GREEN FUTURE TECH
LIMITED / HONG KONG SAR

GFT RESEARCH / WARP AND SIGNAL

Print on Demand, Sample on Screen

Digital printing, three-dimensional sampling and on-demand manufacturing for local apparel

wp20
RESEARCH EDITION

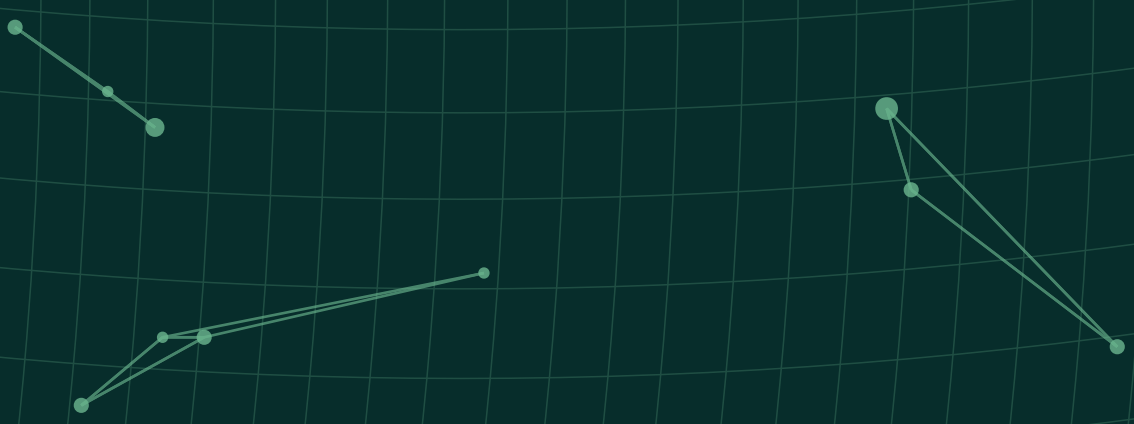
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THE GFT THESIS

Value is made where it is measured.

GFT engineers sustainable factories that capture their own data from the first shift, so raw-material economies can keep the value they grow.



Read the evidence before acting on the recommendation.

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Build the factory and its evidence as one system.

Digital printing, three-dimensional sampling and order-triggered manufacturing can help a local apparel maker delay commitments until the buyer has approved a product. Their value depends on a complete operating system: qualified materials, valid patterns, credible fit simulation, physical tests, controlled production release and reliable fulfilment. Buying a printer or producing an attractive render does not establish that system. This paper argues for a bounded service built around repeatable orders rather than speculative collections. It distinguishes decoration of stocked blanks from printed-fabric cut-and-sew and made-to-measure manufacture. It compares print routes against fibre compatibility, finishing requirements and accepted-output economics. It then connects calibrated digital materials and representative avatars to physical fit, colour and care approval. The economic method includes training, software, residual samples, idle maintenance, remakes, refunds and delivery. Environmental comparisons state their boundaries and avoid transferring overseas case results into Cameroon savings claims. GFT's Cameroon textile programme supplies the greenfield operating concept and performance-management discipline. Public research, standards catalogue scopes, institutional guidance and manufacturer documentation provide the external research base, with their limitations stated. The closing pilot protocol separates calibration from validation and advances capability only when agreed evidence gates pass. The result is a practical research and decision framework for local apparel production, not a claim that GFT has installed or proved an on-demand factory.

01 On-demand manufacturing changes the order and production system, while digital printing changes one process within it. [S01] [S03]

02 Decorating imported blanks can create local service value without demonstrating local cotton-fibre transformation. [R06] [R07] [S15]

03 Print routes must be selected against the substrate, pretreatment, fixation, quality and service requirement. [S01] [S02] [S15] [S30]

04 A valid digital garment needs manufacturable pattern geometry, measured material behaviour and a suitable avatar. [S04] [S05] [S09] [S13] [S32]

05 Physical fit and care testing remain necessary release evidence within the proposed adoption method. [S06] [S07] [S08] [S10] [S11] [S12] [S27]

06 Sample reductions create value only after digital workflow costs and residual physical validation are counted. [S04] [S07] [S16]

07 Low order volume does not remove maintenance, consumable supply or curing-capacity dependencies. [S15] [S17] [S30] [S31]

08 Smaller speculative stock is insufficient evidence of lower whole-system environmental impact. [S19] [S20] [S25] [S26]

09 A credible delivery promise must include approval, recovery, assembly and acceptance rather than printer completion alone. [S01] [S28]

10 A matched pilot with held-out styles and pre-agreed gates should decide which service expands. [S04] [S07] [S18] [S29]

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01

PART I: CONFIRM THE ORDER BEFORE CHOOSING THE MACHINE / THE GFT POSITION

Local value starts with a garment that can be reordered

GFT argues for a measured order-to-garment service that reduces speculative commitments while retaining physical proof of quality.

CHAPTER 01
DECISION TEST

GFT argues for a measured order-to-garment service that reduces speculative commitments while retaining physical proof of quality.

Local value becomes durable when a buyer can accept a garment, order it again and receive the same agreed result. Digital printing and virtual sampling can reduce premature commitments, but neither establishes that outcome. GFT therefore recommends a measured order-to-garment service built around an approved specification, physical release evidence, controlled fulfilment and a reconciled order ledger. The repeat order is the test that connects product quality with commercial use. This chapter defines that test, separates the technologies that are too often bundled together and sets a narrow pilot for checking the thesis. It proposes an extension of GFT's Cameroon textile programme. It does not report an installed on-demand factory, a commercial customer result or a supplier partnership.

1.1

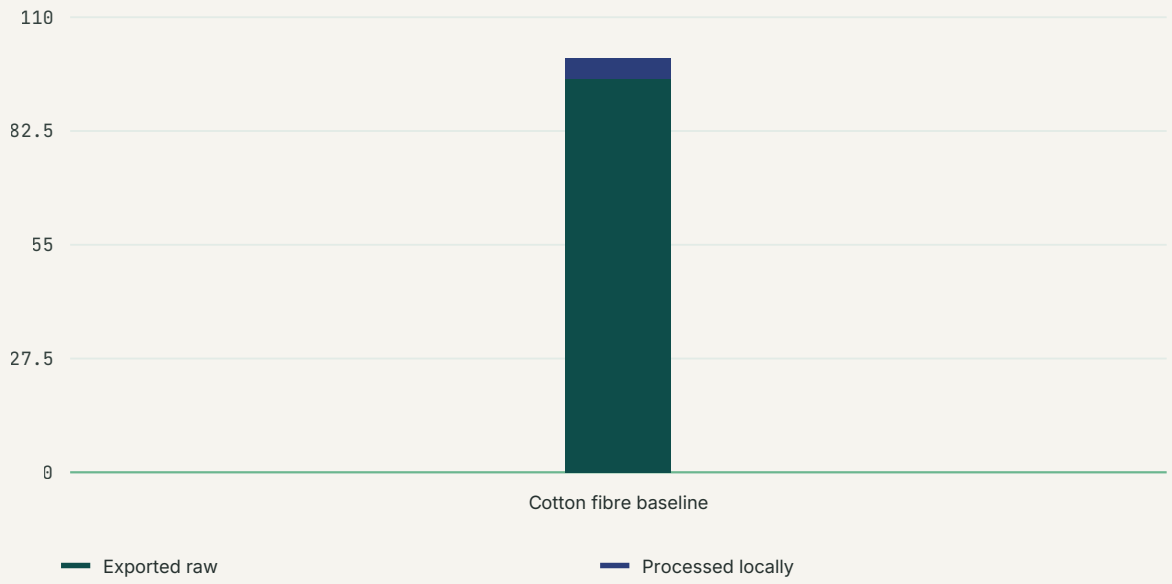
Cameroon needs processing capability that wins repeat orders

The inherited sector register records an approximate split in which 95 percent of Cameroon's cotton fibre is exported raw and 5 percent is processed locally. It also records an industrialisation ambition associated with that baseline. The national development strategy restates a target of 50 percent local processing by 2030. These entries provide historical source-text context, not a current census of fibre movement or a measure of GFT activity. Their original publication dates were not recorded in the shared register. [R06] [R07]

Exhibit 1, p. 16 preserves that distinction by showing only the approximate fibre baseline. It does not convert the national target into an apparel-sales forecast, and it does not imply that the two observed shares describe seed cotton, fabric output or garment output.

EXHIBIT 01 / APPROXIMATE PERCENT OF COTTON FIBRE

The processing gap concerns cotton fibre, not decorated blanks



SOURCED [R06] Inherited source-text baseline. Original publication date not recorded. Shares are approximate and sum to 100 percent. They do not describe seed-cotton production, garment sales, installed capacity or a GFT result.

The denominator matters because each transformation answers a different industrial question. Seed-cotton production is not the same measure as fibre processing. Fibre becomes yarn, then fabric, then a garment through further processes. [S01] Printing an imported ready-made blank can create local design, handling and finishing value without demonstrating that Cameroonian fibre has been spun, knitted or woven locally. A national processing target therefore cannot be used as evidence that a blank-decoration service transforms domestic cotton. Nor can a count of printed garments establish the quantity of local fibre processed.

This boundary does not make blank decoration worthless. It assigns the claim to the correct level. A local service may create value through artwork preparation, customer support, decoration, inspection and delivery. A printed-fabric cut-and-sew service adds panel preparation, cutting and assembly. An integrated cotton-to-garment route raises additional questions about upstream fibre and fabric origin. GFT recommends recording material origin and the actual operations performed rather than applying one local-content label to every route. The buyer should be able to see what was made locally and what was merely finished locally.

A repeat order adds a second boundary: time. The first accepted garment shows that one article passed an agreed check. A later order shows that the buyer returned after experiencing the product or service. That later decision is more informative than a render count, a social-media reaction or a machine demonstration. It is still not proof of national industrialisation. It is evidence that a defined service retained enough usefulness for a buyer to commit again.

For this chapter, a repeatable order means a subsequent commitment by an identifiable buyer against a controlled product specification after an earlier order reached its defined acceptance outcome. A reprint caused by a defect is not a repeat order. A second payment for an unfulfilled first order is not a repeat order. Two purchases by unlinked anonymous transactions cannot be counted as one buyer returning without an agreed, privacy-conscious identity rule. The observation window and treatment of cancellations must also be fixed before results are reported.

The operating implication is demanding. The service must preserve the approved artwork, pattern, material, size set, construction instructions and acceptance evidence that made the first garment acceptable. It must then reproduce that package or record an approved change. A buyer who receives a different blank, an altered print placement or an unexplained fit has not received the same product promise. Repeatability is therefore a production-control property before it becomes a marketing claim.

> **GFT NOTE**
>
> Design the first service around a product family whose next order can be specified before the first order is sold. Record what must remain unchanged, what the buyer may customise and which evidence would be required again. Report fibre transformation, local service work and repeat purchase as separate outcomes. Do not use one to imply another.

This position also disciplines demand assumptions. The national ambition indicates a policy direction, not a queue of buyers for customised apparel. Local willingness to pay, acceptable delivery time, repeat-purchase incidence and order size remain unmeasured inputs for the proposed pilot. A credible service should collect those observations through fulfilled orders rather than borrowing an overseas conversion rate. The commercial question is not whether digital production sounds attractive. It is whether accepted garments lead to retained orders and subsequent commitments under conditions that the operation can repeat.

1.2

Printing, sampling and order timing solve different problems

The reviewed taxonomy of on-demand manufacturing places print-on-demand garment production, mass customisation, digital sampling and other production models within a wider structural change. Its central distinction is between production after confirmed demand and forecast-driven preproduction. The review supports a systems interpretation, not a prediction that every order-driven service will reduce cost or waste in Cameroon. [S03]

Three decisions follow from that distinction. Digital printing selects a way to place colour on a substrate. Digital product development selects a way to represent, evaluate and revise a garment before or alongside physical sampling. Order timing selects the event that authorises production. Each can be changed without changing the other two. A factory can print digitally against a forecast, develop garments virtually

for bulk production or wait for an order before using an analogue print route. Combining the three may be useful, but the combination is a design choice rather than a technical necessity.

This separation prevents a weak procurement question: which machine should the service buy? The stronger sequence asks what the buyer commits to, what evidence releases the product and which process can fulfil the accepted specification. A printer cannot decide whether a quotation, deposit or confirmed purchase should trigger work. A simulation application cannot decide who is authorised to approve fit. An order platform cannot establish colour fastness. Management must assign those decisions before equipment is specified.

The order trigger needs particular care because not every expression of interest is demand. An enquiry, an artwork upload, a quotation, a paid deposit and an accepted order represent different commitments. GFT proposes naming the production-release event in the service terms and recording it in the order ledger. Work before that event is development or speculative setup. Work after it is order-specific production. The distinction allows the pilot to measure how much material and labour are committed before demand is confirmed.

GFT infers that order-driven production need not erase every input stock. Blank sizes, base fabric, inks, films, adhesives, packaging and machine consumables may still need to be available before an individual order arrives. [S03] Postponement moves the product-specific commitment later; it does not remove the need to plan upstream supplies. The reorder model therefore concerns controlled commitment, not a slogan of zero inventory. Detailed stock policy belongs elsewhere in the research library, but the order record must identify when each material became specific to a customer.

Digital sampling has a different economic role. It may help a team reject an unsuitable design, compare variants or communicate construction intent before cutting cloth. [S03] Those benefits exist even when the eventual order is large and forecast-driven. Conversely, a one-off order can be produced with no virtual garment at all. Counting every digital sample as an on-demand sale would confuse product-development activity with demand. The two ledgers should link through a style and order identifier while retaining separate event meanings.

Mass customisation adds another condition: variation must remain manufacturable. Allowing a buyer to alter a motif, size or approved component can be useful only if the production system recognises the permitted options. Unbounded customisation creates a new development task for each order and weakens the premise of repeatability. GFT recommends bounded variation inside a qualified product family, with any out-of-scope request routed to separate development approval rather than silently entering production.

> **METHOD**
>
> Use three linked but distinct records. The product-development record holds design and approval revisions. The process-route record holds material, printing, fixation and assembly requirements. The order record holds commitment, release, fulfilment and acceptance events. A machine or software purchase may support one record, but it must not redefine the others without a controlled review.

An integrated microfactory should be evaluated only after these responsibilities are clear. The technical review of digital textile printing describes a microfactory concept containing visualisation, preparation, printing, post-treatment, cutting and sewing. That description makes the integration boundary visible; it does not prove that one site, one supplier or one software suite must deliver every stage. [S01] GFT's recommendation is to decide whether each stage should be owned, outsourced or deliberately excluded before treating integration as the objective.

The repeat-order thesis benefits from this discipline. When a buyer returns, the team can identify whether the original success came from the design, the product-development decision, the material route or reliable fulfilment. It can then reproduce the relevant conditions rather than merely rerun a print file. Separating the decisions makes learning possible and prevents an attractive technical bundle from hiding the actual source of value.

1.3

A digital sample must lead to a manufacturable specification

A rendered garment is a representation. It can communicate silhouette, styling and placement, but its existence does not define the pieces that must be cut or the operations that must assemble them. Research on computational pattern making addresses that separate translation problem: a three-dimensional garment model is segmented and flattened into sewing-pattern pieces while accounting for constraints such as seams, darts, grain and distortion. The method is research evidence for the distinction, not an automatic release route for a local factory. [S09]

A valid pattern is a stronger object than an image, but it is still not the complete production instruction. GarmentCode's abstract makes valid sewing patterns central to accurate simulation and eventual fabrication, and explores parametric components for constructing them. This supports the importance of controlled geometry and construction relationships. It does not establish that an automatically generated pattern is ready for every material, size or sewing line. [S32]

The released production package sits beyond both. GFT proposes that it contain the approved pattern revision, dimensions and tolerances, bill of materials, fabric or blank identity, grain and orientation, seam and stitch instructions, artwork scale and placement, intended care, and the physical approval record. The package should also identify permitted customisation and the exact buyer selections for the order. A production operator should not need to infer a hidden seam, an unrecorded size decision or a material substitution from a presentation image.

This distinction gives the repeat order a stable reference. Reopening the same visual file is insufficient if the pattern, fabric lot or construction note has changed without review. The order ledger should point to an immutable approved package, while a later revision receives a new identifier. If the buyer asks for the same garment, the team can compare the new request with that package and reproduce its controlled conditions. If the buyer requests a variation, the service can identify which approvals remain valid and which must reopen.

Digital fit review belongs inside this chain, not outside it. The physical-versus-virtual fitting study used patterns, measured material inputs, avatars, digital workmanship and expert evaluation. It found that simulation could support fitting decisions while still requiring garment and pattern knowledge. Its conclusion states that virtual simulation cannot fully replace real physical fitting within the unresolved technical limits studied. [S07] The appropriate response is not to discard digital sampling, but to assign it bounded decisions and retain physical evidence where the decision requires it.

For a proposed reorderable service, the physical gate should cover the properties that the screen cannot settle. Fit needs an appropriate wearer or form, agreed poses and a documented evaluation. Tactile acceptance needs the actual fabric and print in the intended finished state. Construction needs inspection of the sewn article. These checks should be tied to the product family and buyer requirement rather than performed as vague reassurance. A failed result returns to a named cause, such as pattern, material, avatar, simulation setup or assembly.

Laundering evidence requires equal specificity. ISO's public catalogue entry for colour fastness to domestic and commercial laundering explains that industrial and hospital articles may face special procedures that can be more severe in some respects. The intended use therefore affects the selected evidence. The catalogue scope does not supply a buyer's pass grade or replace the complete agreed laboratory procedure. [S10] A visually approved fresh print is not, by itself, proof of acceptable behaviour after care.

> **METHOD**
>
> Release the order only when the approval bundle reconciles four objects: the buyer-visible design, the valid pattern, the controlled material and process route, and the physical evidence required by the product's use. Record who approved each object and which decisions remain conditional. A digital sample may reduce uncertainty before that bundle is complete; it cannot declare the bundle complete.

Physical approval does not mean making every possible sample for every subsequent order. The purpose of qualification is to learn which evidence must be repeated and which can be reused within a stable product family. A repeat order against an unchanged package may justify a different release routine from a new size, fabric or construction. That difference should be decided in advance through risk and observed variation, not improvised under delivery pressure. Where the service lacks evidence to reduce a check, it should retain the check.

This approach also prevents sample reduction from becoming cost displacement. A team may produce fewer presentation prototypes while creating more fit corrections, reprints or customer returns. GFT proposes counting residual physical iterations and downstream failures alongside any digital samples avoided. The relevant result is the complete development and fulfilment record for an approved style, not the number of attractive renders produced along the way.

A manufacturable specification is therefore the bridge between local creative work and repeatable industrial value. It gives the patternmaker, print operator, sewing team, quality reviewer and buyer a common reference. It also makes the next order opera-

tionally possible without relying on the memory of one individual. That is the sense in which a digital sample earns a place in the service: it improves the controlled package from which acceptable garments can be made again.

1.4

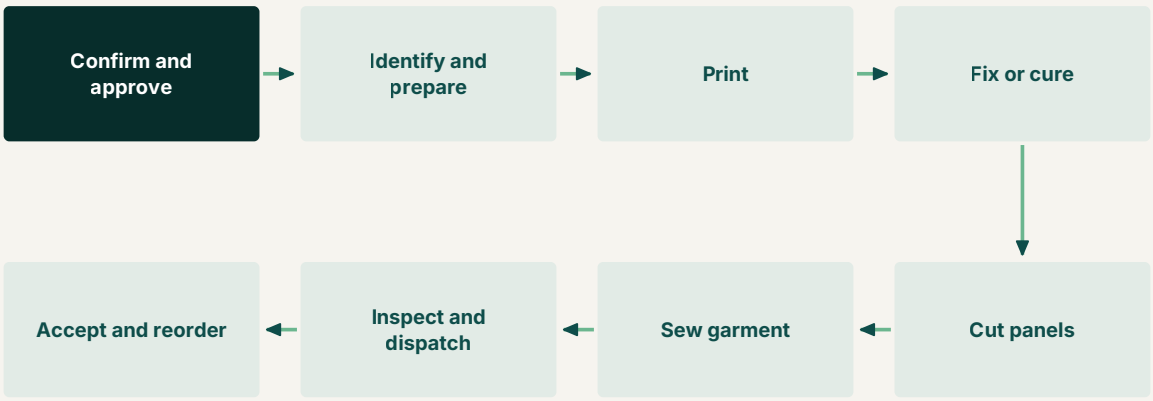
Short runs need a complete process boundary

A short run changes batch size, not the number of obligations attached to an acceptable garment. The material must still be identified, the required preparation completed, the print fixed, the article assembled where necessary, and the finished order inspected and delivered. The technical review of digital textile printing places printing within a longer chain that includes fabric preparation, post-treatment, cutting and sewing. Manufacturer guidance for garment decoration likewise identifies pretreatment and heat curing for direct-to-garment work, and film, adhesive powder, curing and heat pressing for a film-transfer route. [S01] [S15]

Exhibit 2, p. 21 shows the proposed boundary for a printed-fabric cut-and-sew order. It begins with commitment and ends with buyer acceptance and a possible reorder. The stages are a GFT process design, not measured cycle times or a claim that every print chemistry uses the same operations.

EXHIBIT 02 / ILLUSTRATIVE GFT PROCESS BOUNDARY

An approved order must survive every transformation



ILLUSTRATIVE [S01] [S03] [S15] Printed-fabric cut-and-sew route informed by the cited process descriptions. Preparation and fixation depend on the selected system. A blank-decoration route omits cutting and sewing but retains its applicable preparation, curing, inspection and acceptance controls. No durations or achieved performance are asserted.

The exhibit deliberately makes approval and acceptance separate. Internal inspection can release a garment for dispatch, but the buyer's acceptance determines whether the service promise closed successfully. A shipping scan does not prove fit, appearance or durability. A reprint completed quickly does not erase the earlier failure. The order record should retain both the physical events and the commercial outcome so that a later repeat purchase can be connected to the experience that preceded it.

Every handoff can also invalidate an earlier approval. A fabric substitution may change print behaviour or fit. A revised artwork file may move a motif into a seam. An incomplete cure may affect later performance. A cutting error may remove the approved placement even when the printed roll looked correct. A sewing change may alter dimensions or construction. [S01] [S09] [S15] GFT's proposed response is to identify which decisions each stage can change and to stop the order when a change reopens an approval.

The blank-decoration route has a shorter assembly boundary but not a weaker evidence requirement. The blank arrives with its own fibre origin, construction, size and care history. Decoration adds preparation, printing or transfer, curing and inspection. [S15] It does not add local cutting and sewing merely because those operations exist elsewhere in the building. The order ledger should preserve that distinction so the service can report local operations honestly and compare routes on equivalent accepted outcomes.

A fast printer addresses only one stage in this chain. Good-garment throughput depends on loading, setup, print completion, fixation, cooling, cutting, assembly, inspection and any recovery work. If one stage waits, the order waits. If a defect is discovered late, earlier speed may become rework rather than output. GFT therefore infers that nameplate print speed cannot establish delivery performance for the whole service. [S01] [S15] The promise must be tested against accepted orders crossing the full boundary.

Short runs can make recovery especially visible. Setup rejects, wrong versions, incomplete panel sets and remakes consume the same constrained stages as first-pass work. They should remain attached to the order rather than disappear into a general waste account. The proposed log records starts, accepted garments, rejected work, rework, remakes, dispatched units and buyer-accepted units. These quantities have different denominators and should not be combined into one yield claim without definition.

> **GFT NOTE**
>
> Quote and schedule the accepted order, not the print job. Before release, reserve every constrained stage required by the chosen route and name the physical evidence that can stop downstream work. Record recovery inside the order's labour, material and delivery history. A printer completes a task; the service completes an accepted garment.

The complete boundary also clarifies what a pilot must observe. Timing only the print cycle would leave approval delays, fixation queues, assembly interruptions and buyer disputes outside the measurement. Counting only fresh material would exclude remake consumption. Recording only dispatch would exclude refunds and rejected deliveries. A narrow service can be tested credibly if its ledger follows the same boundary from commitment to acceptance and retains the events that prevented a clean first pass.

Repeatability emerges when this chain can be executed again under controlled conditions. The next order should not depend on rediscovering the cure state, reconstructing the cut set or guessing which artwork was approved. Each stage needs enough identity and event history to recover the original decision. That operational memory is what allows a small service to learn without turning every reorder into a new development project.

1.5

The programme supplies a management design, not field results

GFT's Cameroon textile programme provides the starting discipline for this proposal. Its feasibility work describes a greenfield garment operation centred on cut, make, trim and finishing, with upstream spinning and knitting considered as optional partnered stages rather than assumed parts of the initial base case. It also presents domestic and regional service hypotheses under conditions, not realised sales. That operating concept supports a focused route to garment value; it does not establish an operating factory or a proven on-demand service.

The performance-management design supplies the measurement spine. It calls for source capture from the first shift, stable measure definitions, named ownership and a daily, weekly and monthly review rhythm. Its production, quality, delivery, cost, people and sustainability families connect line events with management decisions. For this chapter, the relevant extension is an order ledger that distinguishes starts, accepted output, buyer acceptance, retained orders and later commitments. Those measures would sit inside the same management logic rather than form a separate digital dashboard with incompatible denominators.

The digital strategy adds sequencing. It prioritises data capture before modelling, bought capability before bespoke development where appropriate, and local buffering for variable connectivity. Digital printing and sample reduction appear as candidate capabilities within a staged portfolio, not as deployed assets. This paper applies that staged logic to a bounded order-to-garment pilot: establish records and approvals first, qualify a physical route, then consider broader integration only when the evidence supports it.

The programme therefore informs management design, while the technologies and evidence in this paper come from separately cited public research, standards scopes and manufacturer documentation. No on-demand GFT installation, customer reorder rate, commercial saving or equipment partnership is established. The proposed service remains a testable extension of the programme's greenfield concept and performance discipline.

1.6

Evidence must remain attached to each claim

The research base answers different questions at different strengths. The digital-printing status report is a historical technical review that explains processes and system boundaries. [S01] Manufacturer pages describe particular garment-printing

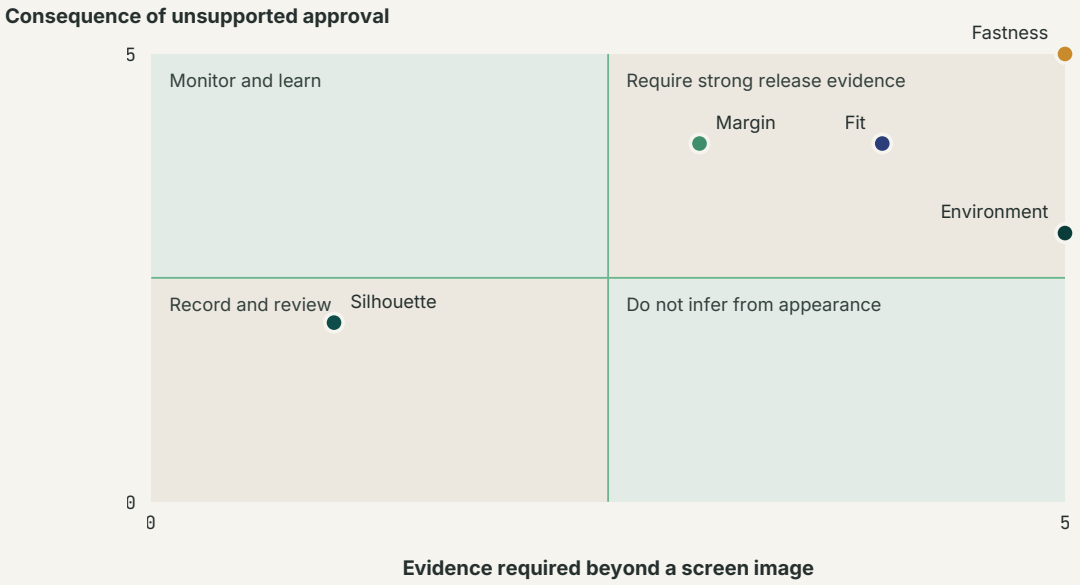
workflows and software behaviour; they are useful for identifying dependencies, not for proving local profitability or independent performance. [S15] [S16] ISO's public catalogue entries define the scope of methods, not a factory's test result or a buyer's acceptance threshold. [S10] GFT proposals sit in another category: they are recommended controls to be tested, not observations from a completed installation.

Historical environmental studies need the same care. The Finnish Printscorpio case compared digital and screen printing under stated life-cycle assumptions and found lower greenhouse-gas emissions for digital printing in its smaller-batch analysis. Its authors also varied lifetime and batch conditions and retained cotton within the assessed system. The case does not measure a Cameroon service, a current equipment fleet or the impact of a retained garment. [S26] It supports a boundary question, not a transferable saving.

Exhibit 3, p. 24 turns that restraint into a workshop tool. The coordinates are illustrative GFT judgements about how far a decision sits beyond visual review and how consequential an unsupported decision could be. They are ordinal positions for discussion, not measured risks or statistical scores.

EXHIBIT 03 / ILLUSTRATIVE ORDINAL SCORES FROM 0 TO 5

Different claims require different evidence



ILLUSTRATIVE [S07] [S10] [S17] [S26] GFT workshop scoring only. The horizontal axis represents required evidence beyond a screen image; the vertical axis represents the consequence of deciding without adequate evidence. Fit and laundering positions reflect physical-release needs. Resource and environmental positions reflect process-boundary needs. Margin requires a reconciled order ledger. Scores are not measurements, probabilities or acceptance thresholds.

The matrix does not rank the importance of the claims in absolute terms. It shows why one evidence object cannot settle them all. A render may support silhouette review while leaving fit unresolved. A fit approval cannot establish laundering fastness. Physical quality evidence cannot prove retained-order contribution. A small-batch environmental comparison cannot substitute for measured local energy, water, remakes and delivery. Each claim needs its own method, denominator and owner.

The same rule applies to missing local knowledge. Prices, order conversion, repeat demand, process performance and supplier service coverage remain unmeasured until the proposed service collects them. Blank fields should remain blank or carry an explicitly labelled assumption with a basis. Missing inherited annex references are excluded rather than reconstructed. An illustrative value can demonstrate arithmetic, but it cannot become evidence through repetition.

Exhibit 4, p. 25 assigns the wider questions to their intended research homes. This is an editorial scope map based on the library register, not a claim that the related papers or tools have supplied local results.

EXHIBIT 04 / ILLUSTRATIVE EDITORIAL SCOPE MAP

The library gives each decision a home

Research home	Decision owned	WP20 boundary
WP04	Demand forecasting	Supply committed-order history
WP06	Water and energy intensity	Capture print-route readings
WP10	Design generation	Receive a controlled concept
WP12	Inventory policy	Identify order-specific commitment
WP16	Product carbon accounting	Provide order and process boundaries
WP18	Factory architecture	Define recoverable order events
WP20	Release-to-order execution	Prove an accepted, reorderable garment

ILLUSTRATIVE Scope assignments from the paper-library register opened in this session. The map prevents duplication and identifies inputs needed from companion research. It is not evidence of completed papers, operating tools or measured outcomes.

This allocation keeps the chapter's claim narrow. This paper can define how an approved digital product becomes a fulfilled and repeatable order. It cannot also prove the national demand forecast, the optimal stock policy or a full product footprint. Keeping those dependencies visible makes the eventual pilot easier to inspect and prevents a local technical result from being expanded into an unsupported sector conclusion.

1.7

A narrow pilot can test the thesis

GFT proposes starting with one bounded product family, an agreed physical approval route and a reconciled order ledger. The product family should have a defined material route, size coverage, customisation limits and intended care. The approval route should state which decisions a digital sample may support and which require a physical article. The ledger should connect commitment, release, production events, dispatch, buyer acceptance, refunds and later orders. Expansion is justified only if the complete service passes, not if the render or print stage works in isolation.

The pilot needs a counterfactual. Compare the proposed route with the existing or outsourced way of developing and fulfilling an equivalent article under matched quality requirements. Record residual physical samples rather than assuming they disappear. A virtual fitting study supports retaining physical fit evidence, while IFC guidance makes heat, resource use and monitoring part of the operating boundary. [S07] [S17] The comparison should therefore include development labour, calibration, failed work, thermal stages, delivery and recovery.

Success has four connected conditions. Acceptable garments must meet the agreed physical release and buyer-acceptance definitions. Reliable fulfilment must be measured against the original promise across the complete process. Retained-order contribution must include remakes, refunds and order-specific recovery rather than stop at gross print revenue. Resource use must be reconciled against accepted output, with its meters and observation period stated. A count of digital samples is not one of these outcomes.

The order ledger should also expose the next-order question. Define a retained order after the agreed cancellation, refund and return window. Define a repeat order as a new commitment from an eligible earlier buyer, not a correction to the original order. State the observation window and whether several subsequent orders from one buyer count individually or as one returning buyer. Both views can be useful, but they answer different questions and must not share an unlabelled percentage.

> **WORKED EXAMPLE: REPEAT PURCHASE NEEDS ITS OWN DENOMINATOR**
>
> Assume an illustrative cohort of 40 paid single-garment orders. Two are cancelled before release and two are refunded after delivery, leaving 36 retained orders. Production uses 44 starts to deliver 38 internally accepted garments. Within a pre-agreed observation window, 12 of the 36 retained customers place a subsequent order. Every value is invented solely to demonstrate the arithmetic.
>
> The illustrative retained-order share is 36 divided by 40, giving 90 percent. The illustrative accepted-output yield is 38 divided by 44, giving 86.36 percent, or 86.4 percent rounded to one decimal place. The illustrative returning-customer incidence is 12 divided by 36, giving 33.3 percent. These are different denominators: paid orders, production starts and retained customers. The refund affects the commercial cohort but is not silently reclassified as a production reject.
>
> These illustrative results would not establish a forecast, a target or a causal effect of digital production. They would show only how a real pilot cohort could be reported once its definitions and window were fixed. A later cohort could produce a different result. The arithmetic is an operational measurement example, not investment advice or evidence of demand.

Delivery promises need a responsible capacity check. OECD guidance identifies inefficient production planning and poor purchasing practices among common factors that can drive excessive working hours in garment manufacturing. [S28] The pilot should therefore record overtime, unplanned subcontracting and late specification changes alongside on-time delivery. Hitting a promise through unrecorded recovery would not demonstrate a repeatable service.

Before launch, agree the failure conditions as well as the desired outcomes. An unresolved physical-release failure should stop the affected route. Negative retained-order contribution should trigger diagnosis rather than be hidden by allocating recovery elsewhere. Unstable identifiers or incomplete order events should prevent a repeatability claim. The decision can be to stop, repair and retest, outsource a stage or continue only within the qualified scope.

The thesis is consequently falsifiable. If buyers do not return, if acceptable garments cannot be reproduced, if fulfilment depends on exceptional recovery or if retained orders do not cover the complete cost, the proposed service has not earned expansion. If the bounded route does succeed, its records will show exactly which product, approvals and operating conditions produced that result. That is the evidence required before local value can be described as repeatable.

A reorder is the moment a garment becomes a repeatable service.

CHAPTER SOURCE NOTES

R06 Cameroon Trade Hub. Publication date unrecorded; inherited source-text check.

R07 Ecofin Agency. Publication date unrecorded; inherited source-text check.

S01 Society for Imaging Science and Technology. 2021.

S03 The Korean Fashion and Textile Research Journal. 2025-12-31.

S09 arXiv, Pietroni and co-authors. 2022.

S32 arXiv, Korosteleva and Sorkine-Hornung. 2023-06-06.

S07 3DBODY.TECH conference proceedings. 2020.

S10 International Organization for Standardization. 2010.

S15 Epson United Kingdom. 2026.

S16 CLO Virtual Fashion. 2026-10-05.

S26 VTT Technical Research Centre of Finland. 2014.

S17 International Finance Corporation, World Bank Group. 2007-04-30.

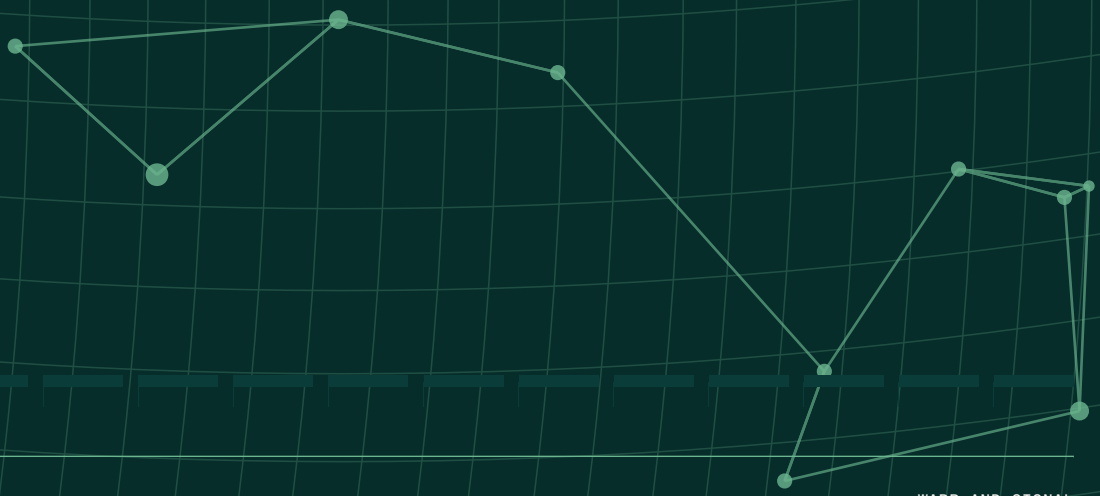
S28 Organisation for Economic Co-operation and Development. 2018.

02

PART I: CONFIRM THE ORDER BEFORE CHOOSING THE MACHINE / DEMAND COMMITMENT

The order promise determines the production model

Choose what the buyer commits to and where customisation occurs before quoting a minimum order or delivery date.



CHAPTER 02
DECISION TEST

Choose what the buyer commits to and where customisation occurs before quoting a minimum order or delivery date.

An on-demand apparel operation succeeds or fails on the precision of its commercial promise long before a printhead fires a single picolitre of ink. [S03] When a local producer in Cameroon offers digital printing, three-dimensional sampling, or short-run garment manufacture, the quotation defines which party carries inventory risk, which party absorbs geometry and shade variation, and how many hours the shop floor has to turn raw materials into accepted output. [S01] Research on order-triggered textile systems shows that on-demand production represents a structural transformation in supply-chain control rather than a simple technological upgrade. [S03] Green Future Tech Limited (GFT), drawing on the green-field operating concept, performance-management system design, and digital strategy prepared on 31 January 2024 for its Cameroon textile programme (with source-refresh notes retained in 2026), argues that a factory must define its customer-order decoupling point, payment gates, permission records, and end-use testing boundaries before purchasing equipment or publishing lead times. [S03] Without an enforceable service boundary, an on-demand offer converts speculative finished-goods stock into unfunded design labour, disputed deposits, emergency consumable purchases, and unscheduled overtime. [S28]

2.1

A confirmed order is stronger than a page view

Digital catalogues and social-media storefronts blur the boundary between curiosity and commitment. [S03] A prospective buyer who views an online garment render, requests a motif placement change, or asks for a pro-forma price breakdown has not triggered an on-demand manufacturing event. [S03] In an order-driven production system, the customer-order trigger is the exact administrative and financial threshold at which an upstream capacity reservation becomes an irreversible commitment of fabric, pretreatment liquor, ink, thermal curing energy, and operator time. [S01] Confusing pre-sales design exploration with confirmed demand corrupts both capacity scheduling and unit-economics accounting. [S28]

GFT proposes that a local apparel service separate commercial intake into seven auditable state transitions: an initial design enquiry, a scoped technical quotation, a verified rights and measurement clearance, a funded financial commitment, a frozen technical approval bundle, an authorised shop-floor release, and a retained sale measured after the return and dispute window closes. [S03] Under this governance discipline, which extends the event-logging architecture of GFT's Cameroon textile programme performance-management design, no job enters raster image processing (RIP) or marker preparation on the strength of a verbal promise or an unfunded purchase order. [S01]

Financial accounting must mirror this operational separation. When an institutional buyer or independent designer pays an advance deposit to initiate custom strike-offs or short-run manufacture, that cash receipt is an unearned contract liability, not realised revenue, in GFT's proposed order ledger. [S03] The deposit remains encumbered until the factory delivers garments that satisfy the agreed physical release criteria and the buyer signs off acceptance or the contractual claim window

expires. [S07] Recording cancellations, pre-release drop-outs, post-delivery remakes, and cash refunds in distinct ledger accounts prevents a high volume of unpaid enquiries from disguising a negative retained-order contribution. [S28]

> **GFT NOTE**
>
> Never trigger fabric cutting, garment pretreatment, or digital printing from an unverified enquiry or an unapproved artwork file. In GFT's proposed order-control design, an order exists only when three records coincide under one immutable identifier: cleared buyer funds (or verified institutional credit), signed acceptance of the frozen technical specification, and confirmed availability of the qualified substrate and consumable lot. [S03]

2.2

Decorating a blank differs from making a garment

The phrase *print on demand* is routinely applied to three distinct manufacturing services that share almost no upstream inventory, patternmaking, or quality-control requirements. [S03] Treating them as a single business model causes capital misallocation and broken delivery promises. [S01] A producer must decide whether the buyer is purchasing surface decoration on an existing finished garment, cut-and-sew assembly of custom-printed roll fabric in standard graded sizes, or individualised garment construction tailored to personal body dimensions. [S32]

In **stocked-blank decoration**, the garment is knitted, dyed, cut, and sewn before the customer approaches the service. [S15] The operator holds unprinted cotton T-shirts, hoodies, or piqué polo shirts across sizes and colours, applying buyer artwork after order confirmation via direct-to-garment (DTG) inkjet printing or direct-to-film (DTF) heat transfer. [S15] Customisation is restricted to printable platen zones avoiding seams, collars, and plackets, with lead time governed by pretreatment drying, printing, and thermal curing. [S30] Decorating imported blanks can create local service value, but it must remain distinct from Cameroon's national industrialisation baseline, where about 95 percent of cotton fibre is exported raw against about 5 percent processed locally. [R06] As Cameroon's National Development Strategy (SND30) targets 50 percent local cotton-fibre processing by 2030, a business case must state whether its blanks use domestic fabric or imported garments. [R07]

In **printed-fabric cut-and-sew**, the customer-order decoupling point moves upstream to prepared-for-print roll fabric. [S01] After the buyer approves the artwork and size breakdown, the facility prints yardage or engineered panel markers using pigment or reactive ink, fixes the colour through dry heat or steaming and washing, cuts the panels, and assembles the garment. [S01] This route permits all-over prints, seam-to-seam motif alignment, and custom trims, but requires validated graded sewing patterns, shrinkage compensation, marker nesting, bundle tracking, and full cut-make-trim competence. [S09] [S32]

In **made-to-measure or parametric custom manufacture**, customisation extends into pattern geometry itself. [S32] Each order adapts a base block or parametric sewing program to an individual wearer's anthropometric measurements and

preferred ease allowance before printing and cutting. [S0202] Programmable pattern research shows that maintaining valid seam matching, grainline orientation, and dart geometry under dimensional retargeting is computationally and technically demanding. [S32] Furthermore, virtual try-on studies confirm that digital simulation cannot yet replace physical fitting across all garment types and body shapes, giving made-to-measure production the highest prep burden and remake risk. [S07]

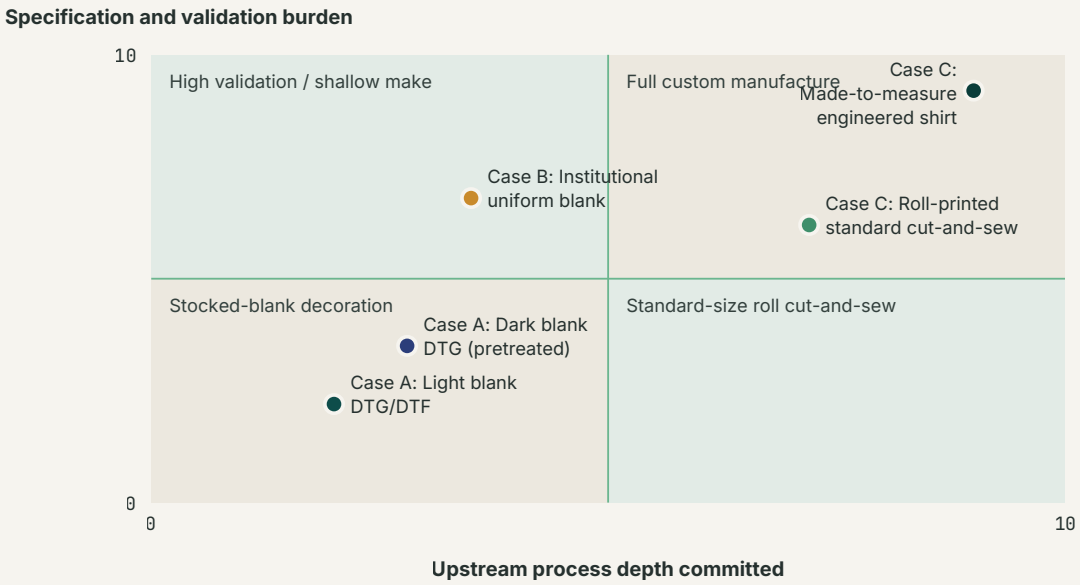
To keep these operational differences concrete throughout this paper, GFT evaluates three illustrative product cases that represent test designs rather than known GFT customers or completed factory runs:

1. **Illustrative Case A (Promotional cotton crew-neck T-shirt):** Chest-logo and back-graphic decoration on stocked 180-gram-per-square-metre ring-spun cotton jersey blanks in four standard sizes using DTG or DTF transfer, requiring pretreatment control on dark bases and dry-heat curing. [S30]
2. **Illustrative Case B (Institutional uniform polo shirt):** Multi-size runs of piqué polo shirts with matched collar and cuff ribs, chest branding, and specified commercial or domestic laundering durability, requiring verified wash and rubbing fastness before bulk commitment. [S10]
3. **Illustrative Case C (Engineered-print woven cotton shirt):** Short runs of a tailored long-sleeve woven cotton shirt where a geometric motif aligns continuously across the front placket, yoke, and sleeve heads, requiring roll-to-roll printing, shrinkage-calibrated markers, and precision cut-and-sew assembly. [S09]

As shown in **Exhibit 5**, p. 32, each service model places the customer-order decoupling point at a different depth of the manufacturing chain and demands a correspondingly higher degree of technical specification before release. [S03]

EXHIBIT 05 / ILLUSTRATIVE INDEX (0 TO 10)

Each service commits stock at a different stage



ILLUSTRATIVE [S01] [S03] [S15] Illustrative GFT classification informed by S01, S03 and S15. Horizontal axis scores upstream process depth committed per order (0 = finished blank in stock, 10 = pattern, fabric print and full garment assembly). Vertical axis scores specification and validation burden per order (0 = print file only, 10 = body measurement, pattern adaptation and physical fit verification).

Exhibit 5, p. 32 illustrates why a producer cannot quote a uniform minimum order quantity or a single turnaround time across its catalogue. [S03] Moving from light-garment blank decoration in the lower-left quadrant to an engineered-print cut-and-sew or made-to-measure shirt in the upper-right quadrant multiplies both shop-floor transformations and pre-cutting verification. [S01] What **Exhibit 5**, p. 32 cannot establish is which quadrant yields the highest net margin in Cameroon; that outcome depends on local price realisation, reject rates, and utilisation measured in a pilot. [S03]

2.3

Postponement moves inventory upstream

Promotional literature often claims that on-demand manufacturing eliminates inventory working capital. [S03] In engineering reality, postponement never abolishes inventory; it relocates stock upstream from finished, graphic-specific garments to neutral intermediates held immediately behind the customer-order decoupling point. [S03] If those upstream intermediates are out of stock, expired, or uncalibrated when a buyer places a paid order, the promised short lead time collapses. [S31]

In a stocked-blank DTG or DTF service, postponement shifts inventory into unprinted garments across styles, weights, colours, and sizes. [S15] Offering three styles in five colours and six sizes requires thirty blank stock-keeping units (SKUs) before a single order arrives, illustrative of the combinatorial stock behind delayed decoration. [S03] Alongside blanks, the operator must hold pretreatment solutions for dark cotton and polyester, white and colour ink packs, cleaning fluids, transfer film rolls, and adhesive

powder. [S30] Chemical and ink stocks carry shelf-life and agitation obligations even at zero order volume: commercial DTG maintenance instructions specify shaking white ink units daily and colour ink units monthly to prevent pigment settling. [S31]

In a printed-fabric cut-and-sew service, blank SKU proliferation is replaced by roll stock of prepared-for-print (PFP) fabrics, interlinings, threads, closures, and labels. [S01] While roll fabric is flexible across sizes, it locks capital into specific fibre compositions, yarn counts, weave structures, and scouring states. [S02] If a buyer orders an engineered-print shirt on a cotton poplin base that has not been pre-qualified for shrinkage and colour profile, substituting another fabric weight invalidates both pattern ease and the ICC colour profile. [S05]

The scope division across the GFT library keeps these inventory calculations modular: `wp04` governs demand distributions and forecasting, while `wp12` governs safety-stock sizing and working-capital optimisation across fibre, yarn, fabric, and trims. [S03] Here, `wp20` defines the decoupling boundary where neutral upstream stock becomes an irreversible, order-specific commitment protected by deposits and cancellation terms. [S03]

METHOD

Method: Order-commitment exposure and deposit-coverage balance

To test whether a deposit policy protects the factory at the decoupling point, GFT partitions the cost of an order of q accepted garments under route m into three sequential buckets: [S03]

1. **Pre-release commitment ($C_{\text{pre},m}$):** Prepress labour, pattern verification or grading adaptation, rights clearance, and physical strike-off confirmation incurred before bulk release. [S09]
2. **Irreversible conversion commitment ($C_{\text{conv},m}(q)$):** Neutral upstream stock (blanks or PFP fabric, pretreatment, ink, film, trims) plus printing, curing, cutting, and sewing labour consumed after release, adjusted for first-pass accepted yield $y_m \in (0, 1]$: [S01]

$$C_{\text{conv},m}(q) = \frac{q}{y_m} \left(u_{\text{mat},m} + u_{\text{ink},m} + u_{\text{cure},m} + u_{\text{lab},m} \right) + F_{\text{setup},m}$$ 3. **Fulfilment and recovery reserve ($C_{\text{post},m}(q)$):** Packaging, dispatch, collection fees, and expected remake or refund allowance. [S28]

To avoid working-capital subsidy when neutral stock is converted into buyer-specific graphics or cut panels, the cleared advance deposit $D_m(q)$ collected before release must satisfy: [S03] $$D_m(q) \ge C_{\text{pre},m} + \alpha_m C_{\text{conv},m}(q)$$ where $\alpha_m \in [0, 1]$ is the non-salvageable share of converted cost if the buyer cancels or fails to collect ($\alpha_m = 1.0$ for custom uniforms or made-to-measure garments). [S03]

WORKED EXAMPLE

Worked example: Deposit coverage across three 20-unit illustrative orders

Consider an illustrative comparison of three 20-garment orders ($q = 20$) in CFA franc (XAF), using the euro peg of 655.957 XAF per euro and Cameroon's statutory minimum wage of XAF 43,969 a month (about US$76 from 23 February 2024 across a 40-hour standard week) as floor context, while pricing skilled technician time at an illustrative burdened rate of XAF 1,500 per hour (against the XAF 43,969 floor and US$359 multi-sector monthly average in the register). [R14] [R15] [R16] [R32] All unit figures are **illustrative** method inputs, not measured GFT prices:

- **Case A (20 dark cotton T-shirts, stocked-blank DTG):** Illustrative pre-release prepress of 0.5 hours ($C_{\text{pre},A} = \text{XAF } 750$), setup $F_{\text{setup},A} = \text{XAF } 2,250$, yield $y_A = 0.9524$ (21 starts for 20 accepted units), blank $u_{\text{mat},A} = \text{XAF } 2,500$, pretreatment and ink $u_{\text{ink},A} = \text{XAF } 1,400$, curing $u_{\text{cure},A} = \text{XAF } 200$, and labour $u_{\text{lab},A} = \text{XAF } 400$ per start ($\text{XAF } 4,500$ variable total). [S15] [S30] Conversion cost is $C_{\text{conv},A}(20) = 21 \times 4,500 + 2,250 = \text{XAF } 96,750$, and cumulative commitment is $\text{XAF } 97,500$ (illustrative). [S30]
- **Case B (20 institutional polo shirts, wash-tested strike-off):** Illustrative $C_{\text{pre},B} = \text{XAF } 18,000$ (strike-off plus wash/dry check per ISO 6330 and ISO 105-C06 scopes), setup $F_{\text{setup},B} = \text{XAF } 3,500$, yield $y_B = 0.9091$ (22 starts), blank and trim $u_{\text{mat},B} = \text{XAF } 4,200$, film, powder and ink $u_{\text{ink},B} = \text{XAF } 1,100$, curing $u_{\text{cure},B} = \text{XAF } 250$, and labour $u_{\text{lab},B} = \text{XAF } 450$ per start ($\text{XAF } 6,000$ variable total). [S10] [S12] [S15] Conversion cost is $C_{\text{conv},B}(20) = 22 \times 6,000 + 3,500 = \text{XAF } 135,500$, and cumulative commitment is $\text{XAF } 153,500$ (illustrative). [S10]
- **Case C (20 engineered-print woven shirts, roll print and cut-and-sew):** Illustrative $C_{\text{pre},C} = \text{XAF } 32,000$ (marker alignment, strike-off, and shrinkage readback), setup $F_{\text{setup},C} = \text{XAF } 8,000$, yield $y_C = 0.8696$ (23 starts), PFP shirting and trims $u_{\text{mat},C} = \text{XAF } 5,000$, ink and fixation $u_{\text{ink},C} = \text{XAF } 1,800$, thermal energy $u_{\text{cure},C} = \text{XAF } 450$, and cutting, sewing, and pressing labour $u_{\text{lab},C} = \text{XAF } 2,750$ per start ($\text{XAF } 10,000$ variable total). [S01] [S09] Conversion cost is $C_{\text{conv},C}(20) = 23 \times 10,000 + 8,000 = \text{XAF } 238,000$, and cumulative commitment is $\text{XAF } 270,000$ (illustrative). [S01]

Operational consequence: At illustrative prices of XAF 7,000 for Case A (order XAF 140,000), XAF 10,500 for Case B (order XAF 210,000), and XAF 18,000 for Case C (order XAF 360,000), a 25 percent deposit leaves XAF 62,500 unhedged in Case A, XAF 101,000 in Case B, and XAF 180,000 in Case C once blanks are printed or rolls are cut ($\alpha_m = 1.0$). [S03] Full conversion coverage requires a minimum pre-release deposit of $97,500 / 140,000 = 69.6$ percent for Case A, $153,500 / 210,000 = 73.1$ percent for Case B, and $270,000 / 360,000 = 75.0$ percent for Case C (or staged payments clearing 100 percent of $C_{\text{pre},m}$ before strike-off and 70 percent of order value before bulk release). [S03] This arithmetic is an operational decision aid, not investment, legal, or tax advice.

