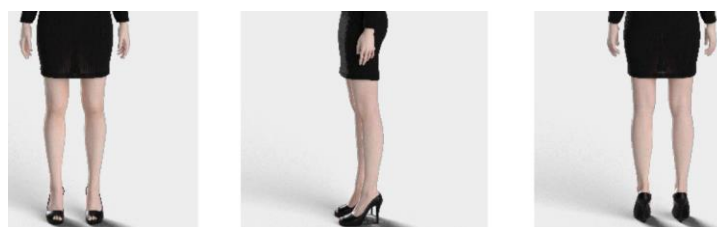


Fig. 3. Pencil silhouette, constructed with lapped and reinforced seams



Fig. 4. Shift silhouette, constructed with minimal, straight-cut seaming

3.3 Pattern Development and Materials

Flat patterns for each silhouette were developed in Gerber AccuMark software to ensure dimensional precision and adherence to industrial seam-allowance standards (1.5 cm throughout). Patterns were plotted onto pattern paper and used as templates for fabric cutting. Fabric selection was matched to each silhouette's structural and drape requirements: lightweight cotton-elastane and

cotton-polyester blends (150–180 gsm) were used for fitted and structured silhouettes, and lighter cotton and chiffon-type fabrics (70–90 gsm) were used for looser, flowing designs. All fabrics were pre-treated by washing and pre-shrinking at 40°C prior to cutting to ensure dimensional stability. A single garment size (small) was used throughout to control for fit-related variation between silhouettes.

3.4 Equipment

Table 2 lists the principal machinery and software used in pattern development and construction.

Table 2. Machinery and software used in pattern development and construction.

Equipment	Function in this study
Gerber AccuMark	Digital flat-pattern development and grading
Adobe Photoshop	Visualization and adjustment of design details
Single-needle lockstitch machine	Main structural and reinforced seams
Overlock/serger machine	Edge finishing and stretch-seam construction
Zigzag machine	Elastic seam finishing on stretch fabrics
Gathering machine	Controlled fabric gathering for volume
Blind-hemming machine	Invisible hem finishing

3.5 Construction

Garments were constructed on the industrial machines listed in Table 2, matched to each operation. Seam types applied across the five silhouettes included plain, princess, French, overlock, flat-felled, gathered, and lapped seams; stitch types included lockstitch, chain stitch, overlock stitch, and zigzag stitch, selected

according to structural role (e.g., high-stress seams) and fabric behavior (e.g., stretch versus woven). Table 3 summarizes the dominant seam/stitch pairing used for each silhouette's primary structural and finishing operations, and Table 4 provides the corresponding ISO seam and stitch classification codes referenced during construction.

Table 3. Dominant seam and stitch types by silhouette.

Silhouette	Dominant seam type(s)	Dominant stitch type(s)	Stitch density (SPI)
Ballgown	Princess, gathered, lapped	Lockstitch, gathering stitch	10–12
Frock	Plain, gathered, overlock	Lockstitch, gathering stitch, overlock	8–12
Pencil	Lapped, plain (reinforced)	Lockstitch	10–12
T-shirt	Overlock, plain	Overlock, cover stitch	10–14
Shift	Overlock, plain	Overlock, lockstitch, cover stitch	10–14

Table 4. ISO seam and stitch classification codes referenced during construction.

Construction element	ISO seam/stitch code	Typical application
Princess seam	ISO LDS 601	Bodice contouring, high-stress shaping
Plain seam	ISO SSa-1	Basic panel joins, general assembly
Flat-felled seam	ISO LSc-2	High-strength, enclosed-edge seams
Lapped seam	ISO LSa 605	Bias-tape edge encasement
Reinforced/stretch seam	ISO 406	Stretch-fabric structural seams
Lockstitch	ISO 301	Main structural stitching
Top / lapped stitch	ISO 401 / LSA 104	Decorative and reinforcement stitching
Zigzag stitch	ISO 304	Stretch-fabric edge finishing
Blind hem stitch	ISO 103	Invisible hem finishing

Representative close-up seam constructions are shown in Fig. 5–Fig. 7: the plain seam (Fig. 5), used as the baseline joining method across silhouettes; the overlock seam (Fig. 6), applied to

stretch and knit fabrics in the T-shirt and Shift silhouettes; and the flat-felled seam (Fig. 7), used selectively for high-stress structural reinforcement.



Fig. 5. Plain seam construction



Fig. 6. Overlock (serged) seam construction



Fig. 7. Flat-felled seam construction.

3.6 Time Measurement

Construction time was measured using Standard Minute Value (SMV) methodology. The duration of each construction step from initial bodice stitching through final hemming was recorded with a stopwatch across multiple construction cycles per silhouette to ensure reliability, and both per-seam and total-garment times were derived.

3.7 Cost Analysis

Production cost was estimated from three components material consumption, labor time (derived from the SMV data), and

machine/finishing requirements for each silhouette. Relative cost differences between silhouettes are expressed as a percentage increase or decrease relative to a simple-construction baseline, consistent with standard apparel-costing practice.