2.4

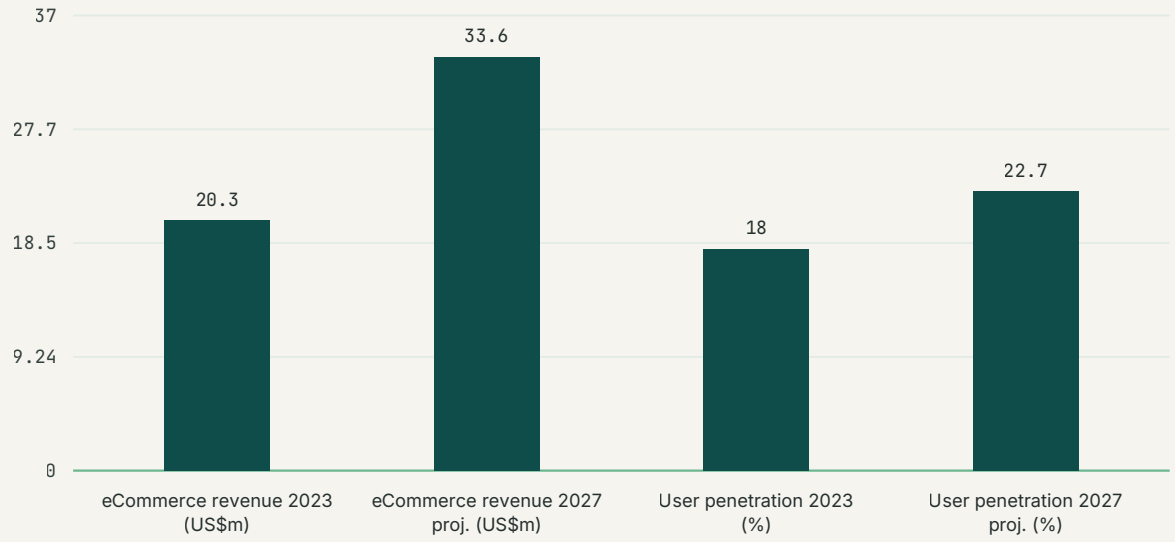
Local demand requires a test of willingness to wait

An on-demand model trades immediate shelf availability for design specificity and lower finished-stock risk. [S03] Whether local buyers in Cameroon will accept that trade-off cannot be deduced from macro-economic targets or imported survey statistics. [R07] In the inherited evidence register, Cameroon's clothing and footwear spend is recorded at about US$94.70 a person in 2024 across roughly 8.0 pieces a person, while domestic apparel eCommerce revenue is projected to rise from US$20.32 million in 2023 to US$33.61 million in 2027 (13.41 percent a year), with user penetration expanding from 18.0 percent in 2023 to 22.7 percent in 2027. [R26] Meanwhile, the African textile market is estimated at about US$37.3 billion in 2025 and projected to reach US$49.41 billion by 2030 at 4.73 percent a year (with another market estimate projecting US$72.7 billion by 2035 and noting fashion and apparel at 48.1 percent of the market in 2024). [R24] [R25]

Exhibit 6, p. 35 displays the reported Cameroon apparel eCommerce revenue and user-penetration figures from the inherited register. [R26]

EXHIBIT 06 / US$ MILLION AND PERCENT PENETRATION

Reported Cameroon apparel eCommerce growth does not establish custom-order conversion



SOURCED [R26] Sourced from inherited register entry R26 (Statista; refreshed 2026, original publication date not recorded). Shows 2023 baseline and 2027 projection for Cameroon apparel eCommerce revenue (US$ million) and user penetration (percent). These sector aggregates cover all online apparel sales and do not measure demand for local on-demand printing or custom-fitted garments.

As **Exhibit 6**, p. 35 underscores, even by 2027 projected online apparel user penetration in Cameroon reaches 22.7 percent and total apparel eCommerce revenue is US$33.61 million across all imported, ready-made, and second-hand categories combined. [R26] Neither a share of that US$33.61 million aggregate nor the 50 percent national cotton-processing target in SND30 can be converted into a local apparel order forecast. [R07] [R26] Equally, overseas consumer surveys on mass customisation

cannot be transferred to Cameroon: an empirical study of online apparel mass customisation in South Korea evaluated perceived benefits and emotional product attachment across 290 female online shoppers and stressed that formal measurement-invariance testing (configural, metric, and scalar invariance) is required before comparing consumer behaviour across groups. [S0203]

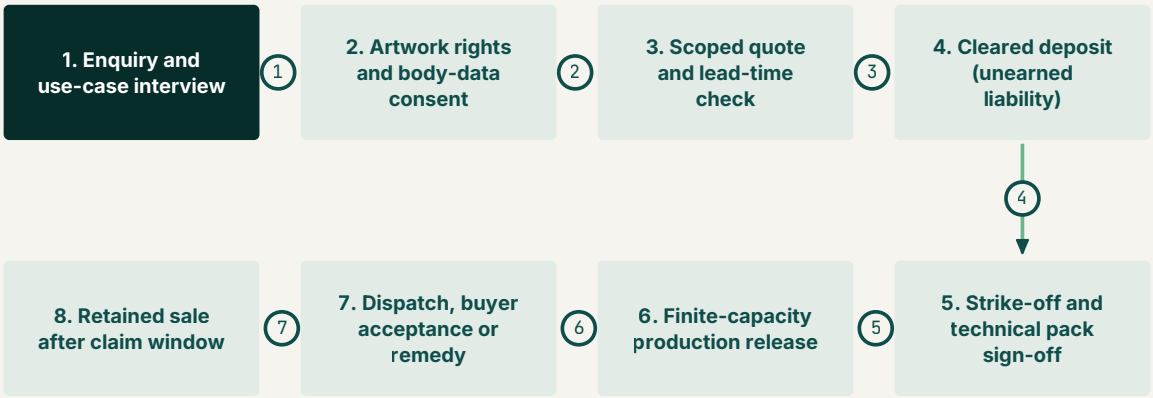
Instead of inventing demand percentages, GFT proposes treating willingness to wait and willingness to pay deposits as measurable hypotheses inside the pilot order ledger across direct retail, institutional uniform, and designer channels: [S03]

- **Quoted versus accepted lead time:** Calendar days promised from deposit clearance to dispatch, paired with whether the buyer accepted the quote, requested a rush override, or abandoned the enquiry. [S28]
- **Artwork and specification iteration count:** Prepress or pattern review cycles consumed before the buyer signs off the approval bundle, separating minor placement shifts from file replacements. [S09]
- **Deposit-stage abandonment cause:** Structured codes recording whether an uncompleted quote failed on unit price, deposit share, delivery date, lack of a physical sample, or artwork readiness. [S03]

Exhibit 7, p. 37 maps the controlled commercial and operational state sequence that GFT proposes for every order so that only verified, funded, and approved work crosses the release boundary. [S03]

EXHIBIT 07 /

Only accepted and funded work enters production



1. Valid end-use
2. Rights cleared
3. Terms accepted
4. Funds cleared
5. Physical/digital gate passed
6. Passed final QC
7. No return/refund

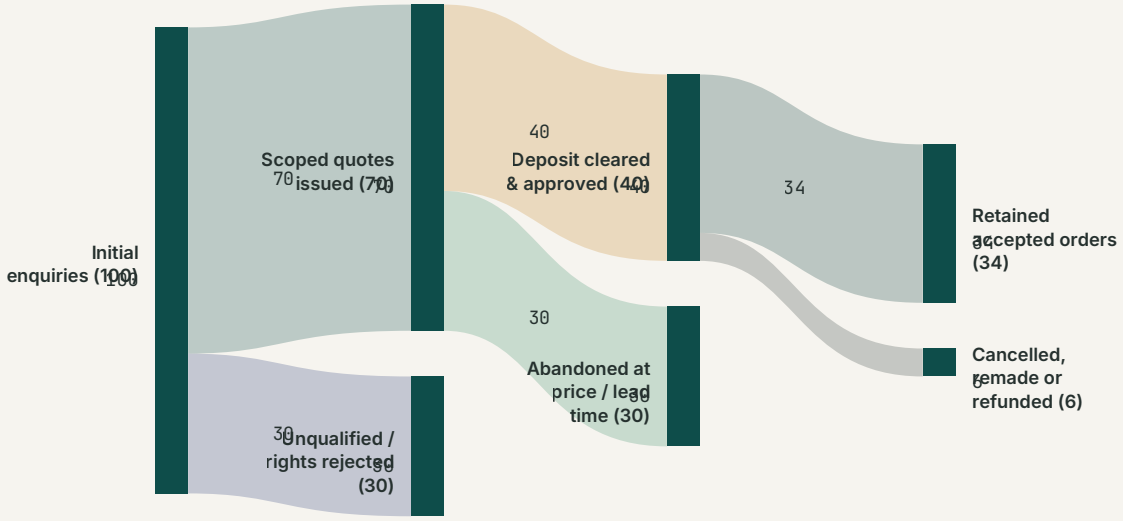
ILLUSTRATIVE [S03] [S28] Illustrative GFT order-governance flow informed by S03 (order-triggered production) and S28 (planning discipline to prevent excessive overtime). Every transition requires a timestamped record in the order ledger before the next stage opens.

In **Exhibit 7**, p. 37, stages 1 through 5 occur upstream of bulk manufacturing release. [S03] If an order stalls at stage 2 (missing permission to reproduce a logo or cultural motif) or stage 5 (a physical strike-off that fails buyer shade expectations), no bulk blanks are printed and no roll fabric is cut. [S01] What **Exhibit 7**, p. 37 cannot prevent on its own is administrative delay between stages; if prepress review and strike-off sign-off take longer than printing and sewing, the buyer still experiences a slow service. [S03]

To make attrition across these states visible without fabricating market conversion rates, **Exhibit 8**, p. 38 shows an illustrative pilot cohort accounting structure of 100 initial enquiries tracked through quotation, deposit commitment, technical approval, dispatch, and retained sales. [S03]

EXHIBIT 08 / ILLUSTRATIVE INDEX COHORT (100 ENQUIRIES)

Orders can disappear before they become retained sales



ILLUSTRATIVE [S03] [S20] [S0203] Illustrative GFT cohort accounting template informed by S03, S20 and S0203. Uses a symbolic base of 100 enquiries to demonstrate flow conservation across commercial and fulfilment leakage points. Values are illustrative accounting placeholders, not observed Cameroon conversion rates; actual counts must be populated from the pilot order ledger.

The flow balance in **Exhibit 8**, p. 38 demonstrates why commercial viability must be evaluated per **retained order** (the 34 illustrative units at stage 3) rather than per enquiry (100 units) or per quote (70 units). [S03] The 30 enquiries rejected at intake for unverified wash requirements or missing permissions and the 30 quotes abandoned over price or lead time consume sales and triage minutes, while the 6 orders lost after deposit to strike-off rejection, late delivery, or refund consume laboratory, print, and administrative resources. [S28] Populating **Exhibit 8**, p. 38 with pilot ledger counts reveals whether the bottleneck lies in pricing, lead-time tolerance, or shop-floor execution. [S03]

2.5

Cultural designs and body records need explicit permission

Digital printing and three-dimensional customisation lower the technical barrier to reproducing existing visual motifs and capturing human body geometry. [S01] [S13] In Cameroon, apparel orders frequently incorporate distinctive cultural heritage textiles, such as Grassfields *ndop* indigo resist-dyed geometries, royal or lineage insignia, artisanal embroidery patterns, school and corporate crests, or contemporary artworks by independent illustrators. [S29] Treating a digital printer as a copying machine exposes the factory to commercial disputes, reputational harm, and community or legal challenges. [S29]

GFT proposes a mandatory **prepress permission and provenance record** attached to every artwork identifier before file rasterisation, classifying each graphic asset into one of four categories: [S03]

1. **Buyer-created original artwork:** Signed warranty confirming authorship, ownership, and indemnity against third-party claims, plus an explicit election stating whether the factory may photograph the finished garment or must delete the print file after the reorder window closes. [S29]
2. **Institutional, corporate, or event trademarks:** Written purchase authorisation from an institutional officer naming the permitted quantity, colourway, and distribution channel, prohibiting overrun sales of branded rejects into informal markets. [S29]
3. **Traditional cultural expressions and community motifs:** Documentation of motif origin, verification of permission from the relevant artisanal guild, traditional authority, or commissioning community, and prohibition on registering or reselling heritage motifs as factory templates. [S29]
4. **Third-party licensed or stock graphics:** Archival of the licence receipt verifying that merchandise reproduction (print-for-sale) covers the ordered volume. [S29]

Applying the risk-based due diligence guidance of the Organisation for Economic Co-operation and Development (OECD), which expects each company to identify priority risk areas based on its specific circumstances including risks not listed in generic summaries, a local service network must screen design rights alongside material suppliers. [S29] Equally, the International Finance Corporation (IFC) Environmental and Social Management System (ESMS) handbook emphasises using structured risk-assessment forms to prioritise which operational risks require immediate controls. [S18]

A parallel governance duty applies to **customer body records** in made-to-measure and virtual-fitting services. [S13] Creating a custom-fit garment requires standardized anthropometric measurements as defined in ISO 8559-1:2017, paired with garment size rules and ease allowances reflecting wearer proportions and fit preferences. [S13] [S0202] To avoid stationary three-dimensional scanning booths, recent workflows propose smartphone photography: a 2025 study in *Ergonomics* demonstrated a low-cost three-dimensional body reconstruction method from front, side, and back smartphone photographs using segmentation and point-cloud registration, reporting girth average absolute errors within 2 cm across 80 subjects. [S0201]

Because body photographs are sensitive personal records and a 2 cm girth error can shift a tailored woven shirt across half a size grade, GFT proposes three controls for body records, without asserting unverified local privacy statutes (which require qualified legal review): [S06] [S29] [S0201]

- **Informed consent and data minimisation:** Collect silhouette photographs or body dimensions only when the service modifies pattern geometry (`Case C`) or provides a requested size recommendation; never collect scans for standard-size blank decoration (`Case A`). [S13]

- **Separation of body data from catalogue assets:** Store raw photographs and named dimensions in an access-restricted record separate from shop-floor bundle tickets; the cutting and sewing line receives only numeric pattern dimensions and an anonymised order identifier. [S32]
- **Scheduled retention and deletion:** Agree in writing whether derived numeric measurements are retained for a bounded reorder window (such as twelve months) or purged upon acceptance, and delete raw photographs once girths and avatar parameters are verified. [S0201]

2.6

Buyer specifications constrain attractive niches

Entrepreneurs evaluating digital textile printing often target institutional niches, such as school uniforms, hospitality shirts, clinic tunics, workwear, and sports kits, because institutional buyers place larger, more repeatable orders than individual consumers. [S03] However, institutional garments face frequent washing, vigorous drying, perspiration, abrasion, and sunlight. [S10] Quoting an institutional uniform using a decorative retail print specification leads to delaminated film transfers, faded pigment graphics, shrunk collars, and batch rejection. [S02]

Public international standards scopes make these technical distinctions explicit. **ISO 105-C06:2010** (*Colour fastness to domestic and commercial laundering*) warns that industrial and hospital articles may undergo special laundering procedures more severe in several respects than domestic washing. [S10] Similarly, **ISO 6330:2021** (*Domestic washing and drying procedures for textile testing*) states that a complete test consists of both a washing and a drying procedure, since tumble, flat, or line drying alters shrinkage and appearance. [S12] For printed textiles, **ISO 105-X12:2016** (*Colour fastness to rubbing*) specifies separate dry and wet rubbing tests, as prints passing dry crocking often transfer colour when wet. [S11] On the input side, the ZDHC Manufacturing Restricted Substances List (MRSL) establishes which chemical substances must be avoided in intentional manufacturing formulations, distinct from finished-product restrictions. [S23]

GFT proposes that sales intake enforce a strict **end-use qualification boundary** before quoting: [S10]

1. **Promotional and casual fashion apparel:** May use qualified DTG, DTF transfer, or pigment roll printing provided domestic care instructions (wash temperature, drying method, and no-iron rules over film transfers) are disclosed on the quote and agreed before payment. [S12] [S15]
2. **Corporate, school, and hospitality uniforms:** Require documenting the buyer's laundering regime (domestic versus commercial laundry, temperature, bleaching agents, and drying method) during intake and verifying wash fastness (`ISO 105-C06`), wet and dry rubbing fastness (`ISO 105-X12`), and dimensional stability (`ISO 6330`) on the exact fabric and ink combination before bulk commitment. [S10] [S11] [S12]

3. **Protective, medical, and high-visibility workwear:** Must be **excluded** from an uncertified print service unless the facility holds accredited test evidence and regulatory sign-off for the functional claim (such as hospital thermal disinfection, flame retardation, or chemical splash protection). [S10] Decorating a cotton smock in hospital colours does not create a certified medical barrier garment, and GFT recommends an explicit contractual disclaimer refusing functional safety or medical claims on decorative apparel. [S10]

Exhibit 9, p. 41 sets out GFT's proposed pre-quotation interview and service-specification template across the three illustrative product families, leaving local demand and price fields intentionally unfilled until collected in a pilot. [S10] [S12] [S28]

EXHIBIT 09 / SPECIFICATION TEMPLATE FIELDS

The buyer must accept the complete service specification

Specification field	Case A: Stocked-blank T-shirt	Case B: Institutional polo uniform	Case C: Engineered cut-and-sew shirt
Order decoupling point	Stocked jersey blank by size/colour	Qualified piqué blank + collar trim lot	Prepared-for-print woven cotton roll
Customisation scope	Platen graphic area only	Chest crest + back text within platen	All-over or panel-matched print + size/fit
Intended care regime (S10, S12)	Domestic wash & line dry stated on quote	Buyer wash/bleach/dry route verified first	Domestic gentle wash, drip dry, warm iron
Pre-release physical gate	Batch first-article print & cure check	Signed strike-off + wash & rub test record	Signed strike-off + marker shrinkage check
Working-time capacity check (S28)	Platen & tunnel cure hours within 40-48h week	Transfer press & QC hours within 40-48h week	Print, cut & sew hours within 40-48h week
Pilot demand & price (XAF)	[To be recorded in pilot]	[To be recorded in pilot]	[To be recorded in pilot]

ILLUSTRATIVE [S10] [S12] [S28] Illustrative GFT pre-quotation interview and contract specification matrix based on S10 (laundering severity), S12 (combined wash and dry specification) and S28 (realistic planning lead times). Demand volume and unit price fields are left intentionally blank ('[To be recorded in pilot]') so operators do not confuse a template with a market forecast.

As **Exhibit 9**, p. 41 shows, every service tier binds the commercial promise to an explicit care regime, a physical pre-release check, and a finite shop-floor capacity check. [S10] [S28] Because a paper form cannot prevent sales staff from bypassing fields to close a deal, GFT's proposed order-orchestration design in Chapter 10 blocks job release unless every mandatory field in **Exhibit 9**, p. 41 carries a verified identifier. [S03]

2.7

Service boundaries make quotes enforceable

Disputes over on-demand orders almost always stem from an ambiguity that existed before printing began: a screen preview brighter than a matte pigment print on cotton, a "medium" blank narrower than a previous supplier's, a late artwork change pushing

delivery past an event date, or a rush promise met through unscheduled night shifts. [S22] [S28] Making quotations enforceable requires writing operational tolerances and remedies into the commercial agreement before accepting the deposit. [S03]

GFT proposes that every formal quotation and order confirmation incorporate six contractual service boundaries:

1. **Frozen design and artwork version:** The quote names the cryptographic hash or version identifier of the approved print file, its dimensions in millimetres, and its placement coordinates relative to a garment landmark (such as 75 mm below the centre-front collar seam in an illustrative placement rule). [S09] Any buyer revision after sign-off cancels the original delivery date and opens a paid change-order revision. [S03]
2. **Qualified substrate and lot identity:** The quote specifies fibre composition, fabric mass per unit area, weave or knit structure, and approved blank or roll lot identifier, noting that substituting another blank brand or fabric lot requires written buyer re-approval. [S01]
3. **Explicit size table or measurement protocol:** For standard sizes (`Case A` and `Case B`), the quote attaches the garment finished-measurement chart and tolerance rather than relying on letter labels (`S`, `M`, `L`, `XL`). [S13] For custom-fitted orders (`Case C`), it records the ISO 8559-1 landmark protocol used, who took the measurements, and who bears the remake cost if buyer-supplied self-measurements are inaccurate. [S13] [S0201]
4. **Screen-to-fabric colour disclaimer and physical reference:** The quote states that uncalibrated screens emit light (RGB) whereas textile inks absorb and reflect light on fibre, so shade-critical orders require approval of a physical strike-off swatch under agreed viewing conditions before bulk printing. [S14] [S22]
5. **Finite-capacity lead time and labour protection:** The OECD Due Diligence Guidance for the Garment and Footwear Sector identifies low wages, inefficient production planning, and poor purchasing practices as three of the most common causes of excessive working hours. [S28] In Cameroon, the inherited register records a standard 40-hour working week, a 48-hour statutory maximum, and overtime at 1.2 times the base rate, within an economy where informal employment is about 90 percent. [R16] GFT proposes that promised delivery dates be calculated strictly from remaining finite capacity across printing, thermal curing (`S15`, `S17`), cutting, and sewing within standard 40-to-48-hour shift schedules, never by offloading overflow work to unvetted informal subcontractors (`S29`). [R16] [S28] [S29]
6. **Structured acceptance window and remedy hierarchy:** The quote defines a fixed inspection window upon delivery (such as five business days in an illustrative term), objective defect criteria (print placement outside tolerance, unapproved shade deviation against the signed strike-off, seam failure, or failed wash fastness), and the ordered sequence of remedies: repair where feasible, reprint within a recovery window, or pro-rata refund upon return of nonconforming garments. [S07] [S11]

WARNING

Operational warning: Rush promises and informal overflow destroy quality and compliance

Accepting last-minute orders without checking thermal curing capacity (S15, S17) and standard shift hours (R16) forces a destructive choice: shorten dryer dwell times (causing uncured binder that washes out per S10), force excessive overtime (S28), or pass sewing bundles to unapproved informal workshops (R16, S29). GFT's proposed order-release gate requires a supervisor-signed capacity reservation across print, cure, cut, and sew before quoting a rush date. [S28] Contract and employment terms require qualified local legal review; this framework provides operational controls, not legal advice.

By locking what the customer is buying, where stock is committed, how permissions are verified, and how working hours and quality gates are protected, the order promise establishes the exact boundary conditions that the technical print route must satisfy. [S01] [S03] Chapter 3 now examines how fibre chemistry, garment construction, and batch volume govern the choice among pigment, reactive, sublimation, direct-to-garment, film-transfer, and screen-printing processes. [S01] [S02]

An on-demand factory does not sell printer time; it sells a bounded promise that an approved specification will become an accepted garment within normal working hours.

CHAPTER SOURCE NOTES

S03 The Korean Fashion and Textile Research Journal. 2025-12-31.

S01 Society for Imaging Science and Technology. 2021.

S28 Organisation for Economic Co-operation and Development. 2018.

S07 3DBODY.TECH conference proceedings. 2020.

S32 arXiv, Korosteleva and Sorkine-Hornung. 2023-06-06.

S15 Epson United Kingdom. 2026.

S30 Epson America. 2026.

R06 Cameroon Trade Hub. Publication date unrecorded; inherited source-text check.

R07 Ecofin Agency. Publication date unrecorded; inherited source-text check.

S09 arXiv, Pietroni and co-authors. 2022.
S0202 Elsevier, Heliyon; author abstract hosted by PubMed. 2023-07-08.
S10 International Organization for Standardization. 2010.
S31 Epson America. 2026.
S02 Wiley, Coloration Technology. 2024-01-29.
S05 Kaunas University of Technology, Materials Science. 2011-07-04.
R14 WageIndicator. Publication date unrecorded; inherited source-text check.
R15 wage.is. Publication date unrecorded; inherited source-text check.
R16 WageIndicator. Publication date unrecorded; inherited source-text check.
R32 Wise; XE. Publication date unrecorded; inherited source-text check.
S12 International Organization for Standardization. 2021.
R26 Statista. Publication date unrecorded; inherited source-text check.
R24 Mordor Intelligence. Publication date unrecorded; inherited source-text check.
R25 Market.us. Publication date unrecorded; inherited source-text check.
S0203 Journal of Visualized Experiments; author abstract hosted by PubMed. 2019-09-27.
S20 Ellen MacArthur Foundation. 2021-11-23.
S13 International Organization for Standardization. 2017.
S29 Organisation for Economic Co-operation and Development. 2026-02-26.
S18 International Finance Corporation. 2014.
S0201 Taylor and Francis, Ergonomics; author abstract hosted by PubMed. 2025-01-08.
S06 Kaunas University of Technology, Materials Science. 2020.
S11 International Organization for Standardization. 2016.
S23 ZDHC Foundation. 2026.
S22 International Color Consortium. 2026.
S14 International Organization for Standardization. 2017.

GREEN FUTURE TECH

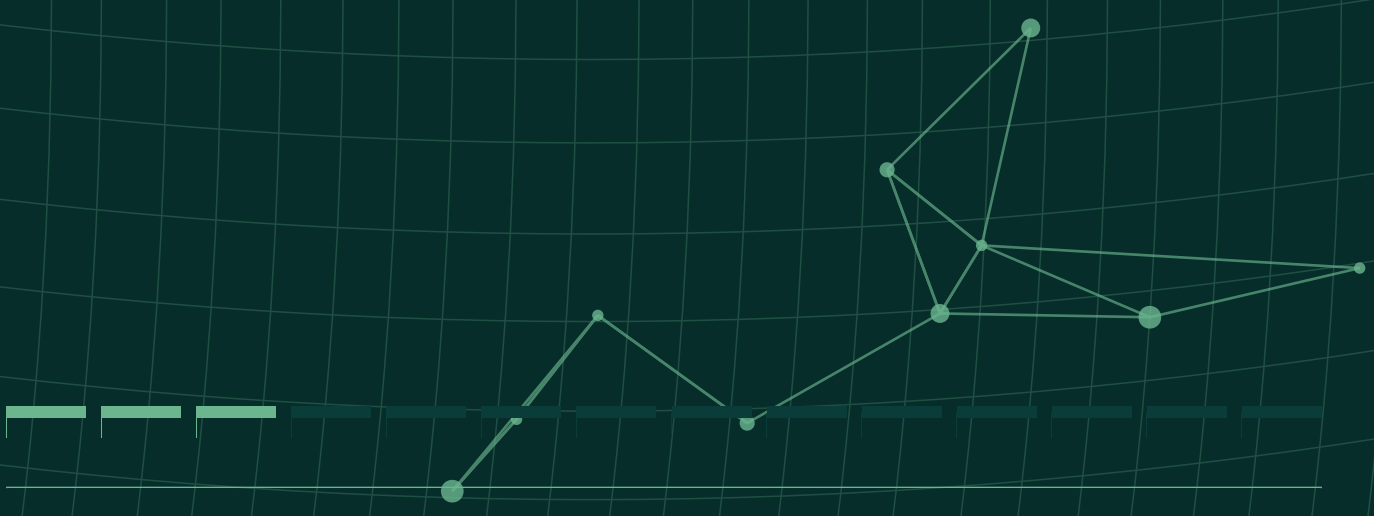
LIMITED / HONG KONG SAR

03

PART I: CONFIRM THE ORDER BEFORE CHOOSING THE MACHINE / PROCESS SELECTION

Fibre and order geometry determine the print route

Select a process against the substrate, print area, quality requirement and true batch cost.



CHAPTER 03
DECISION TEST

Select a process against the substrate, print area, quality requirement and true batch cost.

No single digital printing machine can serve every garment structure, fibre composition, artwork geometry, and batch volume economically. [S01] When an apparel producer selects a printing technology before locking the base fibre, the placement boundary, the end-use laundering specification, and the expected order-size distribution, the factory either buys wet-finishing obligations it cannot operate or accepts garment-decoration limits that exclude cut-and-sew production. [S01] [S02] Green Future Tech Limited (GFT), extending the candidate capabilities identified in the digital strategy of its Cameroon textile programme (prepared on 31 January 2024 alongside the programme's feasibility study and performance-management system design, with source-refresh notes retained in 2026), argues that process selection is a system boundary decision rather than a printhead comparison. [S03] The programme's digital strategy lists digital printing as a candidate capability for staged evaluation, not a deployed GFT asset, and this chapter presents an analytical selection method rather than results from an installed GFT print shop. [S03] In Cameroon, where the inherited sector baseline indicates that about 95 percent of cotton fibre is exported raw against about 5 percent processed locally, and where the National Development Strategy (SND30) restates a 50 percent local-processing target by 2030, an investor or production manager must distinguish between routes that finish locally woven or knitted cotton yardage and routes that decorate ready-made garment blanks. [R06] [R07] Choosing the print route requires matching ink chemistry to the polymer substrate, mapping every pre-print and post-print thermal or wet stage, benchmarking digital unit costs against screen-printing alternatives at realistic acceptance yields, and accounting for maintenance during idle shifts. [S01] [S02] [S31]

3.1

Pigment and reactive routes have different finishing burdens

For cellulosic textiles such as cotton, viscose, and linen roll fabrics, the primary engineering choice in digital roll-to-roll printing lies between pigment ink systems and reactive dye ink systems. [S01] On a computer monitor or in a machinery brochure, both routes appear to deposit cyan, magenta, yellow, black, and spot droplets onto a moving fabric web from piezoelectric printheads. [S01] On the factory floor, however, pigment and reactive chemistries govern completely different chemical bonding mechanisms, utility connections, floor-space footprints, and effluent responsibilities. [S01] [S17] Treating ink chemistry as a drop-in consumable swap is a recurring cause of failed capital budgets in short-run apparel projects. [S01]

Pigment printing attaches insoluble colourant particles to the surface of the textile fibres through a polymeric binder matrix and cross-linking mechanism rather than forming a covalent bond inside the fibre polymer. [S01] As the Society for Imaging Science and Technology status report notes of pigment digital textile printing, "The fixation is operated only by dry heat." [S01] Because curing relies on passing the printed cloth through a dry-heat oven or conveyor dryer to polymerise the binder film, a pigment roll line avoids high-pressure steam fixation and multi-stage post-print washing ranges. [S01] That streamlined finishing path reduces process water intake and avoids

dyed wash-off effluent at the fixation stage, making pigment roll printing attractive for urban microfactories or cut-and-sew workshops operating without an industrial wastewater treatment plant. [S01] [S26]

Yet dry fixation does not make pigment printing a chemical-free or energy-free operation. [S01] [S17] Untreated cotton fibres carry a complex capillary structure that causes low-viscosity inkjet droplets to wick along yarns and penetrate deep into the interstices of the cloth. [S0302] As surface-chemistry research on cotton inkjet printing confirms, "In cotton fabric inkjet printing, the spreading and penetration of the ink seriously damage printing resolution and color strength." [S0302] To hold pigment particles on the optical surface of the yarn, increase colour yield, and protect wet and dry rubbing fastness, cotton yardage normally requires a chemical pretreatment pad or coating application followed by thermal drying before printing. [S01] [S24] Furthermore, because the cured polymeric binder encapsulates the surface fibres, heavy pigment ink laydowns can stiffen the fabric hand feel and remain more vulnerable to mechanical abrasion and wet crocking than dyes fixed inside the fibre interior. [S01] [S11]

Reactive printing follows a fundamentally different chemical pathway designed specifically for cellulosic and protein fibres. [S01] Reactive dye molecules penetrate the swollen amorphous regions of the cellulose polymer and, in the presence of an alkali and moisture at elevated temperature, react with hydroxyl groups on the cellulose chains to form covalent bonds. [S01] [S02] Because inkjet printheads cannot tolerate high-viscosity printing pastes or aggressive alkaline solutions inside the firing chambers without nozzle corrosion and premature hydrolysis, the thickening agent (such as sodium alginate or hydroxypropyl methyl cellulose), alkali (such as sodium carbonate or sodium bicarbonate), and hydrotropic urea must be padded onto the fabric as a controlled pretreatment layer and dried prior to inkjet deposition. [S0301] [S0302] As recent research on cotton inkjet preparation emphasises, "Natural polymer pretreatment was the essential process to enhance the quality of textile inkjet printing." [S0301]

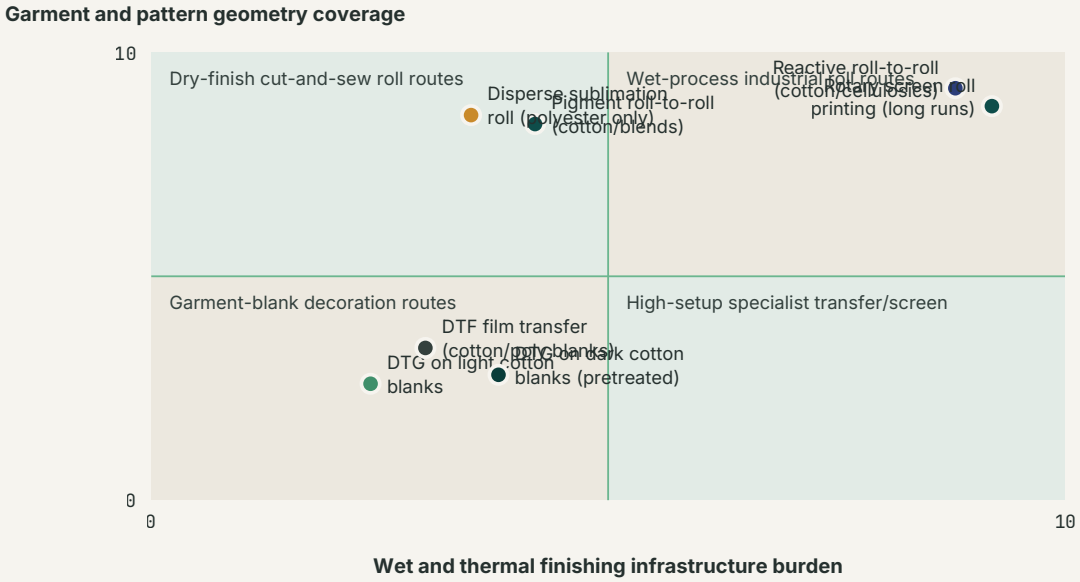
Once the reactive ink droplets land on the pretreated cotton web, the colour is not yet fixed to the cellulose. [S01] The printed roll must pass through an intermediate drying zone, enter a saturated steamer at controlled temperature and humidity to drive the covalent fixation reaction, and then undergo an intensive multi-bath washing-off and soaping sequence to remove unfixed hydrolysed dye, residual alkali, urea, and thickener film before final stentor drying. [S01] [S02] Without complete washing-off, unfixed reactive dye bleeds onto adjacent white or light panels during the customer's first domestic or commercial launderings. [S10] Consequently, reactive digital printing delivers superior softness of hand, brilliant chroma, and high wash fastness on cotton shirting and dress fabrics, but it obliges the factory to fund, staff, power, and permit a complete wet-finishing and effluent-management line. [S01] [S17]

GFT proposes that procurement and production engineering teams never approve a print route without compiling a full **Process Route Sheet** that documents every chemical, thermal, mechanical, and environmental stage from raw substrate receipt to cut-ready cloth or pack-ready garment. [S01] [S17] To illustrate how substrate polymer class and order geometry jointly constrain route selection, **Exhibit 10**, p. 48 places

the major textile printing candidates across two engineering dimensions: the wet and thermal finishing infrastructure burden required on site, and the breadth of garment and pattern geometry the route can serve. [S01] [S15] [S30]

EXHIBIT 10 / ILLUSTRATIVE ENGINEERING INDEX (0 TO 10)

A route must fit both the fibre and the service



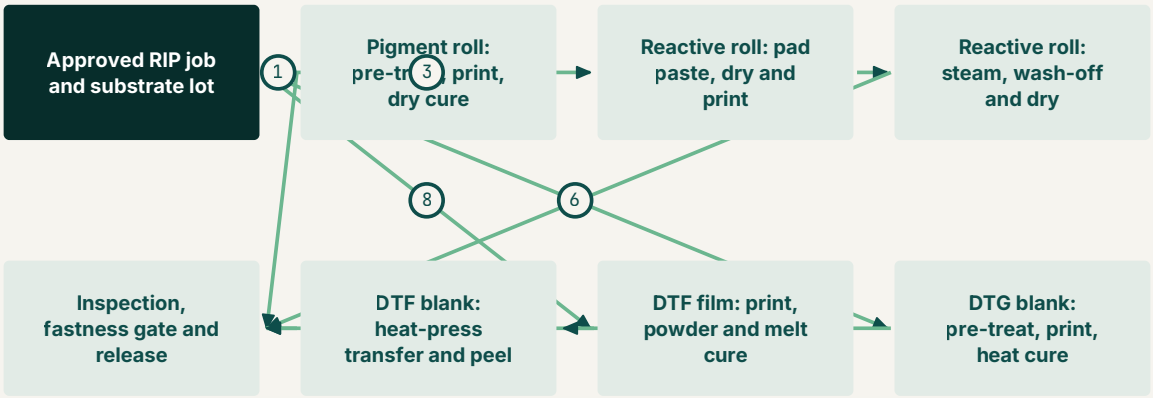
ILLUSTRATIVE [S01] [S15] [S30] Illustrative GFT qualification matrix informed by S01, S15 and S30. Horizontal axis scores on-site wet, chemical and thermal finishing infrastructure burden (0 = compact heat press only, 10 = industrial padding, steaming, multi-stage washing, stentor drying and effluent plant). Vertical axis scores structural and geometric versatility across garment panels (0 = platen-constrained spot decoration on blanks, 10 = full-width roll yardage and seam-to-seam engineered cut-and-sew panels).

As **Exhibit 10**, p. 48 demonstrates, garment-blank decoration routes (DTG and DTF in the lower-left quadrant) keep on-site wet infrastructure modest because the garment has already been knitted, scoured, bleached, dyed, cut, and sewn upstream, but they cannot produce full-width engineered cut-and-sew yardage. [S01] [S15] Conversely, moving into the upper half of **Exhibit 10**, p. 48 enables seam-to-seam panel printing for custom cut-and-sew apparel, while forcing a strategic choice between the dry-heat cure of pigment roll printing on the upper left and the steaming and washing plant of reactive roll printing on the upper right. [S01] What **Exhibit 10**, p. 48 cannot establish is universal machine superiority: each point remains conditional on passing buyer fastness standards, local utility reliability, and batch-cost verification. [S02] [S17]

To make the hidden auxiliary steps behind these routes explicit before capital commitment, **Exhibit 11**, p. 49 maps the sequential process transformations across pigment roll printing, reactive roll printing, direct-to-garment (DTG) printing, and direct-to-film (DTF) transfer. [S01] [S15]

EXHIBIT 11 /

Finishing steps distinguish routes that look similar on screen



1. Roll cotton (dry route)
3. Roll cotton (wet route)
6. Finished blank (direct)
8. Finished blank (transfer)

ILLUSTRATIVE [S01] [S15] [S17] Illustrative GFT process comparison synthesised from S01 (pigment dry-heat fixation versus reactive steaming and washing), S15 (DTG pretreatment and heat cure versus DTF film printing, adhesive powder, melting and heat pressing) and S17 (thermal drying and wet-treatment boundaries). Represents required engineering stages, not an installed GFT line.

Inspecting **Exhibit 11**, p. 49 confirms why printer-only capital quotes mislead project sponsors. [S01] In every branch, ink deposition is bracketed by chemical preparation and thermal or wet post-processing. [S15] [S17] As the International Finance Corporation (IFC) guidelines for textile manufacturing state, "Heat consumption is particularly significant in drying and curing operations and in activities involving wet treatments." [S17] A feasibility model that prices the inkjet carriage while omitting the pad mangle, pre-dryer, curing conveyor, steamer, washing range, or extraction hood understates both capital expenditure and unit energy cost. [S01] [S17] What **Exhibit 11**, p. 49 cannot show on its own is the quantitative water, kilowatt-hour, and chemical balance of each node, which must be metered on site using the resource-intensity methods of wp06 and the life-cycle boundaries of Chapter 11. [S17] [S26]

3.2

Sublimation is a separate substrate decision

In regional commercial printing markets, dye-sublimation transfer printers are widely promoted to apparel startups because the hardware is relatively inexpensive, the transfer paper acts as a mechanical buffer between the printhead and the cloth, and fixation requires a dry calender or flat heat press rather than a steamer and washing range. [S01] That operational simplicity regularly tempts entrepreneurs to propose

sublimation transfer for local cotton T-shirts, polo shirts, or woven cotton garments. [S01] From a polymer-chemistry standpoint, however, disperse dye-sublimation is a synthetic-substrate process and cannot serve as a direct cotton-printing route. [S01]

Sublimation transfer relies on low-molecular-weight disperse dyes printed in reverse onto a coated release paper or applied directly to prepared polyester cloth. [S01] When heated in a thermal calender or press (typically near two hundred degrees Celsius in standard industrial practice, illustrative of thermal transfer conditions), the disperse dye transitions into the gas phase and diffuses into the amorphous regions of hydrophobic thermoplastic polymers, primarily polyethylene terephthalate (polyester), whose polymer chains gain segmental mobility above their glass-transition temperature. [S01] As the polyester cools below its glass-transition threshold, the polymer chains close around the dissolved dye molecules, trapping the colour inside the synthetic fibre with high wash and rubbing fastness and zero perceptible change to the fabric hand feel. [S01]

Cellulosic cotton fibres do not undergo a thermoplastic glass-transition opening that accepts non-ionic disperse dyes from the vapour phase, nor do cotton hydroxyl groups form stable chemical or solid-solution bonds with sublimed disperse dye molecules. [S01] If an operator heat-presses a sublimation transfer paper onto pure, unmodified cotton cloth, any superficial staining washes out rapidly during the first domestic laundering cycle. [S01] [S10] Workarounds marketed to small workshops, such as spraying acrylic or polyester-resin coatings onto cotton garments or laminating thick polymeric glitter and flock films to receive sublimed dye, effectively convert the garment surface into a synthetic plastic film, degrading breathability, altering hand feel, and introducing wash-delamination risks that require full care testing under ISO 105-C06:2010 and ISO 6330:2021 scopes. [S10] [S12]

GFT therefore recommends that programme sponsors and local apparel producers maintain a strict analytical and commercial separation between polyester sublimation and cotton value-addition. [R06] [S01] Producing sublimated polyester teamwear, athletics jerseys, promotional banners, or soft signage on imported synthetic knitwear can be a viable commercial service in Cameroon if local institutional and sports buyers pay for rapid customisation. [S03] However, decorating imported polyester fabric via disperse sublimation does not process a single kilogram of domestic Cameroonian cotton lint and cannot be counted toward closing the national gap between raw cotton-fibre exports (about 95 percent) and local processing (about 5 percent) or achieving the SND30 target of 50 percent local cotton processing by 2030. [R06] [R07] Where a product line combines polyester sportswear with cotton casualwear, the factory must budget separate ink sets, separate substrate inventories, and separate environmental and fastness records for each polymer stream. [S01] [S23]

3.3

DTG decorates garments directly

When the commercial offer is rapid surface decoration of stocked cotton or cotton-rich garments (such as Illustrative Case A and Illustrative Case B introduced in Chapter 2), direct-to-garment (DTG) inkjet printing eliminates roll-to-roll fabric handling and post-print cutting by jetting aqueous textile pigment inks directly onto a sewn blank mounted on a rigid platen. [S15] [S30] Because the garment seams, collar,

and hem already exist, DTG shifts engineering attention from web tension and marker nesting to garment preparation, platen geometry, underbase opacity, and thermal curing. [S15] [S30]

The physics of DTG printing divide sharply between light-coloured garments and dark-coloured garments. [S15] [S30] On a white or very pale cotton blank where only cyan, magenta, yellow, and black (CMYK) pigment inks are required, the cotton fibres themselves supply the reflective white background behind the translucent colour droplets, although pretreatment may still be specified to sharpen fine lines and boost wash durability. [S15] [S30] On a dark or brightly dyed cotton blank, translucent CMYK inks disappear into the dark substrate unless the printer first deposits an opaque titanium-dioxide white ink underbase layer beneath the graphic. [S15] [S30] As Epson America's technical guidance for garment printers states explicitly, "When using white ink or printing onto polyester, pre-treatment is necessary." [S30]

Liquid pretreatment in a dark-garment DTG workflow performs two indispensable functions: it chemically coagulates or immobilises the titanium-dioxide white ink droplets the instant they strike the surface of the cotton yarn so they do not wick into the interior of the knit loop, and it promotes adhesion between the cotton surface, the white underbase, and the subsequent wet-on-wet colour pass. [S15] [S30] If pretreatment liquor is sprayed unevenly, applied at the wrong gram-per-square-metre add-on weight, or dried under inconsistent pressure before printing, cotton hairiness pokes through the white underbase (causing pinholing and dull colour), or excess chemical pools around the graphic perimeter, leaving a visible yellow or glossy box mark after heat curing. [S15] [S30]

Following ink deposition, the printed garment remains wet and unfixed until the polymeric binder is cross-linked. [S15] As Epson United Kingdom's garment-printing guide notes, "The final stage is curing the inks using heat." [S15] Thermal curing may be performed in a flat clam or swing-away heat press, a drawer curing oven, or a forced-air conveyor tunnel dryer. [S15] Each curing device imposes a different operational trade-off: a flat heat press is compact and flattens raised cotton fibres during pre-treat drying, but can flatten the surface texture of the ink film and scorch heat-sensitive dyes if dwell time and platen pressure are not tightly governed; a conveyor tunnel dryer cures continuous runs without mechanical contact pressure and removes evaporated water and glycol carrier vapours more uniformly, but demands substantially higher electrical power and local exhaust ventilation. [S15] [S17]

GFT proposes that any local apparel service evaluating DTG printing qualify light blanks and dark blanks as two distinct production processes with separate cycle times, consumable budgets, and quality checks: [S15] [S30]

- **Blank construction and surface hairiness:** Combed ring-spun cotton jersey with a tight, smooth knit surface yields sharper fine-line typography and requires less white underbase ink than loose, hairy carded open-end jersey. [S02] [S15]
- **Pretreatment application and drying control:** Standardise liquor dilution, spray-nozzle pass speed or roller pick-up, wet add-on mass checked by weighing test blanks before and after spraying, and pre-print drying temperature and time. [S15] [S30]

- **Platen selection and seam clearance:** Match platen dimensions to the garment size so side seams, collar ribs, pocket edges, and zipper plackets hang below the printing plane; raised seams risk printhead strikes or variable throw-distance blurring. [S15]
- **White-ink agitation and nozzle verification:** Perform logged daily agitation of white pigment ink packs and print a nozzle-check pattern at the start of every shift before loading customer blanks. [S31]
- **Thermal cure verification:** Verify actual garment-surface temperature and residence time inside the press or tunnel dryer using thermal strips or a calibrated pyrometer rather than relying solely on controller setpoints, then validate wash and rubbing fastness under ISO 105-C06:2010 and ISO 105-X12:2016 scopes. [S10] [S11] [S17]

> **GFT NOTE**
>
> Never accept a vendor's DTG cost-per-print estimate based on a single-pass CMYK graphic on a white T-shirt if your target catalogue includes dark uniforms or vibrant street-wear graphics. In GFT's proposed route-qualification protocol, dark-garment DTG must be costed and timed as a six-stage operation: blank inspection, liquid pretreatment application, pretreatment drying and fibre flattening, white-underbase plus colour pass printing, thermal curing, and post-cure cooling and wash-fastness verification. [S15] [S30] Both ink consumption and platen residence time on dark garments typically exceed light-garment figures by a substantial margin, which must be measured directly on the candidate machine using the factory's own artwork files before quoting unit prices. [S15] [S30]

3.4

Film transfer adds adhesive and handling stages

Over the past several years, direct-to-film (DTF) transfer printing has emerged as a widely adopted alternative or companion to DTG for garment decoration. [S15] [S30] Instead of mounting a garment on a printer platen and pretreating the cloth directly, a DTF workflow jets water-based pigment inks onto a coated polyethylene terephthalate (PET) release film, printing the colour layers first and a white ink backing layer directly on top of the wet colour image. [S15] While the printed ink on the film remains wet, the film passes through a powder shaker or manual applicator that coats the tacky ink surface with a granular thermoplastic polyurethane (TPU) hot-melt adhesive powder, shakes or vacuums off excess powder from the unprinted film background, and passes the powdered film through a thermal curing oven or heater plate to melt the granules into a continuous adhesive backing. [S15]

To decorate the garment, the operator places the cured transfer film onto the blank at a heat press, presses at the specified temperature, pressure, and dwell time so the remelted TPU adhesive flows into the surface yarns of the cloth, peels away the carrier PET film (either hot or cold depending on the film release coating), and frequently performs a brief second post-press to embed the transfer edges into the knit struc-

ture. [S15] Many commercial DTG printers can also be configured to print onto film sheets in a hybrid DTG/DTF mode, while dedicated roll-to-roll DTF lines couple a wide-format printer to an inline powder-shaker and curing tunnel. [S15] [S30]

From a shop-floor scheduling perspective, DTF changes the decoupling geometry of blank decoration in three ways. [S03] [S15] First, because ink is printed onto a flat, dimensionally stable plastic film rather than directly onto a fibrous textile, DTF avoids spraying liquid pretreatment onto dark cotton garments and can transfer graphics onto substrates that are awkward to load onto a flat DTG platen, including sleeve cuffs, cap fronts, pocket flaps, nylon windbreakers, and cotton-polyester workwear blends. [S15] [S30] Second, printing can be nested tightly across a continuous film roll and stored in dry conditions as pre-printed transfers, allowing a small workshop to print multiple chest logos in one nested film batch and press them onto garments later as individual size orders arrive. [S03] [S15] Third, however, DTF introduces its own physical, tactile, environmental, and occupational health constraints that must be weighed before choosing it over direct ink deposition. [S15] [S17]

Because a DTF transfer bonds a continuous layer of pigment ink, white underbase, and melted thermoplastic adhesive polymer onto the face of the garment, large solid-area graphics create an impermeable, patch-like film that restricts air and moisture-vapour transmission across the chest or back, which is a major comfort liability in Cameroon's warm, humid coastal and equatorial climates. [S15] If the artwork is not carefully halftoned or knocked out, or if adhesive powder granulation and curing temperature are poorly controlled, the transfer feels stiff and rubbery, cracks under repeated biaxial stretching of a knitted jersey, or peels at sharp corners after repeated domestic laundering and tumble or line drying. [S10] [S12] [S15]

Furthermore, DTF shifts waste and chemical exposure into two areas that require explicit shop-floor governance. [S17] [S23] Every square metre of DTF production generates a square metre of stripped PET release film coated with residual release silicones or waxes that cannot be recycled through cotton-textile waste streams and must be disposed of as solid plastic waste. [S15] At the powder-application and curing stage, agitating fine thermoplastic adhesive granules and heating them alongside glycol-containing inkjet inks releases particulates and thermal fumes that require local exhaust capture, respiratory and skin protection, and chemical screening against the ZDHC Manufacturing Restricted Substances List (MRSL) rather than unvented room operation. [S17] [S23]

GFT therefore recommends that a factory evaluate DTF and DTG as complementary, geometry-specific tools rather than treating DTF as a universal replacement for direct textile printing: [S15] [S30]

1. **Small emblems, multi-location logos, and mixed-fibre workwear:** Where a buyer orders left-chest emblems, back-neck labels, sleeve badges, or durability-tested logos on poly-cotton or nylon workwear (such as elements of Illustrative Case B), DTF avoids full-garment pretreatment and cumbersome sleeve-platen changes, provided peel resistance and wash fastness pass ISO 105-C06:2010 and ISO 105-X12:2016 evaluations. [S10] [S11] [S15]

2. **Large breathable graphics on pure cotton casualwear:** Where a buyer orders a large chest or back graphic on a soft ring-spun cotton T-shirt (Illustrative Case A) and expects a breathable, soft hand feel, direct-to-garment (DTG) printing, especially on light blanks or with well-knocked-out dark-garment designs, avoids gluing a continuous thermoplastic sheet across the wearer's torso. [S15] [S30]
3. **All-over and seam-to-seam engineered garments:** Neither DTG nor DTF can print continuously across uncut garment panels for seam-matched assembly (Illustrative Case C); those orders belong to roll-to-roll pigment or reactive printing connected to precision cutting and sewing. [S01] [S09]

3.5

Screen printing remains a valid comparator

Enthusiasm for digital printing often leads business plans to compare a new digital printer only against another digital printer, ignoring conventional flat-bed or rotary screen printing. [S01] [S02] In industrial reality, screen printing remains the dominant global volume benchmark for both roll-to-roll textile yardage and multi-hundred-unit garment decoration because, once screens are engraved, registered, and mounted, paste deposition per unit is fast and chemical cost per square metre or per garment is substantially lower than formulated piezoelectric inkjet ink. [S01] [S02] As a recent integrated review in *Coloration Technology* observes, "However, due to its high complexity, rotary printing requires great technical knowledge." [S02] That same review underscores that rotary and flat-screen processes remain vital industrial comparators whose competence, substrate preparation, paste rheology, and end-use fastness properties set the commercial bar that any digital route must clear. [S02]

The economic boundary between digital printing and screen printing is governed by the trade-off between **fixed batch setup cost** and **variable cost per accepted unit**. [S01] [S02] In flat-screen garment printing or rotary-screen roll printing, every distinct colour separation in an artwork file requires a physical screen frame or nickel cylinder, emulsion coating, ultraviolet exposure, washout, drying, press registration, strike-off approval, and post-run paste reclamation and screen washing. [S02] [S26] For a six-colour motif ordered in a batch of fifteen garments or twenty metres of cloth, amortising six screen setups and press washdowns across fifteen units makes screen printing prohibitively expensive and slow, giving digital printing (where setup is a software rasterisation and nozzle check) a decisive cost and lead-time advantage. [S01] [S26]

However, when an institutional buyer in Cameroon orders five hundred identical uniform polo shirts or two thousand metres of a stable two-colour school or corporate print, the fixed cost of engraving and registering two or three screens spreads thinly across the batch. [S02] At that volume, the high millilitre price of digital inkjet inks, liquid pretreatment, or transfer film and powder causes the digital total-cost curve to rise steeply above the screen-printing curve. [S01] [S15] A short-run cost and environmental advantage at small batch sizes (such as the historical Finnish case study by VTT Technical Research Centre of Finland, which found that "When smaller printing batches are studied, digital printing causes less greenhouse gas emissions than screen printing" [S26]) does not establish that digital printing wins at every repeat order volume. [S02] [S26]

METHOD

Method: Yield-adjusted batch-cost and route crossover model

To compare candidate print routes `i = 1, 2, ..., M` (such as DTG, DTF, digital roll pigment, and flat-screen or outsourced rotary printing) for a specific garment style and colour count requiring `q` **accepted** units, GFT defines the complete batch production cost `C_i(q)` in CFA francs (XAF) as: [S01] [S02]

```
C_i(q) = F_i + (v_i / y_i) * q
```

where each parameter is defined and measured at the same process boundary: [S01] [S15]

- `F_i` (non-negative, in XAF per batch) is the **fixed batch setup cost** for route `i`, comprising prepress file preparation, colour separation and screen engraving or RIP queueing, machine setup and registration labour, setup strike-off substrates and ink, and post-batch washdown or line changeover (`F_i = C_prepress,i + n_col * C_screen,i + C_reg,i + C_clean,i`). [S02] For digital routes where the screen count `n_col` is zero, `F_i` is small but strictly positive because operator job setup, platen change, and first-article check still consume paid minutes and test consumables. [S15]
- `v_i` (positive, in XAF per started garment or linear metre) is the **direct variable cost per started unit** on route `i`, summing the unprinted blank or prepared fabric (`u_sub,i`), pretreatment chemical (`u_pre,i`), deposited and purge-allocated ink or paste (`u_ink,i`), film and adhesive powder where applicable (`u_tf,i`), thermal drying and curing energy (`u_eng,i`), direct operator and helper labour at practical throughput (`u_lab,i`), and per-unit maintenance and printhead amortisation (`u_mnt,i`), so that `v_i = u_sub,i + u_pre,i + u_ink,i + u_tf,i + u_eng,i + u_lab,i + u_mnt,i`. [S15] [S17] [S30]
- `y_i` (between 0 and 1) is the **first-pass accepted yield** of route `i` (accepted units divided by started units after inspection and fastness verification), so that producing `q` accepted garments requires `q / y_i` started units (or the rounded-up integer starts in discrete shop-floor scheduling). [S11] [S21]

When comparing a lower-setup, higher-variable-cost digital route `d` (`F_d` less than `F_s`) against a higher-setup, lower-variable-cost screen route `s` (`F_s` greater than `F_d`) on the same substrate and quality specification, a finite positive **crossover batch volume** `q*_d,s` exists if and only if the yield-adjusted variable cost of screen printing is strictly lower than that of digital printing (`v_s / y_s` less than `v_d / y_d`): [S01] [S02]

```
q*_d,s = (F_s - F_d) / ((v_d / y_d) - (v_s / y_s))
```

For accepted batch demands `q` below `q*_d,s`, route `d` yields the lower total batch cost; for batch demands `q` above `q*_d,s`, route `s` yields the lower total batch cost. If `v_s / y_s` is greater than or equal to `v_d / y_d`, route `d` dominates across all positive volumes. Full sensitivity extensions including remakes, refunds, and multi-period capital recovery are developed in Chapter 9. [S02]

WORKED EXAMPLE: ILLUSTRATIVE BATCH-COST CROSSOVER ACROSS DTF, DTG, AND FLAT-SCREEN DECORATION

Consider an illustrative route-selection calculation for a batch of dark navy ring-spun cotton crew-neck T-shirts (180 grams per square metre) carrying a four-colour front chest graphic measuring 240 mm by 280 mm (Illustrative Case A). All monetary figures in this box are **illustrative** operational inputs in CFA francs (XAF) constructed solely to demonstrate the crossover arithmetic; they are not quotes from a Cameroon supplier or operating results from a GFT facility. Using the reference exchange-rate note in R32 (where the CFA franc is pegged to the euro at 655.957 XAF per euro and recent US dollar estimates sit near 563 to 577 XAF per US dollar), an operator can translate foreign consumable quotes into XAF while keeping currency assumptions explicit. [R32]

Suppose the production manager evaluates three candidate routes that have all passed initial wash and rubbing fastness checks under ISO 105-C06:2010 and ISO 105-X12:2016 scopes on the same blank lot (illustrative blank cost `u_sub = 2,200 XAF` per started garment across all three routes): [S10] [S11]

1. **Route 1 (Direct-to-film transfer, DTF):** Illustrative fixed batch setup `F_DTF = 6,000 XAF` (RIP nesting, film loading, and heat-press verification). Illustrative variable conversion cost per started shirt is 1,420 XAF (comprising 850 XAF for CMYK+white ink, PET film, and TPU powder; 150 XAF for curing and press electricity; 270 XAF for operator printing, weeding, and two-stage pressing labour; and 150 XAF for head and maintenance allocation), giving total variable cost per start `v_DTF = 2,200 + 1,420 = 3,620 XAF`. With an illustrative first-pass accepted yield `y_DTF = 0.960`, the yield-adjusted variable slope is `v_DTF / y_DTF = 3,620 XAF / 0.960 = 3,770.83 XAF` per accepted shirt. [S15]
2. **Route 2 (Dark-garment DTG with liquid pretreatment):** Illustrative fixed batch setup `F_DTG = 9,500 XAF` (pre-treat spray calibration, nozzle check, platen setup, and wash test confirmation). Illustrative variable conversion cost per started shirt is 1,835 XAF (comprising 320 XAF for liquid pretreatment; 1,050 XAF for white underbase and CMYK pigment ink; 185 XAF for double thermal drying and curing electricity; 160 XAF for platen loading and spray labour; and 120 XAF for maintenance and head reserve), giving `v_DTG = 2,200 + 1,835 = 4,035 XAF`. With an illustrative first-pass accepted yield `y_DTG = 0.950` (reflecting occasional pre-treat box marks or lint defects), the yield-adjusted variable slope is `v_DTG / y_DTG = 4,035 XAF / 0.950 = 4,247.37 XAF` per accepted shirt. [S15] [S30]
3. **Route 3 (Four-colour manual/semi-automatic flat-screen printing with high-opacity water-based ink):** Illustrative fixed batch setup `F_SCR = 78,000 XAF` (four film positives, four screen coatings and exposures, press registration, strike-off shirts, and post-run screen reclamation). Illustrative variable conversion cost per started shirt is 646 XAF (comprising 260 XAF for screen paste; 190 XAF for flash and tunnel dryer energy; and 196 XAF for crew printing and unloading labour), giving `v_SCR = 2,200 + 646 = 2,846 XAF`. With an illustrative first-pass accepted yield `y_SCR = 0.940` (accounting for registration and screen-drying rejects during short runs), the yield-adjusted variable slope is `v_SCR / y_SCR = 2,846 XAF / 0.940 = 3,027.66 XAF` per accepted shirt. [S02] [S17]

Applying the crossover formula from the method box reveals two critical operational insights in this illustrative scenario: [S01] [S02]

- **DTF versus DTG on this graphic:** Because `F_DTF` is less than `F_DTG` and `v_DTF / y_DTF` is less than `v_DTG / y_DTG`, DTF has a lower monetary cost than dark-garment DTG at every batch size for this specific four-colour emblem. A buyer would

choose DTG over DTF here only if the specification requires the softer, more breathable hand feel of direct ink deposition without a continuous TPU adhesive film. [S15]

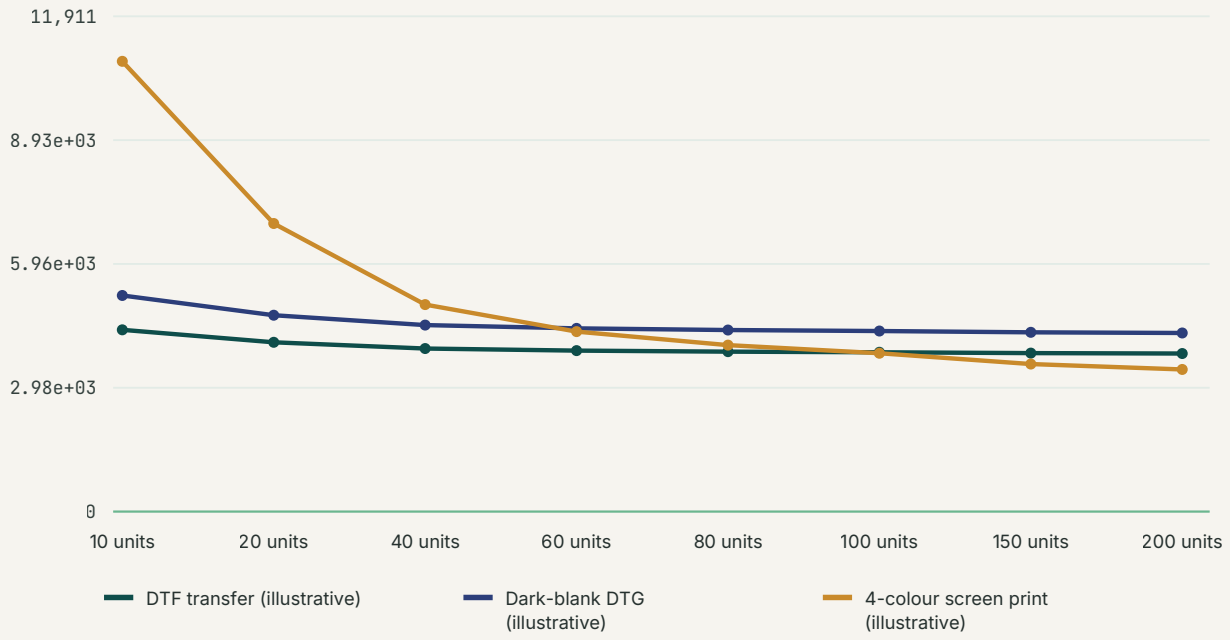
- **Digital versus Flat-Screen crossover:** Comparing DTF against flat-screen printing gives an illustrative crossover volume of $q^*_{DTF,SCR} = (78{,}000 - 6{,}000) / (3{,}770.83 - 3{,}027.66) = 72{,}000 / 743.17 = 96.88$ accepted shirts, whereas comparing dark-garment DTG against flat-screen printing gives an illustrative crossover volume of $q^*_{DTG,SCR} = (78{,}000 - 9{,}500) / (4{,}247.37 - 3{,}027.66) = 68{,}500 / 1{,}219.71 = 56.16$ accepted shirts. [S02] [S15]

Thus, under these illustrative parameters, DTG is cheaper than four-colour screen printing up to 56 accepted shirts, DTF is cheaper than four-colour screen printing up to 96 accepted shirts, and four-colour screen printing achieves the lowest unit cost from 97 accepted shirts upward. At an illustrative batch of $q = 20$ accepted shirts, total batch cost is 81,417 XAF (4,071 XAF per shirt) for DTF, 94,447 XAF (4,722 XAF per shirt) for DTG, and 138,553 XAF (6,928 XAF per shirt) for screen printing. At $q = 150$ accepted shirts, total batch cost reverses to 532,149 XAF (3,548 XAF per shirt) for screen printing versus 571,625 XAF (3,811 XAF per shirt) for DTF and 646,605 XAF (4,311 XAF per shirt) for DTG.

The unit-cost trajectories from this illustrative worked case are plotted across batch sizes from 10 to 200 accepted shirts in **Exhibit 12**, p. 57, demonstrating why a disciplined on-demand business retains screen printing (either in-house or through a qualified local subcontractor) as a comparator for larger repeat orders. [S01] [S02]

EXHIBIT 12 / ILLUSTRATIVE XAF PER ACCEPTED GARMENT

The cheapest route can change with accepted batch volume



ILLUSTRATIVE [S01] [S02] [S15] Illustrative unit-cost curves $C_i(q)/q = F_i/q + v_i/y_i$ from the worked example for a four-colour graphic on dark cotton T-shirts. Inputs are illustrative assumptions (DTF: F=6,000 XAF, v/y=3,771 XAF; DTG: F=9,500 XAF, v/y=4,247 XAF; 4-colour screen: F=78,000 XAF, v/y=3,028 XAF), not observed Cameroon quotes or GFT operating data. Crossover occurs near 56 shirts (DTG vs screen) and 97 shirts (DTF vs screen).

Exhibit 12, p. 57 shows why quoting a flat per-shirt price without knowing the batch volume and colour count exposes a print shop to adverse selection. [S02] In small batches of 10 to 40 units, screen-printing unit costs spike above 4,900 XAF per shirt because screen preparation dominates the batch, whereas DTF and DTG flatten the curve by eliminating physical screens. [S01] [S15] Above 100 accepted units, the lower ink cost of screen paste pulls the screen-printing curve below both digital routes in this four-colour illustration. [S02] What **Exhibit 12**, p. 57 cannot establish is a universal national crossover number for Cameroon: if an artwork contains twelve photorealistic tonal gradations rather than four spot colours, screen setup cost F_{SCR} triples and pushes the crossover point far above two hundred shirts; conversely, if local electricity tariffs or imported OEM ink prices rise, the digital variable slope steepens. [S01] [S17] Every producer must populate the `unit-economics` tool with its own dated local supplier quotes and measured pilot yields. [S02]

3.6

Nominal speed is not good-garment throughput

Equipment brochures for digital textile and garment printers routinely headline maximum carriage speed in square metres per hour or shirts per hour measured in draft print mode without loading, pretreatment, drying, or maintenance pauses. [S01] [S31] If a feasibility spreadsheet multiplies that nameplate speed by eight hours a shift and two hundred and fifty working days a year, the resulting capacity forecast is an engineering fiction. [S31] In short-run on-demand production, actual **good-garment throughput** (accepted garments produced per paid staffed hour) is governed by non-printing handling steps, thermal curing bottlenecks, quality-assurance holds, and mandatory machine maintenance. [S15] [S17] [S31]

Consider the physical work cycle required to produce a single dark cotton garment on a single-platen DTG line. [S15] [S30] Before the printhead fires, an operator must unpack and inspect the blank, mount it on the pre-treatment spray platen, apply the metered pre-treatment liquor, transfer the wet shirt to a heat press or dryer to evaporate the water carrier and flatten raised cotton fibres, load the dried shirt onto the printer platen, smooth out wrinkles and verify seam clearance, confirm the correct RIP job file and print height, execute the white underbase pass and the CMYK colour pass, unload the wet printed shirt onto the curing press or conveyor tunnel dryer, wait for the thermal cure and cooling cycle, and inspect the finished print for nozzle dropouts, registration shift, or pre-treat staining. [S15] [S30] Even if the printhead carriage completes its passes in ninety to one hundred and twenty seconds (illustrative of production-quality multi-pass modes), manual loading, pre-treating, heat-pressing, and job changeover frequently limit sustained single-operator output unless upstream pre-treatment and downstream curing are balanced with separate equipment and staff. [S15] [S17]

Furthermore, digital inkjet printheads require scheduled cleaning, purging, and ink-agitation routines that consume both operator time and expensive ink whether customer orders are running or the shop floor is completely idle. [S31] Titanium-dioxide particles in white DTG and DTF inks have a higher specific gravity than the aqueous carrier vehicle and settle toward the bottom of ink supply packs, dampers, and lines if left stationary. [S31] As the Epson SureColor F2270 user guide instructs

operators, "Shake the White ink supply units once a day, and shake the color ink supply units once a month." [S31] Alongside daily pack shaking, piezoelectric garment and roll printers perform automated or manual head cleanings, wiper-blade and capping-station maintenance, and white-ink recirculation flushes that discharge ink into the waste-ink pad or bottle. [S31]

When an on-demand workshop operates at low or intermittent order volume during its launch phase, maintenance purge ink and daily operator care become a fixed daily overhead that can exceed the ink deposited onto sold garments. [S31] General factory methods for decomposing calendar time into availability, performance speed, and first-pass quality yield are owned by `wp15` (and modelled in the `oee-line` and `line-balancing` tools), while `wp20` specifies the print-specific time states and consumable losses that must enter the shop-floor log under GFT's Cameroon textile programme performance-management design. [S17] [S31]

To prevent equipment procurement teams from evaluating printers on brochure speed and hardware price alone, **Exhibit 13**, p. 60 defines the mandatory operational and financial fields that GFT requires in every supplier quotation and acceptance trial before a route is approved. [S17] [S30] [S31]

EXHIBIT 13 / REQUIRED PROCUREMENT AND PILOT LOG FIELDS

Printer specifications omit costs that the service must carry

Cost or capacity category	Brochure omission risk	Required GFT measurement and unit
Good-garment throughput	Quotes draft-mode carriage speed only	Accepted garments or m2 per staffed hour at approved pass count
Pretreatment liquor and labour	Excludes dark-blank spray, waste and press time	Grams applied per shirt, XAF per litre and drying minutes per unit
Deposited versus purge ink	Quotes image ink only at zero head-clean loss	Total ml consumed (image + daily clean + white flush) per accepted unit
Film and adhesive powder (DTF)	Quotes net graphic area without nesting trim	Gross m2 of PET film and grams of TPU powder issued per accepted unit
Thermal drying and cure energy	Lists printer wattage (~0.1 to 0.5 kW) without dryers	Metered kWh per batch across pre-treat dryer, heat press, steamer and tunnel
Idle-period maintenance burden	Assumes zero cost on days without customer orders	Daily white-ink shake, nozzle check and head-flush ml and labour per week
Printhead and wear-part life	Treats printheads as permanent machine capital	Warranty conditions, landed replacement XAF and expected litres per head
Ventilation and effluent control	Omits extraction hoods and wash-water treatment	Exhaust airflow m3/h, filter replacement XAF and wastewater litres/m2

ILLUSTRATIVE [S17] [S30] [S31] Illustrative GFT procurement and cost-accounting specification informed by S17 (thermal drying, curing and EHS controls), S30 (pretreatment and consumable dependencies in DTG/DTF) and S31 (mandatory daily and monthly ink agitation and maintenance routines). All monetary and rate fields remain to be populated from dated local quotations and pilot trials.

Every row in **Exhibit 13**, p. 60 closes a specific gap between a vendor brochure and a bankable operating budget. [S17] [S30] [S31] In particular, the fifth row highlights why electrical sizing cannot be based on the inkjet printer nameplate alone: while the piezoelectric carriage motor and electronics draw modest power, the companion conveyor curing dryer, flash cure unit, heat press, or steam generator dominates the connected kilowatt load of the department. [S17] Similarly, the third and sixth rows require the pilot ledger to reconcile ink purchased against both image millilitres reported by the RIP and waste ink collected in the maintenance tank during low-utilisation weeks. [S30] [S31] What **Exhibit 13**, p. 60 cannot supply prior to bidding is the actual landed XAF price of consumables in Douala or Yaoundé, which must be obtained through formal vendor tenders under the procurement protocol of Chapter 12. [S18]

3.7

Emerging chemistry should pass the same release gate

Because conventional reactive printing requires intensive steaming and washing and conventional pigment and DTG routes require chemical pretreatment and thermal drying, academic and industrial laboratories are actively developing modified ink and pretreatment chemistries aimed at shortening the process chain on cotton. [S24] [S0301] [S0302] When evaluating white-paper literature or trade-show announcements, a local apparel producer needs a clear rule separating promising laboratory research from commercially supported shop-floor capability. [S24]

Three recent peer-reviewed research directions illustrate both the potential and the current operational boundaries of emerging cotton inkjet chemistry: [S24] [S0301] [S0302]

- **Binder-free or self-cross-linking pigment inks without separate pretreatment:** A study published in *Langmuir* investigated direct inkjet printing on cotton fabric without a separate chemical pretreatment stage, noting of conventional workflows that "Additional chemical treatment generates a large amount of wastewater and complicates the process." [S24] While eliminating pretreatment padding or spraying is an attractive research objective, an experimental formulation demonstrated on laboratory swatches does not establish commercial ink shelf life, printhead nozzle reliability across thousands of firing hours, or local service support in Central Africa. [S24] [S31]
- **Drying-free wet polymer pretreatment for dye inks:** A study in the *International Journal of Biological Macromolecules* examined controlling dye diffusion in wet sodium alginate films to avoid the energy cost of drying pretreated cotton before inkjet printing, observing that "Natural polymer pretreatment was the essential process to enhance the quality of textile inkjet printing." [S0301] Although wet-on-wet or drying-free preparation could reduce thermal energy demand in industrial roll mills, it requires tight synchronisation between padding pick-up and printhead carriage passage and still requires downstream dye fixation and washing. [S01] [S0301]
- **Rheology-tuned cellulose-ether pretreatments:** Another *Langmuir* study varied the viscosity grade of hydroxypropyl methyl cellulose (HPMC) pretreatments to form a continuous surface film that restricts drop wicking on cotton, while cautioning that excessively high viscosity grades hindered subsequent dye fixation. [S0302] This finding reinforces a fundamental engineering lesson: any chemical change made to improve surface sharpness or eliminate a drying step can simultaneously alter fixation yield, colour strength, or wash fastness. [S0302]

GFT proposes that a local apparel operation treat all novel ink sets, single-step inline-fixation systems, and third-party aftermarket consumables as unqualified candidates until they pass the exact same **five-point release gate** required of established pigment, reactive, DTG, and DTF routes: [S10] [S18] [S23]

1. **Substrate compatibility across target local fabrics:** Demonstrate repeatable drop formation, colour gamut, and edge sharpness on the actual cotton or blended fabric lots recorded in the factory's material passport, not solely on vendor-supplied test swatches. [S01] [S21]
2. **Input chemical safety and MRSL conformance:** Provide complete safety data sheets (SDS) and verifiable declarations against the ZDHC Manufacturing Restricted Substances List so banned substances are excluded at chemical intake. [S17] [S23]
3. **Physical fastness and care durability:** Pass independent or buyer-witnessed wet and dry rubbing tests (ISO 105-X12:2016 scope), domestic and commercial laundering tests (ISO 105-C06:2010 scope), and dimensional-change washing and drying procedures (ISO 6330:2021 scope) on the cured article. [S10] [S11] [S12]
4. **Printhead warranty and local supply continuity:** Confirm in writing that the ink formulation is approved by the printhead and machine manufacturer without voiding equipment warranties, and verify shelf life, cold-chain or ambient storage limits, and landed replenishment lead times into Cameroon. [S18] [S31]
5. **Reconciled full-batch cost and resource measurement:** Measure total ink, auxiliary chemical, electricity, water, reject rate, and maintenance purge volume per accepted garment in a controlled trial before replacing the baseline process. [S17] [S26]

WARNING

Warning: Unverified aftermarket inks and inline pretreatment claims can destroy printheads and customer orders

In cost-sensitive apparel markets, operators are frequently offered unbranded third-party pigment, DTG, or DTF inks and adhesive powders at a steep discount to original equipment manufacturer (OEM) consumables, or promised that a new ink eliminates pretreatment on dark cotton. Adopting an unverified ink or skipping required pretreatment creates three severe operational hazards: [S23] [S30] [S31]

- **Nozzle coagulation and warranty forfeiture:** Pigment dispersion stability, particle-size distribution, and surface tension are tuned to specific piezoelectric nozzle plates. Off-spec white or colour inks settle rapidly, clog dampers and nozzle channels during brief idle windows, and typically void the manufacturer's printhead warranty, turning a minor consumable saving into a multi-thousand-dollar printhead replacement and weeks of machine downtime. [S31]
- **Delayed wash-off and crocking failure:** A print that looks vibrant immediately after leaving the heat press can fail wet rubbing (ISO 105-X12:2016) or wash out on the customer's first laundering cycle (ISO 105-C06:2010) if pretreatment immobilization or binder cross-linking was incomplete, triggering 100 percent order remakes and refunds. [S10] [S11] [S30]
- **Unscreened chemical exposure:** Unbranded inks, pretreatment liquors, and hot-melt powders without verifiable safety data sheets and ZDHC MRSL screening may contain restricted heavy metals, formaldehydes, Phthalates, or sensitising monomers released during thermal curing. [S17] [S23]

Resolution requires locking approved consumable lot numbers into the route sheet, prohibiting unapproved substitutions at the press, and running the paired physical validation protocol defined in Chapters 4, 7, and 13 before any new chemistry touches a paid customer order. [S18] [S21]

By binding the print route to the polymer chemistry of the fibre, the geometric decoupling point of the garment, the full thermal and wet finishing chain, and the yield-adjusted batch crossover curve, a local producer avoids buying a machine in search of a product. [S01] [S02] [S03] Once a candidate print route is selected and its finishing stages are mapped on the route sheet, the next operational problem is ensuring that the colour approved by the buyer on screen or swatch is what the cured fabric actually delivers, which is the subject of Chapter 4. [S01] [S21]

Choose the print route for the fibre you hold and the finishing line you can run, never for the brochure speed of the carriage alone.

CHAPTER SOURCE NOTES

S01 Society for Imaging Science and Technology. 2021.

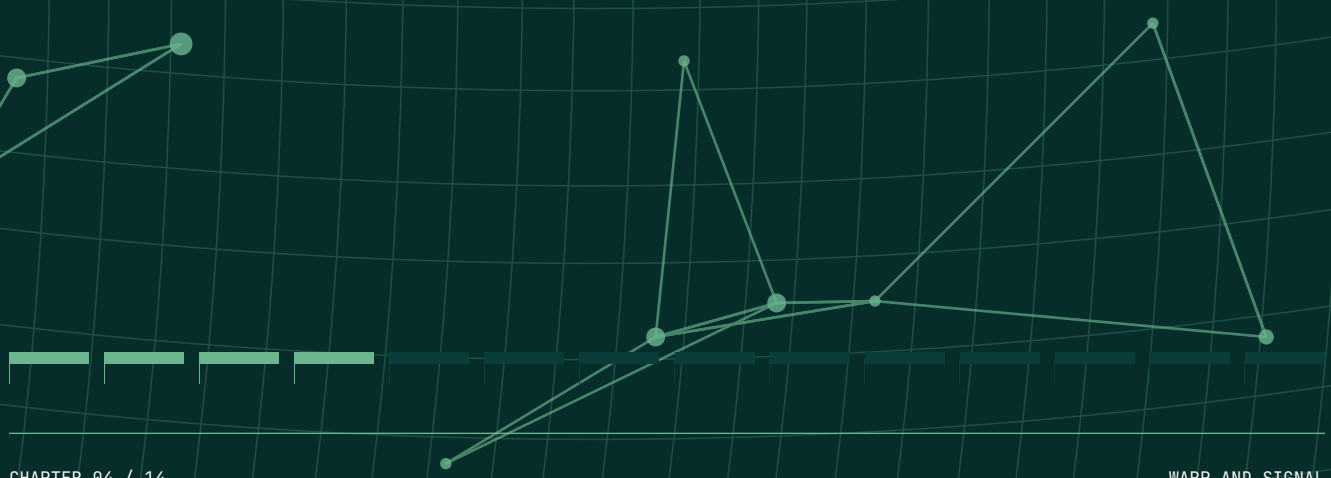
S02 Wiley, Coloration Technology. 2024-01-29.
S03 The Korean Fashion and Textile Research Journal. 2025-12-31.
R06 Cameroon Trade Hub. Publication date unrecorded; inherited source-text check.
R07 Ecofin Agency. Publication date unrecorded; inherited source-text check.
S31 Epson America. 2026.
S17 International Finance Corporation, World Bank Group. 2007-04-30.
S26 VTT Technical Research Centre of Finland. 2014.
S0302 American Chemical Society, Langmuir; author abstract hosted by PubMed. 2024-08-19.
S24 American Chemical Society, Langmuir; author abstract hosted by PubMed. 2023-04-18.
S11 International Organization for Standardization. 2016.
S0301 Elsevier, International Journal of Biological Macromolecules; author abstract hosted by PubMed. 2025-03-06.
S10 International Organization for Standardization. 2010.
S15 Epson United Kingdom. 2026.
S30 Epson America. 2026.
S12 International Organization for Standardization. 2021.
S23 ZDHC Foundation. 2026.
S09 arXiv, Pietroni and co-authors. 2022.
S21 Fogra Research Institute for Media Technologies. 2026.
R32 Wise; XE. Publication date unrecorded; inherited source-text check.
S18 International Finance Corporation. 2014.

04

PART II: MAKE THE DIGITAL SAMPLE PHYSICALLY ACCOUNTABLE / MATERIAL QUALIFICATION

Colour approval belongs to a fabric and process combination

A controlled colour workflow links artwork, fabric preparation, ink, cure and measured output.



CHAPTER 04
DECISION TEST

A controlled colour workflow links artwork, fabric preparation, ink, cure and measured output.

Colour approval in an on-demand apparel operation cannot attach to an isolated digital image or a generic colour code. GFT argues that a valid colour release belongs to a documented combination of base substrate, chemical preparation, ink system, raster image processor configuration, thermal fixation state and physical evaluation condition. When a local apparel maker separates visual design approval from substrate qualification, the screen preview promises a shade, sharpness and durability that the production line has not proved it can deliver. Both digital inkjet routes and rotary screen processes depend on substrate properties, chemical compatibility and fixation conditions to achieve acceptable colour and end-use retention. [S01] [S02]

The procedures in this chapter are GFT proposals extending the quality-logging discipline of GFT's Cameroon textile programme into print-on-demand and short-run apparel manufacturing. They do not describe an installed GFT printing facility, a certified laboratory or a completed commercial trial. Where the inherited baseline indicates that about 95 percent of Cameroon's cotton fibre is exported raw and about 5 percent is processed locally, alongside a 50 percent local-processing target by 2030, an apparel service must distinguish between printing on domestically transformed cotton cloth and decorating imported ready-made blanks. [R06] [R07] In both cases, physical material qualification and controlled strike-off approval must precede production release.

4.1

Base fabric is part of the colour specification

A digital print file contains pixel values, not textile colour. The physical appearance of a printed motif emerges from the interaction between deposited colourants, auxiliary chemicals and the structure of the receiving cloth. In digital textile printing, ink chemistry must match the fibre class: reactive inks require cellulosic fibres with subsequent steaming and washing, disperse sublimation routes require compatible synthetic polymers, and pigment systems rely on a binder and dry heat fixation across cotton and blended substrates. [S01] Within a single fibre category, rotary and digital printing studies confirm that yarn twist, weave or knit tightness, surface hairiness and prior wet processing alter drop spread, penetration depth and perceived shade depth. [S02]

A local apparel producer cannot treat unprinted white or dyed cloth as a uniform commodity. Two cotton jersey lots that look similar on a rack may carry different spinning oils, optical brighteners, residual alkalinity, mercerisation levels or mechanical finishes. When an aqueous inkjet drop strikes those surfaces, differences in wetting tension and capillary wicking change both fine-line dot gain and solid-area reflectance. [S01] [S02] If the factory does not record which fabric lot received the approved print trial, a later batch printed with the same file and machine settings can shift noticeably in hue, saturation or edge definition.

GFT proposes that every substrate entering a print-on-demand or short-run service carry a versioned material passport before colour profiling or customer sampling begins. The passport is an operational control record within the factory performance-

management system rather than a marketing certificate, binding the physical roll or blank batch to the parameters governing colour reproduction and dimensional stability. [S12] [S15]

- **Supplier and lot identity:** Record mill or blank distributor, article code, delivery date, batch or dye-lot identifier and roll or carton numbers. [S21]
- **Verified fibre composition:** State declared fibre percentages and require supplier test documentation where pure cotton or a blend is specified. [S01] [S02]
- **Construction and areal mass:** Document weave or knit structure, yarn count, gauge, width and mass per area, governing ink penetration and pretreatment pick-up. [S01]
- **Preparation and surface finish:** Identify bleaching, optical brighteners, dyeing, singeing, mercerisation, enzyme washing or softeners that resist pretreatment and binder adhesion. [S01] [S30]
- **Base shade and whiteness baseline:** Retain an unprinted cutting and record its visual or instrumental baseline under agreed viewing conditions to detect lot drift. [S14] [S21]
- **Thermal and care shrinkage:** Record length and width change after curing and intended washing and drying, referencing ISO 3759:2011 and ISO 6330:2021 scopes. [S12] [S27]

Keeping these records attached to the fabric lot prevents blaming the printer or operator for a shade shift caused by an unannounced blank substitution. When a service decorates imported T-shirt blanks via direct-to-garment (DTG) or direct-to-film (DTF) routes, the blank manufacturer controls spinning, knitting, scouring and garment dyeing upstream. [S15] [S30] Mixing cartons from different upstream production runs alters liquid pretreatment pick-up and heat-press scorching behaviour within the same size run, so mixed lots must be segregated at goods receipt and assigned distinct lot identifiers before prepress release. [S15] [S17]

For roll-to-roll cut-and-sew printing, the material passport also connects colour qualification to pattern engineering and marker planning. Reactive printing requires steaming, washing and drying after ink deposition, whereas pigment printing relies on dry heat fixation, so mechanical relaxation through the finishing line differs by route. [S01] A cotton poplin or jersey that contracts during pretreatment drying or conveyor curing changes both its areal density and the geometric scale of the printed motif, requiring colourists and patternmakers to evaluate the same prepared physical cloth. [S12] [S17]

4.2

A screen image is a conditional preview

In a digital sampling workflow, designers and buyers routinely inspect three-dimensional garment renders or two-dimensional artwork layouts on monitors. That screen review is useful for checking motif arrangement, typography, proportion and general tonal balance, but it cannot serve as an unqualified textile colour standard. A monitor

produces colour by emitting light through additive red, green and blue subpixels, whereas a printed textile produces colour by selectively absorbing and scattering incident illumination across a textured fibre assembly. [S14] [S22]

Even on the display side of the workflow, screen appearance drifts over time unless the device is actively governed. As the International Color Consortium notes in its display calibration guidance, "Since displays tend to drift over time, periodic calibration is needed to maintain colour performance." [S22] An uncalibrated buyer laptop, tablet or telephone applies unknown brightness, white-point temperature, ambient glare compensation and operating-system tone mapping to the preview file. Approving an emailed render does not define which physical colour was approved. [S22]

Calibrating the studio display sets white point, luminance and tone response curve paired with a display profile so colour-managed software translates document encodings consistently. [S22] [S0401] Yet pigment or reactive ink gamuts on cotton fabric do not coincide with standard display spaces: saturated screen greens, deep emissive blues and luminous oranges frequently lie outside the reflective gamut of textile ink sets on unbrightened or matte cellulosic cloth. [S01] [S22]

A textile print also exhibits surface micro-geometry and illuminant sensitivity absent from a flat RGB preview. Yarn crowns, interstices and binder films scatter light directionally, and metamerism can make a printed swatch match a target reference under studio daylight lamps while diverging noticeably under warm retail lighting or outdoor sun. [S14] Public standards scopes such as ISO 13655:2017 confirm that colorimetric computation requires explicitly defined spectral measurement and viewing illumination conditions even within graphic arts workflows. [S14]

GFT therefore recommends treating every screen render or soft proof as a conditional layout and palette preview rather than a binding shade contract, stating three distinct approval classes in the quotation and order acceptance form before the buyer pays a deposit:

1. **Non-calibrated buyer devices:** Where a customer reviews artwork on their own telephone or computer screen, approval covers graphic layout, spelling, motif scale and approximate colour family only, with an explicit warning that device screens vary and cannot match printed cloth. [S22]
2. **Soft-proof studio reviews:** Where a buyer inspects a design on a studio monitor maintained on a logged calibration schedule under controlled ambient light, the review narrows candidate shades for sampling, but shade-critical production release still requires a physical reference. [S21] [S22]
3. **Physical swatch and strike-off authority:** For institutional uniforms, brand logos, repeat corporate orders or matched multi-garment sets, the binding colour target must be a physical swatch or approved strike-off evaluated under a stated lighting condition. [S02] [S21]

Separating these classes protects both the local apparel maker and the customer. Promotional orders may willingly accept approximate screen colour in exchange for rapid turnaround without a couriered strike-off, whereas institutional uniform buyers

require repeatable physical shade matching across reorders. [S02] Making the preview boundary explicit in the service contract prevents an economical screen-only workflow from carrying the financial liability of a custom-matched dye lot.

4.3

Prepress must preserve scale and placement

Colour accuracy fails operationally if the right shade lands at the wrong scale, orientation or seam position. Prepress translates visual artwork into a dimensionally locked production file mapped onto valid sewing patterns. [S09] [S32] Scaling a graphic arbitrarily to fit an avatar or cropping without seam allowances and shrinkage rules distorts the assembled garment.

Research on computational and parametric pattern making confirms that a realistic three-dimensional garment model depends on valid two-dimensional pattern geometry, including seam correspondence, darts, grainlines and ease. [S09] [S32] For all-over or engineered prints, prepress must map against released two-dimensional patterns rather than painting a mesh without unwrap checks, preventing motifs from stepping across side seams. [S09] [S32]

GFT proposes a mandatory prepress lock checklist before any file enters the raster image processor (RIP):

- **Locked physical dimensions and resolution:** Specify width, height and repeat pitch in millimetres at the print plane alongside pixel density, prohibiting automatic driver scaling. [S21]
- **Grainline and print direction:** Fix pattern orientation relative to warp or wale direction, since rotating a panel alters stretch and directional reflectance. [S02] [S09]
- **Seam allowance and bleed:** Extend background colour and motifs across the full seam allowance plus a cutting bleed margin to prevent white seam flashing. [S09] [S32]
- **Registration and piece markers:** Place alignment marks and piece codes outside the finished boundary for accurate cutting and sewing. [S09]
- **Graded placement rules:** Define whether motifs scale across graded sizes or keep fixed dimensions relative to an anatomical landmark. [S32]
- **Directional shrinkage compensation:** Apply measured length and width contraction factors from the material passport only when backed by repeatable test data on that fabric and curing route. [S12] [S27]

WORKED EXAMPLE: SHRINKAGE COMPENSATION AND BLEED FOR AN ENGINEERED PANEL PRINT

Consider an illustrative prepress calculation for a cut-and-sew cotton jersey front body panel carrying a full-bleed motif and a chest emblem. All figures in this case are illustrative design inputs created to demonstrate the arithmetic method, not measurements from a GFT factory.

Suppose the released sewing pattern for the medium size specifies an illustrative net finished panel length of 680.0 mm and an illustrative net finished panel width of 520.0 mm. The technical pack specifies a 10.0 mm seam allowance on each side seam, a 10.0 mm allowance at the shoulder and a 20.0 mm hem turn-up at the bottom edge, plus an illustrative 5.0 mm print bleed outside every cut edge. Before shrinkage compensation, the required illustrative cut-and-bleed print box length is 680.0 mm + 10.0 mm + 20.0 mm + 5.0 mm + 5.0 mm = 720.0 mm, and the illustrative uncompensated width is 520.0 mm + 10.0 mm + 10.0 mm + 5.0 mm + 5.0 mm = 550.0 mm.

Suppose the material passport for this cotton jersey lot and conveyor dry-heat pigment curing route records an illustrative repeatable lengthwise contraction of 2.5 percent and a widthwise contraction of 1.5 percent during printing and fixation, measured using specimen marking procedures aligned with ISO 3759:2011. [S01] [S27] Expressing contraction as a proportion s, a printed dimension L_{print} contracts to $L_{\text{cured}} = L_{\text{print}} \times (1 - s)$ after curing. Dividing the target dimension by $(1 - s)$ gives an illustrative compensated print length of $720.0\text{ mm} \div 0.975 = 738.46\text{ mm}$ (rounded to 738.5 mm) and an illustrative compensated print width of $550.0\text{ mm} \div 0.985 = 558.38\text{ mm}$ (rounded to 558.4 mm).

If the chest emblem centre in this illustrative model must sit 210.0 mm below the net shoulder stitch line after curing, its distance from the top bleed edge before curing is $(210.0\text{ mm} + 10.0\text{ mm} + 5.0\text{ mm}) \div 0.975 = 225.0\text{ mm} \div 0.975 = 230.77\text{ mm}$ (230.8 mm). Omitting the 2.5 percent lengthwise compensation would leave the cured panel 18.0 mm short and place the emblem 5.6 mm too high. Both the uncompensated geometry and the applied compensation divisors belong on the job ticket, verified by a physical rule check against the illustrative 720.0 mm by 550.0 mm boundary after curing.

For garment decoration on ready-made blanks via DTG or DTF, prepress placement faces a different constraint: the garment is already sewn, and seam thickness, collar ribbing and tubular tolerances vary across pieces. [S15] [S30] Prepress must define platen size, neck-seam stop, vertical offset from the collar seam and maximum printable width clearing armhole seams across the ordered size range. [S15] Printing an oversized graphic designed on a large avatar onto a small blank without a size-specific check forces the operator either to shrink the graphic arbitrarily at the console or to print over raised seams, causing ink pooling, head strikes or poor transfer adhesion. [S15] [S30]

4.4

Profiles belong to a controlled process state

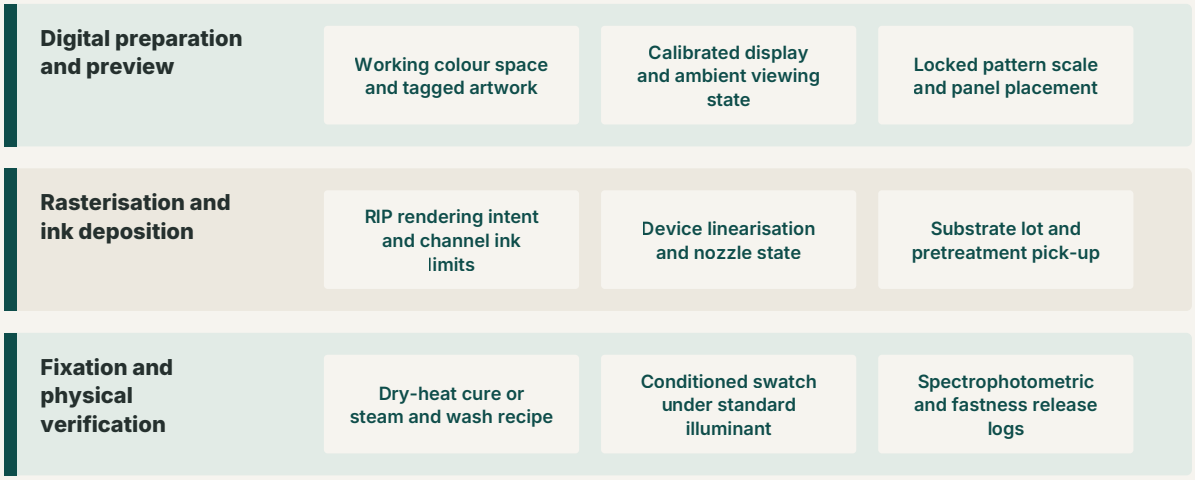
Between the locked artwork file and the finished cloth lies a sequence of mathematical and physical transformations. Colour management connects these stages through International Color Consortium (ICC) profiles and RIP calibration tables. As the ICC specification overview states, "The ICC specification defines the file format for profiles that connect between colour encodings." [S0401] In a textile printing line, however, an ICC profile is valid only for the exact physical process state measured when the characterization chart was printed and cured. [S21] [S0401]

Many small print shops treat a downloaded printer profile as a permanent software plugin, assuming that selecting "cotton" in a menu guarantees accurate output. The International Color Consortium explicitly warns against unverified reliance on general library profiles: "The ICC is unable to recommend profiles for particular applications, and accepts no responsibility for the performance of these profiles." [S0402] In digital textile production, changing the base fabric lot, liquid pretreatment concentration, printhead resolution, pass count, ink drop limit or thermal curing profile alters the physical relationship between device ink signals and reflected spectral colour. [S01] [S15] [S30] Once any of those variables shifts, the stored profile describes a process that no longer exists.

The illustrative architecture in **Exhibit 14**, p. 71 separates the colour chain into three governed layers: digital preparation and preview, rasterisation and ink deposition, and chemical-thermal fixation and verification. Every layer contains specific state variables that must remain locked together for a profile and strike-off approval to hold. [S14] [S21] [S22]

EXHIBIT 14 / GOVERNED WORKFLOW LAYERS

The colour chain contains several controlled transforms



ILLUSTRATIVE [S14] [S21] [S22] [S0401] Illustrative GFT control architecture informed by ICC profile specifications (S0401), ICC display calibration guidance (S22), ISO 13655 colorimetric scope (S14) and Fogra ProcessStandard Digital principles (S21). Not a claim of an installed GFT system or external certification.

As **Exhibit 14**, p. 71 shows, the middle and lower layers are where textile workflows diverge from office paper printing. Fogra's ProcessStandard Digital framework describes process reliability in digital printing through defined interfaces, target values, tolerances and run-length consistency checks. [S21] Adapting that discipline to a local workshop means treating the RIP configuration and finishing line as a coupled recipe. While **Exhibit 14**, p. 71 maps control points conceptually, physical testing on the chosen cloth is still required to confirm shade gamut coverage. [S01] [S21]

GFT proposes that a production colour profile record bind six parameters into an immutable recipe identifier before generating a strike-off:

1. **Artwork working space and rendering intent:** State embedded source space, rendering intent and spot-colour channel mapping. [S22] [S0401]
2. **RIP version, screening and ink limits:** Record RIP build, screening algorithm, resolution, pass mode, carriage direction and channel or total ink limits. [S21]
3. **White underbase policy (for dark DTG or DTF):** Specify choke distance, underbase density percentage, flash sequence and white ink agitation state. [S15] [S30]
4. **Ink set and batch provenance:** Log ink chemistry class, manufacturer, formulation code, lot numbers and expiry dates. [S01] [S23]
5. **Substrate passport and pretreatment recipe:** Link to a material passport ID, recording solution code, dilution, applied mass per area and drying state. [S01] [S30]
6. **Thermal fixation or wet-finishing state:** Specify curing equipment, dwell time, measured fabric surface temperature and any washing sequence. [S01] [S15] [S17]

Thermal curing belongs inside the profile state because colour development and binder film formation occur during fixation. [S01] [S15] Under-curing leaves uncrosslinked binder that causes wash failure, while over-curing yellows cotton or shifts sensitive pigments. [S15] [S17]

4.5

A strike-off is an approval object

When a digital profile and prepress file are ready, the factory produces a physical strike-off on the production substrate using the intended recipe. Informal workshops often treat a strike-off as a loose scrap viewed under ceiling tubes, approved verbally and misplaced before production. GFT argues that a strike-off creates operational security only when governed as a numbered approval object inside the quality system. [S02] [S21]

Before order release, a strike-off gives the buyer and technical lead tangible proof of shade, sharpness, hand feel and fabric interaction under agreed lighting. [S02] [S21] During production and post-delivery review, a retained master portion serves as the physical reference for first-article checks and dispute resolution.

GFT recommends cutting every strike-off large enough to divide into matched parts marked with the same identifier: one dispatched to the buyer, one master reference archived in a dark, dry envelope at the factory, and one specimen reserved for wash and rub fastness checks. [S10] [S11] [S12] Cured swatches should rest and condition before evaluation so temporary thermal dye shifts stabilise. [S14] [S17]

The illustrative structure in **Exhibit 15**, p. 73 defines the mandatory fields GFT proposes for every strike-off approval event. [S02] [S11] [S21]

EXHIBIT 15 / GOVERNED APPROVAL FIELDS

A strike-off record makes approval reproducible

Record field	Required content	Control purpose
Strike-off ID and date	Unique specimen code, iteration number and timestamp	Prevents mixing rejected trials with final approved swatch
Material passport and lot	Fabric or blank code, supplier lot and pretreatment log ID	Locks approval to the exact physical substrate state
Artwork and prepress hash	Design version, compensated dimensions and RIP profile ID	Ensures bulk run uses the identical rasterised file
Print and cure recipe	Printer ID, ink lot numbers, pass mode, cure temp and time	Captures thermal and chemical fixation conditions
Viewing and illuminant state	Light booth illuminant, secondary light and observer angle	Controls metamerism and ambient lighting bias
Instrumental reading	Spectrophotometer geometry, backing and colour coordinates	Provides objective drift reference for production runs
Care and rub test link	Linked wash, dry and rubbing test report identifiers	Prevents releasing a shade that fails in use
Buyer decision and scope	Approved, rejected or conditional with named authority	Establishes enforceable release permission for the lot

ILLUSTRATIVE [S02] [S11] [S14] [S21] Illustrative GFT strike-off register template based on digital print process control (S21), colorimetric measurement conditions (S14), textile printing durability requirements (S02) and rubbing fastness scopes (S11). Example entries are illustrative structure definitions, not records from a GFT operation.

Each row in **Exhibit 15**, p. 73 addresses an operational ambiguity. The table records both visual viewing conditions and instrumental metadata without assuming that every workshop owns a spectrophotometer from day one. [S14] [S21] Recording primary and secondary light-booth illuminants forces a check for metamerism before sign-off, while recording instrument geometry, aperture, UV state and specimen backing prevents translucent jersey readings from shifting with table colour. [S14]

A fresh strike-off cannot prove durability, however. End-use performance depends on how the colourant-binder-fibre system withstands washing and abrasion. [S02] Unfixed surfactant on a fresh pigment or DTG print can make dark shades look richer before washing than after laundering, while reactive prints require complete scouring of unfixed dye before true shade evaluation. [S01] [S02]

GFT NOTE

Never accept a customer's visual signature on an unwashed, unconditioned strike-off as full production release for a garment with a care-durability requirement. Mark initial visual acceptance as "Shade approved pending care and fastness verification" in the strike-off register, releasing production only after post-care specimens pass.

4.6

Colour difference and fastness answer different questions

A frequent mistake in digital apparel proposals is treating a single colorimetric difference number (such as ΔE) as a complete measure of print quality. Colorimetric difference and colour fastness measure different physical phenomena, use different instruments and protect against different customer failures. [S10] [S11] [S14]

Colorimetric evaluation compares spectral reflectance or tristimulus coordinates against a target under stated illumination and observer conditions. [S14] It asks how closely a solid patch matches the reference shade right now. Even within that question, an unqualified numerical limit is meaningless without its formula and measurement geometry, and point spectrophotometers can report large variation on textured or micropatterned cloth simply from yarn crossover positioning. [S14] [S21]

Colour fastness measures resistance to change or transfer when the printed textile faces physical or chemical stress during care and wear. [S10] [S11] Public catalogue scopes of International Organization for Standardization standards illustrate why separate checks are required:

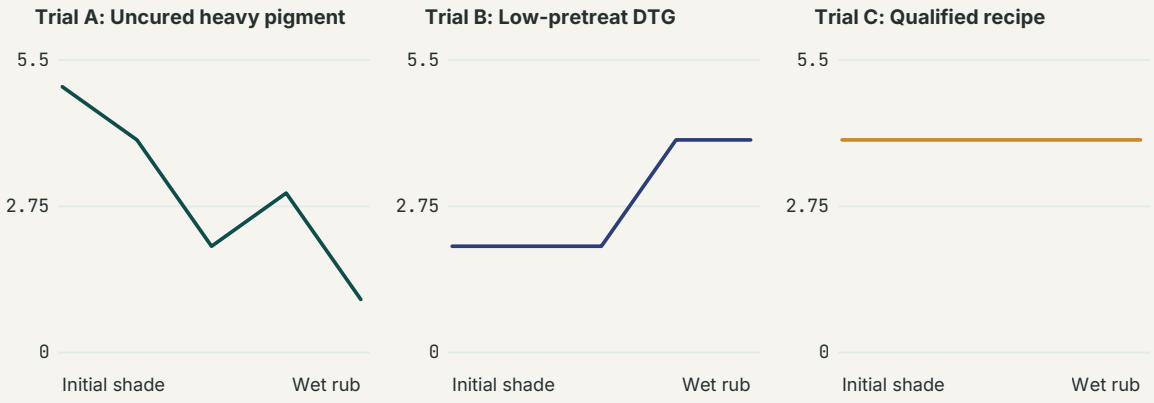
- **Laundering colour fastness (ISO 105-C06:2010):** Evaluates colour resistance to domestic and commercial washing, assessing shade change and adjacent multifibre staining. Its scope cautions, "Industrial and hospital articles may be subjected to special laundering procedures which may be more severe in some aspects." [S10]
- **Rubbing colour fastness, or crocking (ISO 105-X12:2016):** Evaluates surface colour transfer by rubbing: "Two tests may be made, one with a dry rubbing cloth and one with a wet rubbing cloth." [S11]
- **Domestic washing and drying procedures (ISO 6330:2021):** Specifies testing procedures where "A complete test consists of a washing and drying procedure," because drying routes alter shrinkage and surface fibrillation. [S12]

Consider a dark pigment or DTG print on cotton jersey. [S01] [S15] If heavy ink is passed through a fast dryer belt, the surface may feel dry and match the colorimetric target closely, yet under the wet rubbing protocol of ISO 105-X12:2016 uncross-linked binder and cotton fibrils transfer dark staining onto the rubbing cloth. [S11]

The illustrative layout in **Exhibit 16**, p. 75 separates initial shade match, line sharpness, wash retention and dry/wet rubbing into distinct panels. [S10] [S11] [S12] All values are illustrative indices constructed to show how failure modes diverge, not measured results.

EXHIBIT 16 / ILLUSTRATIVE READINESS INDEX (0 TO 5)

Colour, sharpness and durability need separate evidence



ILLUSTRATIVE [S10] [S11] [S12] [S14] Illustrative GFT multi-criteria evaluation layout informed by ISO 105-C06 laundering scope (S10), ISO 105-X12 dry and wet rubbing scope (S11), ISO 6330 washing and drying scope (S12) and ISO 13655 colorimetry (S14). Values are invented illustrative profiles showing how a candidate trial can score high on initial colour match while failing wet rub or aftercare appearance; not empirical measurements.

In **Exhibit 16**, p. 75, illustrative Trial A achieves a high initial shade match (index 5) and line sharpness (index 4), but poor binder fixation causes wash retention (index 2) and wet rubbing (index 1) to fail. [S01] [S11] In illustrative Trial B, low DTG pretreatment prevents wet rubbing transfer (index 4), but ink wicks into the yarn core and dulls initial shade (index 2) and sharpness (index 2). [S15] [S30] Only illustrative Trial C balances all five criteria. A local factory must populate its release register with actual laboratory grades agreed for each product family.

GFT recommends specifying three rules in each technical pack rather than inventing a universal Delta E or fastness grade: 1. **Solid shades versus micropatterns:** Apply instrumental tolerances (with stated formula, illuminant, observer and backing) only on designated solid control patches, evaluating complex motifs visually against the master strike-off in a light booth. [S14] [S21] 2. **Product-specific care and rubbing schedule:** Align laundering and drying conditions with end use under ISO 105-C06:2010 and ISO 6330:2021, and require both dry and wet rubbing under ISO 105-X12:2016, verifying current standard editions at contracting. [S10] [S11] [S12] 3. **Compound-defect hold rule:** Place the recipe on hold if any required fastness or aftercare check fails, regardless of fresh shade accuracy. [S02] [S11]

4.7

Material substitutions must reopen the right decisions

Supply disruptions, price changes and urgent deadlines create constant pressure to substitute inputs: switching blank brands, accepting a new bleach lot, buying third-party ink or transfer powder, or speeding up a dryer conveyor. [S15] [S17] Under GFT's governance model, any change to the qualified material, chemical or thermal state is a formal engineering change event that reopens the specific verifications affected. [S01] [S21] [S23]

Chemical input governance is essential when evaluating alternative inks, pretreatments or adhesives. Finished-garment fastness tests do not show whether a formulation introduced restricted hazardous substances into the workplace or wastewater. [S17] [S23] The ZDHC Manufacturing Restricted Substances List (MRSL) governs input formulations: "It establishes which ones to avoid, in particular those banned from intentional use." [S23] Similarly, while laboratory research explores binder-free pigment inks for untreated cotton because "Additional chemical treatment generates a large amount of wastewater and complicates the process," a factory cannot adopt a novel or substitute chemistry without verifying both safety documentation and durability on the target cloth. [S24]

The illustrative matrix in **Exhibit 17**, p. 76 maps five production changes against five verification gates on an illustrative severity scale from 0 (no re-check) to 3 (mandatory hold and full requalification). [S01] [S12] [S21] [S23]

EXHIBIT 17 / ILLUSTRATIVE RE-VERIFICATION LEVEL (0 TO 3)

Substitution risk depends on what changed

	Prepress check	Colour profile	Strike-off shade	Wash and rub test	Chemical MRSL review
Minor motif resize	3	0	1	0	0
New lot, same fabric	1	1	2	1	1
Alternate blank brand	3	3	3	3	2
Ink or pretreat change	0	3	3	3	3
Cure temp or time shift	1	2	2	3	0

Cell scale: 0 to 3

ILLUSTRATIVE [S01] [S12] [S21] [S23] Illustrative GFT change-control matrix informed by ink-substrate dependencies (S01), ISO 6330 care testing scope (S12), Fogra digital print process control (S21) and ZDHC MRSL chemical input management (S23). Scale: 0 = no new check, 1 = operator spot check, 2 = technical lead re-test, 3 = mandatory order hold and full requalification. Scores are normative GFT control rules, not empirical defect rates.