4. Results

4.1 Total Construction Time

Total construction time ranged from 1.5–2 hours for the simplest silhouettes (T-shirt, Shift) to 4–6 hours for the Ballgown, the most structurally complex silhouette studied (Table 5).

Table 5. Total construction time by silhouette

Silhouette	Total construction time
Ballgown	4–6 hours
Frock	2.5–3.5 hours
Pencil	2–3.5 hours
T-shirt	1.5–2 hours
Shift	1.5–2 hours

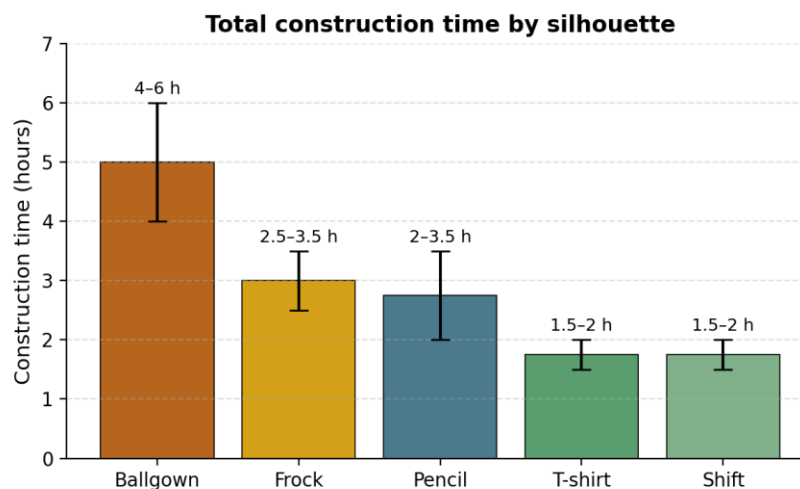


Fig. 8. Total construction time by silhouette (bars show the midpoint of the reported range; error bars show the reported minimum–maximum range from Table 5)

4.2 Illustrative Operation-Level Time Breakdown

To illustrate how total construction time accumulates across operations, Table 6 reports the operation-level SMV breakdown recorded for the

Ballgown silhouette, the most time-intensive garment studied. Skirt assembly and gathering accounted for the largest single share of total construction time, consistent with the seam- and stitch-usage composition reported in Section 4.3.

Table 6. Operation-level SMV time breakdown for Ballgown construction

Construction operation	Time estimate
Bodice construction and neckline stitching	45–60 min
Skirt assembly and gathering	2.5–3.5 hours
Joining skirt to bodice	30–40 min
Hemming and finishing	45–60 min

4.3 Per-Seam Time and Cost Impact

Per-seam construction time and the associated percentage change in production cost, relative to a simple-construction baseline, are summarized in

Table 7. More elaborate silhouettes required more time per seam and carried a positive cost premium, while simpler silhouettes reduced both time and cost.

Table 7. Time-per-seam and cost impact by silhouette.

Silhouette	Time per seam	Total time	Cost impact
Ballgown	10–15 min	4–6 hours	+25 to +30%
Frock	8–12 min	2.5–3.5 hours	+10 to +15%
Pencil	8–10 min	2–3.5 hours	+10 to +15%
T-shirt	5–7 min	1.5–2 hours	–20%
Shift	10–15 min	1.5–2 hours	–25%

4.4 Seam and Stitch Usage Composition

Table 8 decomposes each silhouette's construction into its dominant seam/stitch categories, expressed as an approximate percentage share of total stitching operations, alongside the associated net cost change relative to the baseline. Ballgown construction was dominated by gathered (40%)

and princess (35%) seams, the two most time-intensive categories observed; Frock construction balanced gathered (35%) and plain (40%) seams; Pencil relied primarily on lapped seams (40%); and both T-shirt and Shift were dominated by overlock stitching (50% and 45%, respectively), the fastest category observed.

Table 8. Seam and stitch usage composition and associated cost change by silhouette

Silhouette	Key seam/stitch types	Approx. usage share	Net cost change
Ballgown	Princess, gathered seams	40% gathered, 35% princess	+25 to +30%
Frock	Gathered, overlock, plain seams	35% gathered, 40% plain	+10 to +15%
Pencil	Lapped seams, lockstitch	40% lapped, 35% plain	+10 to +15%
T-shirt	Overlock, cover stitch	50% overlock, 30% cover stitch	–20%
Shift	Overlock, lockstitch, cover stitch	45% overlock, 35% plain	–25%

5. Discussion

The results indicate a consistent, monotonic relationship between silhouette structural complexity and both construction time and production cost. Ballgown and Frock silhouettes, which depend on gathered and princess seams to create volume and contour, required 2.5 to 6 hours of construction and carried a 10–30% cost premium relative to simpler garments. This is consistent with the literature’s characterization of gathering and princess-seam operations as inherently labor-intensive, since fabric must be manipulated and eased into position rather than joined along a straight line [11], [17].

By contrast, T-shirt and Shift silhouettes, which rely predominantly on overlock seams and cover stitching, were the fastest and least expensive to produce, achieving 20–25% cost reductions and completion times under two hours. This aligns with prior findings that overlock-based construction can cut production time by up to a quarter relative to lockstitch-heavy alternatives [17] and confirms that this efficiency advantage persists when measured at the level of a complete garment rather than an isolated seam.