Reading across **Exhibit 17**, p. 76 shows how targeted holds match verification effort to physical risk:

- **Minor motif resize on the same fabric and recipe:** Requires an illustrative level 3 prepress scale check and level 1 first-article visual check, leaving profile, fastness and chemical review unchanged (illustrative level 0). [S09] [S21]
- **New lot of the same specified fabric:** Triggers a material passport baseline and control-wedge check (illustrative level 1 to 2) to catch brightener, shrinkage or pH drift. [S14] [S21]
- **Alternate blank brand or fabric construction:** Triggers an illustrative level 3 hold across prepress shrinkage, profiling, strike-off and fastness, plus level 2 supplier chemical review. [S01] [S12] [S15]
- **Ink, pretreatment or adhesive powder change:** Triggers an illustrative level 3 hold on profiling, strike-off, wash/rub durability and MRSL chemical input screening. [S01] [S23] [S24]
- **Curing temperature or dwell shift:** Requires illustrative level 3 wash and rub re-testing and level 2 shade and shrinkage checks to confirm complete fixation without scorching. [S01] [S12] [S17]

SUBSTITUTION HOLD AND REQUALIFICATION PROTOCOL

When an incoming material lot, consumable or machine state departs from the approved strike-off record, GFT proposes a four-step hold protocol before releasing the job queue:

1. **Quarantine and classify:** Place the order in `HOLD_MATERIAL_CHANGE` status and classify the departure using **Exhibit 17**, p. 76. [S21]
2. **Screen chemical documentation:** Verify safety data sheets and restricted-substance declarations for any new ink, pretreatment, film, powder or treated cloth before shop-floor use. [S17] [S23]
3. **Execute physical and colorimetric checks:** Print the control wedge and strike-off on the candidate material, condition the specimen, check shade against the master reference and run required rubbing and washing procedures. [S10] [S11] [S12] [S21]
4. **Record buyer concession or new baseline:** Obtain written buyer re-approval on a new revision ID whenever appearance, feel or dimensions shift, never overwriting the original strike-off record. [S21]

UNVERIFIED CHEMICAL AND FASTNESS SUBSTITUTIONS CREATE UNINSURABLE REWORK

Do not allow a vendor to waive re-testing by calling a replacement ink, pretreatment or transfer powder a "drop-in equivalent." Small shifts in binder glass-transition temperature, humectant evaporation or surfactant wetting can cause nozzle deflection, shade drift or wash delamination on cotton garments. [S01] [S15] [S30] Chemical compliance and product safety obligations require review by qualified technical and legal specialists; this chapter provides an operational control framework, not legal or regulatory certification.

Linking material passports, conditional screen previews, compensated prepress files, state-locked colour profiles, physical strike-offs and substitution holds completes the first half of Part II's accountability chain. A local apparel operation enforcing these controls knows which physical fabric, chemical recipe and thermal state produced an approved colour sample. The next chapter applies the same engineering discipline to three-dimensional garment geometry: building accountable sewing patterns and representative body avatars so virtual fit review rests on measured physical foundations.

Approve the shade on the cloth that will carry it, through the heat and wash that must keep it.

CHAPTER SOURCE NOTES

S01 Society for Imaging Science and Technology. 2021.

S02 Wiley, Coloration Technology. 2024-01-29.

R06 Cameroon Trade Hub. Publication date unrecorded; inherited source-text check.

R07 Ecofin Agency. Publication date unrecorded; inherited source-text check.

S12 International Organization for Standardization. 2021.

S15 Epson United Kingdom. n.d..

S21 Fogra Research Institute for Media Technologies. n.d..

S30 Epson America. n.d..

S14 International Organization for Standardization. 2017.

S27 International Organization for Standardization. 2011.

S17 International Finance Corporation, World Bank Group. 2007-04-30.

S22 International Color Consortium. n.d..

S0401 International Color Consortium. n.d..

S09 arXiv, Pietroni and co-authors. 2022.

S32 arXiv, Korosteleva and Sorkine-Hornung. 2023-06-06.

S0402 International Color Consortium. n.d..

S23 ZDHC Foundation. n.d..

S10 International Organization for Standardization. 2010.

S11 International Organization for Standardization. 2016.

S24 American Chemical Society, Langmuir; author abstract hosted by PubMed. 2023-04-18.

05

PART II: MAKE THE DIGITAL SAMPLE PHYSICALLY ACCOUNTABLE / PRODUCT DEFINITION

Digital sampling starts with valid patterns and representative bodies

A technical digital sample needs accountable pattern geometry, body measurements and construction intent.

CHAPTER 05
DECISION TEST

A technical digital sample needs accountable pattern geometry, body measurements and construction intent.

A digital sample is ready for technical review only when its pattern can be made, its avatar represents a defined wearer group and its construction instructions survive transfer into the simulation. An attractive image cannot answer those questions. GFT therefore proposes treating pattern authorship, measurement definitions, avatar coverage and construction readback as release controls, not as preparation work that can remain implicit inside a software file.

This chapter defines those controls for a local apparel service. It does not claim that GFT has validated an avatar library, collected representative Cameroon anthropometry or proved automated pattern generation. The proposals extend the specification and measurement discipline of GFT's Cameroon textile programme into digital product development. Their output is a bounded permission to evaluate a digital garment. Physical fit, comfort and production release remain separate decisions.

5.1

A visual concept does not define a garment

A concept image communicates an intended appearance. It does not, by itself, define the pieces from which the garment will be cut. A front view may leave the back construction, dart placement, seam routing, closure, hem turn and internal support unresolved. It also carries no dependable statement of grain direction, seam allowance, wearing ease or size-dependent dimensions. These omissions matter even when the image looks technically polished.

Computational pattern-making research makes the translation explicit. Pietroni and co-authors compute two-dimensional sewing patterns from three-dimensional garment models while addressing seam symmetry, darts, grain alignment and fabric deformation. Their method is evidence that these constraints belong to pattern generation, not evidence that a visual mesh has already become a production pattern. [S09] A rendering surface and a manufacturable rest shape are different technical objects.

The distinction also limits image-to-pattern automation. Sewformer reconstructs sewing patterns from single images as a research task, using a synthetic training dataset and predicted pattern outputs. [S33] That work makes automated reconstruction a candidate for supervised investigation. It does not establish that hidden construction in a photograph has been recovered correctly, nor that the result can be sewn at the intended size. GFT would therefore prohibit direct production release from an inferred pattern.

A patternmaker should instead receive the concept as a brief with explicit unknowns. The review should record which features are stated by the buyer, which are proposed by the design team and which remain undecided. A back seam inferred from a similar style, for example, should be labelled as an interpretation. The reviewer can then approve that interpretation as design intent, rather than allowing an algorithm's plausible guess to acquire the authority of a customer specification.

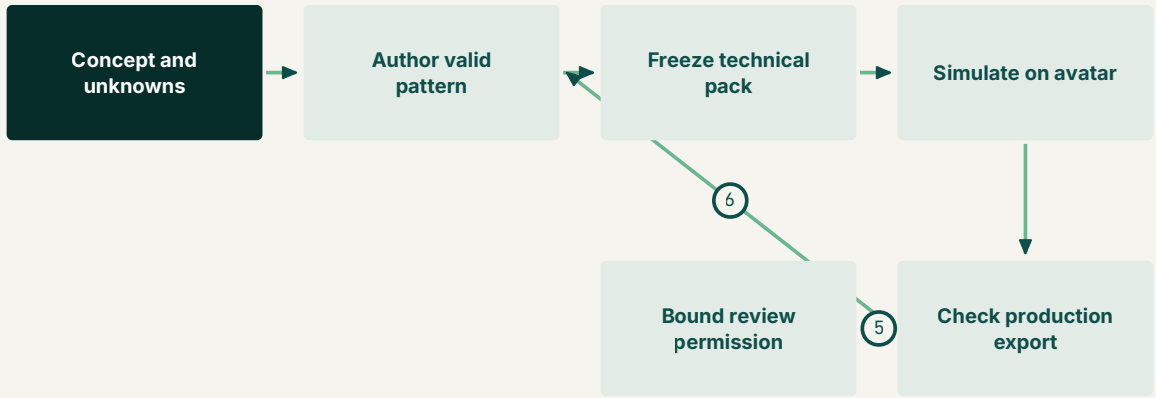
This review also protects the reasons behind a design. Two visually similar garments can require different pattern geometry because one is intended to sit close to the body and the other to accommodate base layers. A neckline that appears identical in a

render may need different facing, stabilisation and seam construction. Recording these choices connects the visible concept to the work that cutting and sewing staff will later have to perform.

GFT proposes a controlled sequence in which pattern authorship precedes simulation and simulation precedes a checked production export. The illustrative route in **Exhibit 18**, p. 81 includes a return path: a discrepancy found during readback goes back to the responsible specification, rather than being repaired only in the simulator. That return path is essential when several files represent the same garment.

EXHIBIT 18 / ILLUSTRATIVE GFT CONTROL SEQUENCE

The release pack must reconcile image, pattern and specification



5. Reconciled

6. Resolve discrepancy

ILLUSTRATIVE [S09] [S32] [S33] Proposed workflow informed by computational pattern making, parametric sewing patterns and image-to-pattern research. No automated production release or achieved workflow performance is asserted.

The flow does not imply that every design must begin in two dimensions. A team may drape on an avatar, reconstruct a shape or edit a parametric component. The control concerns evidence at handover. Whatever the design route, the released pack must contain an accountable pattern, identified construction decisions and a readable export. The origin of the geometry should remain visible so that later reviewers know which assumptions need their attention.

GarmentCode reinforces why valid sewing patterns matter to accurate simulation and eventual fabrication. Its component-oriented representation links design parameters and body measurements to pattern construction. [S32] That is a useful model for controlled customisation, but not a reason to hide pattern logic behind a configurator. A component changed by software still needs technical review at the boundary where it alters seams, dimensions or manufacturing intent.

For a first service, GFT recommends narrowing the accepted design vocabulary. Admit named garment components with reviewed construction rules and keep experimental reconstructions outside customer release. Expand the vocabulary only after physical articles show that the pattern and specification reproduce the intended result. This makes creative exploration possible without confusing an unverified component with an approved production asset.

5.2

The technical pack is the release contract

The technical pack should be the single controlled statement of what the team intends to make. GFT proposes that it combine the pattern revision, bill of materials, measurement table, tolerances, stitch and seam instructions, artwork placement, required base layers and approval history. A render can accompany that pack as a communication aid. It should not substitute for any field needed to construct or inspect the garment.

Each measurement needs a defined point of measure. A label such as chest width is incomplete unless the pack states where the edges lie, how the garment is supported and whether the value applies before or after a specified treatment. Tolerances belong to the buyer and product requirement, not to a generic software default. The pack should also distinguish a body dimension from a finished garment dimension, so ease is neither lost nor counted twice.

Construction instructions need the same precision. Record seam type, stitch expectation, edge finishing, reinforcement, closure and pressing intent where these affect the article. For an engineered print, identify the artwork revision and its registration to pattern landmarks. For a layered garment, state the base layers used in fit evaluation. The Hohenstein study found that technical production instructions had to be converted into the settings available in each simulation system, rather than transferred without interpretation. [S07]

Version control should bind these elements together. A style identifier alone is inadequate when the pattern, artwork and measurement table can change independently. Give each component a revision and give the assembled pack its own release identifier. Record who approved the package, the scope of that approval and any open conditions. A later simulation must name the pack revision it used; otherwise a persuasive image cannot be reconciled with the pattern that reaches cutting.

The proposed contract also needs an export test. Exchange between applications can change units, piece names, seam pairings or orientation while leaving a garment superficially recognisable. The check should compare the source and destination at defined geometric and semantic points. It should include piece count, identifiers, grain, notches, internal marks, seam correspondence and dimensional references. Successful import is an observed readback, not a dialogue box that closes without an error.

The illustrative readback in **Exhibit 19**, p. 83 shows the intended structure. Its dimensions are constructed examples, not measurements from a garment or a prescribed tolerance. The table deliberately includes non-dimensional fields because equal edge lengths alone cannot prove that the correct pattern has arrived. A file can preserve scale while dropping the information that tells a machinist how pieces meet.

EXHIBIT 19 / ILLUSTRATIVE EXPORT CHECK

Pattern transfer needs a dimensional and semantic readback

Check	Source expectation	Illustrative readback	Disposition
Reference edge	640.0 mm	640.0 mm	Scale agrees
Secondary edge	160.0 mm	159.8 mm	Review against agreed rule
Piece identifiers	Front, back, sleeve pair	Front, back, sleeve pair	Identifiers agree
Notch positions	Named seam landmarks	One landmark absent	Hold transfer
Grain directions	Marked on every piece	Marked on every piece	Directions agree
Seam correspondence	Named adjoining edges	Named adjoining edges	Assembly map agrees

ILLUSTRATIVE [S09] [S32] Constructed record for method demonstration. Millimetre values and the example tolerance are illustrative, not buyer requirements or measured software errors. Fields reflect valid-pattern and tailoring constraints identified by the cited research.

A hold should remain until the source and destination agree under the agreed rule. The team should not compensate for a missing notch by adding an unrecorded mark in the destination file. That would make the immediate export look complete while leaving the master pattern defective. Correct the authoritative source or document a reviewed mapping, then repeat the readback. The resulting record should travel with the pack revision.

Parametric patterns require an additional check: changing a body input may regenerate geometry throughout the component hierarchy. GarmentCode demonstrates the value of meaningful design parameters and interchangeable components, while also showing that pattern construction is an explicit computational task. [S32] Before accepting such a change, compare the affected seams and dimensions against the intended construction rules. A parameter name that sounds anatomical does not guarantee that its geometric effect matches the patternmaker's intention.

GFT also recommends retaining a neutral diagnostic export where the service depends on outside suppliers or a later change of software. The purpose is not to prescribe a universal exchange format. It is to prove that the chosen route preserves the information the operation needs. If a proprietary file contains data that the export cannot carry, record the limitation and create a controlled replacement instruction. Undocumented reconstruction at the receiving workstation is not a dependable handover.

The release pack is complete only when its evidence can be inspected without the original author present. Another qualified person should be able to identify the garment, reproduce the digital setup, check the pattern dimensions and understand the

construction intent. That standard exposes ambiguous filenames, unrecorded manual edits and missing decisions before they become disputes between design, simulation and production.

5.3

Body measurements need repeatable definitions

An avatar can only be as accountable as the body record behind it. ISO 8559-1 provides anthropometric measurement descriptions intended to support physical and digital databases, size and shape profiles, garment development and fit mannequins. Its public catalogue scope also makes clear that practitioners must select population market segments and apply measurement knowledge. [S13] A list of dimension names is therefore not a ready-made size chart or a representative survey.

GFT proposes a measurement protocol before any avatar is adjusted. Define the anatomical landmarks, posture, clothing state, instrument, unit and handling of the measuring tape or scan. Record who measured, who was measured under the consent record, when the observation occurred and any departure from the protocol. Where the dimension depends on respiration, arm position or support, state the condition. These details are part of the measurement, not administrative decoration.

The protocol should preserve raw readings. If a second observer checks a dimension, retain both observations rather than replacing the first with a preferred value. If a scan produces a different result from a manual reading, record the methods separately and investigate the landmark and posture definitions. Choosing whichever value makes the digital garment look better would hide the uncertainty that the fit review needs to evaluate.

Repeatability checks should have a rule written before the readings are inspected. The rule should state when a dimension is repeated, how many observations form a set and what happens when the set disagrees. A range check can reveal a landmark or handling problem, but it does not measure every source of error. Nor does averaging turn inconsistent observations into a reliable body record. The response to excessive disagreement should be diagnosis and a fresh set, not silent numerical smoothing.

WORKED EXAMPLE: REPEAT THE SET BEFORE AVERAGING THE BODY RECORD

Consider an illustrative manual chest-circumference protocol for a consenting fit participant. All readings and the screening rule in this case are invented to demonstrate the arithmetic. They are not an ISO requirement, a GFT observation or a proposed universal fit tolerance.

Suppose the first set contains 96.0 cm, 96.4 cm and 95.8 cm. Its range is 96.4 minus 95.8, which equals 0.6 cm. Suppose the illustrative protocol asks for a fresh set when the range exceeds 0.5 cm. The first set therefore fails the repeatability screen. Its arithmetic mean, approximately 96.1 cm, must not be used to conceal that failure.

After checking the landmark and tape position, suppose a fresh set contains 96.1 cm, 96.0 cm and 96.2 cm. The range is 0.2 cm, so this set passes the illustrative screen. Its mean is (96.1 + 96.0 + 96.2) divided by 3, which equals 96.1 cm. The avatar record should retain both sets, the reason for repeating and the final protocol decision. A real service would agree its own rule with its technical reviewer and would investigate systematic observer or instrument differences separately.

Body dimensions and garment ease must remain distinct throughout this work. The body record describes the wearer under stated conditions. The pattern specifies the garment's rest geometry and intended ease. Adding an allowance to an avatar would change the body against which fit is being assessed, while failing to add the required ease to the pattern would misstate the garment. Keep both records visible and reconcile them through the finished measurement table.

A small set of circumferences also does not describe the whole body. Two wearers can share a nominal circumference while differing in cross-section, posture, shoulder form or the distribution of shape around the body. This is why the avatar record should include the source geometry and its derivation, not only the values exposed in an adjustment panel. Where a simulator redistributes a changed dimension automatically, that redistribution is a model assumption requiring review.

The Hohenstein comparison used avatars corresponding to the intended physical fit subjects and emphasised the importance of target-group matching. [S07] GFT's proposed handover follows the same principle: identify the wearer or wearer group, the measurement route, the body-shape assumptions and the aspects that remain unobserved. A circumference match alone should not be read as proof that the avatar represents the person.

GFT NOTE

Do not release a body record for fit simulation until its landmarks, method, units and repeatability decision are complete. Store the raw observations with the derived avatar inputs and name the person responsible for accepting any transformation. If the measurement basis is uncertain, narrow the digital decision or repeat the measurement before revising the garment.

The measurement file should finally state what it does not support. A one-off made-to-measure record does not define a population size chart. A size-set avatar does not validate every body shape within that nominal size. A scan captured in one posture

does not establish geometry in another. Carrying these limits into the fit record prevents a precise-looking body model from acquiring permissions that its observations never provided.

5.4

A convenient avatar may exclude the intended wearer

A default avatar answers a software requirement: it gives the garment a body on which to appear. It does not answer the commercial and technical question of who the garment is intended to fit. The Hohenstein study identified use of the same target group or avatar in virtual and physical evaluation as a central condition for meaningful comparison. [S07] GFT extends that principle into a coverage rule: define the intended wearer group before choosing the bodies used for development.

No representative Cameroon body-size dataset has been established for this paper. The chapter therefore does not offer local size distributions, a claim about typical Cameroonian bodies or a recommended national avatar. Those would require an appropriate measurement programme and explicit population definitions. ISO's measurement framework supports consistent anthropometric description, but its catalogue scope does not supply the missing population evidence. [S13]

The practical starting point is the product's intended size and shape range. Record which sizes the service will accept, which body variations matter to the garment and which movements the intended use requires. A close-fitting work shirt, a loose ceremonial garment and a seated uniform may need different coverage even when their nominal chest sizes overlap. The avatar plan should follow those product requirements rather than the bodies conveniently bundled with the software.

Recruitment should then seek consenting fit participants who can test the intended coverage. Document how each participant relates to the coverage cells without publishing unnecessary identifying detail. Include body-shape variation within nominal sizes where it affects the design. A size set created only by scaling one base body can leave those variations untested, even if its measurement table appears extensive.

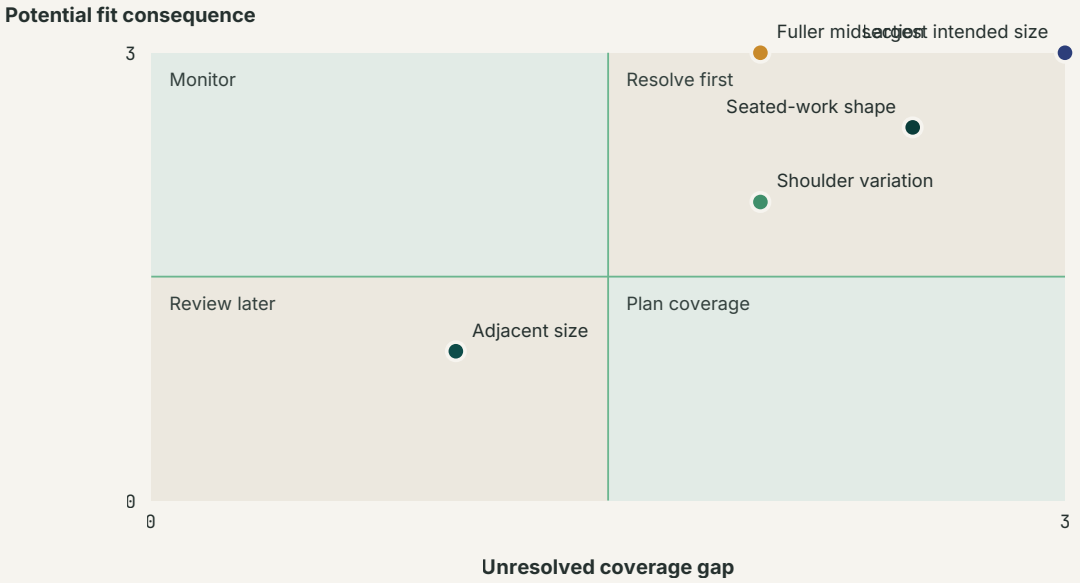
The sampling decision should distinguish development bodies from held-out checks. If the team adjusts patterns and simulation settings against the same few avatars used for final review, agreement may reflect adaptation to those cases. Retain some participants or body configurations outside that adjustment work where practical. A small pilot cannot prove population coverage, but it can show whether the workflow survives cases it was not tuned to satisfy.

GFT proposes an explicit coverage register with three states: not covered, provisionally represented and checked under the defined protocol. These states are evidence labels, not percentages of a population. A cell becomes checked only when the required body definition and evaluation exist. An avatar with edited circumferences may provide provisional representation while its shape assumptions remain unresolved; it should not inherit the status of a measured fit participant.

The illustrative prioritisation map in **Exhibit 20**, p. 87 demonstrates how a team could discuss recruitment gaps. Horizontal position represents an ordinal coverage-gap judgement and vertical position an ordinal fit-consequence judgement for the intended product. The positions are hypothetical planning inputs, not observed body frequencies, defect rates or claims about any named group. Their purpose is to make the sampling conversation visible before results are collected.

EXHIBIT 20 / ILLUSTRATIVE ORDINAL SCORES FROM 0 TO 3

Avatar coverage is a sampling decision, not a software default



ILLUSTRATIVE [S07] [S13] Hypothetical recruitment priorities. Higher x means a larger unresolved gap relative to current avatar coverage; higher y means greater potential consequence for the intended fit decision. Positions are illustrative judgements, not population distributions or measured risk.

After using such a map, the team should replace hypothetical positions with documented pilot observations and retain the reasoning behind each priority. A high-consequence gap should lead to recruitment, a narrower service promise or a decision not to offer that size and shape combination. It should not lead to a visually adjusted avatar being declared representative without supporting evidence.

Coverage limits belong in customer-facing commitments as well as internal records. If the qualified route covers a bounded size set and defined garment constructions, quote within that boundary. Treat an order outside it as a new development case with its own physical approval. This prevents a digital catalogue from advertising combinations that the underlying fit process has never examined.

The register should also record exclusions and changes. A participant withdrawing consent, a revised measurement protocol or a new intended size can alter coverage. Reassess the affected cells instead of carrying forward an unconditional approval. Representative sampling is therefore a continuing control over the service scope, not a one-time avatar selection at software installation.

5.5

Movement reveals constraints that a static image hides

A standing pose can show silhouette and placement, but many fit failures appear when the wearer changes position. Research on personalised garment design explicitly incorporates transitions between body poses to address fit and freedom of movement. [S08] The relevant design object is therefore not only a garment on a stationary avatar. It is a garment that must remain usable through the tasks for which it is intended.

GFT proposes deriving the movement protocol from the product's actual use. A work shirt may require reaching, lifting and sitting. A dress may require walking, sitting and arm elevation without displacing its neckline or hem. The team should describe each start and end pose, the transition, required base layers and the observations that matter. Generic animation is insufficient if it does not represent the wearer's task.

The protocol should define what to inspect at each stage. Possible observations include garment-body clearance, seam migration, closure alignment, restriction at the armhole, hem position and unintended contact between layers. These are proposed review categories, not universal acceptance metrics. Where a numerical measure is used, define its landmarks and observation method so the digital and physical evaluations address the same quantity.

The Hohenstein jacket case provides a warning. Its virtual appearance suggested sufficient ease, while the physical jacket could not be closed comfortably or permit small arm movements. The researchers also found that base layers changed the fit assessment and cautioned against smoothing or pinning a virtual garment into an attractive result. [S07] A clean static image can therefore remove precisely the evidence that a movement review is meant to find.

For that reason, archive the simulation scene as well as its rendered views. Record manual pins, virtual smoothing, collision adjustments and any intervention used to obtain the pose. The reviewer should know whether the garment moved under the stated model or was positioned by hand for presentation. An edited image may support design communication, but it should not be counted as a movement test.

The illustrative small multiples in **Exhibit 21**, p. 89 show one possible review layout. They use constructed counts of unresolved review flags by garment region across standing, seated and reaching tasks. The values demonstrate how exceptions could be displayed; they are not wearer observations, software outputs or GFT results. A real record would link every flag to its scene, evaluator and physical comparison.

EXHIBIT 21 / ILLUSTRATIVE UNRESOLVED REVIEW FLAGS

The same garment must permit every intended movement



ILLUSTRATIVE [S07] [S08] Constructed display example only. Each value is an invented count of unresolved flags for layout demonstration, not an observed defect count or acceptance threshold. Task transitions and base layers must follow the product protocol.

This kind of display should direct attention to exceptions rather than manufacture an average fit score. A closure that fails during reaching remains a failure even if standing and seated views appear acceptable. Retain the individual observations and their locations. Aggregation can summarise workload after the review, but it must not erase a movement or body region where the intended use fails.

Digital and physical task reviews should use matched conditions as far as practicable. Use the same pattern revision, intended material state, body definition, base layers and task description. Where exact equivalence is impossible, record the difference. A physical participant can report pressure, effort and comfort that an avatar cannot supply; those reports belong alongside geometric observations rather than being inferred from a colour map.

Acceptance criteria should be agreed before the task review. The buyer and technical roles should decide which movements are essential, what constitutes a restriction and which observations require revision. If the digital result passes but the physical task fails, the physical failure stops release. Diagnose whether the cause lies in the pattern, avatar, material, layer setup or simulation intervention before changing the garment.

Movement evidence should finally remain attached to the product scope. A qualification for one sleeve construction or base-layer combination does not automatically cover another. Repeat the relevant tasks when the design, size range or intended use changes. The purpose is not to animate every presentation. It is to ensure that the movements on which the promise depends have actually been examined.

5.6

Grading must preserve construction intent

Grading should translate a reviewed garment across the offered size set without losing its construction logic. It is not a licence to scale every edge and motif uniformly. Seam correspondence, notch positions, dart function, grain and intended ease must remain coherent in each size. GFT proposes reviewing those relationships explicitly rather than accepting a nested pattern image as proof that grading is complete.

Parametric pattern research offers useful component and body-measurement controls, but it does not remove the need to inspect regenerated geometry. [S32] For each size, compare adjoining seam lengths under the stated sewing rule, check that landmarks remain aligned and confirm that the intended ease distribution survives. Any manual correction should return to the governing rule or be recorded as a reviewed size-specific exception.

Artwork needs its own grading decision. An engineered motif may remain fixed in size while its registration moves with an anatomical landmark, or it may scale under a deliberate design rule. Record that choice against the pattern pieces and inspect the assembled result. Computational pattern research's attention to grain and tailoring constraints reinforces why surface placement cannot be separated from the underlying pattern. [S09]

Physical checks should concentrate on risk-bearing combinations rather than assuming the middle size represents the set. Consider the largest and smallest offered sizes, substantial changes in body shape, sensitive fabric directions and complex seam or print intersections. The selection is a proposed sampling judgement, not a claim that other sizes require no inspection. Record why each case was chosen and what its result permits.

A graded pack should finally identify unresolved sizes individually. If one size fails seam reconciliation or physical fit, hold that size rather than withdrawing or releasing the whole set by implication. Revision history should show whether a correction changed one size, the grading rule or the base construction. This keeps repeat orders within the combinations that have actually been reviewed.

5.7

Body data needs a smaller audience than product imagery

A catalogue image may be intended for wide circulation. The body measurements, scans and fit comments behind it require a different access policy. GFT proposes separating those records from public product assets, using role-based access and a documented retention decision. A file name without a person's name is not sufficient protection when an order, image or measurement history can make the record identifiable.

Consent should describe the intended measurement, simulation, physical fitting, storage and sharing uses. Record who gave consent, for which purpose and how withdrawal is handled. Participants should be able to decline optional reuse without changing the agreed fit service. Any external processing or software upload needs a separate review of what leaves the controlled record and who can access it.

Collect only the data needed for the defined garment and evaluation. Use an internal participant reference in working files and keep the link to contact or order details in a more restricted record. Define retention by purpose, then document deletion or approved archival. These are GFT control proposals, not a statement that a particular technical measure satisfies every applicable obligation.

OECD guidance calls for priority risks to be identified from each company's individual circumstances, including risks absent from a general list. [S29] Apply that risk-based approach to body-data handling, supplier access and participant welfare. Applicable privacy, employment and contract questions require qualified local review; this chapter is not legal advice and does not claim a Cameroon compliance determination.

The release pack should therefore contain a governance status as well as technical approval. It should confirm permitted use, authorised viewers, retention review and any sharing restriction without exposing the underlying body record to every recipient. When consent or permitted use changes, reassess the affected avatar and derived assets. Responsible digital sampling depends on controlling who may inspect the body as carefully as it controls how the garment is made.

A digital garment earns trust when its pattern, body and construction can all be checked.

CHAPTER SOURCE NOTES

S09 arXiv, Pietroni and co-authors. 2022.

S33 arXiv, Liu and co-authors. 2023.

S32 arXiv, Korosteleva and Sorkine-Hornung. 2023-06-06.

S07 3DBODY.TECH conference proceedings. 2020.

S13 International Organization for Standardization. 2017-03.

S08 arXiv, Wolff and co-authors. 2021-02-10.

S29 Organisation for Economic Co-operation and Development. 2026-02-26.

06

PART II: MAKE THE DIGITAL SAMPLE PHYSICALLY ACCOUNTABLE / SIMULATION CREDIBILITY

Measured fabric behaviour makes the digital sample testable

Link the digital material to a physical specimen, control the simulation experiment and qualify the decisions that survive comparison.

CHAPTER 06
DECISION TEST

Link the digital material to a physical specimen, control the simulation experiment and qualify the decisions that survive comparison.

A digital sample becomes testable when its material inputs refer to an identifiable physical fabric and its outputs can be compared under stated conditions. GFT proposes qualifying that connection before using simulation to remove a physical development step. The useful question is whether a particular decision remains trustworthy for the intended material, construction and evaluation setup. This chapter defines a proposed calibration route, its uncertainty checks and the release record that would make the answer inspectable. It does not report a completed GFT calibration or a validated fabric library. Pattern and avatar preparation belong to the preceding chapter; physical garment release remains a subsequent decision.

6.1

A fabric texture is not a mechanical material model

Ancutienė and Sinkevičiūtė investigated virtual fit against tensile, bending and shear properties, together with composition, thickness and area density. Their work distinguishes the material's mechanical description from its visual representation. Its findings belong to the fabrics and software studied, rather than establishing a universal ranking of inputs for current systems. [S05]

GFT proposes treating surface appearance and mechanical behaviour as separate asset components with an explicit link. A photograph, colour description or weave image belongs in the appearance component. Measured response records and their translation into simulator parameters belong in the mechanical component. A supplier's product name can help locate a physical material, but should not serve as its calibration record. The release question should be answerable without opening the presentation render: which specimen supports this model, and which decision was it checked against?

The proposed identity record should connect the asset to the supplier article, receipt reference, roll or lot, finish, face, direction and retained specimen. Where the production process changes the material, record the tested state as well. A raw swatch, prepared printing substrate and finished printed panel should not share an unqualified calibration identity. This is a proposed traceability rule, not a claim that every treatment produces a material change large enough to matter. The purpose is to make that possibility testable rather than erase it through naming.

For an initial service, GFT recommends limiting the library to the materials actually needed by the chosen product family. Admit a provisional material for visual exploration, with its restriction visible to the designer. Require a physical linkage before attempting calibration. Keep any generic asset that it replaces as a separate reference, so the difference between measured input and convenient default remains recoverable. A smaller library with accountable records is a more useful starting point than an extensive catalogue whose apparent completeness obscures its evidence gaps.

The illustrative dictionary in **Exhibit 22**, p. 94 sets out what the proposed asset would retain. It defines record fields, rather than claiming measured values or prescribing a laboratory method. A field should name its measurement boundary, its unit and the

associated raw record. Where a simulator cannot accept a measured property directly, the mapping belongs in the record too. An unsupported field should be marked unavailable; assigning a plausible default would hide a limitation that the evaluator needs to see.

EXHIBIT 22 / ILLUSTRATIVE RECORD DICTIONARY

The material record must retain behaviour and provenance

Input	Retain	Check
Identity	Lot, finish, specimen	Physical link
Direction	Warp, weft, face	Pattern grain
Tensile	Load and extension	Units and mapping
Bending	Method and direction	Repeat readings
Shear	Method and response	Model support
Structure	Mass and thickness	Tested state
Provenance	Operator, files, date	Version link

ILLUSTRATIVE [S05] GFT proposed fields, not measured fabric data. Units and simulator mappings must follow the agreed test route.

For this proposed record, mass should state whether it means specimen mass or mass per area. Thickness should retain the measurement conditions rather than appear as an unexplained scalar. A tensile entry should distinguish its raw load and extension observations from a fitted software coefficient. These are data-definition requirements: they stop unlike quantities from being treated as interchangeable merely because an import dialogue accepts a number. The dictionary cannot establish that the selected tests cover every behaviour relevant to the final garment.

> **GFT NOTE**
>
> Commission a material record and a bounded validation task together. Before digitising a fabric, state what an acceptable result would allow the team to decide. Assign a material custodian to preserve the physical specimen and a technical reviewer to approve the mapping. A visual asset may support styling; additional permissions require their own evidence.

6.2

Digitisation needs a documented test route

The abstract of Youn and co-authors' comparative study describes a virtual drape setup, fabric properties obtained through standard equipment or a simplified kit, and an investigation of particle distance. It supplies a reason to separate measurement route from simulation settings. The abstract does not supply a complete operating procedure or numerical performance guarantee for another installation. [S04]

GFT proposes a written route before collecting measurements. It should identify the equipment, method revision, preparation, specimen dimensions, orientation, conditioning, operating range and recorded output. Record who prepared and who tested the specimen, including departures from the planned method. The route should be specific enough that a replacement operator can repeat the work without guessing which undocumented handling choice produced the original file. Applicable laboratory procedures must be obtained and agreed with the laboratory; the chapter does not reproduce them.

The proposed repeatability check should distinguish repeated readings of the same preparation from measurements on separately prepared specimens. Keep those records separate from sampling across rolls or receipt lots. Repeated instrument readings address a narrower question than production variation. If the operator changes a specimen between readings, record the reason and retain the sequence. Report the spread together with the central value chosen for the simulator. Do not discard an inconvenient result simply because excluding it gives a smoother virtual swatch.

CLO's support page distinguishes library fabrics from fabrics created using its fabric kit and warns that arbitrary changes to physical properties can alter accuracy. The page is a manufacturer description, updated on 5 October 2026, rather than independent validation of the proposed service. Its headline accuracy percentage is not adopted here because it does not define an error measure suitable for this chapter's release decision. [S16]

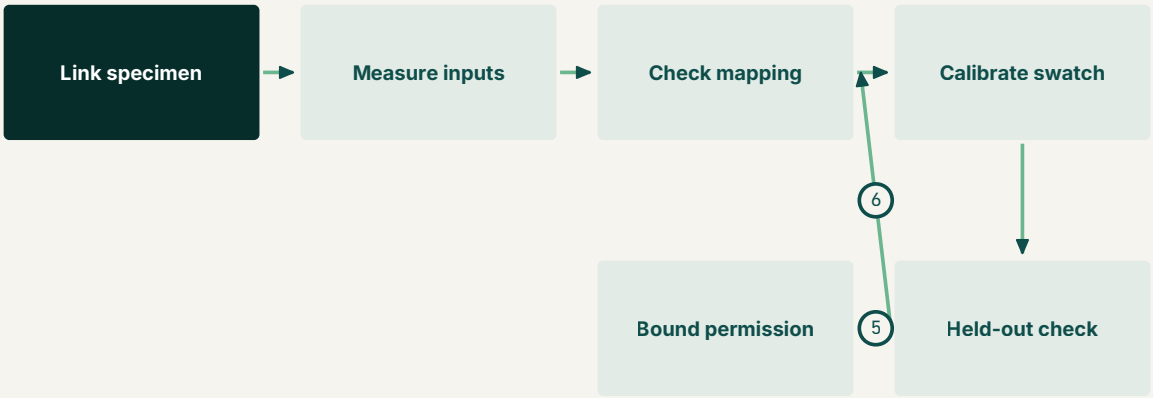
GFT therefore proposes a transfer worksheet between the laboratory record and the application. Each row should state the source quantity, source unit, destination field, conversion rule and any fitting assumption. Preserve the original export beside the converted file. For a response curve, record the range used in fitting and the residual discrepancy rather than pretending that a single imported value retains the entire experiment. When a mapping is undocumented or uncertain, label the resulting asset provisional and restrict its use until a controlled comparison resolves the uncertainty.

A practical pilot should also price this route as development work. GFT recommends recording preparation time, laboratory charges, transport, interpretation, failed imports and repeat measurements against the material family that requires them. This is a proposed accounting boundary, without a cost estimate. The sampling-cost analysis elsewhere in the paper can then compare the full calibration burden with development steps actually avoided. Charging the work only to a software subscription would conceal the effort needed to make its inputs dependable.

The proposed sequence in **Exhibit 23**, p. 96 gives a failed comparison a return path. The review should name whether the issue is specimen identity, measurement, mapping or experimental setup before changing a parameter. Failure is useful evidence when its cause and revision history remain visible. It becomes much less useful when a new material file silently replaces the old one and the team can no longer reconstruct why the output changed.

EXHIBIT 23 / ILLUSTRATIVE GFT PROCEDURE

Calibration must leave a route back to its inputs



5. Pass
6. Diagnose failure

ILLUSTRATIVE [S04] [S07] Proposed sequence. No stage durations or achieved results are asserted. A failed held-out check returns to documented diagnosis.

Before ordering tests, GFT recommends asking the intended evaluator to specify the deformation and loading conditions relevant to the decision. A test that characterises a different range may still be useful, but the limitation should travel with the resulting asset. Request the actual response record and measurement definitions when commissioning outside digitisation, together with a description of the conversion into the target software. A delivered application file alone should not close the measurement task. If a service provider cannot disclose a proprietary conversion, retain that restriction and require a task comparison that does not depend on accepting the undisclosed mapping as proven.

6.3

Warp, weft and bias must survive the data transfer

The directional finding in Ancutienė and Sinkevičiūtė's diagonal-cut garment study concerned the influence of weft tensile properties. It is a warning against erasing orientation during material transfer, not evidence that weft tension will dominate every product. GFT's proposed import check retains directional identity before investigating which properties matter to the chosen article. [S05]

Under that proposal, mark the principal directions on the physical specimen and carry the convention into the test file. The file should identify whether an angle is measured from warp, weft or another defined reference. The patternmaker should then check how that reference appears on the imported pattern piece. A screen rotation made to

arrange pieces conveniently must not be mistaken for a change to the intended fabric grain. The review should compare the recorded direction with the pattern's production intent, rather than infer it from how a weave image happens to look.

GFT recommends a direction-transfer check using a deliberately asymmetric test asset. Give its principal directions visibly different diagnostic settings, inspect the software's reported orientation and then restore the measured asset. This checks the data route; the diagnostic asset must remain excluded from approval work. If an exchange format drops a direction field or substitutes a default, record the loss and correct it through an explicit import step. An unexplained discrepancy should stop the transfer rather than become a convenient adjustment to the garment.

For bias-cut work, the proposed record should state the angle and the scope of evidence behind the model's off-axis response. If a laboratory route tests only principal directions, do not describe an oblique response as independently measured. Keep the distinction between measurement and simulator interpretation visible to the reviewer. Where the product's decision depends on that interpretation, add an appropriate off-axis comparison to the calibration plan. The question is whether the representation supports the intended task, without extending the permissions of the principal-direction tests by assumption.

The same control should apply when an asset is duplicated. GFT proposes retaining the physical identity and direction record in the copy, while changing the asset revision and purpose. A new surface image should not silently create a new mechanical qualification. Conversely, replacing the tested substrate while keeping its old image should not preserve the old permission. The record should reveal whether the designer changed appearance, mechanics or physical origin, because those changes call for different reviews.

This proposed discipline also gives fault isolation a useful order. Check specimen labels, test orientation, import mapping and piece grain before compensating through stiffness edits. Keep an orientation discrepancy as its own failure category. Otherwise the team could obtain an attractive result by changing mechanics to offset a direction error, then carry the incorrect material into another product. The local control is straightforward: preserve the physical reference through each transfer and document any deliberate departure before using the output to make a decision.

For operational use, GFT proposes an import acceptance record signed by the technical role responsible for the pattern. Record the source asset revision, destination application, expected direction convention and result of the diagnostic check. Where pieces intentionally use different grain directions, identify them individually. Keep any approved exception attached to those pieces rather than changing the global fabric record. This allows a later reviewer to distinguish a deliberate product choice from an import defect. It also prevents an exception created for a particular panel from becoming the default behaviour of every subsequent garment that uses the same material.

6.4

Resolution is part of the experiment

Youn and co-authors explicitly included particle-distance effects in their investigation of virtual fabric. That makes resolution a variable to control in a comparison, rather than a presentation preference that can remain undocumented. The opened abstract gives no universal particle-distance setting that GFT can prescribe for a new software version or product. [S04]

GFT proposes separating an editing setup from an evaluation setup. The editing setup serves interactive construction work. The evaluation setup is the frozen configuration used for the comparison and its release record. Store the application build, solver mode, resolution, collision settings, layer arrangement, contact assumptions, initial placement and stopping rule with the material revision. A screenshot of the final garment is insufficient to recover those choices. When the application generates a report, retain it with the native scene and record any setting entered outside the report.

The proposed resolution check should hold the material and geometry fixed while changing the evaluation resolution. Compare a defined output rather than asking only whether the image looks better. Record computation time as an operational observation when measurements become available, without treating faster execution as validation. If the selected output continues changing enough to alter the decision, retain a hold on that decision and investigate. A finer setting is a test condition; it should not be described as more accurate solely because it is more demanding to run.

> **METHOD**
>
> GFT proposed experiment boundary: specify the physical specimen, support geometry, measured material revision, simulator build and output definition before running the resolution comparison. Reinitialise each run from the recorded state. Apply the same stopping criterion, archive intermediate results and document unresolved movement or contact problems. Compare numerical outputs with the physical reference and retain the visual record as complementary evidence. A stable numerical result can still disagree with the physical specimen.

GFT also recommends a repeat-run check at the chosen evaluation setup. Its purpose is to reveal dependence on initialisation, placement or undocumented intervention. The operator should retain failed runs and their cause rather than keeping only the final attractive scene. If manual pins, smoothing or local constraints are needed to complete a run, disclose them and explain whether they have physical counterparts. A result obtained under those constraints should not inherit permission from an unconstrained comparison merely because the underlying fabric filename is unchanged.

Changes to software should trigger a documented impact check under the proposed system. Preserve a reference scene and its prior outputs, then compare the new build before migrating approval work. If the new build changes imported parameters or evaluation behaviour, issue a new qualification record. Keep legacy scenes readable where practical and state any migration limitation. This is a proposed change-control

requirement, not a claim that updates necessarily make a model worse. It makes a changed computational experiment visible before its outputs are compared with earlier approvals.

Finally, GFT recommends preserving the meaning of the output itself. A change in camera, projection, scale or image processing should be recorded when the evaluation uses image-derived geometry. Keep a scale reference and a consistent measurement procedure. The technical reviewer should be able to reproduce the reported quantity from the archived output without guessing which silhouette edge was selected. Resolution control cannot rescue an output definition that changes between the physical and virtual observations.

6.5

Drape calibration should precede full fit judgement

GFT proposes starting with a supported swatch comparison to isolate the material and setup from garment construction and body representation. Match the physical and virtual specimen outline, support dimensions, orientation, loading and observation geometry. Keep preparation and settling conditions in the test record. Use an agreed output such as projected unsupported area alongside the visible fold configuration. This is a proposed diagnostic method, not a substitute for the garment's subsequent physical fit and performance checks.

A useful calibration output must also have a declared denominator. For the illustrative calculation below, define a projected-area index as projected area minus support area, divided by flat specimen area minus support area, multiplied by 100. All areas refer to the same top-view plane. This is an explicitly constructed arithmetic example; it is not a claim that its chosen dimensions, values or tolerances reproduce a published test method.

WORKED EXAMPLE: STABLE OUTPUT CAN RETAIN PHYSICAL DISAGREEMENT

Assume, solely for this illustrative example, a flat specimen area of 18,000 square millimetres and a support area of 8,000 square millimetres. The denominator is therefore 10,000 square millimetres. Assume a physical projected area of 11,800 square millimetres. The defined index is (11,800 minus 8,000) divided by 10,000, multiplied by 100, giving 38 percent.

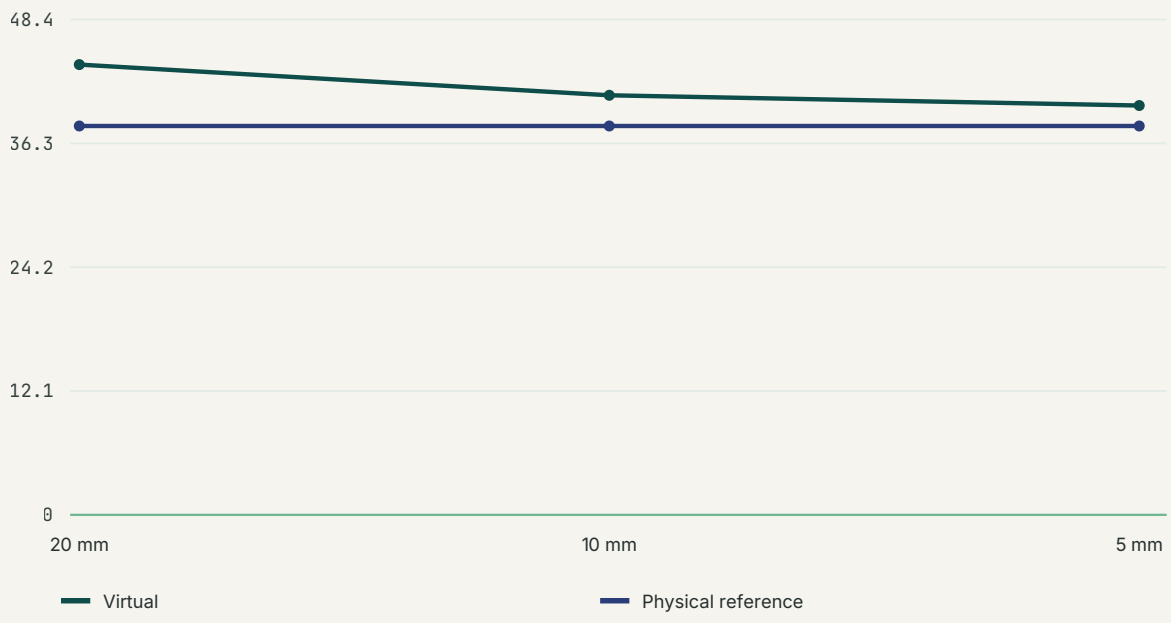
Assume illustrative virtual projected areas of 12,400, 12,100 and 12,000 square millimetres at resolution settings of 20, 10 and 5 millimetres respectively. Applying the same calculation gives indices of 44, 41 and 40 percent. The last resolution change moves the index by 1 percentage point, while the finest run still differs from the assumed physical reference by 2 percentage points. No significance level, uncertainty coverage or acceptance threshold is implied.

If an illustrative task rule allowed an absolute index discrepancy of at most 1.5 percentage points, the finest run would remain outside that rule. That threshold is invented solely to demonstrate a decision and would require independent agreement for actual use. Improving numerical stability has not, in this example, established agreement with the physical reference. The appropriate action is diagnosis, rather than describing the last render as validated because the resolution was refined.

The illustrative comparison in **Exhibit 24**, p. 100 retains the physical reference beside the computed cases. Its lines connect equally spaced categories representing successive halving of the setting, rather than claiming a linear response to distance. The exhibit is an arithmetic teaching example. It contains no sampled material measurements, local pilot results or prediction of how a real simulator responds.

EXHIBIT 24 / ILLUSTRATIVE PROJECTED-AREA INDEX, PERCENT

Numerical stability can coexist with physical disagreement



ILLUSTRATIVE Assumed areas: flat 18000, support 8000, physical 11800; virtual 12400, 12100, 12000 square millimetres. Index = (projected - support)/(flat - support) x 100. Categories are successive resolution halvings.

GFT proposes separating calibration observations from held-out comparisons before any parameter adjustment begins. Use the calibration set to investigate mapping and choose the evaluation setup. Then freeze that setup and test specimens or configurations excluded from those choices. If a held-out failure causes further tuning, retain the failed result and classify that case as development evidence thereafter. A fresh held-out comparison is needed for the next validation claim. Repeatedly tuning to a final reference removes its value as an independent check.

The proposed handover should state which aspects agree and which remain unresolved. Similar projected area does not, by the definition of this example, require identical folds. A plausible swatch does not establish the behaviour of seams, layers or a body interface. Report those exclusions alongside the permitted task. The next chapter can then ask a bounded physical garment question without having to reconstruct whether a material asset was measured, adjusted against the reference, or merely chosen because its render looked convincing.

For the proposed swatch review, GFT recommends recording both signed and absolute discrepancies. A signed discrepancy preserves whether the virtual output lies above or below the physical reference; an absolute value summarises its magnitude. Retain individual specimen comparisons alongside any aggregate, and identify the uncertainty of the physical observation itself. Agreement inside a poorly measured reference interval should not be described as precise prediction. If the physical repeatability is inadequate for the intended decision, improve the reference route or narrow the question before using it to tune the simulator. Otherwise calibration can become an exercise in following measurement noise.

6.6

Parameter sensitivity reveals fragile approvals

GFT proposes testing the decision against the uncertainty retained in the measurements and mappings. Establish the plausible input bounds from the actual record before running the experiment. Do not substitute an arbitrary percentage and call it measured uncertainty. Distinguish repeatability, variation between specimens and uncertainty introduced by conversion. If only a provisional range can be justified, label it an assumption and retain the resulting decision as conditional. The purpose is to expose dependence on uncertain inputs, rather than manufacture a precise confidence claim.

The illustrative plan in **Exhibit 25**, p. 102 uses ordinal codes for input states. Lower, central and upper refer to bounds that a later measurement record must supply. The exhibit contains no simulated response or claimed sensitivity ranking. It offers a reproducible starting sequence for isolating inputs, with bending representing a selected directional parameter rather than an unexplained average. Additional relevant directions and properties should be added in the actual plan.

EXHIBIT 25 / ILLUSTRATIVE PLAN CODES: 0 LOWER, 1 CENTRAL, 2 UPPER

Change a named input before interpreting a changed decision

	Warp	Weft	Bend	Shear
Baseline	1	1	1	1
Warp low	0	1	1	1
Warp high	2	1	1	1
Weft low	1	0	1	1
Weft high	1	2	1	1
Bend low	1	1	0	1
Bend high	1	1	2	1
Shear low	1	1	1	0
Shear high	1	1	1	2

Cell scale: 0 to 2

ILLUSTRATIVE [S04] [S16] Design of a proposed experiment, not measured sensitivity. Bounds must come from retained measurement or mapping uncertainty. Cells encode input settings only; no output or effect size is asserted.

Under the proposed analysis, retain the nominal output, output at each permitted bound and the distance from the agreed decision limit. A decision is fragile when plausible inputs change its disposition. The reviewer should then decide whether to gather better measurements, narrow the permitted use or retain a physical check. Do not hide a sign change or local failure inside an average across observation points. An attractive average may leave the very location that matters to the product unresolved.

The initial isolated-input plan should not be described as a complete uncertainty analysis. GFT proposes reviewing plausible joint changes after identifying influential inputs. Some combinations may be incompatible with the physical material or its fitted model; keep those constraints explicit. Where a mapping couples parameters, preserve that coupling rather than perturbing unrelated fields independently. Report an untested combination as untested. The plan should test the decision's vulnerabilities without implying that every mathematically possible setting is a physically plausible fabric.

For a narrow pilot, GFT recommends attaching the sensitivity record to the proposed permission. A material could support a silhouette comparison while remaining unsuitable for a close-fit decision. State that distinction in the approval interface and the technical pack. If a plausible variation crosses the task's limit, the nominal render should not override the hold. Arbitrary parameter adjustment was specifically qualified in the opened manufacturer guidance; this proposed control makes any adjustment reviewable without adopting the vendor's general accuracy claim. [S16]

The proposed sensitivity review should finish with an action and an owner. A measurement problem returns to the laboratory liaison; an undocumented conversion returns to the asset preparer; a decision limit without buyer agreement returns to the product lead. Keep these dispositions separate from the designer's preferred appearance. Where the data cannot resolve the issue within the development window, retain the physical approval step and describe the digital output as advisory. That is a bounded operating decision. It should not be reported as a failed technology assessment or a successful sample reduction before the service has measured either outcome.

6.7

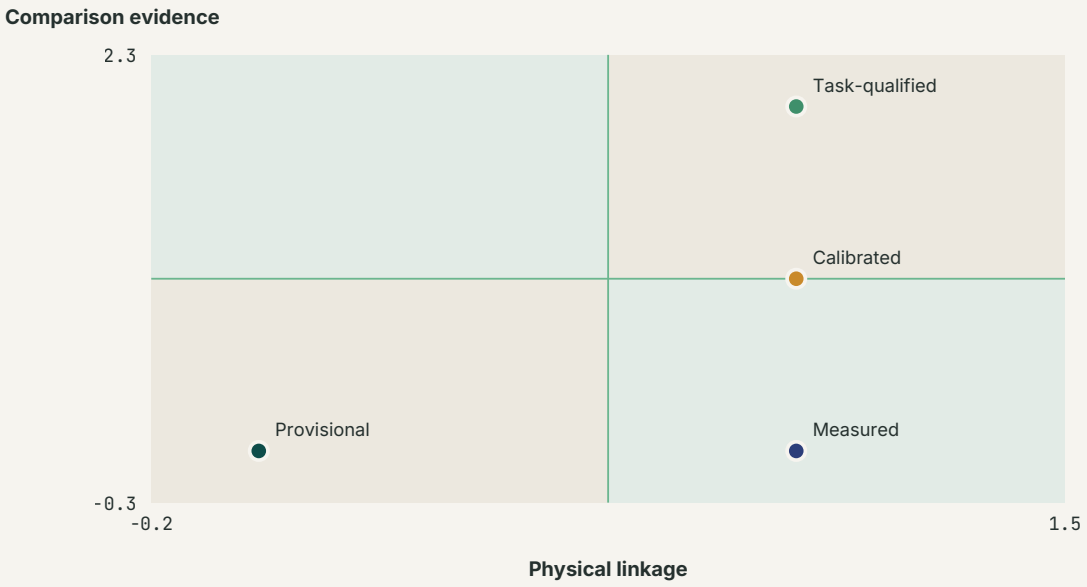
A digital material library needs release control

The conference study by Zangue and co-authors links effective interpretation to garment knowledge and correctly prepared inputs, while retaining a physical fitting boundary. It supports treating the material file as part of a controlled workflow. It does not establish that a passing material comparison alone authorises physical garment release. [S07]

GFT proposes distinct provisional, measured, calibrated and task-qualified states. Provisional records support exploration. Measured records have a physical link and traceable inputs. Calibrated records add a documented swatch comparison. Task-qualified records add held-out evidence for an expressly bounded decision. The illustrative state map in **Exhibit 26**, p. 103 uses ordinal evidence categories, without scoring the quality of a fabric or claiming achieved library coverage. Permission must remain written in the record; position on the map is a guide to the evidence required.

EXHIBIT 26 / ILLUSTRATIVE ORDINAL EVIDENCE CATEGORIES

Library permissions must follow the evidence state



ILLUSTRATIVE [S07] GFT proposed states, not achieved qualifications. X: 0 unlinked, 1 physically linked. Y: 0 no comparison, 1 swatch comparison, 2 held-out task evidence. Coordinates are categories, not confidence or performance scores.

GFT recommends making those states visible wherever a material can be selected, rather than burying them in an archive. The selector should show the physical identity, revision, tested state, permitted task and any unresolved restriction. Exported scenes should preserve that summary so another operator does not interpret a portable asset as an unrestricted approval. If the receiving system cannot retain the fields, attach a readable manifest and require an explicit readback before evaluation. Missing provenance at the receiving boundary should suspend the asset's permission, even when the transferred file opens successfully and produces an image without an error.

Each proposed release record should retain its predecessor, raw data, transformation rules, calibration observations, held-out results, reviewer and permitted tasks. Save the native asset and a readable summary. Separate the person preparing an asset from the role approving a new permission where staffing permits; record combined roles when it does not. Retire obsolete versions from new work without deleting the evidence behind earlier decisions. Existing orders should retain the exact revision they used until a documented review decides whether replacement is needed.

Material state after care also needs a defined boundary. The public scope of ISO 3759 addresses preparing, marking and measuring textile specimens and articles for dimensional-change assessment. ISO 6330 describes domestic washing and drying procedures as a combined test. These opened catalogue scopes identify relevant method boundaries, rather than supplying licensed procedures, pass grades or evidence for a particular fabric. [S27] [S12]

GFT consequently proposes recording whether an asset represents received, processed or care-tested material, and reviewing permission when the physical basis changes. A new supplier, finish, substrate, production route or unexplained measurement shift should trigger an impact assessment. Requalification can then target the affected task instead of automatically repeating every check. The retirement reason must remain visible, particularly when a designer searches by a familiar article name and might otherwise reuse an asset whose physical reference no longer matches production.

The proposed commissioning gate is a reviewable dossier: an identified specimen, repeatable measurement route, checked mapping, frozen setup, calibration record, held-out comparison and bounded permission. Missing evidence should leave a visible restriction. No local pilot measurements are established in this chapter, so no material is declared qualified here. This is the point at which the sampling workflow can make an honest promise: it knows what its digital material represents, what has been compared, and which decision still belongs to the physical garment.

A fabric file earns permission through the comparison it can survive.

CHAPTER SOURCE NOTES

S05 Kaunas University of Technology, Materials Science. 2011-07-04.

S04 Dongguk University research portal; Taylor & Francis, Journal of the Textile Institute. 2025.

S16 CLO Virtual Fashion. 2026-10-05.

S07 3DBODY.TECH conference proceedings. 2020.

S27 International Organization for Standardization. 2011.

S12 International Organization for Standardization. 2021.

GREEN FUTURE TECH

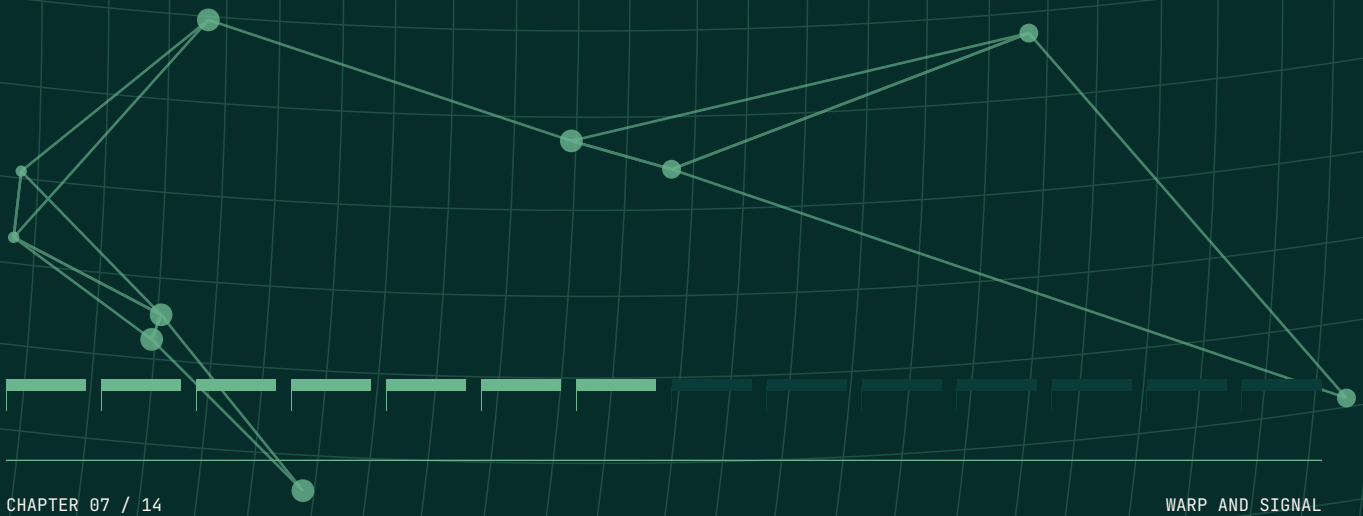
LIMITED / HONG KONG SAR

07

PART II: MAKE THE DIGITAL SAMPLE PHYSICALLY ACCOUNTABLE / FIT AND DURABILITY

Digital approval must survive a physical garment test

Separate decisions that can be made on screen from those that require physical evidence.



CHAPTER 07
DECISION TEST

Separate decisions that can be made on screen from those that require physical evidence.

A calibrated three-dimensional simulation can eliminate early concept and proportion iterations, but it cannot release a garment to commercial production on its own. [S07] Even when pattern geometry is valid, avatar dimensions follow repeatable anthropometric rules and fabric mechanical parameters are measured on real swatches, screen review leaves residual error in location-specific distance ease, dynamic movement comfort, tactile hand feel, post-laundering dimensional change and colour fastness. [S06] [S08] [S10] [S11] [S12] Green Future Tech Limited (GFT), Hong Kong SAR, argues that a local apparel operation in Cameroon should treat digital sampling as an upstream filter that narrows candidate styles before cutting cloth, while keeping an explicit physical release gate that every new style, substrate or ink-and-cure combination must pass before manufacture. [R06] [S07]

That boundary connects Part II of this paper to the factory execution chapters that follow. Earlier chapters established how to qualify base fabrics and colour profiles, construct accountable patterns and representative avatars, and calibrate virtual drape against physical fabric mechanics. [S04] [S05] [S09] [S13] Those controls make a digital sample testable; they do not make the digital image identical to a sewn and laundered garment. [S07] [S16] Where Cameroon's policy seeks to raise local cotton processing from roughly 5 percent toward 50 percent by 2030, a domestic apparel maker wins repeat institutional or retail orders only when delivered garments fit the intended wearers and survive care without unaccepted shrinkage, distortion or colour loss. [R06] [R07] [S10] [S12] Replacing physical release evidence with a screen sign-off merely delays those failures until after fabric has been printed, cut, sewn and shipped. [S07]

7.1

Fit validation needs paired observations

Virtual fit validation is credible only when simulated and real garments are compared as matched pairs at named body cross-sections under controlled conditions. [S06] An informal look at a monitor beside a dress form is an impression, not a validation test. In a comparative study of real and virtual straight-fit dresses across five woven fabrics, researchers scanned women mannequins of different sizes using a three-dimensional body scanner with and without the physical garments, defined fabric mechanical properties using Kawabata Evaluation System instruments, dressed the scanned mannequin meshes in virtual garments of the same pattern size and fabric parameters inside commercial three-dimensional software, and compared distance ease across horizontal bust and waist cross-sections. [S06] That paired design isolated where the virtual garment tracked the physical profile and where local wrinkling or high shear rigidity caused the two profiles to diverge. [S06]

7.2 EQUIVALENCE REQUIRES LOCKED PATTERN, MATERIAL, BODY AND POSE INPUTS

Every comparison between a digital sample and a physical prototype must lock four inputs simultaneously: the two-dimensional sewing pattern, the physical fabric lot and its digital material file, the underlying body or mannequin geometry, and the evaluation pose. [S04] [S06] [S13] [S32] If a patternmaker adjusts a dart or seam allowance at the

cutting table without updating the digital file, or if the sewing room cuts the trial from a substitute twill while the simulator uses default library parameters, any fit difference is confounded across unrecorded changes. [S16] [S32]

GFT therefore proposes a paired-observation protocol for style qualification within its Cameroon textile programme concept. Before a physical validation garment is cut, the technical lead freezes the pattern revision, records the fabric roll identifier and its measured warp, weft and shear parameters, links the avatar to anthropometric landmarks defined under ISO 8559-1 scope, and specifies the static stance and alignment planes at which girth, ease and hem balance will be checked. [S05] [S13] [S16] Where a factory lacks an optical scanner, paired observation still works with physical metrology: marking horizontal reference planes on the dress form or consenting wearer at bust, waist, hip and limb landmarks, measuring circumference and stand-off, and comparing those readings against cross-sectional distance-ease readouts exported from the simulator at the identical heights. [S06] [S13]

> **METHOD**
>
> **GFT paired-fit comparison boundary.** Execute five sequential steps on each paired validation article: 1. **Freeze the specification.** Record the pattern version hash, graded size code, seam-allowance table, stitch class and fabric lot identifier so the virtual mesh and physical cut pieces share an identical geometric origin. [S09] [S32] 2. **Match the body reference.** Use either a rigid mannequin measured at ISO 8559-1 landmarks or a consenting fit participant whose stature, chest, waist, hip and limb girths match the avatar within documented repeatability. [S07] [S13] 3. **Control simulation resolution and settling.** Run the virtual dress-up at the locked evaluation particle distance, allow the solver to reach equilibrium, and export horizontal section measurements at the named landmark planes. [S04] [S06] 4. **Condition and dress the physical article.** Assemble the garment under the specified stitch tension and pressing instruction, place it on the reference mannequin or wearer in the matched neutral pose, and measure circumference, balance and ease at the same landmark planes. [S06] [S27] 5. **Log non-equivalence explicitly.** Record every boundary where physical and virtual conditions could not be kept identical, such as soft-tissue compression under a waistband, interlining stiffness, or bulky seam intersections simplified by the shell mesh. [S06] [S07]

7.3 DISCLOSING BROKEN EQUIVALENCE PROTECTS THE ENGINEERING RECORD

Perfect equivalence between a cloth solver and a sewn garment is rarely achievable, and pretending otherwise corrupts the quality log. [S07] A rigid fibreglass mannequin preserves repeatable geometry across dressings, yet it cannot reproduce soft-tissue compression at a waistband or shoulder strap. [S06] [S07] Conversely, a live fit model provides soft-tissue interaction and breathing movement, but introduces postural sway between measurements. [S07] [S08] Similarly, three-dimensional simulators model panels as thin shells with simplified seam stiffness, whereas a physical garment contains folded hems, overlocked allowances, thread tension, fasteners and heat-cured pigment or transfer layers that alter local bending. [S04] [S15] [S32] Documenting these differences alongside paired measurements builds an engineering register of where simulation is trustworthy and where an early physical toile remains necessary. [S05] [S06]

7.4

Appearance does not establish comfort

A plausible static silhouette on a calibrated monitor does not prove that a garment can be worn comfortably, moved in freely or accepted by the hand. [S07] [S08] Modern rendering engines apply yarn normal maps, studio lighting and colour-managed textures onto simulated meshes so convincingly that buyers can mistake a preview for a verified product. [S05] [S22] Yet the conference literature on virtual versus physical fit states the limitation directly: three-dimensional simulation cannot fully replace a real physical fitting because not all technical and perceptual issues have been solved. [S07]

7.5 STATIC EASE MAPS MISS PSYCHOLOGICAL PREFERENCE AND SOFT-TISSUE PRESSURE

Software tension, strain and pressure maps colour-code where a virtual mesh stretches or contacts the avatar surface, providing a diagnostic screen for obvious pattern errors such as a tight armhole or binding collar stand. [S07] However, those maps are mathematical functions of entered tensile and bending curves against an avatar shell. [S04] [S05] They do not measure thermal comfort, skin friction at an inside seam, label irritation or the subjective threshold at which snug support becomes restrictive pressure. [S07] [S0701]

Empirical modelling of virtual garment fitting reinforces this boundary: even when three-dimensional body measurements, garment sizes and ease allowances are combined with neural-network prediction models, designers find it challenging to recognise customers' motivations and emotions toward their preferred fit and to define ease allowances in a virtual environment. [S0701] Wearers with identical chest and waist circumferences under ISO 8559-1 definitions frequently prefer different ease distributions depending on dress norms, tasks and climate. [S13] [S0701] In Cameroon's warm coastal cities or northern cotton provinces, a close ease allowance that looks sharp on a studio avatar can feel clammy if the fabric construction and print layer trap perspiration. [R03] [S07] [S15]

7.6 DYNAMIC POSES EXPOSE RESTRICTIONS THAT NEUTRAL STANCES HIDE

Garments are worn in motion, not in the symmetrical standing pose used to dress a default avatar. [S08] Research on designing personalised garments with body movement shows that incorporating transitions between distinct body poses is necessary to ensure fit and freedom of movement, because a pattern that hangs cleanly in a neutral standing posture can bind across the scapulae, hike at the hem or pull across the knee and hip during reaching, striding or sitting. [S08] Even in that pose-aware research, the authors validated their method by fabricating physical sewn garments and testing them on real bodies moving through the target postures. [S08] For institutional uniforms, schoolwear or workwear, GFT recommends treating virtual pose checks as an initial filter before cutting, followed by a physical wear trial across a standard task sequence. [S07] [S08] [S10]

7.7 DIGITAL INK AND TRANSFER LAYERS CHANGE LOCAL HAND FEEL

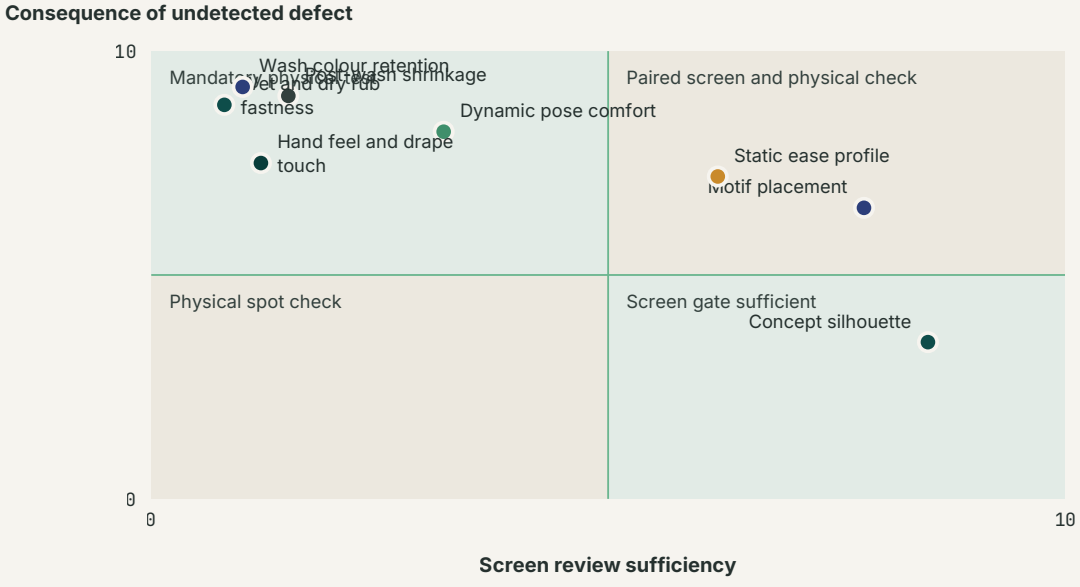
In printed apparel, comfort and drape also depend on the chemistry deposited onto the textile surface. [S01] [S15] On screen, an artwork file mapped onto a garment panel has zero mass, thickness and bending rigidity unless the operator manually overrides the local material zone. [S05] [S16] In the factory, every decoration route alters the substrate:

- **Direct-to-garment (DTG) printing on dark cotton blanks** applies liquid pretreatment, dries that layer, jets a white underbase and coloured pigment inks, and cures the deposit with heat, creating a perceptible hand and reducing local vapour permeability across large graphics. [S15] [S30]
- **Direct-to-film (DTF) transfer printing** prints onto film, coats the wet ink with hot-melt adhesive powder, cures the powder and heat-presses the transfer onto the garment, forming an elastomeric patch that resists stretch differently from the surrounding knit. [S15]
- **Roll-to-roll pigment printing** binds insoluble colourants to the fibre surface through a polymeric binder fixed by dry heat, increasing fabric bending stiffness compared with unprinted base cloth. [S01] [S0702]

None of these tactile shifts can be approved on a monitor. [S07] [S22] **Exhibit 27**, p. 110 maps eight product-approval decisions across the sufficiency of calibrated screen review and the commercial consequence of an undetected defect at delivery. [S06] [S07] [S08] [S10] [S11] [S12]

EXHIBIT 27 / ILLUSTRATIVE SCORE (0 TO 10)

Some decisions still require a physical article



ILLUSTRATIVE [S06] [S07] [S08] [S10] [S11] [S12] Illustrative GFT decision allocation informed by S06 to S12. Horizontal axis scores how completely a calibrated screen review resolves the question (0 low, 10 high); vertical axis scores the commercial consequence of an undetected defect at customer delivery (0 low, 10 high). Positions are analytical judgements for workflow design, not empirical measurements.

As **Exhibit 27**, p. 110 illustrates, screen review can reject poor concept silhouettes early and verify preliminary motif placement and static ease proportions before cutting cloth, provided those high-consequence items still receive paired physical confirmation. [S06] [S07] By contrast, dynamic pose comfort, hand feel over printed zones, post-wash dimensional stability, rubbing fastness and laundering colour retention cluster in the upper-left quadrant, where screen sufficiency is near zero and failure cost is severe. [S07] [S08] [S10] [S11] [S12] Because **Exhibit 27**, p. 110 is an illustrative framework, it cannot establish defect probabilities for a specific factory; its role is to prevent teams from assigning physical durability and comfort sign-offs to a software viewport. [S07]

To prevent evaluator bias during physical fitting, GFT recommends recording two independent logs before reconciling the fit decision: a **wearer comfort log** completed by the fit participant after executing a defined movement routine, and a **technical evaluator log** completed by the patternmaker or quality lead recording dimensional ease, seam balance and grain alignment. [S06] [S07] [S08] [S0701]

7.8

Study discrepancies are warnings, not production tolerances

Published fit-discrepancy numbers from academic simulation studies are warnings that error varies sharply by body location, fabric mechanics and garment size, not benchmark tolerances that a factory may copy into its quality manual. [S06] Extracting a headline percentage or centimetre deviation from a journal abstract and declaring that any prototype within that band is acceptable misreads both cloth-simulation physics and manufacturing tolerances. [S06] [S07]

7.9 LOCATION-SPECIFIC ERROR IN A WOVEN-DRESS MANNEQUIN STUDY

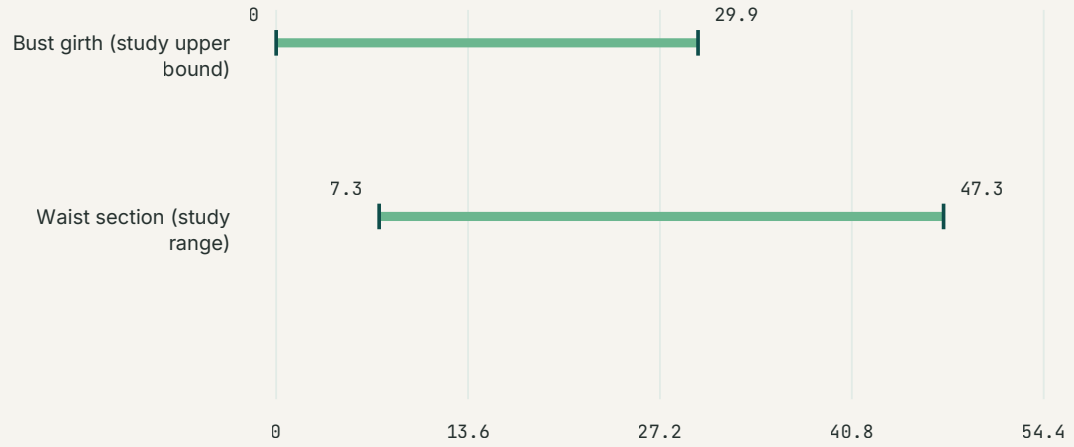
In the Kaunas University of Technology study of real and virtual straight-fit dresses across five woven fabrics on scanned women mannequins, researchers compared horizontal cross-sections of virtual garments simulated in Modaris 3D against three-dimensional scans of the real sewn dresses and found sharply different discrepancy bands at two torso landmarks: [S06]

- At the **bust girth cross-section**, where the garment hangs supported from the shoulders with relatively few deep folds, distance-ease values between real and virtual dresses differed by **up to 29.9 percent (1.16 cm)**. [S06]
- At the **waist cross-section**, where fabric gathers into local wrinkles sensitive to shear stiffness and solver resolution, the distance-ease difference varied from **7.3 percent (0.51 cm) to 47.3 percent (4.30 cm)**. [S06]

Exhibit 28, p. 112 plots those sourced discrepancy bounds from the study abstract to make the contrast between upper-torso support and waist-zone wrinkling visible. [S06]

EXHIBIT 28 / PERCENT DIFFERENCE IN DISTANCE EASE

Fit discrepancy can differ sharply by measurement location



SOURCED [S06] Reported in Lagė et al. (2020) abstract for five woven straight-fit dresses on scanned women mannequins in Modaris 3D: bust girth distance-ease difference up to 29.9 percent (up to 1.16 cm; lower bound shown as 0 where the abstract reports only the upper bound 'differed till 29.9 %'), and waist cross-section difference from 7.3 to 47.3 percent (0.51 to 4.30 cm) due to local wrinkling. Study observations only, not GFT results or production tolerances.

The numbers in **Exhibit 28**, p. 112 carry three lessons for an apparel engineer. [S06] First, simulation accuracy is not a single scalar property; in the same study on the same dress silhouette, the upper bound of distance-ease error at the waist (47.3 percent, or 4.30 cm) was more than three times the centimetre discrepancy at the bust (1.16 cm) because local wrinkling amplified folding differences. [S06] Second, fabric mechanics govern solver fidelity: the authors reported that very high shear rigidity could not be reflected well in the three-dimensional CAD system, and that virtual try-on accuracy was useful when fabric shear rigidity was below 1.6 newton per metre per degree and warp tensile strain exceeded 1.80 percent. [S06] Third, as mannequin size increased, similarities between the virtual and real dresses decreased. [S06]

What **Exhibit 28**, p. 112 cannot establish is a universal error rate for all software, garment types or any GFT facility. [S06] The study examined five woven fabrics in one straight-fit dress style on rigid mannequins in one software environment published in 2020. [S06] Above all, a 4.30 cm distance-ease discrepancy at the waist (nearly two garment grade steps in commercial size charts) would be an outright fit rejection in production, never an acceptable tolerance. [S06] [S07]

7.10 MANUFACTURING TOLERANCES AND SIMULATION RESIDUALS HAVE DIFFERENT DENOMINATORS

GFT separates three quantities that must never be conflated: 1. **Buyer garment measurement tolerance (`tol_spec`):** contractual variation permitted between the technical-pack finished-garment table and the physical garment delivered off the sewing line, agreed per measurement point with the customer. [S07] [S32] 2. **Virtual-to-physical distance-ease residual (`e_sim`):** difference between cross-sectional ease predicted by the simulator and ease measured on the physical sample made

from the identical pattern and fabric lot. [S06] 3. **Post-care dimensional change (`delta_care`):** percentage or millimetre change in length, width and spirality after the physical garment undergoes its specified washing and drying cycle. [S12] [S27]

A vendor claim that a virtual fabric simulator is accurate in general terms cannot replace any of those three numbers; as commercial software documentation cautions, virtual fabric accuracy differs when physical properties are arbitrarily modified. [S16] GFT's rule is explicit: agree finished-garment tolerances and ease expectations with the buyer per product family and size range, calibrate the simulator to reduce `e_sim` during development, and judge final release strictly on whether the physical garment meets the buyer's specification before and after care. [S06] [S07] [S12] [S16]

7.11

Washing and drying can change both fit and print

A garment that fits the reference body and aligns its printed graphics on the sewing-room table has passed only a pre-care assembly check; release requires proving that fit and print geometry survive the complete domestic or commercial washing and drying procedure intended for the article. [S10] [S12] [S27] Cellulosic fibres, above all cotton, swell in water, relax internal spinning, weaving or knitting stresses accumulated during mill finishing and thermal curing, and undergo dimensional change when dried. [R06] [S01] [S12] [S15] Unless a team creates a post-laundering material twin from washed swatches, the screen sample represents only the unwashed state. [S04] [S16]

7.12 SPECIMEN PREPARATION AND CARE PROCEDURES REQUIRE PAIRED STANDARDS

International testing standards treat specimen preparation and care execution as an inseparable pair. [S12] [S27] Under **ISO 3759:2011** scope, preparation, marking and measuring procedures apply to woven and knitted fabric specimens and made-up textile articles before dimensional-change testing. [S27] The technician conditions the garment, places pairs of benchmark points across longitudinal and transverse locations, and records baseline distances before treatment. [S27]

Those marked articles then undergo treatment under **ISO 6330:2021**, whose public scope states a rule that every apparel quality system must enforce: a complete test consists of both a washing procedure and a drying procedure. [S12] Specifying a 40 degrees Celsius wash without naming mechanical action, ballast, detergent and whether the garment is flat-dried, line-dried or tumble-dried leaves cotton shrinkage uncontrolled. [S12]

7.13 THERMAL CURING AND LAUNDERING INTERACT IN DIGITALLY PRINTED GARMENTS

In digital print-on-demand and short-run microfactories, thermal fixation and curing add an upstream driver of dimensional change. [S01] [S15] [S17] In pigment roll printing, fixation is operated by dry heat, while in DTG and DTF workflows the final stage cures inks or adhesive powder using heat. [S01] [S15] Measuring a DTG-printed cotton shirt as it exits the curing dryer captures a dehydrated, heat-flattened state rather than conditioned equilibrium. [S15] [S27] Once that garment enters washing and drying

under ISO 6330 conditions, differential relaxation between the unprinted cotton base and the printed zone produces three defects that only a physical wash test reveals: [S12] [S15] [S30]

- **Seam and panel pucker around high-coverage prints**, where surrounding cotton shrinks while the cured ink or film patch resists contraction. [S12] [S15]
- **Engineered motif misregistration across seams**, where warp and weft shrinkage rates differ on panels cut at different orientations, shifting bands out of alignment. [S05] [S09] [S12]
- **Surface cracking or delamination of prints**, when swelling cotton yarns strain the binder film during wet agitation and tumble drying. [S10] [S12] [S15]

WORKED EXAMPLE

Illustrative arithmetic: how differential wash shrinkage consumes chest ease and shifts an engineered seam. Suppose a local studio develops an illustrative short-run woven cotton tunic in a medium size using calibrated three-dimensional simulation. Every figure in this worked example is explicitly illustrative to demonstrate the calculation and is not a measured GFT factory result.

- **Pre-care design and simulation inputs (illustrative):** Target wearer chest girth is `B = 96.0 cm`, and the approved finished garment chest circumference before wash is `C_0 = 104.0 cm`, providing an illustrative circumference ease of `E_0 = C_0 - B = 104.0 - 96.0 = 8.0 cm`. Minimum acceptable post-care chest circumference ease agreed with the buyer is `E_min = 5.0 cm` (requiring post-care chest circumference `C_min = 96.0 + 5.0 = 101.0 cm`). Front torso panel length marked between ISO 3759 shoulder-to-hem benchmarks before wash is `L_0 = 65.0 cm`, with an engineered horizontal motif band centred at an illustrative `y_0 = 40.0 cm` below the shoulder benchmark, designed to align across a side seam with an adjacent panel. [S09] [S27]
- **Observed post-care dimensional change after an illustrative ISO 6330 wash and tumble-dry cycle:** Warp shrinkage on the unprinted front panel is `s_warp = -4.0 percent`, and weft shrinkage across the chest is an illustrative `s_weft = -3.5 percent`. [S12]
- **Step 1: Reconcile post-care chest circumference and residual ease (illustrative arithmetic).** Multiplying the pre-care circumference by the retained weft factor gives `C_1 = 104.0 * (1 - 0.035) = 104.0 * 0.965 = 100.36 cm`. Subtracting the wearer chest girth leaves an illustrative residual circumference ease of `E_1 = 100.36 - 96.0 = 4.36 cm`. Because `4.36 cm` is below the buyer floor of `5.0 cm`, the garment loses `3.64 cm` of circumference ease (45.5 percent of its initial `8.0 cm` allowance) and fails the post-care fit gate, even though the unwashed garment matched the virtual avatar at `104.0 cm`.
- **Step 2: Reconcile motif alignment across the side seam (illustrative arithmetic).** On the front panel cut along the warp axis, the motif centre moves from `40.0 cm` to an illustrative `y_1_front = 40.0 * (1 - 0.040) = 38.40 cm`. If the adjacent side panel was stiffened by a dense pigment border that restricted local vertical shrinkage to an illustrative `-1.5 percent`, its motif centre moves to `y_1_side = 40.0 * (1 - 0.015) = 39.40 cm`. The post-care vertical step across the seam is `39.40 - 38.40 = 1.00 cm` (`10 mm`), breaking the band after one wash.
- **Decision consequence:** The physical release gate holds the style. To pass on retest, the patternmaker must switch to a pre-shrunk cotton lot or build directional shrinkage compensation into the pattern and print marker before cutting. [S09] [S12] [S27]

7.14

Wash and rub evidence need separate decisions

Passing a shrinkage check or approving a fresh strike-off under a viewing lamp does not establish that a printed garment will retain its colour during laundering or resist crocking onto skin and adjacent clothing during wear. [S02] [S10] [S11] Wash fastness and rubbing fastness test different failure mechanisms, follow separate international standards, and require independent pass decisions in the release record. [S10] [S11]

7.15 LAUNDERING FASTNESS MUST MATCH THE SEVERITY OF THE INTENDED END USE

The public scope of **ISO 105-C06:2010** governs colour fastness to domestic and commercial laundering across textile articles, evaluating both shade change of the specimen and staining of adjacent reference fabrics. [S10] Critically, the ISO 105-C06 abstract notes that industrial and hospital articles may be subjected to special laundering procedures which may be more severe in some aspects. [S10]

Corporate uniforms, school shirts, hospital scrubs and hotel linens are attractive early niches in Cameroon because they generate repeatable batch orders. [S03] [S10] However, an institutional tunic washed at high temperatures with alkaline detergents faces a harsher chemical and thermal environment than a promotional T-shirt washed gently by hand. [S10] GFT requires the order specification to name the intended care category up front, and requires the laboratory laundering test under ISO 105-C06 scope to match that use case before release. [S10]

7.16 DRY RUBBING AND WET RUBBING FAIL FOR DIFFERENT REASONS

Whereas laundering fastness tests whether colourant detaches into a wash bath, **ISO 105-X12:2016** evaluates colour fastness to rubbing (crocking), where colour transfers to another surface by friction. [S11] As the public scope of ISO 105-X12 states, two tests may be made: one with a dry rubbing cloth and one with a wet rubbing cloth. [S11]

In digital pigment printing, DTG decoration and film transfer, pigment particles rely on a cured polymeric binder film or elastomeric adhesive layer rather than covalent fibre bonds. [S01] [S15] [S0702] Peer-reviewed research on polyurethane acrylate binders in textile printing shows how dry and wet rubbing performance can diverge across substrates and binders: while printed cotton fabrics in that study exhibited acceptable wet and dry rubbing across the tested binders, printed polyester and cotton-polyester blends showed enhanced dry rubbing fastness alongside lower wet rubbing fastness depending on the binder used. [S0702] Dry rubbing failure indicates loose surface pigment or incomplete curing, whereas wet rubbing failure occurs when moisture plasticises hydrophilic sites in the binder or swells underlying cotton fibres under shear. [S11] [S0702] Testing both dry and wet rubbing separately is therefore mandatory before release. [S11]

> **WARNING**
>
> **Standards scopes are not automatic pass grades.** The public ISO catalogue entries cited in this paper (`ISO 105-C06`, `ISO 105-X12`, `ISO 6330`, `ISO 3759` and `ISO 8559-1`) define standard test methods and boundaries, not universal pass-fail numbers, and `ISO 105-X12` notes systematic review activity on its catalogue page. [S10] [S11] [S12] [S13] [S27] A factory cannot claim ISO-certified fastness merely by citing a standard number. To close this constraint before commercial launch, the producer and buyer must contract an accredited testing laboratory, confirm the current edition of each method, and write explicit minimum grey-scale grades for colour change, staining, dry rubbing and wet rubbing, together with dimensional-change limits, into the buyer-signed technical pack. [S10] [S11] [S12] [S27]

7.17

Release authority must be explicit

A production order should enter the print queue and cutting room only when a named authority verifies that design approval, paired fit approval, colour strike-off approval and physical care-and-fastness test results are complete and reconciled to the identical specification version. [S07] [S21] [S32] Under the performance-management discipline of GFT's Cameroon textile programme, informal release on the strength of a smartphone render is treated as a primary cause of scrap, rework and unplanned overtime. [S07] [S28]

7.18 FIVE DISTINCT APPROVALS FORM THE RELEASE BUNDLE

To prevent partial evidence from masquerading as complete qualification, GFT separates five state transitions inside the technical pack and order ledger: 1. **Visual concept and artwork approval:** confirmation by the buyer and prepress lead that motif dimensions, repeat geometry, placement coordinates and permissions are locked. [S09] 2. **Paired fit and movement approval:** confirmation by the pattern lead that the virtual sample and physical prototype have been checked across agreed static cross-sections and dynamic task poses, with wearer and evaluator logs reconciled. [S06] [S07] [S08] 3. **Physical colour strike-off approval:** confirmation under controlled viewing conditions that the printed substrate, pretreatment, ink set, raster image processor (RIP) profile and curing recipe match the buyer's reference standard, following Fogra ProcessStandard Digital control principles. [S21] [S22] 4. **Physical care, shrinkage and fastness test completion:** documented test results showing post-care dimensional change within buyer limits after an ISO 6330 wash-and-dry procedure on ISO 3759 marked specimens, alongside separate pass records for ISO 105-C06 laundering fastness and ISO 105-X12 dry and wet rubbing fastness. [S10] [S11] [S12] [S27] 5. **Production release sign-off:** an administrative act by the production or quality lead confirming that approvals 1 through 4 are complete and attached to the exact fabric lot, blank SKU, pattern version and print recipe scheduled for the order. [S07] [S21] [S32]

Neither a three-dimensional render nor a laboratory test-booking receipt satisfies gate 5. [S07] **Exhibit 29**, p. 118 sets out the required contents of this release dossier and the role that owns each sign-off. [S07] [S10] [S11] [S12] [S21] [S27]

EXHIBIT 29 /

A release dossier must prove more than visual approval

Gate domain	Reference scope	Required evidence record	Release owner
Paired static and pose fit	S06, S07, S08, S13	Matched avatar-to-wearer ease and task log; buyer limit: [to be agreed]	Pattern and fit lead
Specimen marking before care	ISO 3759 scope (S27)	Conditioned garment benchmarks and pre-care panel dimensions logged	Quality technician
Domestic wash and dry cycle	ISO 6330 scope (S12)	Exact wash programme, ballast, detergent and drying route with change	Quality lead
Laundering colour fastness	ISO 105-C06 scope (S10)	Colour change and staining ratings for end use; grade: [to be agreed]	Laboratory reviewer
Dry and wet rubbing check	ISO 105-X12 scope (S11)	Separate dry-cloth and wet-cloth rubbing records on printed areas	Laboratory reviewer
Controlled print and release	Fogra PSD scope (S21)	Profile, cure recipe and all prior gates verified for lot release	Production manager

ILLUSTRATIVE [S07] [S10] [S11] [S12] [S21] [S27] Illustrative GFT release dossier structure informed by ISO public standard scopes (S10, S11, S12, S27), digital print process control (S21) and physical fit validation (S07). Threshold cells remain blank until buyer and laboratory agreement.

Exhibit 29, p. 118 is an illustrative governance template; the bracketed threshold fields remain unfilled because no universal Delta E, shrinkage percentage or grey-scale number is valid across every garment category and customer contract. [S10] [S11] [S12] [S21]

> **GFT NOTE**
>
> **Keep release authority independent of commercial rush pressure.** OECD due diligence guidance for the garment and footwear sector identifies inefficient production planning and poor purchasing practices, including last-minute order changes and compressed lead times, as primary drivers of excessive working hours and control breakdowns. [S28] GFT recommends a hard system rule in the order-management workflow: an order may use a pre-qualified release dossier only when it reuses an already approved base fabric lot, blank style, ink set, cure recipe and pattern block; any new substrate, uncalibrated fabric lot or altered cure parameter places the job on quality hold until the physical dossier in **Exhibit 29**, p. 118 is completed and signed by a reviewer independent of sales commissions. [S21] [S28]

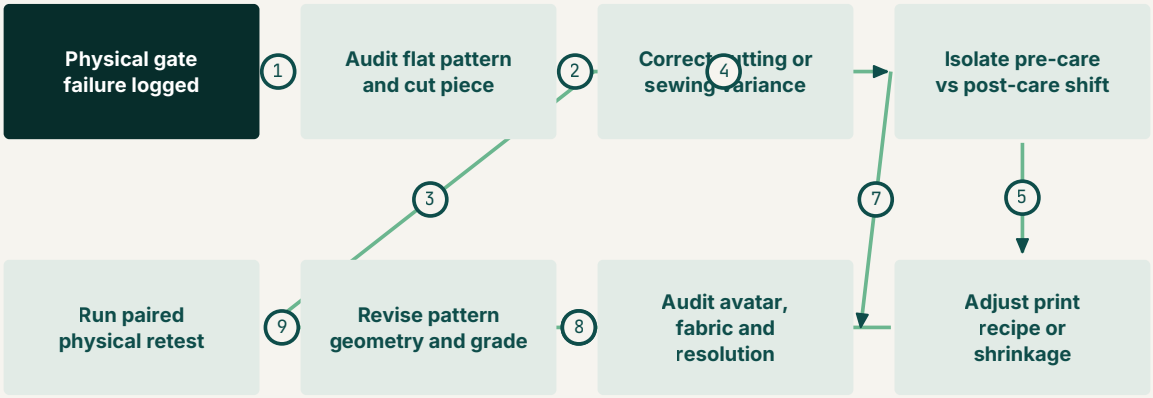
7.19 A FAILED PHYSICAL CHECK MUST ROUTE TO A NAMED ROOT CAUSE

When a physical prototype fails its fit, wash or rubbing gate, trial-and-error edits corrupt the engineering record. [S04] [S16] A failure at the release gate can originate in any of six domains: **pattern geometry or grading error** (S09, S32), **avatar or anthropometric mismatch** (S06, S07, S13), **fabric mechanical calibration error** (S04, S05,

S16), **simulation setup error** (S04), **print, pretreatment or thermal-cure failure** (S01, S11, S12, S15, S21), or **cutting, sewing or pressing variance** (S07, S32). [S01] [S04] [S05] [S06] [S07] [S09] [S11] [S12] [S13] [S15] [S16] [S21] [S32] **Exhibit 30**, p. 119 maps the structured diagnostic sequence that GFT proposes whenever a physical release check fails. [S04] [S07]

EXHIBIT 30 /

A failed physical check returns to a named cause



1. Quarantine sample and open cause code
2. Cut or sewn dimensions deviate from pack
3. Re-assemble under controlled spec
4. Unwashed piece matches flat spec
5. Failure appears after cure, wash or rub
6. Re-qualify cure state or shrinkage allowance
7. Unwashed fit differs from virtual ease
8. Update calibrated model and pattern
9. Freeze new version for paired test

ILLUSTRATIVE [S04] [S07] Illustrative GFT diagnostic workflow separating pattern geometry, avatar correspondence, fabric calibration, simulation setup, print-cure chemistry and sewing assembly before authorising a retest; informed by S04, S07 and the GFT performance-management design.

As **Exhibit 30**, p. 119 shows, the first step after any physical gate failure is a flat dimensional audit comparing the unwashed cut panels and sewn garment against the technical-pack specification. [S07] [S32] Only when the unwashed garment matches the flat specification does the engineer separate post-care shrinkage or fastness failures from pre-care dressed fit discrepancies. [S04] [S06] [S12] [S15]

7.20

Sample reduction is an observed outcome

The economic and operational benefit of digital sampling is measured by the net reduction in physical articles actually made (after counting planned validation samples, pre-release care-gate reworks and post-delivery customer remakes), not

by the number of three-dimensional renders generated on a workstation. [S06] [S07] [S16] Empirical fit research is clear that simulation cannot fully replace physical fitting, and that virtual-to-real discrepancies vary by body zone, fabric shear stiffness and size. [S06] [S07]

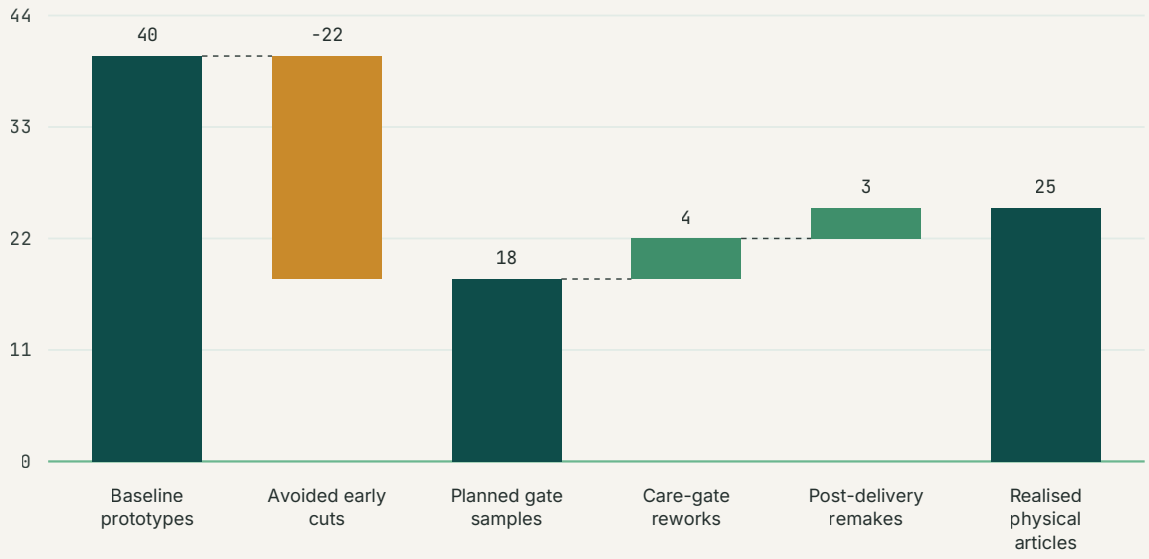
7.21 HIDING PHYSICAL ITERATIONS IN DOWNSTREAM REWORK CORRUPTS UNIT ECONOMICS

If an apparel manager enforces a naive quota such as one physical sample maximum per style without calibrating fabrics or enforcing the physical release gate in **Exhibit 29**, p. 118, two distortions occur: patternmakers cut unlogged test pieces from scrap cloth, or unvalidated styles fail when buyers wash the first delivered batch, transferring sampling work into free reprints, remakes and lost repeat orders. [S06] [S07] [S12]

To prevent a digital-first policy from disguising that transfer, GFT's performance-management design tracks four physical article counters for every style cohort across its development and initial order window: counterfactual baseline prototypes (`N_base`), planned physical validation samples (`N_val`), pre-release gate rework samples (`N_rework`), and post-delivery customer remake garments (`N_remake`). [S06] [S07] [S11] [S12] The net physical articles avoided across a cohort is an observed accounting identity (`Delta_N_net = N_base - N_val - N_rework - N_remake`) rather than a vendor assumption. [S07] **Exhibit 31**, p. 120 illustrates this reconciliation for an explicitly illustrative cohort of 10 new styles. [S06] [S07]

EXHIBIT 31 / ILLUSTRATIVE PHYSICAL GARMENT ARTICLES PER 10 STYLES

Unvalidated screen cuts can return as downstream rework



ILLUSTRATIVE [S06] [S07] Illustrative GFT cohort reconciliation for 10 new styles (assumed 40 physical samples in a conventional baseline). Early screen screening avoids 22 prototype cuts, leaving 18 planned validation garments, plus 4 pre-release care-test reworks and 3 post-delivery remake garments if physical gates are rushed, closing at 25 physical articles (a net saving of 15 articles, not 22).

In the illustrative case shown in **Exhibit 31**, p. 120, a conventional physical workflow across 10 styles is assumed to consume 40 physical prototypes. Calibrated three-dimensional screening eliminates 22 early concept and proportion cuts, leaving 18 planned physical validation garments. [S06] [S07] However, when four styles require a

second physical garment after ISO 6330 wash shrinkage or ISO 105-X12 wet-rubbing adjustments, and three garments have to be remade after customer delivery where a gate was rushed, total physical articles consumed across the cohort rise from 18 to 25. [S11] [S12] The net reduction is 15 articles (37.5 percent of the illustrative baseline), not the 22 articles (55.0 percent) that a naive count of avoided early prototypes would claim.

What **Exhibit 31**, p. 120 cannot establish is the actual baseline or digital sample count in a Cameroon factory before pilot observations are collected; all step heights are illustrative inputs created to define the reconciliation method. [S07] In Chapter 9, these physical counters (`N_val`, `N_rework` and `N_remake`) feed into the sampling-cost and unit-economics models alongside software licences, fabric digitisation labour and laboratory testing fees, ensuring that digital product development is judged on retained-order contribution rather than screen activity. [S04] [S07] [S16] Before an approved style can generate any retained-order contribution, its released pattern, shrinkage allowances and artwork placement must survive cutting, thermal curing and sewing assembly on the factory floor, which is the subject of Chapter 8. [S01] [S09] [S15]

A screen can retire a bad idea in an afternoon, but only a washed and worn garment earns the right to be reproduced.

CHAPTER SOURCE NOTES

S07 3DBODY.TECH conference proceedings. 2020.

S06 Kaunas University of Technology, Materials Science. 2020-01-15.

S08 arXiv, Wolff and co-authors. 2021-02-10.

S10 International Organization for Standardization. 2010.

S11 International Organization for Standardization. 2016.

S12 International Organization for Standardization. 2021.

R06 Cameroon Trade Hub. Publication date unrecorded; inherited source-text check.

S04 Dongguk University research portal; Taylor & Francis, Journal of the Textile Institute. 2025.

S05 Kaunas University of Technology, Materials Science. 2011-07-04.
S09 arXiv, Pietroni and co-authors. 2022.
S13 International Organization for Standardization. 2017.
S16 CLO Virtual Fashion. 2026-10-05.
R07 Ecofin Agency. Publication date unrecorded; inherited source-text check.
S32 arXiv, Korosteleva and Sorkine-Hornung. 2023-06-06.
S27 International Organization for Standardization. 2011.
S15 Epson United Kingdom. 2026.
S22 International Color Consortium. 2026.
S0701 Cell Press, Heliyon; author abstract hosted by PubMed. 2023-07-08.
R03 SODECOTON. Publication date unrecorded; inherited source-text check.
S01 Society for Imaging Science and Technology. 2021.
S30 Epson America. 2026.
S0702 Springer Nature, Scientific Reports; author abstract hosted by PubMed. 2026-03-26.
S17 International Finance Corporation, World Bank Group. 2007-04-30.
S02 Wiley, Coloration Technology. 2024-01-29.
S03 The Korean Fashion and Textile Research Journal. 2025-12-31.
S21 Fogra Research Institute for Media Technologies. 2026.
S28 Organisation for Economic Co-operation and Development. 2018.

GREEN FUTURE TECH

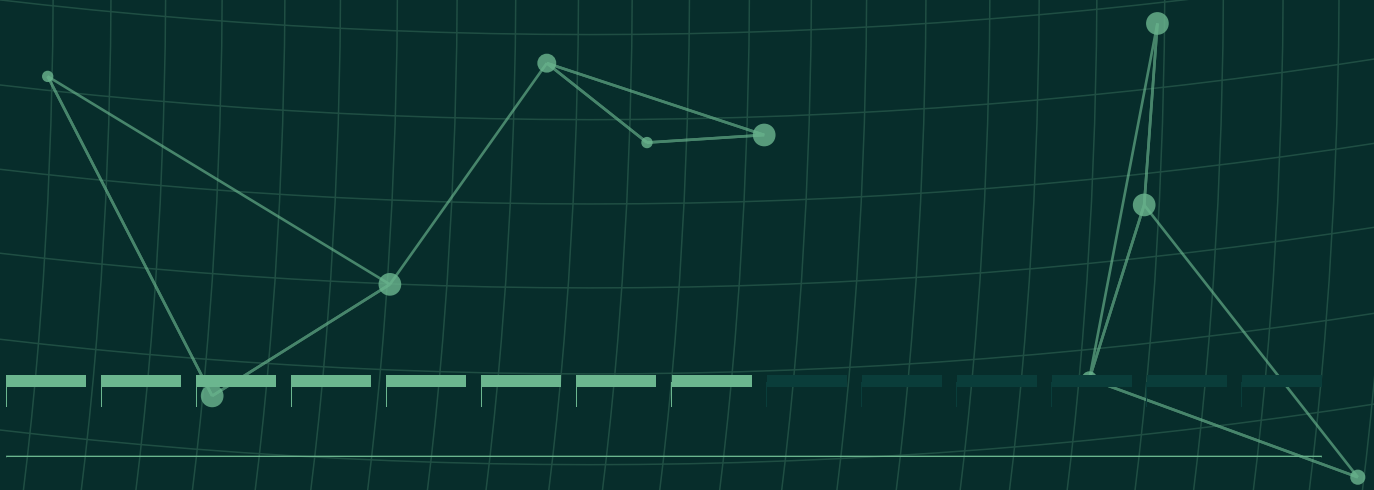
LIMITED / HONG KONG SAR

08

PART III: PROVE THE SERVICE AND THE ECONOMICS / FACTORY EXECUTION

A printed panel creates value only after accurate assembly

Connect approved artwork and patterns to material yield, cutting, sewing and accepted output.



CHAPTER 08
DECISION TEST

Connect approved artwork and patterns to material yield, cutting, sewing and accepted output.

An approved print creates value in this order-triggered service only when the physical process converts it into an accepted garment. Digital printing can form part of a wider sequence that includes preparation, fixation, cutting and sewing, while on-demand manufacturing changes the production system rather than one machine alone. [S01] [S03] GFT therefore proposes one tracked execution chain: every physical panel set carries its approved version identity from raster image processing to dispatch, and yield and throughput are measured in accepted garments rather than linear metres printed. This is a proposed operating design, not a report of an installed GFT line or a measured Cameroon result.