The Pencil silhouette occupied a distinct middle position: although structurally fitted, its reliance on lapped seams and reinforced lockstitching—rather than gathering—kept its cost premium (10–15%) below that of the Ballgown and Frock despite comparable construction time. This suggests that seam type, rather than silhouette fit alone, is the more direct driver of cost, since a fitted but simply-seamed silhouette can approach the efficiency of a looser garment.

From a fabric-efficiency standpoint, silhouettes built around gathering (Ballgown, Frock) also consumed more material relative to their finished dimensions, compounding their labor-driven cost premium with a material-driven one. Silhouettes built around overlock seams (T-shirt, Shift) were fabric-efficient by comparison, since overlock construction trims and finishes an edge without requiring the additional seam allowance that gathering or lapping typically demands.

These findings carry direct implications for manufacturing strategy. For mass-market and fast-fashion production, prioritizing silhouettes and seam/stitch combinations built around overlock and cover-stitch construction offers a clear route to reduced turnaround time and cost. For higher-end or made-to-order production, where gathered and princess-seam silhouettes remain aesthetically necessary, targeted reinforcement of lockstitching in high-stress areas—rather than wholesale seam substitution—may offer a more realistic path to modest efficiency gains without compromising the silhouette’s defining structure.

6. Practical Implications for Industry

Table 9 translates the time-cost findings of Sections 4 and 5 into seam/stitch strategy recommendations for four common production contexts. The recommendations follow directly from the measured relationships: production contexts that prioritize unit cost and turnaround favor overlock- and cover-stitch-dominant construction, while contexts that prioritize structural intricacy or durability justify the added time cost of gathered, princess, or flat-felled seams.

Table 9. Seam and stitch strategy recommendations by production context

Production context	Recommended seam/stitch strategy	Expected benefit
Mass-market / fast fashion	Overlock and cover stitch (T-shirt, Shift pattern)	20–25% lower cost and time versus complex silhouettes
Mid-tier ready-to-wear	Lapped seam with reinforced lockstitch (Pencil pattern)	Balanced durability and cost (+10 to +15%)
Premium / made-to-order	Princess and gathered seams, with lockstitch reserved for high-stress points	Preserves structural silhouette while containing cost through selective, not wholesale, reinforcement

Production context	Recommended seam/stitch strategy	Expected benefit
Workwear / high-durability	Flat-felled seam construction	Maximizes tensile strength at an accepted added time cost

7. Conclusion

This study quantified the relationship between five female garment silhouettes and the seam and stitch types used to construct them, demonstrating that seam and stitch complexity—more than fabric or silhouette type in isolation—is a primary determinant of construction time and cost. Simple silhouettes (T-shirt, Shift), built around overlock seams and cover stitching, required 1.5–2 hours of construction and achieved 20–25% cost reductions. Complex silhouettes (Ballgown, Frock), which depend on gathered and princess seams, required 2.5–6 hours and carried 10–30% higher production costs, while the Pencil silhouette, built around lapped seams and reinforced lockstitching, occupied an intermediate position in both time and cost.

For manufacturers, these findings support prioritizing overlock- and cover-stitch-based construction for high-volume, cost-sensitive production, while reserving gathered and princess-seam construction for niche or premium segments where customers place a higher value on structural intricacy than on unit cost. Strategic seam and stitch selection—rather than simplification of the silhouette itself—offers manufacturers a practical lever for improving production efficiency without necessarily sacrificing design intent.

This study is limited by its focus on a narrow range of lightweight cotton and cotton-blend fabrics and by its use of conventional, non-automated sewing machinery; heavier or synthetic fabrics, as well as automated or robotic sewing systems, could alter the observed time and cost relationships, particularly for complex silhouettes such as the

Ballgown. Future research should extend this analysis to a broader range of fabric types, incorporate automated and robotic construction methods, and examine the effect of sustainable stitching techniques—including reduced-waste seaming and biodegradable threads—on the time-cost relationships identified here.

Acknowledgments

The authors thank the CAD/CAM instructional staff at the School of Design and Textiles, University of Management and Technology, Lahore, for their assistance with Gerber AccuMark pattern development, and the industrial sewing laboratory staff for their support during garment construction and time-and-motion data collection.

Author Contributions

M.N. conducted the pattern development, garment construction, time-and-motion measurement, and cost analysis, and drafted the manuscript. T.N. supervised the research design and methodology and reviewed and edited the manuscript. Both authors read and approved the final manuscript.

Data Availability

The construction-time, cost, and seam/stitch-usage data generated and analyzed in this study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare no conflict of interest.

Nomenclature

Table 1. Nomenclature and abbreviations used in this paper.

Abbreviation	Meaning
CAD	Computer-Aided Design
GGT	Gerber Garment Technology

Abbreviation	Meaning
GTS	Garment Technology Software
SPI	Stitches Per Inch
SMV	Standard Minute Value
ISO	International Organization for Standardization
gsm	Grams per Square Meter
2D / 3D	Two-Dimensional / Three-Dimensional

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