The execution problem begins after the physical release gate. Finished geometry must govern print placement, marker planning must account for order completion as well as fabric area, thermal curing and cooling need capacity, and every cut bundle must remain traceable to its released specification. [S09] [S15] [S0801] [S0802] This chapter extends the greenfield operating concept and shop-floor measurement discipline in GFT's Cameroon textile programme. It defines controls for those handoffs, for short-run changeovers, quality holds and recovery-work accounting. Chapter 9 then prices the complete order. A fast printer cannot, by itself, establish the delivery or economic performance of that chain. [S03] [S17]

8.1

Print placement must respect the finished geometry

An engineered print or cut-and-sew motif needs a controlled translation from the approved three-dimensional garment to flat production pieces. Computational pattern-making research treats that translation as a constrained geometric problem rather than a simple image export. [S09] On the shop floor, printing, heat fixation, cutting and seam construction remain distinct physical events. [S01] [S15] GFT's proposed release check therefore compares artwork contours, pattern contours and the measured material state before rasterisation. Any shrinkage, relaxation or construction compensation must come from the qualified production route, not an operator's universal adjustment. Dimensional-change specimens and garments require defined preparation, marking and measurement, which makes an unrecorded scaling decision especially difficult to diagnose. [S27]

8.2 FIVE PHYSICAL ALLOWANCES GOVERN THE RELEASED MARKER

Translating a three-dimensional garment into manufacturable two-dimensional pattern pieces is a constrained geometric problem involving darts, seam symmetry, grain and surface distortion. [S09] When printed artwork is locked to those pieces, the released marker governs both ink deposition and knife paths. [S01] [S09] In GFT's proposed release discipline, five physical allowances must be embedded in the released marker geometry:

- **Seam and hem allowances:** Every panel contour must carry the exact stitch-class allowance from the technical pack, with print bleed extending beyond the cut line into the seam allowance so sewing variation never exposes unprinted white ground along a join. [S09] [S32]

- **Directional shrinkage and relaxation compensation:** Cellulosic fabrics change dimension during pretreatment drying, thermal fixation, steaming or washing, and pressing. [S01] [S27] Prepress scaling factors must be applied separately along warp and weft using measured dimensional-change records prepared under standard specimen-marking protocols. [S12] [S27]
- **Grainline and mechanical orientation locks:** Fabric tensile, shear and bending behaviour differs between warp, weft and diagonal directions, altering how a cut garment hangs and fits. [S05] Rotating a piece off-grain to save fabric area changes both mechanical drape and the angle of the weave beneath the ink. [S05] [S09]
- **Cross-seam motif registration anchors:** Where a graphic crosses a placket, yoke, sleeve head or side seam, the marker must place match notches and visual registration ticks outside the finished garment boundary but inside the cut perimeter. [S09] [S32]
- **Panel orientation and nap rules:** Single-directional prints, asymmetric panels and directional fabrics must be locked against flipping or rotation in nesting software unless the technical pack authorises rotation. [S09] [S0801]

Checking model and pattern information before cutting is essential because incompatible formats and manual edits introduce dimensional errors between design and cutting. [S0801] Parametric pattern frameworks confirm that valid sewing patterns are required for both simulation and fabrication. [S32] When an apparel maker modifies a pattern contour after the physical release gate in Chapter 7, the print placement file and cut marker must be regenerated from that versioned pattern geometry rather than patched in graphics software. [S07] [S32]

> **GFT NOTE**
>
> GFT recommends treating the print-and-cut marker as a controlled engineering drawing rather than a pressroom layout adjustment. Operators at the raster image processor or cutting table should have read-only access to panel dimensions, grain locks and bleed extensions; if a fabric roll arrives narrower than specified or exhibits different thermal shrinkage during strike-off qualification, the job must return to technical prepress for a controlled marker revision rather than being scaled at the printer console. [S0801] [S21]

For direct-to-garment and direct-to-film decoration on pre-sewn blanks, finished geometry imposes a different but equally strict boundary. [S15] Because the garment is already assembled, seams, collars, zippers and pocket welts create elevation steps on the loading platen. [S15] [S30] Platen selection, garment tensioning during loading, and the clearance between the printhead or heat press and adjacent seams must be specified in the job ticket so that placement remains repeatable across every size in an order cohort. [S15] [S30]

8.3

Markers should minimise total order cost

Geometric marker efficiency, the ratio of nested pattern-piece area to the marker area, is necessary but incomplete for an order-triggered service. Marker-planning research in a mass-customisation context instead minimises the total cost related to the number of markers and excess units while also considering the sewing schedule. [S0802] GFT draws a bounded inference for printed cut-and-sew: a denser layout can be commercially worse if it violates print orientation, delays a confirmed order, creates excess units or leaves incomplete panel sets waiting for remakes. On-demand production makes those order and schedule consequences part of the same decision, rather than treating printing as an isolated equipment upgrade. [S03]

The opened marker-planning study couples marker and excess-unit cost with a sewing-schedule constraint; it does not supply a Cameroon saving or prove that one nesting rule fits every workshop. [S0802] In GFT's proposed digital roll-to-roll route, each printed panel is committed to a specific artwork and size before cutting. Interleaving several customer orders can therefore couple their curing, cutting and sorting events. A defect on one required panel holds that order's set until a replacement is printed, cured and recut, while companion panels need an identified physical hold. The control objective is not to prohibit mixed markers. It is to price that dependency before choosing the layout. [S01] [S03]

8.4 GROSS FABRIC ISSUE DIFFERS FROM NESTED MARKER AREA

GFT proposes that a local on-demand apparel operation evaluate marker strategies using complete order-level material and handling economics rather than software nesting percentage alone. [S03] [S0802] **Exhibit 32**, p. 127 sets out the physical material components that reconcile gross fabric issued from the store to the net fabric area delivered inside accepted garments.

EXHIBIT 32 / SQUARE METRES PER BATCH

Marker yield is only part of material yield

Material accounting stage	Boundary definition	Illustrative area (sq m)	Share of gross issue (%)
Gross fabric issued from store	Total roll length times full nominal width issued to batch	100	100
Selvedge, edge margin and leader loss	Unprintable selvedge guards plus threading and tension leaders	-6	-6
Net printable and cuttable area	Usable substrate area entering the print marker	94	94
Inter-panel marker gap and bleed waste	Unprinted interstitial area plus cut-off print bleed around panels	-14.1	-14.1
Setup, purge and calibration swatches	Nozzle checks, colour control bars and thermal strike-off strips	-2.5	-2.5
Cut-room and print-defect panel rejects	Panels quarantined for misregistration, staining or knife error	-3.4	-3.4
Remake fabric consumed for sewing recovery	Replacement panels printed and cut to replace assembly damages	-2	-2
Usable remnant returned to stock	Verified full-width unprinted roll end returned to inventory	-4	-4
Net fabric delivered in accepted garments	Pattern area inside finished garments passing final release	68	68

ILLUSTRATIVE [S03] [S0802] Illustrative GFT material-accounting ledger for printed cut-and-sew production, informed by S03 and S0802. Numeric values are an illustrative 100 square metre batch reconciliation to demonstrate the method, not measured factory results.

As **Exhibit 32**, p. 127 illustrates, a marker that reports an apparent nesting efficiency of 85 percent on usable printable width (79.9 square metres of nested pattern and bleed out of 94.0 square metres of net printable area in the illustrative table) can deliver only 68.0 percent of gross issued fabric into accepted customer garments once selvedge guards, threading leaders, print purge bars, defective panels and sewing remakes are deducted. [S03] [S0802] This illustrative table cannot establish what yield a Cameroon facility will achieve; rather, it defines the accounting ledger that the pilot must populate on every roll so that procurement and quoting teams do not mistake software nesting percentages for real material consumption. [S0802]

METHOD

To compare two candidate marker strategies (such as single-order boxed markers versus multi-order interleaved markers) on an equal footing, GFT defines the complete marker cost per accepted order cohort as the sum of four measurable terms:

1. **Gross substrate and ink cost:** Total roll length consumed (including leader, selvedge, interstitial gaps and print bleed) multiplied by the landed cost per square metre of prepared fabric plus ink deposited. [S01] [S0802]
2. **Sorting and bundling labour cost:** Operator minutes required at the stripping table to identify, separate, verify and bundle cut pieces into complete garment sets, multiplied by the staffed labour rate. [S0801] [S0802]
3. **Partial-set hold and remake cost:** The expected cost of reprinting, curing and recutting individual panels when a defect occurs, plus the schedule penalty of holding companion panels in work-in-process storage while waiting for the replacement piece. [S03] [S0802]
4. **Excess-unit or remnant write-off:** Any extra garment sets cut purely to fill out a multi-size marker that lack a confirmed paid customer order, valued at full variable cost less verified salvage value. [S03] [S0802]

GFT proposes testing contiguous order zones against interleaved markers rather than assuming either layout wins. A contiguous zone places all panels for one garment or buyer size set within a bounded longitudinal strip. The pilot should record nested area, stripping minutes, identification errors, partial-set holds, remake delay and accepted-order completion for both methods. Contiguous zoning may simplify identification and release, while interleaving may use area more efficiently. The evidence required is the total cost per accepted order and the delivery outcome, not a claimed universal yield advantage. [S03] [S0802]

8.5

Curing and cooling need capacity reservations

Thermal fixation is a production stage, not a zero-duration postscript to ink deposition. Pigment fixation can use dry heat, while direct-to-garment guidance identifies a final heat-curing stage and, for specified white-ink or polyester cases, pretreatment. [S01] [S15] [S30] Direct-to-film adds adhesive and transfer handling. [S15] GFT's proposed route sheet therefore gives pretreatment drying, ink curing and heat-press transfer their own workstation identities, qualified settings and output records. Equipment-specific documentation and physical tests must establish those settings; this chapter does not prescribe a generic temperature or dwell time.

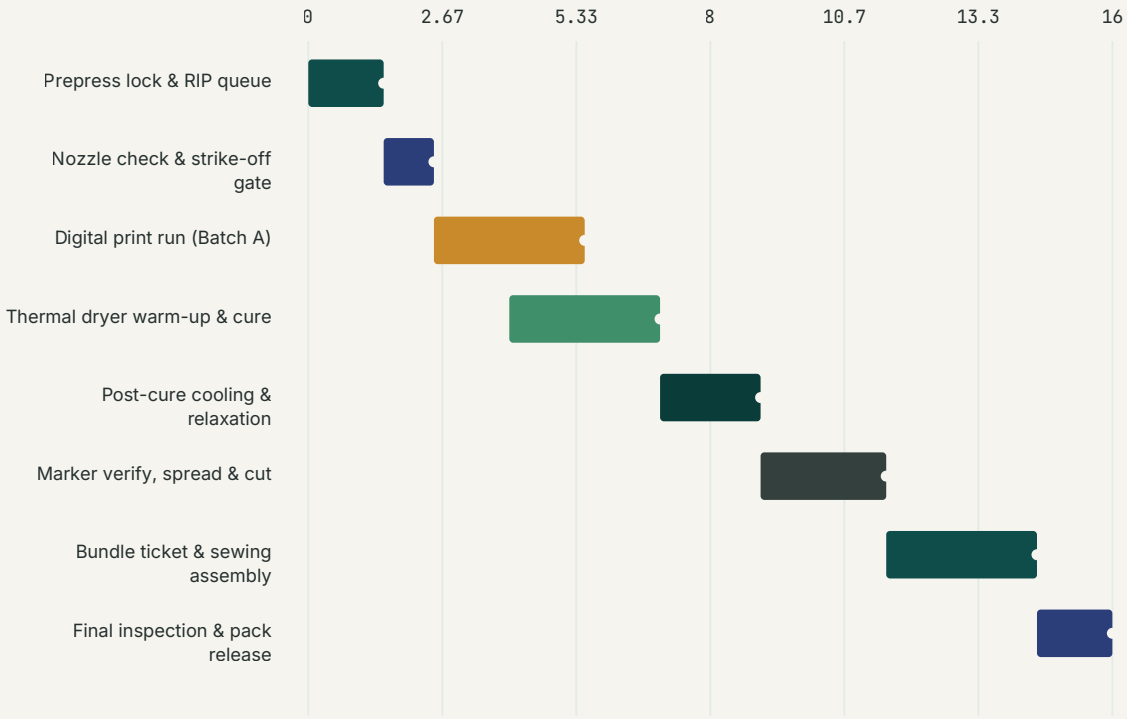
International environmental, health and safety guidelines identify heat consumption as particularly significant in drying, curing and wet treatments. [S17] That supports metering thermal work, but does not establish the warm-up behaviour or capacity of a particular machine. The pilot must time warm-up, stabilisation, active processing, idle holding and shutdown on the selected equipment. It must also test the actual printed and cured article under the agreed laundering and rubbing routes, because visual approval cannot substitute for those separate durability decisions. [S10] [S11] [S12]

8.6 FINITE-CAPACITY SCHEDULING MUST INCLUDE THERMAL DWELL AND CONDITIONING

GFT requires the factory scheduling system to treat pretreatment drying, ink curing and post-cure cooling as explicit finite-capacity workstations rather than zero-duration transitions. [S15] [S17] **Exhibit 33**, p. 129 illustrates how a batch cohort moves across prepress, printing, thermal curing, cooling, cutting, sewing and release inspection when every stage's setup, processing and stabilisation window is reserved on a finite timeline.

EXHIBIT 33 / ILLUSTRATIVE SHIFT HOURS FROM JOB RELEASE

The delivery promise must reserve every constrained stage



ILLUSTRATIVE [S15] [S17] Illustrative finite-capacity schedule across printing, thermal fixation, cooling, cutting, sewing and inspection, informed by S15 and S17. Durations are illustrative planning blocks in hours, not measured GFT cycle times.

Exhibit 33, p. 129 is a capacity hypothesis to test, not an equipment performance claim. Its warm-up and stabilisation block must be replaced by observations from the selected dryer, calender or press. Its post-cure hold makes the material state explicit before cutting: GFT proposes defining the required cooling or relaxation condition during qualification, then measuring the actual panel dimensions under that condition rather than assuming an immediate cut is safe. [S27] Finally, the customer promise spans the whole illustrative sequence from prepress lock to final pack release (16 illustrative shift hours), not only the 3 illustrative hours assigned to ink deposition. The schedule cannot establish real durations; it shows why the pilot must reserve every constrained stage before promising delivery. [S03] [S15] [S17]

To prevent thermal bottlenecks and under-cured shipments, GFT's proposed shop-floor log records five parameters for every curing batch:

1. **Equipment identifier and pre-heat verification:** Confirmation that the conveyor dryer, calender or heat press reached the recipe's target operating state before the batch entered. [S15] [S17]
2. **Specified recipe settings:** The approved temperature, belt speed or dwell time, and pressure or airflow setting linked to the substrate lot and ink chemistry in the material passport, following the equipment manufacturer's technical documentation rather than generic temperatures. [S01] [S15]
3. **Batch entry and exit timestamps:** Actual clock times showing total thermal operating hours versus active curing hours, providing the denominator needed to allocate thermal energy in Chapter 9 and Chapter 11. [S17]
4. **Cooling and relaxation hold completion:** Sign-off that the printed roll or blank completed its specified post-cure cooling and relaxation interval before spreading, cutting or folding. [S27]
5. **Ventilation and operator safety check:** Confirmation that local exhaust ventilation and heat guards were active during pretreatment spraying, powder curing and heat pressing, in line with industrial health and safety management guidance. [S17] [S18]

8.7

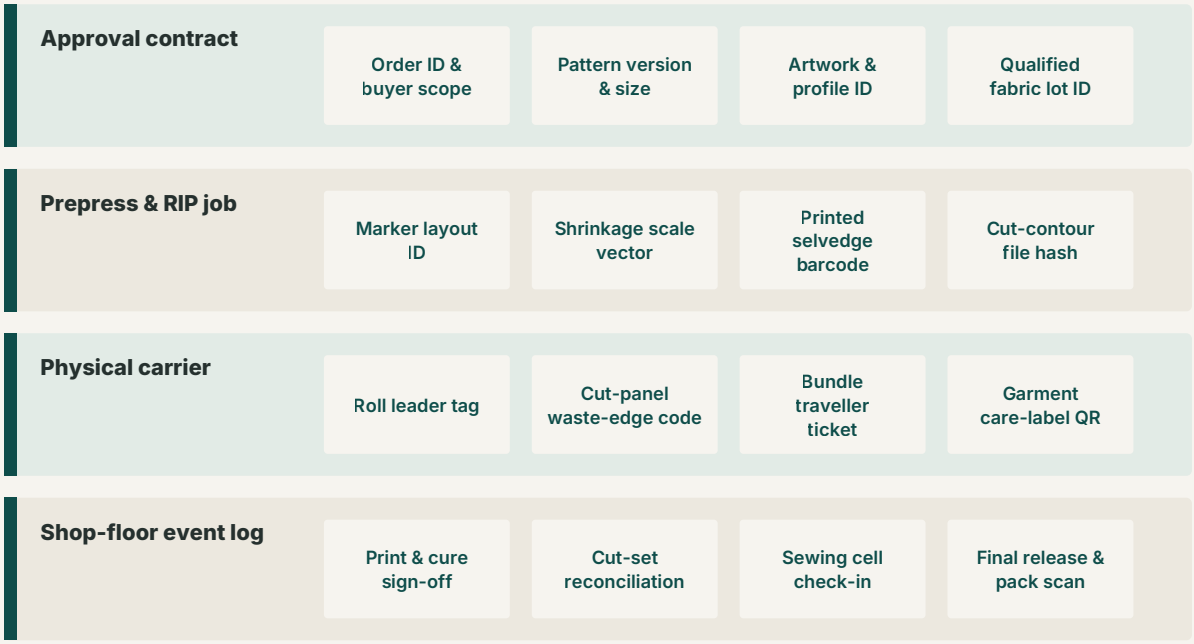
A cut set must remain linked to the approved version

When a cutting knife separates a printed roll into fronts, backs, sleeves, collars and facings, the physical continuity of the roll disappears. [S0801] In a bulk factory making identical white shirts, medium left sleeves from the same dye lot are interchangeable. In an on-demand factory, where consecutive orders on one roll carry different customer motifs, colourways, body dimensions or pattern versions, losing panel identity turns sewing into a sorting puzzle. [S03] [S32] Sewing a sleeve from an earlier pattern revision onto a bodice from the released revision creates a hybrid defect that may go unnoticed until final measurement or customer return. [S09] [S0801]

Responsible supply-chain management requires each enterprise to identify its priority risk areas based on its specific circumstances. [S29] In GFT's Cameroon textile programme performance-management system design, shop-floor control starts with source capture at the workstation using stable identifiers. Extending that discipline to printed cut-and-sew and blank decoration requires an unbroken chain of custody from the approved technical pack down to each bundle and finished garment. [S01] [S09] (The broader enterprise traceability standard from cotton bale to retail label belongs to the companion GFT paper on garment traceability; here we specify the internal execution identifiers required to assemble the right order.) **Exhibit 34**, p. 131 shows the four-layer architecture binding approvals, digital job tickets, physical carriers and performance logs.

EXHIBIT 34 / CONTROL LAYERS FROM APPROVAL TO DISPATCH

The order identifier must survive the physical process



ILLUSTRATIVE [S01] [S09] [S0801] Illustrative GFT execution architecture linking technical release, prepress, physical bundle tracking and shop-floor logging, informed by S01, S09, S0801 and GFT programme design.

As **Exhibit 34**, p. 131 demonstrates, software identifiers in the approval contract and raster image processor (`Order ID`, `Pattern version`, `Marker layout ID`) survive on the shop floor only when physically printed or attached to the material at every transition. [S01] [S0801] Because **Exhibit 34**, p. 131 is an illustrative system design rather than a report of an installed GFT factory system, its purpose is to specify the physical handoffs a pilot workshop must implement before taking multi-style orders:

- **Roll-edge metadata strips:** During roll printing, the raster image processor prints a compact job header in the selvedge margin alongside each marker zone, recording order identifier, pattern revision, artwork revision, colour profile and curing recipe. [S01] [S21]
- **Seam-allowance panel micro-labels:** For cut-and-sew engineered prints, the printer deposits an alphanumeric piece code (order suffix, size and panel code) inside the seam allowance or trim tab of each piece so every panel remains identifiable after stripping until sewn into the seam. [S09] [S0801]
- **Bundle traveller tickets:** At the stripping table, the cutter verifies that all required pieces for a garment or single-size bundle are present and undamaged before attaching a bundle traveller ticket. [S0801] No partial bundle may enter sewing; if one panel in a five-piece shirt is rejected at cutting, the remaining four pieces go to a remake-hold rack with an exception tag while the replacement piece is queued. [S0802]

- **Work-in-process kit verification before sewing:** Before assembly begins, the line feeder checks the bundle traveller ticket against the trim kit (threads, buttons, interlinings, size labels and care labels) so a printed cotton panel is never sewn with the wrong thread shade or labelled with an incorrect care instruction. [S12] [S0801]

8.8

Changeovers can dominate a short-run line

On-demand manufacturing changes the production system, but it does not remove the operator minutes, machine availability or setup material consumed between jobs. [S03] GFT's short-run planning hypothesis is that ungrouped changes can dominate available time when orders are small and varied. The workshop must test that hypothesis with timestamps rather than assume it. This matters for responsible planning as well as cost: OECD guidance identifies inefficient production planning and poor purchasing practices among common factors associated with excessive working hours. [S28]

8.9 SIX CHANGEOVER CLASSES AND SCHEDULED MAINTENANCE MUST BE LOGGED SEPARATELY

A short-run printed apparel line experiences six classes of changeover, plus mandatory maintenance that continues even when order queues are light:

1. **Substrate and roll changeovers:** Unloading a woven poplin roll and threading a knitted jersey roll requires cleaning lint, adjusting feed tension and platen gap, loading the colour profile and running a leader strip. [S01] [S21]
2. **Platen and fixture changeovers:** On direct-to-garment and heat-press lines, switching from adult crew-neck shirts to youth sizes, polo plackets or fleece requires swapping platens, adjusting head height and verifying press pressure. [S15] [S30]
3. **Ink-route and pretreatment changeovers:** Changing between light garments (colour ink only) and dark garments (white underbase plus pretreatment) introduces spray setup, dryer temperature changes and white-ink verification. [S15] [S30]
4. **Cutting-table and knife setups:** Loading a new cut contour file, adjusting vacuum hold-down or spreading tension, and replacing blades or underlay paper consume cutting-room availability between markers. [S0801]
5. **Sewing-machine thread, needle and attachment changes:** Re-threading lockstitch and overlock machines for a new colourway, swapping needle sizes between shirting and piqué, or changing folder attachments interrupts rhythm and requires test seams on scrap cloth before sewing printed panels. [S03] [S28]
6. **Scheduled daily and periodic maintenance:** Digital printing systems require model-specific maintenance regardless of how few garments are printed on a shift; for example, one commercial DTG user guide instructs operators to shake white ink supply units once a day and colour ink supply units once a month, alongside nozzle checks and cleaning cycles. [S31]

WORKED EXAMPLE

Consider an illustrative single-shift comparison for a small printed cut-and-sew cell staffed for 480 minutes (8 hours, aligned with a standard 40-hour five-day working week). [R16] Suppose the cell processes 12 small customer orders of 5 garments each (60 garments total) during the shift, and daily printer maintenance, nozzle verification and thermal warm-up consume 45 illustrative minutes. [S17] [S31]

In **Case A (Unbatched first-in, first-out sequence)**, orders arrive in random substrate, shade and thread-colour order. Each of the 12 orders triggers a full substrate, platen, thread and test-seam changeover averaging 18 illustrative minutes across printing, cutting and sewing, consuming 12 times 18 equals 216 minutes. Subtracting 45 minutes of maintenance and 216 minutes of changeovers from 480 staffed minutes leaves 219 productive minutes (45.6 percent of shift time). At an illustrative net print and assembly pace of 6.0 minutes per garment once running, the cell completes only 36 garments during the regular shift, leaving 24 garments (4 orders) unfinished or forcing overtime. [S28]

In **Case B (Family-batched sequence within a fixed shift window)**, the planner groups the same 12 orders into 2 substrate and thread-colour families without breaching promised delivery dates. [S0802] The cell performs 2 major family changeovers of 18 minutes (36 minutes) and 10 minor digital-artwork switches of 3 minutes (30 minutes), reducing total changeover time from 216 minutes to 66 minutes. After 45 minutes of maintenance and 66 minutes of changeovers, 369 productive minutes remain (76.9 percent of shift time), allowing all 60 garments (60 times 6.0 equals 360 minutes) to finish within the regular 480-minute shift with 9 minutes of buffer. Every numeral in this case is an illustrative model calculation demonstrating why changeover logging and family sequencing matter, not an observed GFT factory result.

While general sewing-line balancing, standard-minute values and overall equipment effectiveness methods belong to the companion GFT paper on line balancing and overall equipment effectiveness, an on-demand workshop must log setup duration and setup scrap by changeover category on every shift so quoting models in Chapter 9 allocate real changeover burdens to small orders. [S28] [S31]

8.10

Quality holds must stop downstream duplication

In a connected print-to-sew workflow, an undetected nonconformity can consume material and labour at every subsequent station. A print or cure problem can reach cutting and assembly before final inspection exposes it. GFT's control response is to stop the affected scope at the earliest useful physical boundary, identify the suspect panels and prevent further work until disposition. This is a proposed loss-containment rule, not a measured defect-rate claim. The cutting-room study supports checking model information before cutting, while print-process control requires defined references and tolerances. [S0801] [S21]

GFT's proposed quality-hold protocol establishes four stop gates between print release and packing:

- **Gate 1: Pre-run nozzle and control-bar verification.** Before printing customer panels or blanks, the operator prints a nozzle check and colorimetric control strip, verifying that no nozzles are deflected and measured colour values lie within tolerance for that profile and substrate. [S14] [S21]
- **Gate 2: Post-cure first-article physical hold.** On any multi-unit order or new material lot, the first printed and cured panel or garment is held before the batch is released to cutting or sewing. [S15] [S21] The reviewer checks motif dimensions against the technical pack, inspects for scorching or powder residue, and performs dry and wet rubbing checks on a sacrificial test patch where specified. [S11] [S27]
- **Gate 3: Post-cut bundle audit.** Before a bundle leaves the stripping table, the cutter checks cut-edge accuracy against notches, verifies that registration marks align across mating panels, and confirms that all pieces carry matching order and revision identifiers. [S09] [S0801]
- **Gate 4: First-sewn garment construction and appearance check.** On a batch order, the first assembled garment is checked for seam pucker, stitch density, motif continuity across seams, and key body measurements before the cell completes the remaining bundles. [S07] [S09]

When any gate fails, the operator attaches a quarantine tag and logs the defect under one of two classes: **reworkable process deviation** (such as an unpressed seam, loose thread, or curable dwell shortfall that the ink specification permits re-passing) or **non-recoverable reject** (such as nozzle banding, colour mismatch, miscut geometry, oil staining or needle-cut damage). [S02] [S11] Non-recoverable panels go immediately into a locked quarantine bin so they cannot be bundled into a shipment. [S0801]

> **WARNING**
>
> A visual pass at the cutting table or packing bench cannot detect latent chemical or durability failures such as insufficient binder cross-linking, poor washing fastness, or excessive shrinkage during the buyer's first wash. [S10] [S12] Resolving that constraint requires linking every batch to a qualified material-and-cure recipe verified by washing, drying and rubbing tests under the protocols in Chapter 4 and Chapter 7, and re-testing whenever ink lots, pretreatment formulations, blank suppliers or thermal settings change. [S11] [S12]

8.11

Good throughput must include recovery work

A factory that measures printing performance by square metres jetted per hour and sewing performance by gross pieces stitched per shift creates a blind spot: reprinting rejected panels and remaking defective garments look like productive activity on machine counters while destroying profitability and consuming thermal and operator

capacity. [S03] [S17] In GFT's Cameroon textile programme performance-management system design, production performance is anchored on accepted output reconciled against inputs at a shared boundary.

For an on-demand print-and-assemble line, GFT proposes two linked reconciliations using seven principal counters. The counters answer different questions, so they are not mutually exclusive destinations:

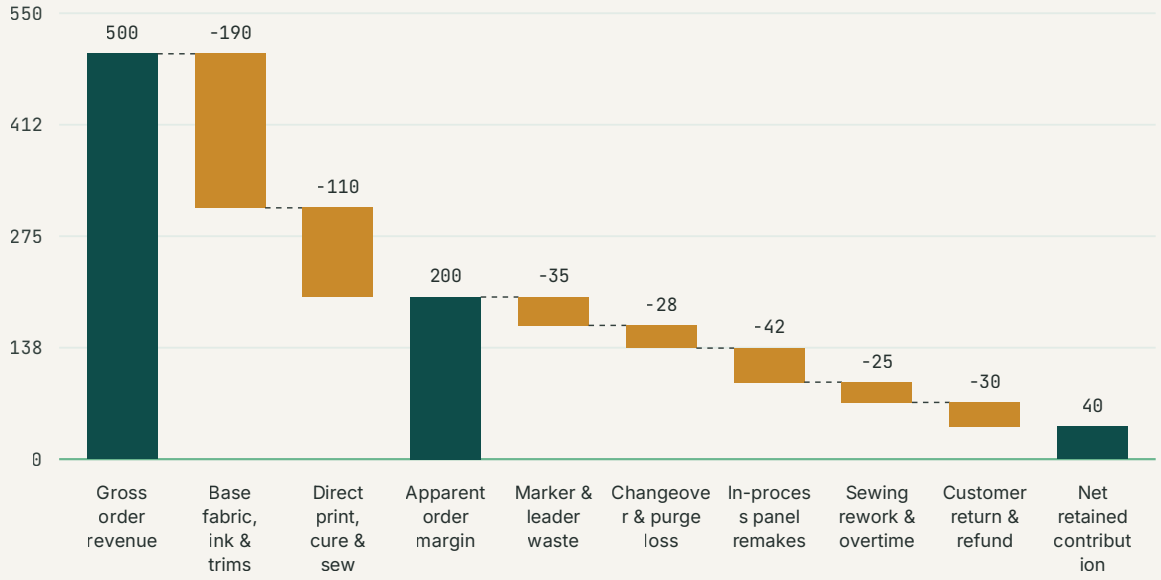
1. **Ordered quantity (Q_{ordered}):** Confirmed, funded garments promised under the accepted specification, excluding cancellations recorded before release. [S03]
2. **Started quantity (Q_{started}):** All initial and replacement garment sets released into printing and cutting. [S03] [S0802]
3. **Rejected quantity (Q_{rejected}):** Started units scrapped at printing, curing, cutting, sewing or inspection because the defined disposition does not permit recovery. [S0801]
4. **Reworked quantity (Q_{reworked}):** Units that failed an internal check, received logged corrective labour and subsequently passed release inspection. This is an event attribute, not an additional physical unit.
5. **Remade quantity (Q_{remade}):** Replacement panels or garments produced to recover an order. These replacements are already included in started quantity and must not be added to it a second time.
6. **Shipped quantity (Q_{shipped}):** Released garments transferred to the delivery route, with dispatch recorded separately from buyer acceptance.
7. **Accepted and retained quantity (Q_{accepted}):** Shipped garments retained by the buyer after the defined return, refund and dispute window. [S03]

The internal balance is `started = rejected + open work + ready to ship + shipped`. Open work includes held and in-process sets; ready to ship means released but not yet dispatched. The fulfilment balance is `shipped = accepted + returned + pending acceptance`. Pending acceptance includes goods still in transit or inside the agreed review window. GFT recommends freezing these definitions by order cohort and observation time. Otherwise a remade unit can inflate output, a rework event can be counted as a new garment, or a dispatch scan can masquerade as buyer acceptance.

Tracking those counters alongside the labour minutes, ink millilitres, fabric square metres and dryer hours consumed by rework and remakes makes recovery work visible in the execution ledger. [S17] [S28] **Exhibit 35**, p. 136 shows an illustrative order-cohort contribution waterfall in CFA francs (XAF), demonstrating how setup losses, panel remakes, sewing rework and returns erode the apparent order margin when recovery costs are accounted for rather than buried in overhead.

EXHIBIT 35 / THOUSAND XAF PER ILLUSTRATIVE ORDER COHORT

Recovery work consumes the apparent short-run margin



ILLUSTRATIVE [S03] [S28] Illustrative order-cohort contribution bridge in thousand CFA francs (XAF), constructed by GFT to demonstrate recovery-cost accounting (S03, S28). All monetary values are illustrative model inputs, not observed GFT revenues or local price quotes.

In **Exhibit 35**, p. 136, an order cohort with 500 thousand XAF of illustrative gross revenue and 300 thousand XAF of nominal material, ink and direct processing cost appears on a naive quote sheet to generate 200 thousand XAF (40 percent) of apparent order margin. Once 35 thousand XAF of unrecovered marker and leader waste, 28 thousand XAF of changeover and purge losses, 42 thousand XAF of emergency panel remakes, 25 thousand XAF of sewing rework and overtime, and 30 thousand XAF of customer returns are deducted, the net retained contribution drops to 40 thousand XAF (8 percent of gross revenue), before fixed software, depreciation and administrative overheads are covered. Every monetary input is illustrative; the arithmetic is 500 - 190 - 110 - 35 - 28 - 42 - 25 - 30 = 40 thousand XAF, not a local quotation or financial forecast. [S03] [S28]

The arithmetic in **Exhibit 35**, p. 136 is an illustrative accounting example rather than an empirical forecast or investment calculation. A remake can consume additional fabric, pretreatment, ink, thermal processing, cutting time and sewing labour while occupying capacity promised to another order. [S01] [S03] [S17] GFT's practical conclusion is narrower than a claim of guaranteed profitability: measure first-pass execution

and its recovery burden before scaling the service. Chapter 9 builds on this ledger to price the complete order and test whether retained orders cover the defined fixed and variable costs of digital sampling and on-demand production. [S03]

A digital print becomes a garment only when the pattern, the knife and the needle share the same truth.

CHAPTER SOURCE NOTES

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S21 Fogra Research Institute for Media Technologies. 2026.
S30 Epson America. 2026.
S10 International Organization for Standardization. 2010.
S11 International Organization for Standardization. 2016.
S18 International Finance Corporation. 2014.
S29 Organisation for Economic Co-operation and Development. 2026-02-26.
S28 Organisation for Economic Co-operation and Development. 2018.
S31 Epson America. 2026.
R16 WageIndicator. Publication date unrecorded; inherited source-text check.
S14 International Organization for Standardization. 2017.
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GREEN FUTURE TECH

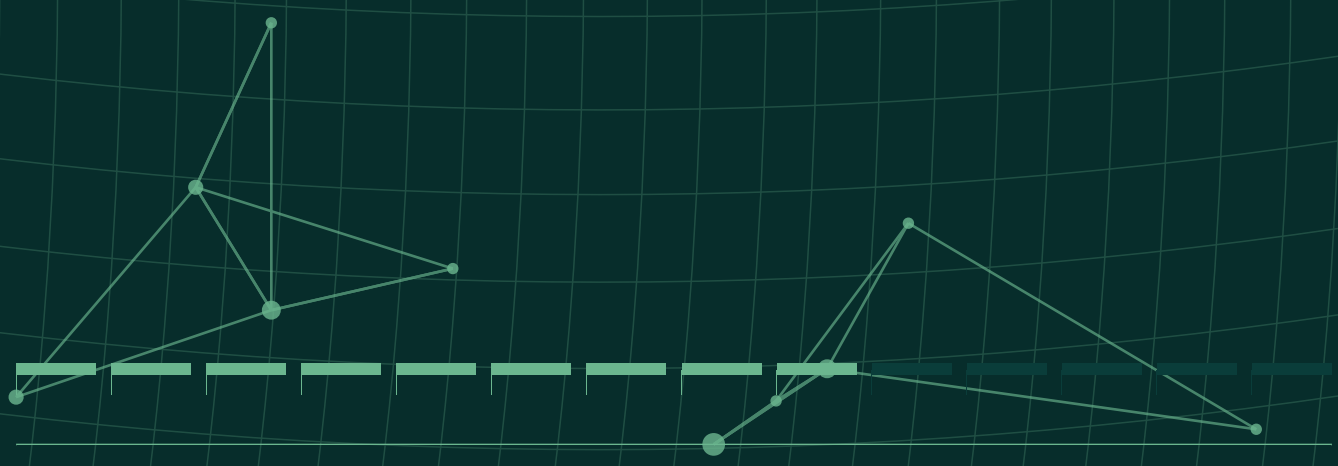
LIMITED / HONG KONG SAR

09

PART III: PROVE THE SERVICE AND THE ECONOMICS / UNIT ECONOMICS

On-demand wins only when retained orders cover the complete cost

Compare physical sampling and digital sampling, then compare production routes under matched quality and service conditions.



CHAPTER 09
DECISION TEST

Compare physical sampling and digital sampling, then compare production routes under matched quality and service conditions.

On-demand production is economically preferable only when net sales from retained orders cover the complete cost of earning, making, recovering and delivering those orders, including the capacity and cash that the service ties up. A customer order changes when production starts; it does not prove willingness to pay, acceptable quality or a positive margin. On-demand manufacturing is a structural change to the production system, not a technological guarantee of profitability. [S03] GFT therefore separates three calculations: the cost of developing an approved style, the contribution of a retained order and the period result after capacity costs. Each needs its own denominator and evidence.

No local supplier quotation, order cohort or operating cost has been established for this paper. The numerical cases below are explicitly illustrative decision models in CFA franc (XAF), not prices, forecasts or GFT results. They show where an attractive digital case can fail. The practical recommendation is to populate the same equations with dated quotations and a reconciled pilot ledger, then preserve negative outcomes rather than hiding them inside an average.

9.1

Sampling economics need a matched style cohort

The sampling comparison begins with equivalent work, not with a physical garment on one side and a screen image on the other. Both routes must carry the same style intent, fabric, size coverage, construction requirement and approval obligations. The output is an approved style with a defined production pack. A render that has not passed the required fit, colour, care or construction decisions is not equivalent to a physical sample that has. Research on virtual and physical fitting supports retaining a physical fitting gate because simulation does not resolve every technical issue. [S07]

GFT proposes a matched cohort assembled before results are reviewed. Each style enters a stratum defined by construction complexity, material familiarity, artwork placement, size range and whether it is new or repeated. The physical counterfactual then records the work that would actually be required for that style, using the existing or outsourced route. The digital candidate performs the same approval tasks. Random allocation is less important here than preventing a convenient comparison between simple digital cases and difficult physical cases.

The physical ledger includes pattern preparation, sample labour, fabric and trims, courier work, fitting sessions, buyer review and every internal iteration. It also includes failed samples and the staff time used to diagnose them. The digital ledger includes pattern conversion, material digitisation, simulation setup, avatar preparation, technical review, rendering only where it serves a decision, and residual physical validation. Fabric digitisation cannot be treated as free because a visual texture already exists. Drape research shows that digitised physical properties and simulation settings, including particle distance, require investigation in their own right. [S04]

9.2 AN AVOIDED SAMPLE MUST REMOVE EQUIVALENT APPROVAL WORK

A physical sample counts as avoided only when the digital route removes an iteration that would otherwise have been required for the same approval purpose. Moving a fit failure into production, or asking the buyer to discover it after delivery, does not

reduce the complete cost. It transfers cost into remakes, refunds, delivery and lost confidence. The cohort should therefore record physical iterations proposed, physical iterations performed, approvals achieved and later failures by cause. The denominator is approved styles, while the numerator retains the cost of styles that failed.

Shared material assets need an explicit allocation rule. A measured fabric file may serve several styles, but only if their physical material and process state remain within its qualified use. The first style should not silently carry every digitisation cost while later styles appear free. GFT would allocate shared preparation across the styles that demonstrably use the asset during the comparison period, and would show the unallocated remainder separately. This is an accounting design choice, not an observed saving.

The comparison also needs a time boundary. Software fees, training and equipment belong to a stated period. Sample materials and courier charges belong to a style iteration. Buyer delays belong to neither route merely because they occur while a file is open. A delay should enter the route comparison only when its cause and duration differ measurably between routes. This discipline prevents the digital case from claiming speed-related savings that the ledger cannot support.

9.3 THE COHORT MANIFEST MUST SURVIVE THE RESULTS

Before work starts, the cohort manifest should assign each style an identifier and record its route pair, complexity stratum, required approvals, material assets and planned comparison period. It should also state the baseline route. An outsourced physical sample and an internally made sample can have different cash costs and internal labour demands, so combining them without identification would weaken the counterfactual. The manifest is the denominator contract for every later cost per approved style.

Completion rules matter just as much as selection rules. A style withdrawn by the buyer should remain visible with its incurred cost and reason, but it should not count as an approved style. A style that fails digital approval should not be replaced by an easier style merely to make the route appear successful. If the physical route also fails, the pair should be reported as a joint development failure rather than silently removed. New designs, exact repeats and revised designs need separate subtotals because their legitimate work differs.

The final cohort review should reconcile the manifest to pattern files, material tests, sample receipts, courier documents and approval records. Missing labour is not zero labour, and a borrowed workstation is not zero capability cost. Where a value cannot be obtained, the analysis should show an evidence gap and test a bounded assumption rather than allowing the cheapest possible value to enter by default.

9.4

Digital sampling carries fixed and variable costs

A useful sampling model separates period capability costs, style-specific costs and iteration-specific costs. Period capability includes the software subscription or licence, suitable workstation, training and technical support. Style-specific work includes pattern conversion, construction setup and material digitisation. Iteration-

specific work includes simulation review, fit interpretation, revision labour and physical validation. Valid sewing patterns remain fundamental to accurate simulation and eventual fabrication, so pattern correction cannot be omitted from the digital budget. [S32] Vendor guidance also warns that arbitrary changes to fabric physical properties can change accuracy, which makes uncontrolled adjustment a source of labour and validation cost rather than a free calibration shortcut. [S16]

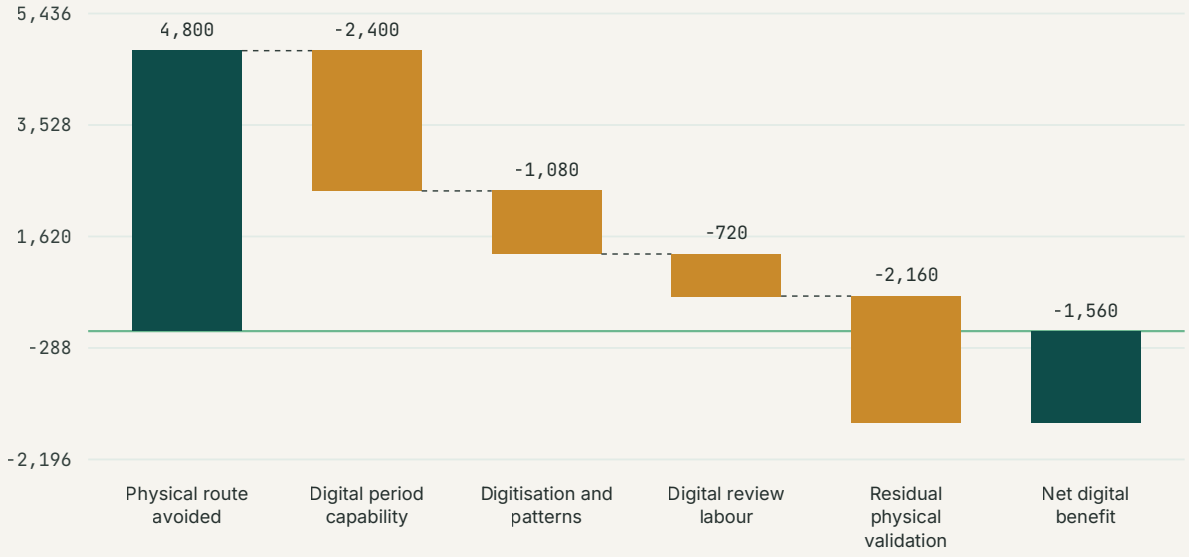
These categories answer different questions. For an adoption decision, the relevant comparison is future avoidable cost under each route, with any already incurred expenditure shown but not allowed to distort that choice. For ongoing pricing, the business still needs a rule for recovering capability costs through a credible number of approved styles. Dividing annual software and training costs by an optimistic garment volume mixes unlike units. It also hides failed development work. GFT instead amortises development capability across approved styles within a stated period, while retaining all relevant failed-style costs in the numerator.

9.5 THE DIGITAL ROUTE CAN LOSE BEFORE PRODUCTION BEGINS

Exhibit 36, p. 141 constructs an illustrative cohort of twelve approved styles. The physical route requires two sample iterations per style, each costing 180,000 XAF, plus 40,000 XAF of review labour per style. Its total is 4,800,000 XAF. The digital route carries 2,400,000 XAF of period licence, workstation and training cost, then 90,000 XAF of digitisation and pattern conversion, 60,000 XAF of digital labour and 180,000 XAF of residual physical validation per style. Every value is an illustrative assumption chosen to test the method, not a market quotation.

EXHIBIT 36 / THOUSAND XAF PER ILLUSTRATIVE 12-STYLE COHORT

Avoided samples must pay for the digital workflow



ILLUSTRATIVE [S04] [S07] [S16] [S32] Illustrative GFT model, not observed prices or results. Physical cost = 12 x (2 × 180,000 + 40,000) = 4,800,000 XAF. Digital cost = 2,400,000 + 12 x (90,000 + 60,000 + 180,000) = 6,360,000 XAF. Net digital benefit = 4,800,000 - 6,360,000 = -1,560,000 XAF. Sources establish workflow dependencies and residual validation, not the assumed costs.

The result is negative: the illustrative digital route costs 1,560,000 XAF more than the physical counterfactual. Under the same constant assumptions, physical development costs 400,000 XAF per style and digital variable development costs 330,000 XAF per style. The saving of 70,000 XAF per style must first recover the 2,400,000 XAF period capability cost. Arithmetic gives a crossover of about 34.3 approved styles, so the illustrative route becomes cheaper only from the thirty-fifth style. This is not an adoption threshold. If residual validation or digital labour rises, the crossover moves further away or disappears.

The waterfall also exposes what a simple count of avoided samples would miss. In this illustrative case, one physical iteration per style remains inside the digital route. Removing that requirement from the digital budget would create a fictitious benefit. Equally, charging the full physical baseline to a repeat style that would need little work would flatter digital adoption. The matched cohort and the cost categories matter more than the visual appeal of the bridge.

9.6

Order contribution must reconcile refunds and remakes

A retained order is the commercial unit that remains after the defined cancellation, refund and return window. It is not an enquiry, a checkout event, a print job or a dispatch scan. This distinction follows the operating logic of order-triggered production: confirmed demand authorises work, but the commercial outcome closes only after fulfilment and acceptance. [S03] The order ledger must therefore preserve gross sales, discounts, cancellations, refunds and additional recovery work as separate fields. A favourable average selling price cannot compensate for missing outcomes.

GFT defines order contribution as net retained sales less material, ink and other consumables, direct production labour, metered or allocated process energy, packaging, payment charges, delivery, expected recovery and allocated order setup. Pretreatment and heat curing belong in that boundary where the selected process requires them. [S15] [S30] Thermal work should not disappear into a generic overhead because drying and curing can be significant heat-consuming operations. [S17] Maintenance requires equal care: work driven by a job belongs to that job, while unavoidable period maintenance remains visible in the period result. Model-specific guidance demonstrates that ink-handling tasks can continue on a routine schedule, so idle time is not necessarily cost-free time. [S31]

This produces two connected measures rather than one ambiguous margin. Order contribution tests whether an additional retained order pays its identifiable commercial and production costs. The period result subtracts capability, support and idle-capacity costs from the sum of those contributions. Complete costing does not require every shared cost to be forced arbitrarily into each garment. It requires every shared cost to remain visible in a named reconciliation.

WORKED EXAMPLE: RETAINED-ORDER CONTRIBUTION

Consider an illustrative order for twenty accepted garments sold at `18,000 XAF` each, giving net retained sales of `360,000 XAF`. The assumed costs are `120,000 XAF` for fabric or blanks and trims, `35,000 XAF` for ink and consumables, `70,000 XAF` for direct labour, `10,000 XAF` for process energy, `35,000 XAF` for packaging, payment and delivery, `20,000 XAF` for order setup and `10,000 XAF` for expected recovery. These values are illustrative model inputs, not quoted Cameroon prices.

Complete cost is `300,000 XAF`, calculated as `120,000 + 35,000 + 70,000 + 10,000 + 35,000 + 20,000 + 10,000`. Illustrative order contribution is therefore `60,000 XAF`, or `3,000 XAF` per retained garment. The calculation does not include period capability costs. If those costs were `600,000 XAF` in the same illustrative period, ten identical orders would merely cover them, before any return on capital or financing cost. That extension demonstrates why a positive order contribution is necessary but not sufficient.

Recovery should be estimated by cause, not buried in a general contingency. A wrong-size remake may consume a new blank, printing, curing, assembly and delivery. A repairable placement fault may consume labour but not another garment. A refunded late order may reverse revenue while leaving the completed item unusable for that customer. The expected value for each cause is its observed frequency multiplied by its measured incremental cost, with the observation window and order cohort stated. Until those observations exist, a scenario range is more honest than a single recovery percentage.

GFT NOTE

GFT recommends that every quotation carry a contribution sheet alongside the technical specification. Sales, production, quality and fulfilment roles should sign the same version before release. The sheet should identify the approved design, material lot, accepted quantity, promised service, setup allocation and remedy assumptions. After the return window, actual net retained sales and all recovery costs should replace the estimates. If actual contribution is negative, the response is to revise the product, price, process or service boundary, not to describe the loss as growth without an explicit funded decision.

9.7 QUOTED VOLUME MUST EQUAL ACCEPTED VOLUME

The contribution denominator is the accepted and retained quantity, not the number of garments started. Setup rejects, print defects and sewing remakes consume inputs before the buyer receives the agreed output. A quote based only on good units therefore needs either an accepted-output yield assumption or an explicit recovery allowance. Both must come from the same order definition. Adding a yield uplift and a full remake allowance could double count the same loss, while omitting both would understate cost.

9.8 EVERY COST INPUT NEEDS A UNIT AND A BOUNDARY

A usable cost register records currency, price date, supplier or internal source, unit, quantity and treatment of taxes or delivery. It also records whether a figure is quoted, observed, derived or illustrative. A material price per purchased length is not yet a cost per accepted garment. It must pass through issued quantity, nesting and cutting

loss, setup consumption, rejected panels and usable returns. Labour paid hours likewise need reconciliation to the work performed, including setup and recovery, rather than relying only on a theoretical operation time.

Shared services require consistent allocation keys. Payment charges may follow collected revenue, delivery may follow a consignment, and order setup may follow a design or batch. Applying all three per garment would distort orders of different sizes. Energy should identify the meter or allocation method and the operating state included, such as warm-up, active processing and idle holding. These are GFT model rules, not claims about a particular utility tariff or tax treatment.

The quotation should state exclusions without allowing them to vanish from the decision. If a supplier price excludes pretreatment equipment, freight, installation, training or consumable starter stock, the adoption model must add the relevant item once and place it in the correct period or order category. If the existing operation already owns a usable curing station, the incremental adoption case differs from a new-service case. Keeping those boundaries explicit prevents both double counting and false savings.

9.9

Crossover volume depends on comparable acceptance yield

Production-route comparison needs a second model because sampling economics do not determine the cheapest way to make repeated orders. For route `i`, GFT defines total cost as `C_i(q) = F_i + (v_i / y_i) * q`, where `q` is accepted garments, `F_i` is fixed route or design setup cost, `v_i` is variable cost per started garment and `y_i` is accepted garments divided by starts. The starts required are `q / y_i`. This formulation makes recovery visible in the denominator instead of assuming that every start becomes saleable output.

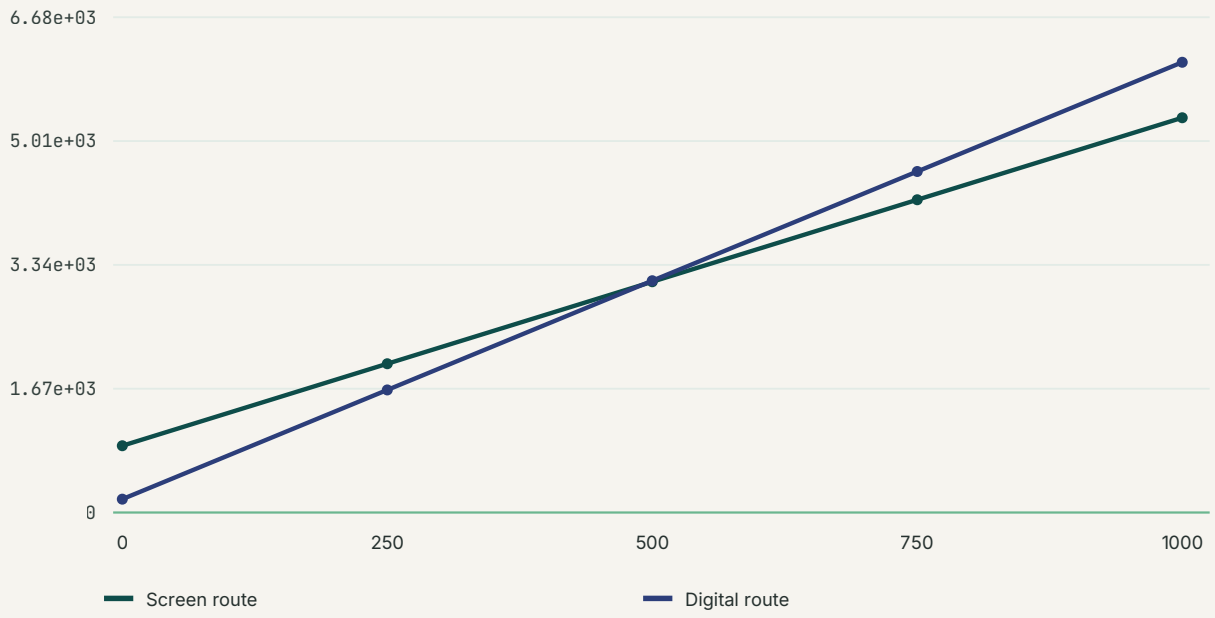
The comparison must hold the artwork, substrate, size set, print placement, end-use quality and delivery requirement constant. Digital textile printing supports short runs and design flexibility, while rotary screen printing remains a relevant technical comparator with its own application knowledge and substrate requirements. [S01] [S02] Neither statement supplies a universal cost ranking. A screen route may amortise design setup over a stable repeat, while a digital route may avoid some setup but carry different ink, pretreatment, curing and recovery costs. The valid evidence is a matched quotation and trial for the intended article.

9.10 A FEASIBLE CROSSOVER NEEDS A SIGN AND DOMAIN CHECK

Exhibit 37, p. 145 shows an illustrative comparison. Screen setup is `900,000 XAF`, variable cost is `4,200 XAF` per start and accepted-output yield is `0.95`. Digital setup is `180,000 XAF`, variable cost is `5,300 XAF` per start and yield is `0.90`. These are invented model inputs. They do not describe any supplier or machine. Equal accepted volume is used on the horizontal sequence, so the different yields affect cost rather than the service delivered.

EXHIBIT 37 / THOUSAND XAF PER ACCEPTED-ORDER BATCH

Breakeven exists only with a feasible cost difference



ILLUSTRATIVE [S01] [S02] Illustrative route model, not supplier quotations. Screen: F=900,000 XAF, v=4,200 XAF/start, y=0.95. Digital: F=180,000 XAF, v=5,300 XAF/start, y=0.90. C_screen=900,000+(4,200/0.95)q; C_digital=180,000+(5,300/0.90)q. Equal-cost q=490.518 accepted garments. Sequence intervals are 250 accepted garments. Values rounded to 0.1 thousand XAF.

Setting the two illustrative equations equal gives `q = (180,000 - 900,000) / ((4,200 / 0.95) - (5,300 / 0.90))`, or about `490.5` accepted garments. Below that volume, the lower digital setup cost dominates in this case. Above it, the lower effective variable cost per accepted garment favours the screen route. The chart does not establish that either route passes the required physical tests. It shows only the arithmetic conditional on the assumed costs and yields.

A solver must test the denominator before reporting breakeven. If effective variable costs are equal and fixed costs differ, there is no finite crossover. If the calculated volume is negative, one route dominates throughout the non-negative production domain under the model. If the volume exceeds practical capacity or the demand horizon, the mathematical crossover is not an actionable result. A zero yield invalidates the equation and represents a route that cannot deliver accepted output.

Fixed cost also needs the correct repeating unit. Artwork setup may repeat per design, screen preparation per colour set, and machine setup per batch. A reorder using an unchanged approved specification should not automatically inherit the full first-design cost. Conversely, a material or artwork substitution may reopen setup and approval work. Separating new designs, exact repeats and revised repeats prevents a spurious route advantage created by inconsistent allocation.

9.11

Capacity and utilisation change the cost of a promise

Nameplate speed describes a machine condition, not the number of retained orders a staffed service can deliver. Practical capacity must use the complete route: approval, preparation, printing, curing, cutting, sewing, inspection, packing and recovery. It must also reflect product mix, changeovers, planned maintenance, operator availability and the constraining thermal stage. The significance of heat in drying and curing supports metering and reserving that work rather than treating printer completion as order completion. [S17] Routine equipment tasks also belong in the capacity calendar, using the chosen manufacturer's actual instructions rather than a generic interval. [S31]

GFT defines practical staffed capacity as the accepted output the complete route can deliver under its approved work plan and product mix, after planned allowances. Commercial utilisation is retained orders delivered divided by that practical capacity, expressed on a consistent order or garment basis. This is deliberately different from printer uptime. A busy printer can coexist with unapproved samples, incomplete panel sets, a curing queue or unpaid delivery work. The economic question is how much funded, accepted output reaches the retained-order ledger.

Fixed period costs must be reconciled outside the per-order variable allowance. They may include digital capability, technical support, unavoidable maintenance and staffed capacity retained between orders. The appropriate evidence includes rosters, maintenance records, software agreements and support quotations, each with its period and scope. Assuming full utilisation before demand exists would spread those costs over imaginary orders. It would also conceal the cash and service risk of promising capacity that the complete route does not possess.

9.12 REPRINTS AND LOW UTILISATION CAN REVERSE THE RESULT TOGETHER

Exhibit 38, p. 147 presents an illustrative monthly sensitivity. At full practical utilisation, the service completes `200` retained orders. Each contributes `10,000 XAF` before recovery and period costs. A remake affects the stated share of retained orders and costs `35,000 XAF` per affected order. Fixed period cost is `600,000 XAF`. For utilisation `U` and remake rate `r`, illustrative period contribution is `200 * U * (10,000 - r * 35,000) - 600,000`, expressed in XAF. The model isolates recovery expense; any additional capacity lost to remakes should be measured separately and can make the result worse.

EXHIBIT 38 / THOUSAND XAF PER ILLUSTRATIVE MONTH

Reprints and utilisation can reverse a decision

	0% remakes	5% remakes	10% remakes	15% remakes
25% utilisation	-100	-188	-275	-362
50% utilisation	400	225	50	-125
75% utilisation	900	638	375	112
100% utilisation	1,400	1,050	700	350

Cell scale: -362 to 1,400

ILLUSTRATIVE [S17] [S30] [S31] Illustrative GFT sensitivity, not a demand or cost forecast. Full practical volume = 200 retained orders/month; pre-recovery contribution = 10,000 XAF/order; recovery = 35,000 XAF per remade order; fixed period cost = 600,000 XAF. Cell = 200 x utilisation x (10,000 - remake rate x 35,000) - 600,000, divided by 1,000. Sources support thermal, pretreatment and maintenance cost categories, not these values. Additional capacity consumed by remakes is excluded and requires separate measurement.

Every cell at low illustrative utilisation is negative, and the highest-remake case at half utilisation also falls below zero. Negative values are retained because they identify the operating conditions that a proposal must avoid or finance. The model does not say that a real service will face these rates. It shows why average contribution at full capacity cannot answer an adoption question when order coverage and recovery remain uncertain.

Capacity recovery needs its own feedback loop. If remakes consume the same printing, curing or sewing hours as first-pass orders, practical capacity falls after the initial estimate. The next sensitivity should therefore reduce available output as well as charging recovery cost. Otherwise the model can be optimistic twice: once by paying for the remake and again by selling the capacity it consumed. Pilot scheduling records should link every recovery event to the constrained stages it revisits.

9.13

Sensitivity analysis should expose a failed case

A decision model should begin with the assumptions that can overturn it, not with a single favourable base case. For sampling, those assumptions include the number of approved styles, physical iterations avoided, shared-asset reuse, residual validation and digital review labour. For production, they include accepted-output yield, order size, delivery cost, remake incidence, practical utilisation and the period over which fixed capability must be recovered. Each input needs a source status: observed, quoted, derived or illustrative.

Ranges should come from evidence rather than a mechanical upward and downward adjustment. A dated supplier quotation can support a price range only within its stated scope. A pilot can support an observed range only for the styles and conditions tested. Where neither exists, the scenario should be called illustrative and its basis stated. Complex styles may increase both physical and digital work, so varying one while holding the other artificially cheap can manufacture a crossover. Joint scenarios should preserve such plausible relationships.

Reverse stress tests are particularly useful because they start at the decision boundary. In the illustrative retained-order case, all costs other than recovery total `290,000 XAF` against net sales of `360,000 XAF`. Recovery could therefore reach `70,000 XAF` before contribution became negative, compared with the `10,000 XAF` initially assumed. This is not an acceptable defect allowance. It is a numerical warning showing how much room the case contains, before period costs and physical quality gates are considered.

The sampling crossover needs the same treatment. If digital variable development cost per approved style equals or exceeds the physical variable cost, no finite positive style count can recover an additional digital fixed cost. If the calculated crossover lies beyond the credible number of styles in the review period, the correct answer is no breakeven within that horizon. A spreadsheet should display that condition explicitly rather than returning a large number that looks like a plan.

Failed scenarios should lead to bounded actions. A service might narrow its product family, outsource a process, retain physical sampling for difficult materials, renegotiate delivery scope or stop the proposed investment. These are operational choices, not evidence that adoption must eventually succeed. GFT's recommendation is to preserve the failed case in the decision record alongside the assumptions that would repair it, then require new observations before changing the decision.

9.14 THE DECISION REGISTER MUST PRESERVE MODEL VERSIONS

Each sensitivity run should have a scenario identifier, input register version, formula version, reviewer and decision consequence. The output should show order contribution, period result, crossover feasibility and maximum cash deficit together. A favourable margin is not sufficient when the cash deficit exceeds an approved funding limit, and a funded case is not acceptable when physical release evidence fails. This joined review keeps economic optimisation from overriding quality or responsible operating constraints.

Model versions should change only through recorded evidence. A new supplier quotation may replace an illustrative price within its quoted scope, but it should not silently overwrite material yield or accepted-output assumptions. Likewise, a successful trial on one fabric does not justify changing every material scenario to the best observed case. The reviewer should be able to trace every changed input to its source and reproduce the previous decision.

Complex probabilistic analysis is unnecessary while the underlying distributions are unknown. A small set of named, inspectable scenarios is more useful than precise-looking probabilities invented for an untested order book. As observations accumu-

late, the team can add distributions and correlations with their sample boundaries visible. Until then, the decision register should report what would have to be true, who will measure it and what result would stop or narrow the service.

9.15

Cash timing is distinct from accounting margin

An order can show a positive expected contribution and still run out of cash before collection. Deposits, blank or fabric purchases, consumable minimums, labour payment, packaging, dispatch, final settlement and refunds occur on different dates. Order-triggered production changes when work begins, but it does not remove those payment events or the stock held upstream. [S03] The cash model therefore belongs beside the contribution sheet, not inside a single margin percentage.

Exhibit 39, p. 149 uses the same illustrative order as the worked example. The buyer pays a 180,000 XAF deposit on approval and 180,000 XAF on final collection. Material, ink and consumables are paid before production; labour, energy and setup follow; packaging, payment and delivery are paid at dispatch; and the assumed recovery cost occurs later. Cumulative cash is the sum of receipts less payments at each event. All dates and amounts are illustrative and do not establish customer terms.

EXHIBIT 39 / ILLUSTRATIVE DAYS FROM ORDER APPROVAL

A positive margin can still require working capital



0
Approval and deposit
+180,000; cumulative +180,000

2
Materials and consumables
-155,000; cumulative +25,000

5
Labour, energy and setup
-100,000; cumulative -75,000

7
Pack and dispatch
-35,000; cumulative -110,000

12
Final collection
+180,000; cumulative +70,000

20
Recovery event
-10,000; cumulative +60,000

ILLUSTRATIVE [S03] [S28] Illustrative event sequence using the worked-example order. Amounts in each detail are XAF, with cumulative cash in parentheses. Final cash surplus = 360,000 receipts - 300,000 payments = 60,000 XAF. Maximum cumulative deficit = 110,000 XAF on day 7. This is a cash-timing model, not accounting, investment, legal or tax advice.

The illustrative order ends with 60,000 XAF of cash surplus but reaches a cumulative deficit of 110,000 XAF before final collection. That deficit is the working-capital exposure in this simplified case. It can be larger when materials must be bought in supplier packs greater than the order requirement, when several orders share a production week or when settlement is delayed. The timeline should therefore be aggregated across all open orders rather than assessed one order at a time.

Commercial terms should make cancellation, approval, acceptance and remedy events explicit. Operationally, a refundable deposit is not equivalent to free cash while the related obligation remains open. The cash ledger should identify which receipts are restricted by the agreed terms and which expected payments remain exposed to refund or recovery. Responsible purchasing and production planning also matter beyond liquidity: OECD guidance identifies low wages, inefficient production planning and poor purchasing practices as common factors associated with excessive working hours. [S28] A cash-saving rush promise is not acceptable if it silently depends on unreasonable hours or unapproved subcontracting.

The final control is a reconciliation between three ledgers. The order ledger explains net retained sales and contribution. The capacity ledger explains what the complete route can deliver and what fixed period costs remain. The cash ledger explains when funding is needed. Capital structure, tax treatment and contractual obligations require separate qualified review; these examples are operational decision aids, not investment, legal or tax advice. Adoption should proceed only when all three views support the same bounded service under evidence that the pilot actually collected.

Retained orders, not printed units, must carry the whole service.

CHAPTER SOURCE NOTES

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S04 Dongguk University research portal; Taylor & Francis, Journal of the Textile Institute. 2025.

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S31 Epson America. 2026.

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S28 Organisation for Economic Co-operation and Development. 2018.

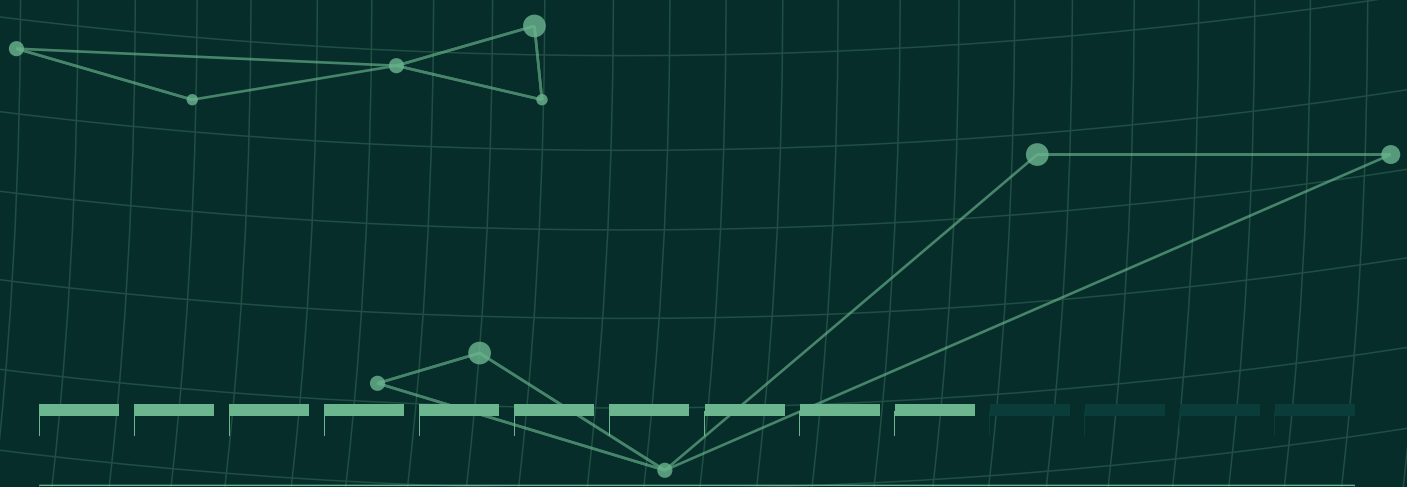
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10

PART III: PROVE THE SERVICE AND THE ECONOMICS / ORDER ORCHESTRATION

A reliable on-demand service needs controlled order states

Make every design revision, production release and fulfilment event recoverable and auditable.



CHAPTER 10
DECISION TEST

Make every design revision, production release and fulfilment event recoverable and auditable.

A reliable on-demand service releases only work whose specification, authority, materials and capacity can be proved, then preserves enough evidence to recover that work after a change or interruption. The print job is not the order. An order begins with a commercial commitment and ends only after fulfilment, acceptance and the agreed refund or return window. Between those boundaries, GFT proposes separate but linked states for the buyer commitment, the approved specification, each physical job and the final commercial outcome. This control design is a proposal for a future service, not a claim that GFT has deployed an order platform or achieved a measured recovery rate.

The central rule is that every transition must have an input, an authorised role and an inspectable record. A buyer can revise a design, but the revision cannot silently overwrite what production already received. Software can retry a release request, but the retry cannot create a second physical job. A supervisor can restart interrupted work, but only after reconciling the material and process state. On-demand manufacturing changes the production system rather than merely adding a machine, so these controls belong to the service design from the outset. [S03]

10.1

Each order needs an immutable approved specification

The order record must identify exactly what the buyer accepted and what the factory may make. GFT proposes distinct identifiers for the order, style, artwork, pattern, material, size set and approval bundle. Each identifier refers to a controlled revision, not to a filename that different people can overwrite. The approved bundle connects those revisions to the buyer commitment, intended care, print placement, construction instructions, acceptance criteria and authorised release decision. Valid sewing patterns are fundamental to accurate simulation and eventual fabrication, which makes pattern identity and validation part of the release record rather than an informal design dependency. [S32]

This structure answers questions that a shared folder cannot. Which artwork revision was approved? Which pattern export carried the approved dimensions? Which fabric or blank lot was permitted? Which size set and quantity were funded? Which physical checks were required, and which reviewer accepted them? A shared name such as `final-shirt` answers none of them reliably. The system should store a human-readable title for convenience, but release should resolve identifiers to immutable assets and a recorded approval bundle.

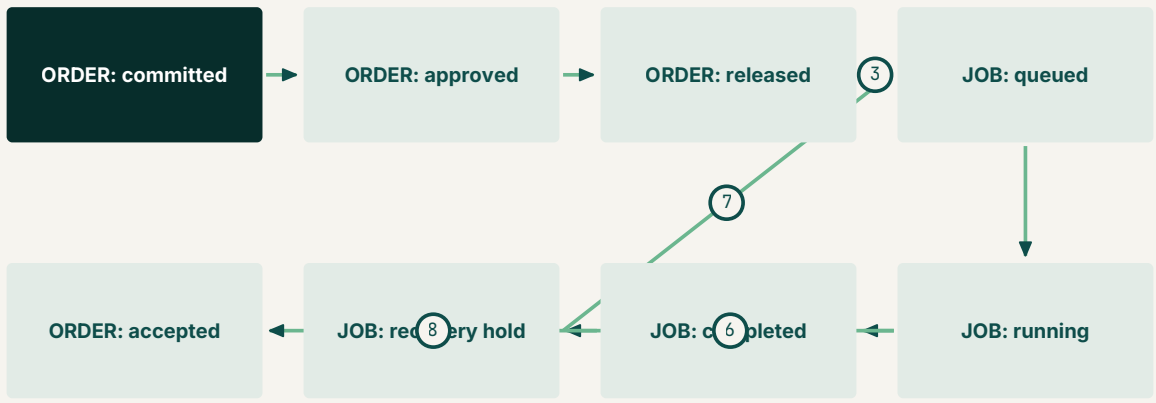
Immutable does not mean unchangeable. It means that an approved revision remains available for inspection while any substantive change creates a new revision. Changing a telephone number in a delivery note may be an administrative correction. Changing artwork scale, pattern ease, fabric lot, print recipe or accepted quantity is a production-relevant change. The order needs an explicit supersession event that names the old bundle, the new bundle, the reason, the requester, the approver and the effective time. Production jobs already released against the old bundle require their own hold, cancellation or completion decision.

10.2 ORDER AND MACHINE STATES MUST REMAIN DISTINCT

Exhibit 40, p. 153 shows the proposed relationship. The order becomes releasable only after approval. That release authorises a job, whose queue and execution states remain subordinate to the order. A recovery hold can return physical work to a reconciled queue, but it cannot rewrite the approved specification. Packing and buyer acceptance are subsequent order events, not synonyms for machine completion.

EXHIBIT 40 /

The order state must be separate from the machine state



3. authorised release
6. interruption
7. reconciled restart
8. after fulfilment

ILLUSTRATIVE [S03] Illustrative GFT control design informed by the order-driven production concept and by internal programme principles G02 and G03. States are proposed, not implemented software or measured cycle times. A job-completed event does not prove buyer acceptance.

The important separation is evidential. A machine can report completion while a panel is missing, a cure is unverified or the buyer has cancelled. Conversely, a buyer can approve a design while no machine capacity exists. Collapsing those conditions into one `done` field destroys the information needed for a safe decision. The state model should therefore permit an order to be commercially committed but technically held, technically approved but capacity held, or physically complete but commercially disputed.

The programme's performance-management design supplies the principle of stable definitions and event capture, while the digital strategy supplies local data ownership and buffering principles.[^G02][^G03] WP20 extends those principles into print-order execution. It does not assume a particular database, message broker, printer interface or enterprise system. The minimum credible implementation can be small, provided that the state transitions and physical evidence remain explicit.

10.3 CANCELLATION NEEDS AN EFFECTIVE BOUNDARY

A cancellation request is not instantly a cancelled physical order. The service must locate every authorised job and determine whether material has been committed, printing has started, assembly has begun or dispatch has occurred. The outcome might be cancellation before release, cancellation with material liability, completion by agreement, or return after delivery. Each outcome needs its own commercial and physical record. Otherwise, a cancelled flag can conceal work in progress or invite an operator to discard material without a reconciled instruction.

The same rule applies to a design change. If the buyer replaces artwork after release, the service must identify every job and asset carrying the superseded revision. A new release should name the replacement bundle and the disposition of affected material. The audit trail must preserve both decisions. Deleting the old artwork or marking the whole order `revised` would make later dispute analysis and recovery unnecessarily uncertain.

10.4

Release requires both approval and available capacity

A technically approved order is still not necessarily ready to print. GFT proposes a release gate that checks commercial commitment, reproduction permissions, quality approvals, material availability and finite capacity at every constrained stage. The gate should return a complete decision: release, hold with a named reason, or reject with a required correction. An operator should not have to infer readiness from a mixture of messages, spreadsheets and verbal assurances.

Commercial commitment means that the service's defined order trigger has occurred under the quoted terms. That trigger may be an accepted order, a deposit or another explicitly agreed commitment. The design should not confuse an enquiry or artwork upload with authority to consume materials. Reproduction permission also belongs at this boundary when the service requires it. The release record should point to the commitment and permission evidence without exposing sensitive buyer records to production roles that do not need them.

Technical approval must match the exact release candidate. A fit approval for one pattern and material combination does not automatically approve another. A colour decision attached to an earlier fabric lot cannot be silently inherited by a substitute. The gate should compare the approval bundle's asset identifiers with the identifiers in the release request. Any mismatch creates a hold, not an informal opportunity for the operator to choose the closest available file.

10.5 CAPACITY MEANS THE WHOLE PROMISE CAN BE STAFFED

Material availability requires more than a positive stock balance. The service must establish that the approved blank sizes, fabric, ink, adhesive, trims and other order-specific inputs are usable and allocated under the chosen stock policy. It must also preserve material for earlier authorised commitments. A last-minute substitution reopens the relevant approval decisions. WP12 owns the broader inventory policy; this chapter requires only that release cannot consume an unapproved or already committed input.

Capacity must include printing, pretreatment where required, curing, cooling, cutting, sewing, inspection, recovery and packing. Manufacturer guidance identifies heat curing as a distinct garment-printing stage, so printer availability alone cannot establish order capacity. [S15] Drying and curing can also carry significant heat demand, which makes the thermal stage an operating constraint rather than invisible spare time. [S17] The release check should reserve the required stages against the promised service, using observed durations when they exist and clearly labelled planning estimates before then.

A feasible schedule must remain consistent with responsible work planning. OECD guidance identifies inefficient production planning and poor purchasing practices among factors associated with excessive working hours in garment supply chains. [S28] GFT therefore treats an unreasonable lead-time promise as a release defect, not as a sales ambition that production must absorb. If the only feasible schedule depends on unapproved overtime or undisclosed subcontracting, the order requires a revised promise or an authorised alternative.

> **GFT NOTE**
>
> GFT recommends a single release certificate for every production authorisation. It should name the order, immutable approval bundle, quantity, allocated material, planned constrained stages, original delivery promise, release role and any explicit exceptions. A missing field creates a hold with an owner and due action. The release role should have authority to refuse work even after a buyer has paid, because payment does not supply a missing pattern, material, test or capacity reservation.

10.6 THE ORIGINAL PROMISE MUST SURVIVE LATER REPLANNING

Schedules will change, but the service should not erase the original buyer promise when it does. The order record should retain the initial committed date and any later revision agreed with the buyer, together with the cause and authority for the change. Internal planned completion can move more often, provided that it remains distinguishable from the external promise. This separation allows the performance review to distinguish genuine promise attainment from a date rewritten after a delay became visible.

A release certificate also needs an expiry or revalidation rule when its assumptions cease to hold. A material lot consumed by another order, a changed machine state, an expired approval or a revised buyer specification can invalidate the planned release. Revalidation should check the affected conditions rather than forcing every order through an identical delay. The aim is controlled authority at the point of commitment, not bureaucracy detached from physical risk.

10.7

A network retry must not print an order twice

A release request can fail in a more dangerous way than a visible rejection. The request may reach the local execution service, create a job and then lose its acknowledgement. The sender sees a timeout, not proof that nothing happened. If it responds

by creating another job, the same approved order can be printed twice. GFT therefore designs for repeated messages and ambiguous outcomes rather than assuming that a network failure leaves no physical trace.

The control begins with a release intent. An authorised role creates an intent for a defined order, approval bundle, quantity and production purpose. That intent receives a unique identifier before any request is sent. Every retry carries the same identifier. The execution service stores the first accepted intent and returns the existing job identity for subsequent copies. This is the proposed idempotency rule: repeating the same release request does not create an additional production job.

A legitimate second job needs a new intent, not a reused key. For example, a quality-approved reprint after a documented failure is a new production purpose linked to the original job and recovery case. A size addition authorised by the buyer is another new intent. This distinction prevents two opposite errors: duplicate work caused by transport retries, and suppressed work caused by treating every later request for the order as a duplicate.

10.8 ACKNOWLEDGEMENTS MUST DESCRIBE THE RECORDED JOB

An acknowledgement should identify the release intent, assigned job, immutable specification and current recorded state. `Received` is insufficient if the receiver cannot say what it received. The order service can then reconcile its intent with the execution record. A timeout leaves the intent in an unknown state until reconciliation; it does not automatically prove failure, and it does not authorise a fresh release under another identifier.

The execution service should distinguish queued, running, completed, failed and unknown states with explicit transition events. Completion needs a defined source, whether that is a machine interface, an operator confirmation or a reconciled local record. Failed needs an equally clear meaning. A communication failure, an aborted job and a physically rejected print are different conditions and should not share one vague error code.

Local buffering is valuable because work and event capture can continue through a connectivity interruption, but a buffer does not by itself prevent duplication. The programme's digital strategy supplies the local-buffering principle and the preference for controlled data capture.[^G03] WP20 adds the release-intent store, stable job identity and reconciliation rule. Those elements must work during ordinary operation, not only in an exception report after duplicate material appears.

Exhibit 41, `p. 157` places these responsibilities in a deliberately small architecture. The order and decision layer owns authority. The control layer owns specifications, release intents and reconciliation. The local execution layer owns the queue, acknowledgements and buffered events. Physical stages supply evidence of what actually happened. The design does not require every stage to be digitally integrated, but every manual boundary then needs a controlled record.

EXHIBIT 41 /

Print-order integration can remain small and accountable



ILLUSTRATIVE [S03] Illustrative GFT architecture extending internal programme principles G02 and G03. It is a responsibility model, not a deployed system, vendor selection or claim of automatic printer integration. Manual execution requires equivalent controlled records.

The architecture's value lies in ownership, not in the number of software components. A single well-controlled local application could implement several layers. A larger estate could still fail if two services can independently create jobs for the same intent. Before adoption, the service should test repeated requests, delayed acknowledgements, restarted applications and out-of-order events against one persistent order history.

10.9 RECONCILIATION MUST PRECEDE ANOTHER ATTEMPT

When the state is unknown, the operator or reconciliation service should inspect the release-intent store, local queue and available physical evidence before trying again. If the original job exists, the retry returns its identity. If no job exists and the execution record is trustworthy, the same intent can be submitted again. If records disagree, the order enters a recovery hold. An automatic retry policy should never convert uncertainty into an unbounded series of new identifiers.

Manual operation needs the same discipline. A paper or spreadsheet release log can carry the intent identifier, job identifier, specification revision and acknowledgement. The receiver repeats the recorded job identity when confirming a duplicate request. This is less convenient than an integrated interface, but it tests the control logic without pretending that connectivity or software integration has already been established.

10.10

An interruption needs a safe physical restart

A digital queue cannot describe the physical restart on its own. After a stoppage, the service must reconcile the approved job with printed length, panel position, blank identity, cut-set completeness and cure state. The aim is to resume only the verified remaining scope. Restarting the original job from its first instruction may duplicate panels or garments; skipping ahead without locating the last good article may omit them.

The restart record should identify the interruption, affected job, last verified physical state, quarantined material and authorised next action. Equipment-specific documentation and vendor testing must establish the actual stop and restart procedure. This chapter makes no claim that a particular printer can resume at an arbitrary panel or that an interrupted cure can be continued safely. Where the process state cannot be verified, the affected work remains held until an approved test, reprocessing route or rejection decision resolves it.

Thermal and maintenance dependencies belong in that decision. Garment-printing guidance includes heat curing, and sector guidance identifies the heat demands of drying and curing. [S15] [S17] Model-specific maintenance instructions can also require routine ink handling even when production is intermittent. [S31] Those examples support recording process and maintenance state, not transferring one machine's settings or schedule to another.

Exhibit 42, p. 159 converts common failure cases into evidence and recovery requirements. Each row ends with a controlled release decision. None permits an operator to hide uncertainty by changing the job identifier or starting the whole order again.

EXHIBIT 42 /

Every failure needs a reconciled recovery

Failure	Required evidence	Recovery release
Duplicate submission	Order, specification and release-intent identity	Keep original job; reject duplicate
Network loss after send	Local queue and last acknowledgement	Reconcile before any retry
Partial printed roll	Artwork, panel positions and verified printed length	Quarantine; release only missing verified panels
Interrupted cure	Batch identity and verified cure state	Hold; test, reprocess or reject under approved route
Wrong artwork	Released specification versus RIP readback	Stop; isolate all affected jobs and panels
Missing panel	Cut-set reconciliation and bundle identity	Complete the set before assembly or dispatch

ILLUSTRATIVE [S15] [S17] [S31] Illustrative GFT recovery design. The sources support physical-stage and maintenance dependencies, not these proposed procedures or any equipment restart capability. Actual methods require equipment documentation, trials and authorised quality decisions.

The table shows why recovery cannot be only a software function. The release-intent record may prove that a job was authorised, but physical inspection establishes what now exists. The quality record determines whether an affected article can proceed. Operations should retain the original identifiers through quarantine, rework and remake so that the later performance review can count the event and its cost accurately.

> **WORKED EXAMPLE: RESTART ONLY THE VERIFIED REMAINDER**
>
> Consider an illustrative order for 40 accepted garments. At interruption, 18 have completed every required process and passed inspection, 6 are printed but have unverified cure state, and 16 have not been started. The physical reconciliation is 18 + 6 + 16 = 40. These quantities are invented solely to demonstrate the recovery calculation.
>
> The restart does not authorise 22 new starts. It holds the 6 uncertain garments and releases only the 16 verified unstarted garments, while the 18 accepted garments remain outside the restart scope. If an approved later test rejects 2 of the held garments, a separate recovery intent authorises 2 replacements linked to the original job. The revised total start count becomes 42, with 40 accepted garments only if all other output passes. This is illustrative arithmetic, not an observed yield or equipment capability.

10.11 QUARANTINE NEEDS A DISPOSITION, NOT A HIDING PLACE

Held material should carry its order, job, specification, physical state and reason for hold. Its location and status must prevent accidental return to production. The disposition options should be explicit: release after evidence, rework under an approved instruction, remake through a new recovery intent, return to usable stock where valid,

or reject under the applicable waste procedure. Scrapping an item does not close the recovery record. The event still consumed material, labour and capacity, and its cause still needs review.

A restart test should include the awkward cases before the service makes dependable promises. The pilot can interrupt a queued job, delay an acknowledgement, stop after partial printing and remove a panel from a controlled cut set, all under an agreed safe protocol. Success means that the team reconciles the order and physical scope without duplication or omission. It does not mean that the software remained available throughout.

10.12

Fulfilment must close the order rather than the print job

The order remains open after printing because the buyer has not yet received and accepted the promised article. GFT proposes separate events for packed, dispatched, delivered, accepted, disputed and refunded. Each event records quantity as well as status. A parcel scan concerns logistics. Buyer acceptance concerns the agreed product and service. Neither should overwrite the other, and neither follows automatically from a completed print job.

Packing requires reconciliation of the order, size set, quantities, garment identities where used, care information and consignment. If the order ships in parts, each consignment should identify the quantities included and the balance remaining. Dispatch records what left the service and under which carrier reference. Delivery records what the carrier reports as received. Acceptance records the buyer's decision under the agreed terms and window. These distinctions allow a missing parcel, a wrong size and a rejected print to enter different recovery routes.

The programme's performance-management design calls for delivery measurement and accepted-output discipline.[^G02] WP20 applies that discipline to the complete order. A fast dispatch followed by a quality dispute is not a fulfilled success. Equally, a buyer delay in confirming receipt should not be relabelled as a production defect without evidence. The record should preserve the event source and timestamp so that operational lateness, carrier delay and acceptance delay can be analysed separately.

Commercial closure occurs under the service's defined terms. The retained-order state should follow the agreed cancellation, refund and return window, with any open dispute still visible. Net retained sales must reconcile to credits, refunds and remakes rather than remaining equal to the original checkout value. Where an order closes partially, the ledger should show accepted and unaccepted quantities and their commercial treatment. A simple closed flag is not enough.

Proof of closure should be proportionate to the service. A small operation might use a signed delivery record and a dated buyer confirmation. A more integrated service might consume carrier events and an online acceptance response. In both cases, the event needs a source and an owner. Manual entry is not automatically unreliable, but an unattributed status change cannot provide a dependable audit trail.

10.13

Returns need actionable cause codes

A return record should help the service correct a specification, process or promise. GFT proposes cause categories for sizing, print appearance, durability, wrong item, late delivery and buyer cancellation, with secondary detail where needed. The category should describe the reported and verified condition, not assign blame. `Buyer error` is not an adequate technical finding. `Approved size chart did not match buyer expectation` identifies a different corrective route from `wrong size packed`.

Cause capture begins with the buyer's report in its own terms. The review then records the evidence used to confirm or revise that initial classification. A sizing complaint may require the garment measurements, approved pattern, size label and intended wearer record. Print appearance may require comparison with the approved artwork and physical reference. Durability may require the care history and relevant test evidence. Fit research cautions that simulation does not remove every physical fitting issue, so a digital approval cannot by itself dismiss a later fit complaint. [S07]

The cause code should point to the record that can change. Sizing links to the size definition, avatar coverage, pattern revision and packing check. Print appearance links to artwork, material lot, print recipe and inspection. Durability links to material qualification, cure and care instructions. Where rubbing performance is relevant, the public ISO scope distinguishes dry and wet rubbing tests, which supports retaining the test condition in the evidence rather than recording a generic colour complaint. [S11]

Some cases have several causes. Late delivery may coincide with a wrong item, and a buyer cancellation may follow an earlier delayed promise. The record can hold a primary remedy and secondary contributing causes without forcing false simplicity. The reviewer should also separate reason for return from disposition. An item returned for lateness may be unused and resaleable under the service's rules, while an item with a durability failure needs technical containment. Commercial treatment and physical disposition are different decisions.

Recurrence review is where cause codes earn their keep. A repeated sizing issue should reopen the relevant technical pack or size communication. Repeated wrong artwork should reopen release readback and job identity controls. Repeated late delivery should test the original capacity gate and promise policy. Each corrective action needs an owner, a due state and a later effectiveness check. Counting returns without connecting them to those records produces reporting, not learning.

10.14

Performance reviews need shared denominators

An order-control system becomes useful only when its measures retain the same meaning across shifts and review periods. GFT proposes a dictionary that defines every numerator, denominator, event source, observation window and owner before reporting performance. This follows the programme's stable-definition and management-cadence principles.[^G02] It also prevents a favourable ratio from emerging merely because the team changed which orders or jobs were included.

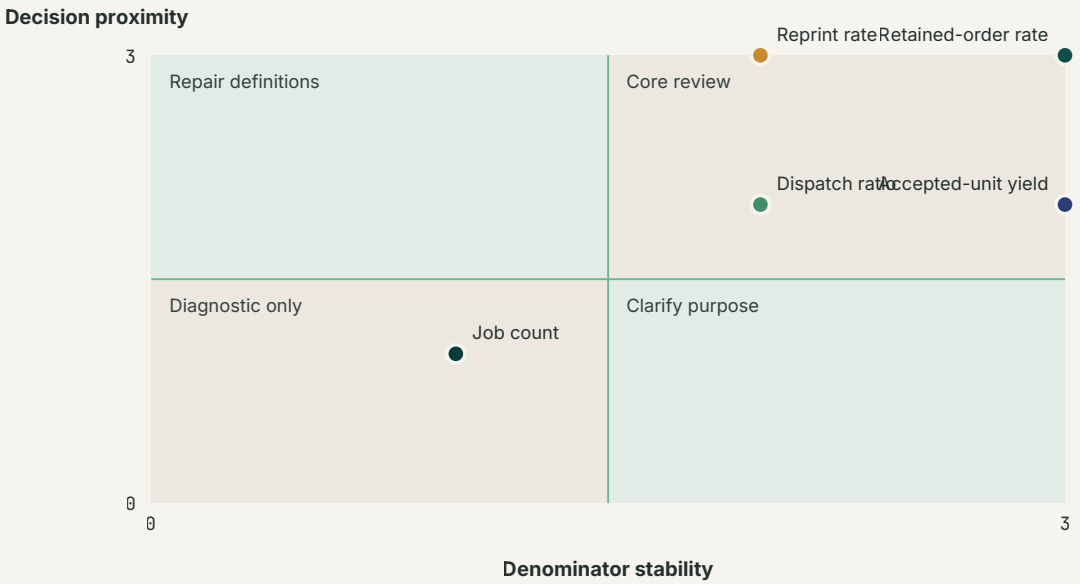
Accepted-unit yield should divide accepted garments by clearly defined starts, with internal acceptance distinguished from buyer acceptance. Retained-order rate should divide retained orders by the order cohort entering the same defined commitment state, after the agreed outcome window. Reprint rate should identify whether its denominator is started jobs, released jobs or printed garments. First physical approval belongs to a style cohort and must retain revisions rather than counting only successful first submissions. Promise attainment should compare delivery or acceptance, as explicitly chosen, against the original buyer promise rather than a revised internal plan.

Hours consumed need an equally clear boundary. Paid production hours, staffed line hours and machine-running hours answer different questions. Recovery, setup and waiting time should remain visible rather than disappearing from the denominator. This also keeps delivery performance connected to the planning risks identified in responsible-supply-chain guidance. [S28] A service should not improve a throughput ratio by omitting the hours used to rescue late or defective work.

Exhibit 43, p. 162 positions proposed measures by denominator stability and proximity to the retained-order decision. The scores are a design aid, not observations. They show why machine activity can be diagnostically useful while remaining a poor substitute for accepted output or retained commercial outcomes.

EXHIBIT 43 / ILLUSTRATIVE DESIGN SCORE, 0 TO 3 ON EACH AXIS

A metric is useful only when its denominator is stable



ILLUSTRATIVE [S03] [S28] Illustrative GFT scoring. On each axis, 0 means absent or unstable and 3 means explicitly defined or directly connected to the retained-order decision. Positions are proposed architecture judgements, not measured performance or universal rankings. Scores should be revisited when definitions or service boundaries change.

The matrix does not say that job count is useless. It says that job count answers an activity question and needs a stable job definition before it can support even that limited purpose. Reprint rate moves closer to the decision because it reveals recovery

burden, but its value still depends on consistent job and reprint classification. The review should show numerator and denominator alongside every ratio so that a reader can inspect the basis rather than accept a coloured score.

10.15 REVIEWS MUST RECONCILE EVENTS TO PHYSICAL AND COMMERCIAL RECORDS

Daily review should focus on open holds, unknown job states, missing physical reconciliation and orders approaching their original promises. Weekly review should examine recurring recovery causes, acceptance outcomes, capacity assumptions and corrective actions. Monthly review should test retained-order economics, metric definitions and whether the qualified service boundary remains valid. These cadences extend the programme's management logic; they are not a claim that a GFT on-demand operation already reports them.[^G02]

Each review should begin with exceptions, not only averages. An order without an acceptance event, a job without a resolved acknowledgement, a held garment without a disposition and a refund without a cause all represent incomplete control. Reconciliation should compare the order ledger with job records, material counts, consignment events and net commercial outcomes. Missing evidence should remain an evidence gap. It should not be converted into a successful outcome to close the report.

The final control is a periodic challenge to the state model itself. New product families, subcontractors, sales channels or equipment can create transitions that the original design did not anticipate. The service should add states or cause codes only with definitions and migration rules, while retaining the old records. Controlled order states are therefore not a one-off software specification. They are an operating discipline that keeps commercial authority, digital instructions and physical garments aligned as the service changes.

Release what can be proved, reconcile what was interrupted, and close only what the buyer accepted.

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S03 The Korean Fashion and Textile Research Journal. 2025-12-31.

S32 arXiv, Korosteleva and Sorkine-Hornung. 2023-06-06.

S15 Epson United Kingdom. 2026.

S17 International Finance Corporation, World Bank Group. 2007-04-30.

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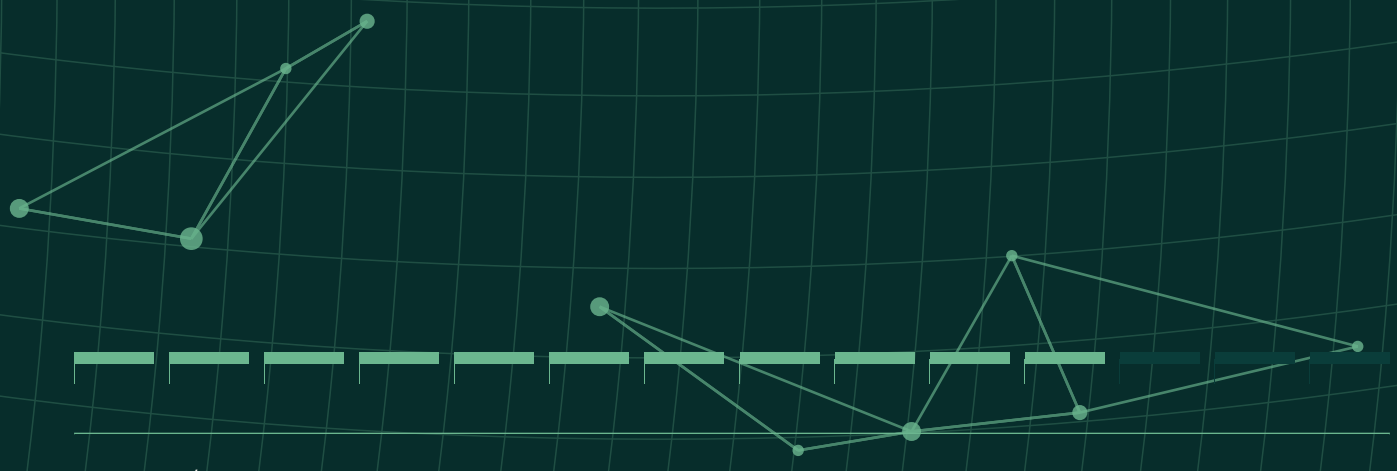
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11

PART III: PROVE THE SERVICE AND THE ECONOMICS / ENVIRONMENTAL COMPARISON

Less speculative stock does not automatically mean less impact

Measure the whole order-to-use system and show which impacts move beyond the printing stage.



CHAPTER 11
DECISION TEST

Measure the whole order-to-use system and show which impacts move beyond the printing stage.

Order-triggered production can reduce unwanted finished stock, but that operational change is not an environmental result by itself. The credible test compares the same garment service under matched quality, durability and delivery conditions, then divides measured burdens by both accepted garments and retained orders. Cotton, preparation, fixation, assembly, packaging, delivery, remakes, returns, care and end of life remain visible. A narrower printing comparison may still be useful, provided it is labelled as such and is not promoted as a whole-product conclusion. GFT therefore recommends a dual-boundary account: one process view for engineering control and one expanded view for the decision about whether the service reduces impact.

11.1

A valid comparison must deliver the same service

The functional unit comes before the footprint. It defines the service delivered, the article that delivers it and the conditions under which the comparison is fair. The historical VTT study used a defined area of printed textile and warned that its results depended on coverage, product lifetime and usability. It also stated that quality and durability are essential when products are compared. [S26] A garment service needs the same discipline. A shirt that fails after limited use does not deliver the same service as a shirt that remains wearable, even if their printed areas match.

GFT would define the primary unit as one accepted garment meeting an agreed specification, within one retained order that remains valid after the contractual cancellation, return and refund window. Acceptance concerns conformity. Retention concerns the commercial and service outcome. The two denominators answer different questions. Impact per accepted garment helps a production team improve material and energy efficiency. Impact per retained order exposes the additional burden of disputes, returns and replacements. Neither measure should silently replace the other.

The comparison must also hold the intended use constant. A decorated fashion garment, an institutional uniform and a work shirt can have different performance requirements, care routines and replacement expectations. The specification should record garment construction, base material, print appearance, dimensional requirements, fastness evidence and intended care before any environmental result is calculated. If one route delivers a lower level of durability or a different service, the analyst must model that difference explicitly rather than hiding it inside a garment count.

Service life belongs in a sensitivity analysis, not in a universal wears assumption. VTT treated lifetime and usability as conditions that could change its printing comparison, and its conclusions discuss the avoided purchase of another product when lifetime is prolonged. [S26] GFT would report impact per garment first, then show how the result changes under documented short, central and long service scenarios. Those scenarios are not observed wear counts unless wear evidence exists. They are a way to test whether the decision reverses when use differs.

A retained order may contain several garments, and a returned garment may be replaced rather than refunded. Allocation therefore needs order-level rules. Shared preparation, delivery and packaging burdens should be assigned using a stated

driver, such as garment mass, printed area or equal allocation per article. The appropriate driver depends on the process being allocated. Printed area may suit ink, while consignment mass may be more informative for transport. The analyst should test important allocation choices rather than presenting one convenient answer.

The order ledger must reconcile starts, acceptances, shipments, returns, refunds, replacements and retained quantities. Environmental accounting uses the physical starts and all resources consumed, while the denominator follows the chosen service unit. A refunded order does not erase the material, energy or transport already used. A replacement adds another physical article. This is why a low cancellation rate cannot be inferred from a clean production report and why a low reject rate cannot establish a low return burden.

> **WORKED EXAMPLE**
>
> An illustrative cohort contains 100 garment starts. Production accepts 90 garments, and 80 orders remain retained after the defined return and refund window. The cohort carries 1,200 arbitrary impact units across the selected boundary. Impact per start is 1,200 divided by 100, or 12.00 units. Impact per accepted garment is 1,200 divided by 90, or 13.33 units. Impact per retained order is 1,200 divided by 80, or 15.00 units, assuming one garment per order. These values demonstrate only the denominator method. They are not emissions factors, GFT observations or forecasts.

The illustrative case shows why reporting only impact per start flatters a service with recovery work. It also shows why the retained-order denominator needs careful wording. It does not claim that each returned article has no utility, nor that all returned garments become waste. It assigns the burdens already incurred to the service actually retained. Any later reuse, resale, recycling or disposal of returned articles belongs in a separate, evidenced account.

11.2 THE COUNTERFACTUAL MUST BE AN OPERATING ROUTE, NOT A SLOGAN

A valid baseline is the route that would otherwise deliver the same service. It might be an outsourced screen-printed batch, decoration of stocked blanks, or a conventional physical-sampling and production workflow. The baseline should not be a deliberately inefficient straw case. Its order mix, quality gate, delivery region and observation period should match the proposed route as closely as the available evidence permits.

Speculative stock enters through that counterfactual. The analyst needs to know what happens to unsold baseline garments, what happens to returned on-demand garments and whether blank or fabric inventories simply move upstream. An unsold article is not an impact-free article, and an avoided article is not a credit unless the comparison genuinely avoids its production. GFT would keep observed stock movements separate from modelled avoidance so that a commercial improvement cannot be mistaken for a measured emissions reduction.

11.3

Cotton and garment production remain inside the decision

A printing-stage account can answer a process question without answering a product question. VTT's cradle-to-gate case found that cotton cultivation, fabric production and refinement dominated the studied impacts of its printed textiles. Its authors cautioned that another base fabric could change the results and conclusions. [S26] This does not supply a Cameroon cotton factor. It establishes why removing base fabric from the display can make two printing routes look decisive while the largest part of that study's product system sits outside the chart.

GFT would therefore publish two adjacent views. The process-only view covers preparation, printing, fixation, cleaning and directly associated rejects. The expanded view adds base fabric or blanks, cutting, sewing, trims, packaging, delivery, returns and the agreed use and end-of-life stages. The views must not be combined into one total without a documented method. Their purpose is different: the first directs process control, while the second tests whether a local improvement survives a wider boundary.

The same base fabric may appear in both routes, but common inputs still matter to absolute impact. They may cancel in a simple difference only when their quantities, origins and upstream factors are genuinely equivalent. Different marker yields, rejection rates, replacement garments or blank inventories can break that equivalence. The expanded account should consequently compare physical quantities before applying any characterisation factor. A common fabric is not a reason to omit fabric mass from the evidence file.

Decoration of a ready-made blank has a different boundary from printed-fabric cut-and-sew. In blank decoration, the garment already exists before the order-specific print decision. Its production burden belongs to the expanded garment account, even though it occurred upstream. In cut-and-sew, fabric issuance, marker efficiency, cutting loss and assembly remain inside the producer's direct operating decisions. Comparing the two services requires equivalent garment function, not merely equivalent artwork.

Digital sampling also needs an honest place in the boundary. An avoided physical sample may reduce material and courier demand, but digitisation, computing, pattern work and residual physical approval still consume resources. The account should count samples actually avoided in a matched style cohort rather than assigning a standard saving to every digital design. If a physical approval remains necessary, its burden remains in both the service design and the environmental ledger.

> **GFT NOTE**
>
> Report process-only and expanded results side by side, with the same order cohort and period. Do not select the boundary after seeing which route wins. GFT's practical recommendation is to freeze the garment specification, baseline route, allocation rules and exclusions before the pilot begins, then retain the excluded stages in a visible limitations register.

The expanded view should distinguish attributional accounting from claims about consequences. An attributional account describes the burdens assigned to the observed service. A consequential claim asks what changes across suppliers, stock disposal, replacement purchases and future production. The latter needs additional evidence and assumptions. A factory ledger can support the first directly; it cannot, by itself, prove the second.

End-of-life treatment requires the same restraint. A return collected at the factory is not proof of recycling, and a recyclable material label is not proof of a recycling route. The evidence file should record the actual destination where known and use scenarios where it is unknown. Detailed carbon characterisation and full product-footprint methods belong to the wider footprint programme; this chapter defines the order and process data that those methods must not lose.

11.4

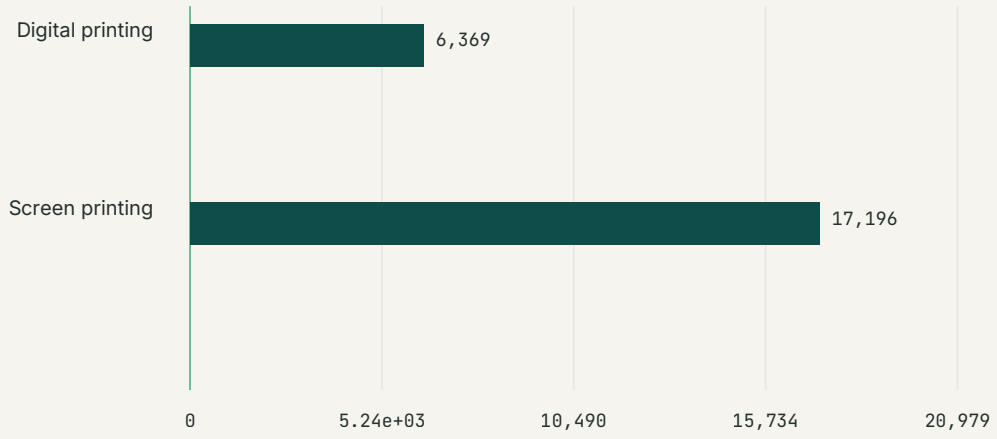
Historical water volumes need their original boundary

The VTT report provides a useful worked case precisely because it separates water balance from water availability impact. Its functional unit was 750 square metres of printed textile, with five colours, three colourways and 88 percent print coverage. The authors warned that coverage affected the results. [S26] These details are not incidental metadata. They define the physical case to which the reported volumes belong and prevent their conversion into a generic litres-per-garment claim.

For that case, the gate-to-gate water balance reported 6,369 litres for digital printing and 17,196 litres for screen printing. The difference was associated mainly with after-washing in the screen route. [S26] **Exhibit 44**, p. 168 preserves the original totals. It does not show expected consumption in Cameroon, a comparison of current machines or a whole-life water footprint.

EXHIBIT 44 / LITRES PER 750 SQUARE METRES OF PRINTED TEXTILE

A historical case reported different process water volumes



SOURCED [S26] VTT Printscorpio case, printed page 26. Gate-to-gate water balance for the stated historical Finnish case, not a current machine benchmark, a Cameroon estimate or a comprehensive product water footprint.

Normalisation helps an engineer compare the case with another area denominator, but it does not widen the evidence. Dividing each reported volume by the stated 750 square metres gives 8.492 litres per square metre for digital printing and 22.928 litres per square metre for screen printing, as GFT's arithmetic in **Exhibit 45**, p. 169 shows. [S26] These are exact divisions of the displayed case totals, presented to three decimal places. They are not independent measurements and gain no new geographical validity through division.

EXHIBIT 45 / LITRES PER SQUARE METRE OF PRINTED TEXTILE

Normalisation changes the unit, not the applicability

Route	Calculation	Normalised volume	Evidence status
Digital printing	6369 / 750	8.49	Historical case
Screen printing	17196 / 750	22.9	Historical case

DERIVED [S26] GFT arithmetic from VTT printed page 26: digital 6369/750 = 8.492; screen 17196/750 = 22.928. Values rounded to three decimals. Historical gate-to-gate process water balance only; no life-cycle, garment-level or scarcity equivalence.

The report's partial water availability footprint adds quality and location to the water balance. Its table lists 196 litres for the digital case and 257 litres for the screen case on the same printed-area basis, while emphasising the good availability of water in Finland. [S26] A larger volumetric difference therefore became a much smaller availability-footprint difference in that setting. This is a methodological warning against treating every withdrawn or consumed litre as environmentally equivalent across locations.

There is also a small reporting discrepancy worth retaining. GFT's subtraction of the tabulated availability results, 257 less 196, gives 61 litres, whereas the report's narrative states a difference of 62 litres. [S26] The source does not explain that difference. The correct response is to preserve the table values, note the narrative discrepancy and avoid inventing hidden decimals. Careful evidence handling is more useful than false tidiness.

The water case excludes raw-material acquisition and production from its gate-to-gate availability assessment. It also assumes the same outgoing water-quality class for both routes because separate quality measurements were unavailable, while explicitly calling that assumption unlikely. [S26] Consequently, the table cannot support a claim about cotton irrigation, total wastewater toxicity or route-specific effluent quality. Each of those claims needs another boundary and suitable measurements.

Water terminology must remain equally precise. Metered inflow is not automatically consumption: some water may leave as wastewater, steam or retained moisture. A water balance should reconcile inflow, outflow, estimated losses and measurement uncertainty over the same period. A scarcity-weighted result then requires a stated method and location. GFT would report the physical balance first and keep any characterised footprint in a separate field with its method and data vintage.

A local pilot should meter preparation, print-related cleaning, fixation or washing where applicable, domestic or non-process exclusions, and any treatment recycle loop. Readings need timestamps, meter identifiers and a reconciliation to production lots. Where a shared meter serves several operations, allocation is an estimate and should be labelled as such. A supplier statement about dry fixation cannot substitute for this site balance.

11.5

Pigment fixation still requires energy and auxiliary inputs

Pigment printing can remove a wet fixation stage, but the wording of that advantage must remain at stage level. The technical review describes pigment fixation as a dry process operated only by dry heat. [S01] That statement supports a distinction in fixation chemistry and operation. It does not establish zero water use across fabric preparation, printer cleaning, garment manufacture or use, and it does not establish zero energy demand.

Heat is part of the account rather than a footnote to it. IFC guidance identifies drying and curing operations, together with activities involving wet treatments, as particularly significant for heat consumption in textile manufacturing. [S17] A comparison that credits a digital route with avoided washing while ignoring curing would therefore miss a physical burden that the source tells us to examine. The same caution applies to pretreatment drying, transfer pressing and any thermal process used to restore or finish a rejected article.

GFT would record electricity and fuel at the process stage, not only at the utility bill. The logging plan should separate printer operation, pretreatment, fixation or curing, drying, ventilation used for process control, compressed air where relevant, and shared ancillary loads. Startup, idle operation, warming, cleaning and maintenance periods belong to the observed production system. Excluding them would make intermittent order-triggered production look artificially efficient.

Allocation should follow physical causation where practical. A curing batch shared by several orders needs a rule based on occupied capacity, processing time, garment mass or another measured driver. The analyst should document part-load operation rather than assuming that a full-load energy intensity applies to every small consignment. If only a whole-line meter exists, the result remains a line-level observation and should not be presented as a precise garment measurement.

The material ledger must accompany the energy ledger. It should record pretreatment chemicals, inks, binders, cleaning agents, purge and flushing waste, transfer media where used, rejected prints and remake inputs. These records reveal whether lower water demand coincides with higher chemical, material or thermal demand. They also provide the quantities needed for later characterisation without claiming that every kilogram of input has the same environmental effect.

IFC guidance calls for environmental monitoring to cover normal and unsettled conditions, with representative frequency, trained personnel and calibrated, maintained equipment. [S17] For the proposed service, this means retaining failed startups, inter-

rupted cures, cleaning events and reprints in the observation window. A tidy week of successful orders is not a representative baseline if the operating route regularly includes recovery work.

> **METHOD**
>
> For each resource, preserve the gross reading, period, meter or document origin, allocation driver, order identifiers and denominator. Calculate process intensity as allocated resource divided by accepted garments, then recalculate the numerator across all starts and recovery work for the retained-order view. Reconcile allocated totals back to the utility or purchase record before publishing either intensity. Missing intervals remain missing; do not fill them with a vendor rating.

The engineering decision should examine trade-offs directly. A route with less process water may require more fixation energy or pretreatment. A small batch may avoid setup materials but operate a thermal stage at low occupancy. Neither direction should be assumed. The measured result can favour one route on one impact category and another route elsewhere, without forcing a single environmental winner.

11.6

On-demand models can move burdens into delivery and remakes

Order-by-order production changes more than the timing of printing. It can change consignment size, packaging, transport frequency, approval courier movements, return handling and the number of physical attempts needed to retain an order. These are measurable operating events. They should appear in the same cohort ledger as fabric and energy, rather than being dismissed as downstream exceptions.

The on-demand wool-knitting LCA illustrates why denominator choice matters. Its abstract reports cradle-to-gate comparisons, a cradle-to-grave calculation per wear and a revenue-normalised comparison of on-demand knitting with mass production. [S25] Those different views can answer different questions. The study concerns Merino wool jumpers, knitting and recycling, so none of its numerical effects should be transferred to printed cotton garments in Cameroon. GFT uses it only to support the practice of declaring the functional unit and denominator.

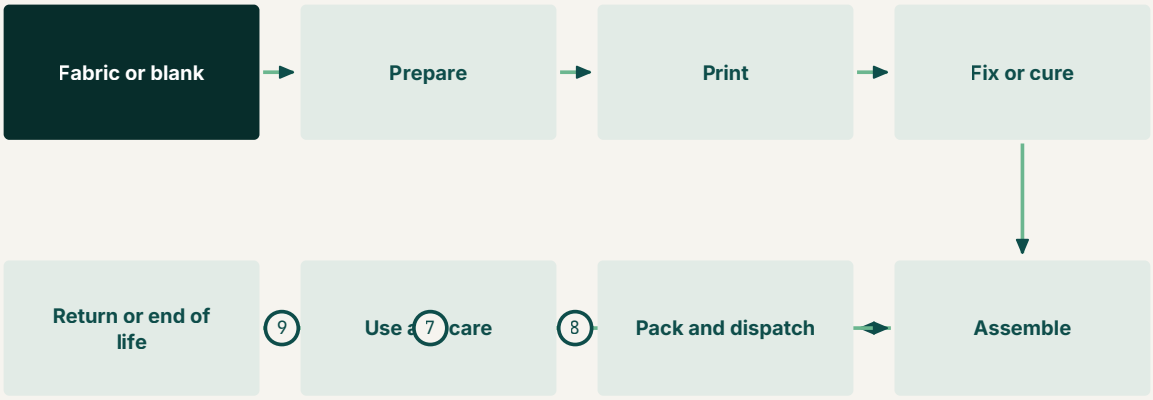
A retained-order account should include the original consignment, any replacement consignment and the reverse movement of a returned article. The evidence can come from carrier records, packaging issue records, delivery distances and actual vehicle or service categories where available. If those data are missing, a scenario must say so. A nominal local-delivery factor borrowed from another market would not convert the estimate into an observation.

Remakes deserve a complete physical record. The remake consumes another set of materials and process time even when the customer pays nothing additional. The original rejected garment also remains a physical output requiring a destination. The ledger should distinguish internal rejection before dispatch, customer return after dispatch and a quality failure discovered during use. These events can have different logistics and end-of-life consequences.

Exhibit 46, p. 172 maps the decision boundary. It is a system map, not a quantified Sankey: every arrow needs evidence before it can carry an impact value.

EXHIBIT 46 / ORDER-TO-USE PROCESS BOUNDARY

An order can move rather than eliminate environmental burdens



7. Dispute
8. Replacement
9. After use

ILLUSTRATIVE [S17] [S20] [S25] [S26] Illustrative GFT boundary map informed by the cited process, business-model and LCA sources. No flow quantity, emissions factor or realised GFT route is asserted. Return, recovery and end-of-life destinations require local evidence.

The map also prevents a false stock credit. Lower finished-garment stock may coincide with more blank stock, more frequent consumable deliveries or more returned articles. The decision should compare total physical movements and final destinations across routes. Only then can the analyst test whether less speculative stock corresponds to lower impact within the stated boundary.

11.7

Personalisation is not proof of circularity

Personalisation changes product specification; circularity concerns what happens to materials, products and resource demand over time. The Ellen MacArthur Foundation states that circular business models must decouple revenue from production and resource use, and warns that such models do not always deliver environmental benefits. [S20] A business selling additional customised new garments has not demonstrated that decoupling merely because each garment responds to an order.

UNEP presents on-demand production as one option for addressing overproduction, alongside better demand and stock management. It also states that overconsumption has no clear, agreed definition and must be considered in social as well as functional

context. [S19] This supports a measured hypothesis, not a universal claim. Producing against an order may reduce unsold stock while still encouraging additional purchases, rapid novelty or short use.

Emotional attachment is similarly a testable proposition. A buyer may value a chosen motif or individual fit, but that preference does not establish longer use. The pilot can record repeat wear only through an appropriate and consented method, alongside observed durability, repair events, resale or handover, and reasons for disposal. Self-reported intention at checkout should not be treated as realised service life.

GFT would evaluate personalisation against three separate questions. Does the garment remain physically usable? Does the wearer continue to use it? Does that use displace another purchase? A positive answer to the first does not prove the second, and the second does not automatically prove the third. This sequence keeps product design, behaviour and counterfactual consumption distinct.

Rebound belongs in the same review. Easier design iteration and shorter release cycles may increase the number of products offered or purchased. The environmental account should therefore observe total garments and total resource use per customer cohort as well as intensity per retained order. A falling intensity can coexist with a rising total when volume grows. Detailed material recirculation routes belong to the circularity programme, but the order data here determines whether circular claims have a credible starting point.

11.8

Environmental claims need a traceable evidence file

Every published comparison needs a claim record that another analyst can reconstruct. That record should identify the garment and service, baseline and proposed routes, functional unit, system boundary, observation period, geography, allocation rules, exclusions, data origins, characterisation method and uncertainty. It should also name the decision supported by the analysis. A process-improvement claim and a whole-product marketing claim should not share an unqualified chart.

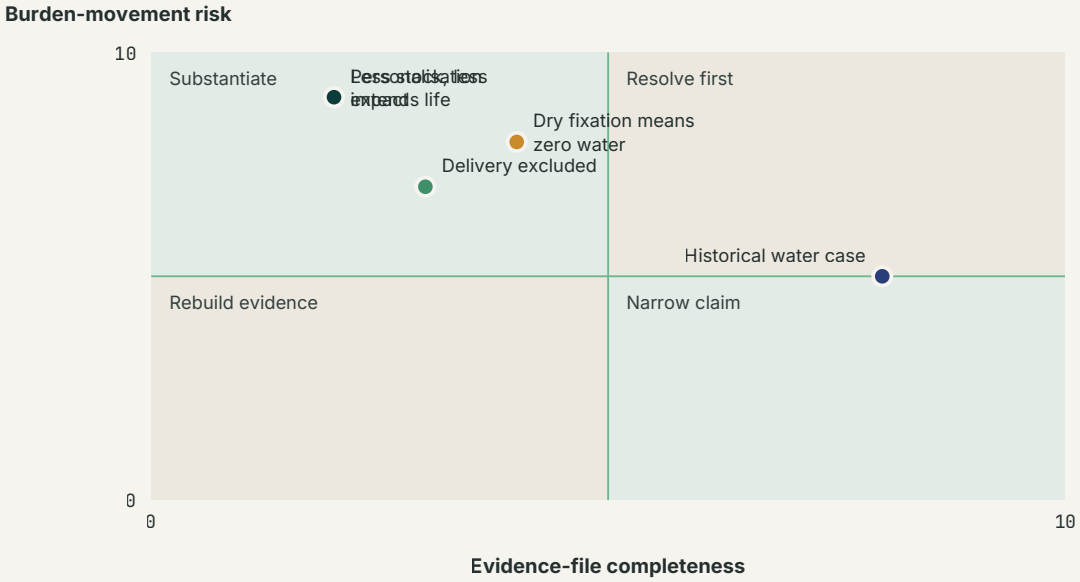
Chemical evidence needs its own place in that file. ZDHC describes its manufacturing restricted substances list as addressing substances in chemical formulations used during production, with acceptable limits and substances banned from intentional use. [S23] This is an input-management reference, not proof that a chosen ink, pretreatment or factory conforms. It also differs from finished-product testing and from an assessment of every environmental impact associated with a formulation.

The evidence register should consequently retain supplier identity, product and lot, safety and technical documents, formulation-conformance evidence where claimed, quantity issued, process used and waste destination. Finished-garment test results remain linked but separate. Neither document set establishes water neutrality, carbon neutrality or circularity. Buying digital equipment likewise establishes none of those outcomes.

Exhibit 47, p. 174 is an illustrative screening tool for the claim review. The positions are not measurements. They show why a claim with a weak denominator or a high chance of burden movement needs more evidence before publication.

EXHIBIT 47 / ILLUSTRATIVE SCREENING SCORE FROM 0 TO 10

Environmental claims must state what was measured



ILLUSTRATIVE [S19] [S23] [S26] Illustrative GFT review positions, not observed performance. Horizontal position is completeness of the proposed evidence file, where 0 is absent and 10 is complete. Vertical position is risk that the claim moves or omits burdens, where 0 is low and 10 is high. Scores are author-assigned for method demonstration only.

A claim should be narrowed when the file cannot support its wording. If only water inflow was metered, report metered inflow rather than consumption. If only the print and cure stages were measured, report a process comparison rather than a garment footprint. If service life was modelled, label the per-wear result as a scenario. If the baseline disposal route is unknown, do not claim measured avoided waste.

Quality control should include arithmetic and reconciliation, not only graphic review. Resource allocations must sum back to meter or purchase totals. Order counts must reconcile to the commercial ledger. Source units and periods must match the numerator, while accepted and retained denominators must remain distinct. Sensitivity results should show adverse cases and decision reversals rather than displaying only the preferred scenario.

Uncertainty also has a decision consequence. Direct meter readings, supplier documents, allocated utility totals and assumed transport factors do not carry equal confidence. The evidence file should grade each input by origin and explain which gaps could change the conclusion. A range based on explicit scenarios is more informative than a precise value assembled from incompatible sources.

11.9 A RESULT SHOULD SURVIVE INDEPENDENT RECOMPUTATION

The publication pack should let a reviewer move from the displayed result back to the underlying records without relying on the author's memory. Each summary value needs a calculation identifier, numerator and denominator definitions, source rows,

unit conversions, rounding rule and software or worksheet version. Manual adjustments should appear as separate entries with a reason and reviewer, never as silent edits to a meter reading or order count.

Observations, derivations and scenarios should remain visibly different. An observation is a reading or document tied to a period and instrument or record. A derivation applies stated arithmetic to those observations. A scenario introduces an assumption about missing data, future operation, product use or disposal. Combining them is often necessary, but the resulting value should inherit a clear label and an explanation of which assumptions dominate its uncertainty.

The reviewer should be able to reproduce both the process-only and expanded views from the same cohort. This requires a bridge between the two boundaries. The bridge lists each added stage, its physical quantities, allocation rule and evidence origin. It also lists stages that remain excluded and explains whether their effects are expected to be common, unknown or potentially decision-changing. An expectation is not a measured effect and should be worded accordingly.

A second check concerns comparability through time. Meters, suppliers, garment patterns and order mix can change between the baseline and proposed observation periods. The evidence register should flag those changes and avoid treating a before-and-after difference as a route effect when the service also changed. Matched cohorts, paired runs or a stated adjustment can help, but their limitations belong beside the result.

Finally, the decision owner should record what the comparison will and will not authorise. A favourable process result may justify continued metering or a bounded procurement test without justifying a public product-footprint claim. A favourable retained-order result within one product family may not support another fabric, print coverage or delivery region. The release decision should inherit the boundary of the evidence rather than the ambition of the proposal.

> **WARNING**
>
> No zero-water, zero-waste, carbon-neutral, certified or impact-free claim follows from purchasing digital printing or sampling equipment. Any formal environmental, legal or marketing claim requires qualified review against the applicable method and jurisdiction. This chapter supplies an operational measurement framework, not investment, legal, tax or product-certification advice.

GFT's release recommendation is therefore conditional. Allow a pilot claim only for the measured stages and period, publish the accepted and retained denominators together, and retain all recovery burdens. Expand the boundary before making a

product-level comparison. If delivery, remakes or service-life effects reverse the apparent printing advantage, report that reversal and reconsider the service design rather than narrowing the evidence until the original claim survives.

Measure the garment service that remains, not merely the stock that disappears.

CHAPTER SOURCE NOTES

S26 VTT Technical Research Centre of Finland. 2014.

S01 Society for Imaging Science and Technology. 2021.

S17 International Finance Corporation, World Bank Group. 2007-04-30.

S25 TU Delft Research Portal; author abstract of Textiles article. 2026.

S20 Ellen MacArthur Foundation. 2021-11-23.

S19 United Nations Environment Programme. 2023.

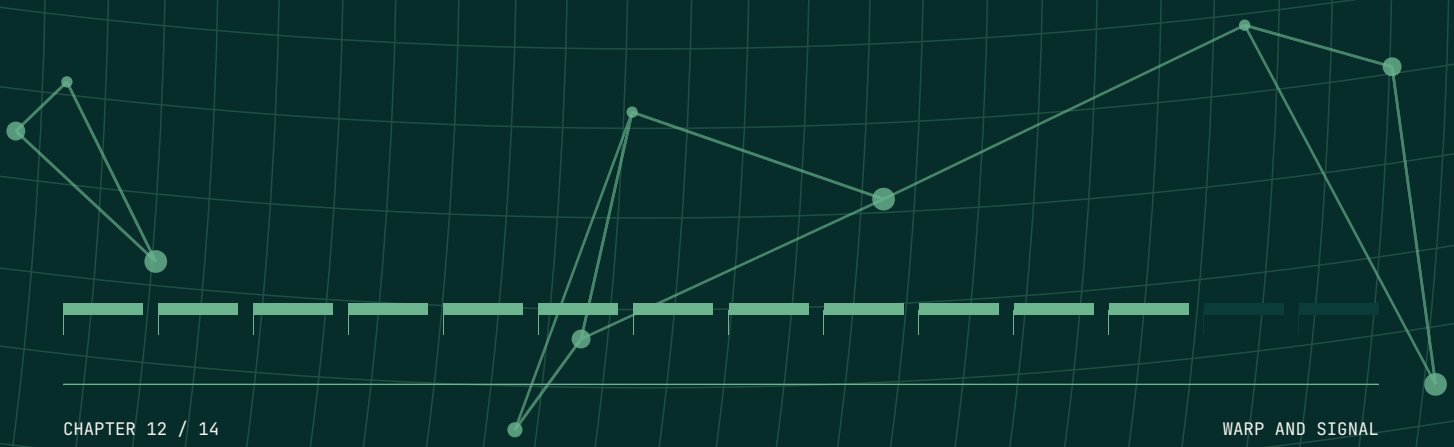
S23 ZDHC Foundation. 2026.

12

PART IV: BUY, PILOT AND SCALE AGAINST EVIDENCE / PROCUREMENT AND PEOPLE

Local support and trained operators determine usable capability

Choose a supported production system and qualify the team that must operate and maintain it.



CHAPTER 12
DECISION TEST

Choose a supported production system and qualify the team that must operate and maintain it.

Usable capability is the ability to make an accepted garment repeatedly with the people, consumables, utilities, support and data available at the operating site. A delivered printer, a software licence or a successful sales demonstration establishes none of those conditions by itself. GFT therefore recommends procuring a complete, testable process and qualifying the team alongside the equipment. The purchase decision should combine a common article specification, a witnessed acceptance run, explicit operating dependencies, safe work controls and observed task competence. Commercial scores can inform a choice only after mandatory physical and safety gates have passed. This approach extends the operating and data disciplines of GFT's Cameroon textile programme. It does not assume a supplier relationship, local service coverage, available skills or an installed GFT production line.

12.1

A procurement package must describe the intended article

A supplier cannot price or demonstrate the required process from a generic request for a digital printer. The buyer should issue a reference pack that describes the intended article and the service around it. For blank decoration, that pack identifies the blank construction, composition evidence, colour range, sizes, print positions and intended care. For printed-fabric cut-and-sew, it identifies the fabric, preparation state, artwork repeat or panel geometry, marker constraints, assembly route and finished-garment tests. Both versions need representative artwork, expected order mix, approval evidence and the meaning of accepted output.

The same pack should go to every candidate supplier. Each then answers the same material, geometry and service problem rather than selecting the demonstration most favourable to its machine. Where a supplier proposes a change, such as a different blank, ink set or transfer route, that change belongs in a separate offer with its own sample and exclusions. The buyer should preserve the original requirement as the comparator. A lower price obtained by changing the article is not a lower price for the same capability.

Process completeness matters because deposition is only one stage. Epson's garment-printing guide describes heat curing as the final stage of its direct-to-garment sequence and separately describes film, adhesive and heat-transfer work. [S15] Its model-family guidance also states that pretreatment is necessary when using white ink or printing onto polyester. [S30] Those statements do not define every supplier's process. They show why the request must name preparation, printing, curing, handling and inspection, and why a printer-only quotation can omit essential work.

The supplied scope should consequently itemise the printer, raster image processor, preparation equipment, curing or transfer equipment, required workstation, installation, commissioning, initial consumables, training and acceptance support. It should also itemise what is not supplied. Ventilation, electrical work, lifting, freight, customs treatment, tax, building work, laboratory testing and production labour can otherwise appear late as unpriced necessities. Their treatment requires current quotations and qualified local advice, not an assumed allowance copied into every offer.

A second schedule should cover the operating period. Ask for ink and other consumable identifiers, storage conditions, shelf life, order quantities, replenishment lead times, cleaning materials, wear parts, recommended spares, warranty boundaries, response arrangements and software terms. Require the supplier to distinguish its commitments from aspirations and to name the organisation responsible for each response. No local availability should be inferred from a sales office address or a global support page. The evidence needed is an offer specific to the site and scope.

> **METHOD**
>
> Build the comparison around two linked schedules. The article schedule fixes substrate, artwork, sizes, order mix, care, acceptance and test evidence. The capability schedule fixes supplied equipment, exclusions, utilities, installation, training, consumables, service, data export and support commitments. Record every supplier deviation against both schedules. Price only comparable scope, and keep unresolved items visible rather than assigning them a favourable nil cost.

Technical scoring should follow disqualification, not precede it. A route that cannot meet the required material, rubbing, care or safety condition remains unacceptable even if its service score is attractive. After those gates, the buyer can score reproducibility, complete scope, support, training and portability with weights set before offers are opened. The weighting expresses the owner's priorities; it cannot convert missing evidence into a pass.

Exhibit 48, p. 180 shows how two summary dimensions can be compared without hiding a failed gate. The positions come from the illustrative scoring case below. They are not observations of actual suppliers, and the diagram does not calculate a universal winner.

EXHIBIT 48 / ILLUSTRATIVE WEIGHTED SCORE FROM 0 TO 5

A procurement decision must include support and evidence



ILLUSTRATIVE [S11] [S15] [S18] [S21] [S31] Illustrative GFT procurement model. Horizontal position combines reproducible-run, physical-test dossier and data-export ratings with weights of 50, 30 and 20 percent. Vertical position combines site response and parts, maintenance and consumables, and training ratings with respective weights of 50, 30 and 20 percent. Ratings are invented to demonstrate scoring and are reconciled in the worked example. Supplier D fails a mandatory physical gate and is disqualified despite high weighted positions. No real supplier, quotation or performance is represented.

The useful comparison is not simply which point sits furthest towards the upper right. Supplier C would require a support remedy before its technical evidence could become dependable capacity. Supplier B would require closer examination of acceptance evidence despite stronger proposed support. Supplier D illustrates why a weighted total must never compensate for a failed mandatory test. The decision record should preserve the underlying ratings, evidence references and unresolved conditions so that a reviewer can challenge both the arithmetic and the judgement.

WORKED EXAMPLE: A HIGH SCORE CANNOT REPAIR A FAILED GATE

Assume an illustrative evidence score using three criteria: reproducible-run quality carries `50 percent`, the physical-test dossier `30 percent`, and data export `20 percent`. Each receives an invented rating from `0` to `5`, where `0` means no usable evidence and `5` means complete evidence against the reference pack. Supplier A receives `4` for each criterion, so its score is `(4 x 0.50) + (4 x 0.30) + (4 x 0.20) = 4.0`. Supplier B receives `3`, `4` and `3`, giving `3.3`. Supplier C receives `5`, `4` and `3`, giving `4.3`. Supplier D receives `5`, `4` and `5`, giving `4.7`. All ratings and weights are illustrative, not supplier assessments or recommended universal weights.

The illustrative support score uses the same arithmetic with site response and parts at `50 percent`, maintenance and consumables at `30 percent`, and training at `20 percent`. Supplier A's ratings of `3`, `4` and `4` produce `3.5`. Supplier B's ratings of `4`, `5` and `4` produce `4.3`. Supplier C's ratings of `2`, `3` and `2` produce `2.3`. Supplier D's ratings of `5`, `4` and `5` produce `4.7`. These calculations show position only. They do not combine evidence and support into one total, because the owner may consider them separately.

Now assume that Supplier D's complete dossier contains a failed mandatory wet-rubbing result on the specified article. The dossier can be well organised and still disclose an unacceptable process. Supplier D is therefore disqualified before its illustrative `4.7` positions are considered. The correct action is rejection, or a materially revised process followed by a new acceptance run, not a larger weight on service. This example demonstrates arithmetic and gate precedence only; it supplies no actual test result or procurement recommendation.

The procurement team should finally separate a condition from a promise. A supplier may commit to training, but the buyer still needs observed competence. A supplier may state a response time, but the buyer still needs the contractual scope, parts route and escalation path reviewed. A supplier may demonstrate export, but the buyer still needs the exported files read back successfully. Each claim becomes usable only when its evidence and accountable owner are attached.

12.2

Acceptance tests must use the real workflow

Acceptance should reproduce the buyer's workflow with the specified materials and the people who will operate it. A supplier's specialist can guide the first run, but cannot be the only person capable of completing it. The protocol should begin with material receipt and identification, then observe file preparation, setup, machine checks, colour approval, printing, curing, cooling, handling, inspection and any required reprint. For printed panels, cutting and assembly must confirm that the approved print survives the production geometry. The endpoint is accepted output with a readable record, not attractive prints laid beside the machine.

The test article must remain the one in the procurement pack. A demonstration on a smoother blank, a different fabric preparation or a simpler artwork can answer a technical question, but it cannot release the proposed route. If material substitution is unavoidable, record the reason and treat the run as exploratory. The supplier should

not receive advance freedom to remove difficult colours, placements or sizes. The buyer should instead predefine a small set of representative challenges and retain the actual attempts, including setup rejects and interrupted jobs.

Process consistency needs evidence across the run, not one selected garment. Fogra describes its digital-printing approach as including recommendations, instructions, target values and tolerances for customary digital print production. [S21] That scope supports the principle of defined interfaces and repeatability checks; it is not a textile certification or proof that a supplier meets a GFT requirement. The acceptance protocol should state its own measurements and tolerances, then retain beginning, middle and end observations where drift is plausible. Any instruments, viewing conditions and judgement rules need identification.

Physical release evidence remains separate from process appearance. ISO's rubbing scope provides for tests with both dry and wet rubbing cloths. [S11] The buyer and competent laboratory should agree the applicable procedure, specimens and acceptance criteria for the intended article. A fresh print that looks consistent has not thereby passed either rubbing condition. The same distinction applies to care, fit and construction evidence specified elsewhere in the technical pack. Supplier acceptance can confirm that evidence exists and belongs to this process; it cannot redefine a failure as a pass.

Exhibit 49, p. 183 defines the minimum record for a reproducible run. It deliberately carries fields rather than invented results. The completed record should let another competent team repeat the run and understand every deviation.

EXHIBIT 49 / ILLUSTRATIVE ACCEPTANCE-RECORD FIELDS

A supplier acceptance run must be reproducible

Run element	Required record	Acceptance consequence
Material and artwork	Supplier, lot, composition evidence, preparation state, file revision and placement	Stop on unexplained substitution
Setup and recipe	Machine, software, ink, mode, pretreatment, cure settings and operator roles	Retain the exact qualified state
Run observations	Start and end events, attempts, setup rejects, interventions and environmental readings	Explain every deviation
Accepted output	Starts, released units, buyer-accepted units and reasons for rejection	Use accepted rather than printed count
Physical evidence	Colour, dry and wet rubbing, specified care, fit and construction records	Apply non-compensable gates
Interruption recovery	Stop cause, safe state, material position, restart authorisation and duplicated work	Prove controlled restart
Maintenance handover	Routine tasks, cleaning, waste, tools, lockout and competency observations	Close unresolved safe-work gaps
Data handover	Job log, profile, recipe, pattern or artwork export and successful readback	Reject unreadable or incomplete export

ILLUSTRATIVE [S11] [S15] [S21] Illustrative GFT protocol, not a completed test. The buyer must populate actual identifiers, readings, criteria and outcomes. Public standards and process-consistency scopes do not supply buyer pass grades or evidence of supplier performance.

Throughput should be calculated from time-stamped events and accepted pieces. Loading, setup, printing, curing, cooling, inspection and rework consume capacity even when the printer is not depositing ink. The record should distinguish active labour, machine occupation and waiting. It should also separate first-pass acceptance from output accepted after correction. Neither a nameplate speed nor a day's gross print count can substitute for this reconciliation.

Recovery is part of acceptance because an interrupted demonstration can reveal whether the process is understood. The team should agree safe test interruptions with the supplier rather than creating an unplanned hazard. After a stop, the operator must identify the job, material position, cure state and any duplicated or missing work before restarting. A restart that relies on the supplier's memory or an undocumented manual adjustment has not established a transferable procedure.

The final certificate should list open items, responsible parties, evidence due and the exact scope accepted. Conditional acceptance may be appropriate for a bounded documentation omission, but not for an unresolved physical or safety requirement.

Final payment and operational release are separate commercial and technical decisions. Their contractual treatment needs qualified review, and neither should erase the buyer's right to address a disclosed failure.

12.3

Consumables and service are operating dependencies

Low order volume does not switch off the process. Ink storage, cleaning, inspection and scheduled maintenance continue according to the selected system. One Epson user guide instructs the operator to shake white ink supply units once a day and colour ink supply units once a month. [S31] Those intervals apply to that documented printer, not to other machines. Their procurement significance is broader: an intermittent service must still staff and record the maintenance obligations in the actual manual.

The buyer should turn every routine obligation into an operating register before purchase. The register identifies the task, interval or trigger, material, tools, expected duration, waste route, competence and record. It distinguishes operator work from work requiring a supplier technician. It also marks tasks that must occur during idle periods, before a restart or after an alarm. This makes the hidden labour of low utilisation visible and prevents a rota built only around paid orders.

Consumable qualification needs more than a unit price. Record the exact formulation or part identifier, compatible equipment, pack size, storage requirement, shelf-life basis and disposal instruction from supplier documentation. For each item, obtain a dated offer stating availability, minimum order, lead time and delivery destination. Test any proposed alternative through the same material, colour, care and maintenance qualification that its change could affect. A chemically similar description is not evidence of interchangeability.

Supply risk should be assessed by consequence and recovery, not by a generic preference for holding more stock. A common cleaning item with several qualified sources differs from a proprietary printhead or ink with one route and a long replenishment cycle. The buyer should map which stockout stops production, which can be recovered by rescheduling, and which creates additional waste through expired material or interrupted work. Detailed stock policy belongs to the inventory model; procurement must supply truthful lead-time and substitution evidence.

Service coverage also needs a site-specific answer. Ask who diagnoses the fault, where that person is based, how remote support is provided, what data must leave the site, who travels, which parts are carried and what happens when the first attempt fails. Obtain the support hours, exclusions, charging basis and escalation route in the offer. Do not infer response capability in Cameroon from a worldwide brand presence. If the answer remains unverified, the procurement case should model a longer interruption rather than inserting an assumed rapid repair.

A support rehearsal can test the arrangement before reliance begins. The operator logs a controlled fault, produces the required job and material identifiers, contacts the stated channel and follows the diagnostic process without disclosing unnecessary

buyer or wearer data. The review records what information was available, which action was safe, which part or specialist was needed and whether the instructions matched the installed configuration. This is a test of the support pathway, not a reason to induce an unsafe failure.

> **GFT NOTE**
>
> GFT recommends making a complete support dossier a condition of technical acceptance. It should contain the actual manuals, maintenance register, consumable and parts identifiers, storage and shelf-life evidence, dated replenishment offers, named escalation roles, warranty exclusions, training records and a tested recovery route. Where local support cannot be evidenced, price and schedule the uncertainty explicitly or retain an outsourced alternative. Do not let an apparent equipment saving depend on an unverified promise of immediate assistance.

The commercial comparison should then preserve dependency costs over the chosen evaluation period. Consumable purchases, routine labour, technician visits, freight, service charges, waste handling and production interruption belong to the process. Some will be estimates until local operation supplies observations. Their basis and date must remain visible. A support agreement can reduce uncertainty, but it does not turn an unmeasured failure rate into a known one.

12.4

Power and environmental conditions need site qualification

Site qualification compares the installed location with the actual equipment documentation. The supplier should state electrical supply, protection, earthing, thermal, ventilation, space and environmental requirements for the complete process, including preparation and curing. A competent local electrician or engineer should then inspect and measure the site rather than assuming that a nearby socket establishes compatibility. The survey should cover supply variation and interruptions, circuit capacity, safe isolation, equipment position, heat rejection and the route for materials and waste.

Curing changes the utility boundary. IFC guidance identifies heat consumption as particularly significant in drying, curing and wet-treatment activities. [S17] The garment-printing guide also places heat curing within the production sequence. [S15] A printer nameplate therefore cannot represent the process's electrical or thermal demand. The buyer needs the connected and measured loads of every required stage, their simultaneous operation, warm-up and idle states, and the effect of an interruption on work in progress. Resilience sizing belongs in specialist engineering, but procurement must provide the complete load and recovery information.

Environmental conditions require equal specificity. Obtain the permitted operating and storage ranges for equipment, inks, films, adhesives and substrates from their respective documentation. Measure the proposed room under representative occupied and operating conditions, including the effect of curing and weather. Record the instruments and observation period. If temperature, humidity, dust or ventilation falls

outside the documented basis, the solution may involve room changes, controls or another process. It should not involve silently operating beyond the qualification and treating subsequent defects as operator error.

The physical layout must support safe flow as well as machine access. Separate clean artwork and approved blanks from used consumables and waste where their contact could compromise the article or expose workers. Preserve clearance for maintenance, emergency isolation and material handling. Consider where hot prints cool, where adhesive powder is handled, where chemical containers are opened and where rejected material awaits disposition. A floor plan that fits the printer but not these activities has not accommodated the process.

Digital dependence also belongs in the site survey. Identify which functions require a network connection, which licences or support sessions need remote access, and which approved files and job records must remain available locally. GFT's programme principle of local buffering is relevant here: an interruption should not destroy the order record or make the physical job ambiguous. The buyer should test offline behaviour and recovery with the supplier rather than assuming either full independence or continuous connectivity. Data destinations and remote permissions require review before support access is enabled.

Acceptance should include a site-readiness certificate linked to the survey. Each utility, environmental and network condition carries an observed state, an exception and a responsible closer. Equipment commissioning starts only when its safety prerequisites are closed. Later changes to the room, curing route, electrical supply or software service trigger a review of the original basis. Site qualification is therefore a maintained condition of operation, not a checklist completed on delivery day.

12.5

Chemical and thermal risks need process controls

The risk assessment must follow the selected materials and tasks. IFC's textile manufacturing guidance addresses heat in drying and curing, chemical handling and machine-related hazards. [S17] It supplies general management and control considerations, not an exposure assessment for a proposed print room. The buyer should collect the actual safety data sheets, chemical inventories, equipment manuals and work sequence, then have competent people assess the operation at its intended site. Applicable local duties and any occupational exposure limits require qualified local review.

Direct-to-film work illustrates why generic printing guidance is insufficient. The process includes film, adhesive and heat transfer in the route described by the manufacturer guide. [S15] The assessment should therefore examine the specific adhesive powder, its handling and the emissions or residues generated under the proposed conditions. Evidence about another powder, another application rate or an unrelated printing process cannot establish exposure in this one. Where the documentation leaves a consequential question open, the response is further supplier information, measurement or specialist assessment, not reassurance from a product label.

Chemical screening begins at input. ZDHC describes its manufacturing restricted substances list as establishing substances to avoid, including those banned from intentional use. [S23] That can support a review of ink, pretreatment, adhesive and cleaning formulations. It does not prove that a purchased product conforms, that a finished garment meets a separate product requirement, or that workplace exposure is controlled. The procurement record should retain the formulation evidence, version and supplier declaration alongside the safety data and required finished-article tests.

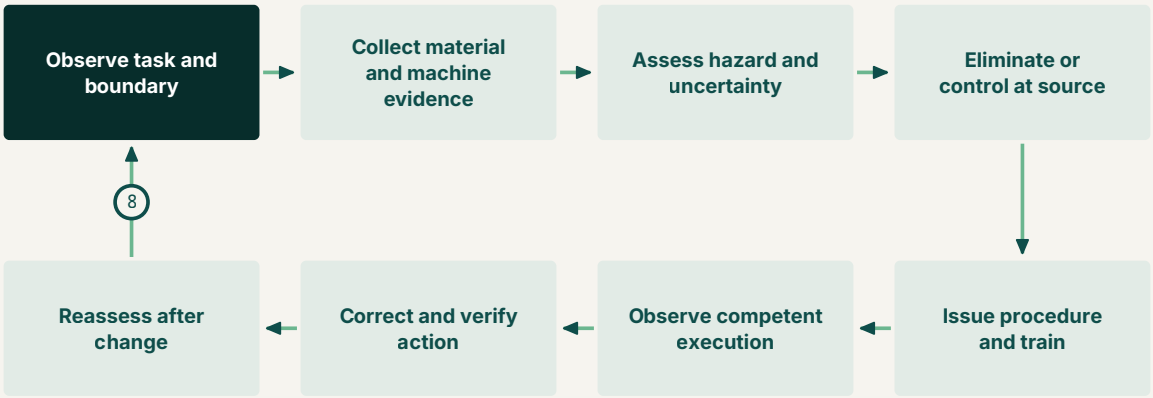
Thermal hazards require controls around the complete hot-work sequence. Map warm-up, normal operation, loading, unloading, cooling, jam clearance, cleaning and maintenance. Identify contact surfaces, retained heat, fire considerations, fumes and any interaction between heat and the actual chemicals. Engineering controls and guarding should address the source where practicable. Work instructions then define safe handling, cooling, isolation and abnormal conditions. Personal protective equipment complements those measures rather than replacing feasible control at source.

Moving equipment and stored energy need the same task-based treatment. A routine operator may clear one defined condition using an approved procedure, while another condition requires isolation and a qualified technician. The distinction must appear in training and at the machine. An acceptance run should not celebrate an improvised intervention by a supplier expert that the operating team cannot perform safely. If safe recovery cannot be demonstrated, the process is not ready for handover.

Exhibit 50, p. 188 places these activities in a closed control loop. IFC's management-system guidance supports using risk assessment to prioritise which risks should be addressed first. [S18] Prioritisation determines the order and depth of action; it does not permit a severe uncontrolled hazard to be averaged against low purchase cost.

EXHIBIT 50 / ILLUSTRATIVE GFT CONTROL SEQUENCE

Hazards should be controlled at their source



8. Change or residual concern

ILLUSTRATIVE [S15] [S17] [S18] [S23] Illustrative management control design informed by the cited process and institutional guidance. It is not a completed site risk assessment, an exposure measurement or a statement of legal compliance. The return path requires reassessment after a material, task, control or incident change.

Observation closes the loop. Supervisors should watch normal work, cleaning, replenishment, jam response and maintenance preparation, then compare behaviour with the approved method. Deviations require a cause review: unclear instructions, awkward equipment position, production pressure and missing materials can defeat a procedure even after attendance-based training. Corrective action should change the condition where possible, followed by another observation. The record needs an accountable role and evidence of closure.

Incident and near-miss learning belongs to the same system. Preserve the job, material, equipment state and relevant environmental conditions without turning the review into a search for blame. Assess whether the same mechanism exists in other products or shifts. A change to powder, ink, curing equipment, ventilation, throughput or work organisation reopens the assessment. Safe capability is maintained through controlled evidence and correction, not through a one-time commissioning signature.

12.6

Digital skills must complement pattern and production skills

Competence is the observed ability to complete and recover a task, not attendance at a course. The required team combines garment knowledge, material understanding, prepress, machine operation, maintenance and quality judgement. One person may hold several roles in a small service, but the tasks and review responsibilities still exist.

Procurement should identify them before choosing training, because a supplier syllabus built around normal operation may omit the failures that determine accepted output.

Digital interpretation cannot replace pattern and production knowledge. The virtual-fit study concludes that simulation cannot fully replace physical fitting because technical issues remain. [S07] A pattern and fit lead must therefore challenge geometry, construction and the meaning of a simulated result. The role includes checking pattern transfer, grain, size intent and physical discrepancies, then deciding whether a digital review is informative. Software fluency without that judgement can produce a convincing image and an unmanufacturable specification.

Fabric digitisation requires a different observed task. The practitioner must identify the physical material, preserve its direction and provenance, obtain the required inputs and map them into the selected software. Assessment should include a material change and a readback of the resulting digital asset. Prepress assessment should cover artwork scale, colour workflow, repeat or placement geometry, rasterisation and the handling of a revised approval. Printing and curing assessment should cover setup, routine care, inspection and a controlled interruption.

Maintenance competence extends beyond following a cleaning video. The technician must recognise the machine state, select the documented procedure, isolate safely where required, record parts and consumables, and decide when to escalate. Quality review requires enough independence to hold work even when delivery pressure is high. That reviewer should be able to connect a defect to its material, recipe, handling or test evidence rather than merely sorting good and bad output.

Exhibit 51, p. 190 provides an illustrative gap analysis for these roles. Its scores describe a hypothetical training exercise, not GFT personnel or an assessed supplier team. The practical output is a list of tasks requiring instruction, supervised practice, reassessment or backup coverage.

EXHIBIT 51 / ILLUSTRATIVE OBSERVED-COMPETENCE SCORE FROM 0 TO 3

Skill coverage must be demonstrated at the task

	Plan	Execute	Diagnose	Instruct
Pattern and fit	3	3	3	2
Fabric digitisation	2	3	2	0
Prepress	3	3	2	1
Print and cure	2	3	2	1
Quality review	2	3	3	2
Maintenance	2	2	3	0

Cell scale: 0 to 3

ILLUSTRATIVE [S07] [S15] [S31] Illustrative GFT training-planning model. Scores are 0 not yet demonstrated, 1 completed with direct supervision, 2 completed independently to the agreed standard, and 3 able to diagnose and coach the defined task. Values describe a hypothetical role-level exercise, not actual people, staffing, recruitment or GFT capability. Do not average the cells into an overall readiness score.

The matrix should become person-specific during implementation. A role may appear covered while only one individual can perform its critical task, leaving no capacity during absence or peak recovery. The rota should therefore identify primary and backup competence by shift and task. Quality release may also require separation from the person under production pressure. These are organisational choices, but their evidence remains observed execution rather than job title.

Training should use the buyer's reference articles and realistic exceptions. Ask the learner to receive a changed material, recover a paused job, identify an unreadable export, respond to a failed physical check and explain why work must stop. Retain the attempt, prompts, errors and assessor decision. A repeat assessment after an interval can test retention. Requalification is also necessary after changes to software, material, recipe, equipment or procedure that alter the task.

Supplier training has a defined place in this system. It can transfer product-specific operation and maintenance knowledge, provide manuals and assess initial execution. It cannot establish the buyer's entire quality governance or create every pattern and production skill. The handover is complete only when the operating team can plan, execute, diagnose and recover the qualified scope without undisclosed reliance on the demonstrator. Remaining dependence should be explicit in the support agreement and training plan.

12.7

Support agreements should preserve the ability to switch

A supported process should not make the buyer's own product and operating history unreadable outside one supplier's environment. Portability covers more than downloading a file. Artwork must retain dimensions and colour intent, patterns must retain geometry and construction identifiers, digital materials must retain their parameters and provenance, and order history must retain meaningful states. The acceptance test should export each required object, read it into the agreed receiving environment and compare the result with the source.

Pattern transfer shows why file existence is insufficient. GarmentCode describes valid sewing patterns as central to accurate digital simulation and eventual fabrication. [S32] A successful export that loses scale, seam relationships or piece identifiers has not preserved that validity. The readback protocol should therefore include dimensional and semantic checks, not just a successful import message. Any manual repair required after transfer belongs in the dependency record and switching-cost estimate.

The portability package should also include current manuals, approved recipes, profiles, material identifiers, maintenance history, acceptance evidence and a map of custom settings. Agree which formats are available, which functions require licensed software and which data the supplier may retain or delete. Remote support should not receive broader access to artwork, buyer details or body records than its task requires. Contract, privacy and intellectual-property terms need qualified review rather than technical assumptions.

Exit planning is a risk-control measure, not an expectation of failure. IFC guidance supports prioritising risks and corrective actions within the management system. [S18] The buyer should identify which supplier interruption, licence change or support withdrawal would stop the service, then preserve an alternative where practical. That alternative may be another qualified route, an outsourced provider or a controlled suspension of the offer. It is credible only if the necessary materials, data and competence can actually transfer.

WARNING

This chapter establishes no local supplier coverage, quotation, equipment reliability, legal compliance or trained-team result. Those conditions require site-specific offers, witnessed tests, safety and contractual review, and observed operation. Economic comparisons remain operational decision aids, not investment or tax advice. Applicable legal, employment, safety, customs, privacy and intellectual-property obligations require qualified advisers.

GFT's recommendation is to accept the smallest complete process whose physical evidence, site readiness, support and people all pass. Preserve the reference pack, failure records and portable data so that a later reviewer can reconstruct the decision. Where support or competence remains unproved, retain outsourcing or delay ownership rather than calling the gap an implementation detail.

Buy the system that can recover, not the machine that can only demonstrate.

CHAPTER SOURCE NOTES

S15 Epson United Kingdom. 2026.

S30 Epson America. 2026.

S11 International Organization for Standardization. 2016.

S18 International Finance Corporation. 2014.

S21 Fogra Research Institute for Media Technologies. 2026.

S31 Epson America. 2026.

S17 International Finance Corporation, World Bank Group. 2007-04-30.

S23 ZDHC Foundation. 2026.

S07 3DBODY.TECH conference proceedings. 2020.

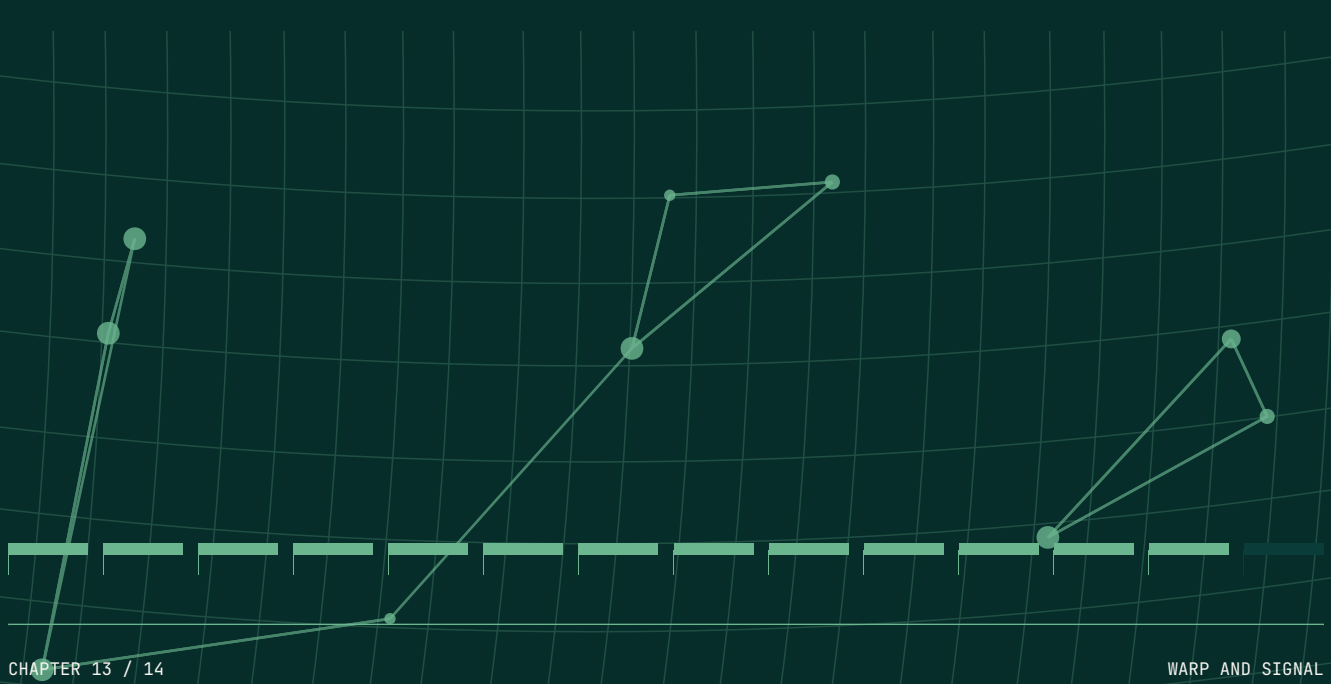
S32 arXiv, Korosteleva and Sorkine-Hornung. 2023-06-06.

13

PART IV: BUY, PILOT AND SCALE AGAINST EVIDENCE / PILOT DESIGN

A controlled pilot can reject an attractive equipment story

Pre-register the comparisons and failure conditions before approving adoption.



CHAPTER 13
DECISION TEST

Pre-register the comparisons and failure conditions before approving adoption.

A controlled pilot should decide whether a defined apparel service deserves adoption, not demonstrate that a preferred machine was right all along. Its comparison must begin with the route that would otherwise deliver the same garment, preserve physical approval, include every learning and recovery cost, and test cases excluded from calibration. Thresholds and stop conditions belong in the protocol before results arrive. GFT therefore proposes a matched, held-out pilot whose valid outcomes include stop, outsource, repair and retest, or adoption of only the scope that passed. The method extends GFT's Cameroon textile programme as an evaluation design. It does not presume an existing GFT production line, local demand, supplier performance or measured savings.

13.1

A pilot needs an explicit counterfactual

The counterfactual is the service that would be used if the proposed digital route were not adopted. It may be conventional physical sampling followed by an outsourced print run, decoration of stocked blanks through an existing supplier, or another route that can genuinely fulfil the intended order. It is not a deliberately weak assembly of unnecessary steps. The comparison should name the garment, approval obligations, accepted quantity, delivery region and commercial terms that both routes must satisfy. Only then can a difference in time, cost or resource use inform adoption.

Equivalence starts with function rather than appearance. The historical VTT printing study makes batch size, quality, durability and product lifetime important to its comparison, rather than treating printed area as a sufficient description of the service. [S26] A pilot should apply the same discipline to a garment. A digital sample that avoids a physical fitting but leaves fit unresolved is not equivalent to an approved physical sample. A printed article with inferior care performance is not equivalent to one that meets the buyer's agreed use conditions. The protocol must either close those differences through testing or retain them as explicit limitations.

Residual physical work therefore belongs in both route definitions. Research comparing virtual and physical fitting concludes that simulation cannot fully replace a real physical fitting because technical issues remain. [S07] The proposed digital route might still reduce some iterations, but the pilot must count the fitting, strike-off, care test or sewn approval that remains necessary. It should not compare a complete baseline service with an incomplete digital preview. The unit of comparison is an approved style or retained order, with all work required to reach that state.

A useful design pairs routes at the style or order level. The same technical brief, material requirement, size coverage, artwork and acceptance evidence go to the baseline and proposed workflows where practical. Pairing reduces the chance that an easy style flatters one route while a difficult style burdens the other. It also lets the reviewer inspect differences within each pair instead of relying only on cohort averages. When simultaneous execution is impossible, the record should identify changes in staff, supplier, material lot and buyer requirements between periods.

Some factors cannot be held constant without distorting the decision. A digital route may require fabric digitisation that the baseline does not need. An outsourced baseline may include courier movement that an internal route avoids. Those differ-

ences are part of the routes and should remain visible. The analyst should not force identical activity lists. The requirement is an equivalent delivered outcome, not identical work. Each route receives the activities and costs that it actually needs to reach that outcome.

> **METHOD**
>
> Write a counterfactual sheet before recruiting pilot styles. Name the baseline decision, the proposed route, the approved end state, the common garment specification, the delivery and care conditions, and the permissible differences in process. For every pair, record why the cases are comparable and where equivalence breaks. Keep unmatched cases in a separate exploratory register rather than inserting them into the main comparison.

The baseline also needs an availability statement. If no stable internal sampling route exists, the protocol should compare documented supplier offers and observed outsourced work rather than inventing current factory performance. If a reliable baseline cannot yet be measured, the first pilot stage is baseline reconstruction. That work may delay an equipment decision, but it prevents a false saving from becoming the foundation of one.

13.2

The test matrix must cover the intended difficulty

A pilot built only from easy repeats cannot support a broad service claim. The test matrix should represent the conditions under which the proposed offer would actually operate: material and blank variation, light and dark bases, print placement, construction complexity, size coverage, new artwork and exact repeats. Each dimension needs a reason tied to a failure mechanism. The objective is not maximum variety. It is enough deliberate variation to expose the conditions that could overturn adoption.

Material direction belongs in that design because mechanical behaviour can affect virtual fit. A study of virtual garment fit found that tensile properties in the weft direction had the greatest influence for the diagonal-cut garments it examined. [S05] That study does not supply a general ranking for every garment. It shows why a pilot containing only one stable material and one grain orientation could miss a consequential sensitivity. Bias-cut or highly deformable cases should be included only if they fall inside the intended service, and their results should remain separate from simpler constructions.

Print preparation creates another axis. Manufacturer guidance for one garment-printing workflow states that pretreatment is necessary when white ink is used or when printing onto polyester. [S30] The statement is specific to that workflow, not a universal rule. It nevertheless shows why light and dark bases, fibre content and ink configuration cannot be treated as interchangeable presentation options. The matrix should record the actual preparation, white-ink use, curing route and material identity for every case.

Physical handling must also survive the comparison. A garment-printing guide identifies heat curing as the final stage of its described direct-to-garment process, while film transfer uses a different sequence. [S15] A test that times only digital design or printer deposition would omit work that can affect accepted output. Placement complexity should therefore include the subsequent curing, cutting where relevant, assembly and inspection needed by the chosen route. An engineered placement across panels poses a different test from a small chest image, and the two should not share an unqualified average.

Repeat work needs its own stratum. An exact repeat tests whether a locked package can be reproduced. Revised artwork tests controlled prepress and approval. A new style tests pattern, material and development capability. Combining them into one productivity measure hides where learning transfers. The matrix should label the novelty of every case before execution so that a favourable concentration of repeats cannot be discovered after the fact and presented as representative of all work.

Exhibit 52, p. 196 illustrates how the team can prioritise conditions for coverage. The coordinates are judgement-based planning positions, not defect probabilities or measured performance. Their purpose is to make omissions visible before cases are selected. A high-consequence, novel condition should not disappear merely because it is inconvenient to test.

EXHIBIT 52 / ILLUSTRATIVE PLANNING POSITIONS FROM 0 TO 10

A pilot should test the conditions that could overturn adoption



ILLUSTRATIVE [S05] [S15] [S30] Illustrative GFT test-planning positions informed by the cited material and process sensitivities. Horizontal position is novelty relative to the locked workflow, where 0 is an unchanged repeat and 10 is entirely new. Vertical position is the consequence of releasing an unverified result, where 0 is negligible and 10 is severe. Coordinates are author-assigned for protocol design, not observed defect rates or probabilities.

Sample counts should follow observed variability and the precision needed for the decision. A stable exact-repeat family may need fewer observations than a family whose results vary by material lot or fit participant. The protocol should begin with a baseline variability assessment, identify the consequential measures and state what

difference would change the decision. It should then document why the planned coverage is informative. There is no defensible universal pilot quota that applies to every garment family.

Small coverage can still produce useful learning, but its conclusion must remain narrow. If only one material lot or size cluster is tested, adoption applies only to that bounded condition pending further evidence. If an important cell cannot be filled, the matrix should show it as untested rather than allowing the completed cells to imply coverage. The final decision inherits the structure of the test, including its empty cells.

13.3

Calibration work must not consume the whole test set

Calibration and validation answer different questions. Calibration adjusts the workflow until it can represent the intended material and garment. Validation asks whether the locked workflow succeeds on cases that did not shape those adjustments. If every style is available for tuning, the final result measures how well the team fitted its tools to the test set. It does not establish transfer to the next order.

The separation applies to more than a fabric model. Development cases can be used to select avatars, resolve pattern imports, choose print settings, revise preparation, establish curing work and train reviewers. Validation cases must arrive after those choices are frozen. The locked package should identify software and process versions, material assets, pattern rules, simulation settings, artwork handling, physical test methods and decision criteria. A shared folder name is not an adequate lock; the record needs a reproducible revision identifier.

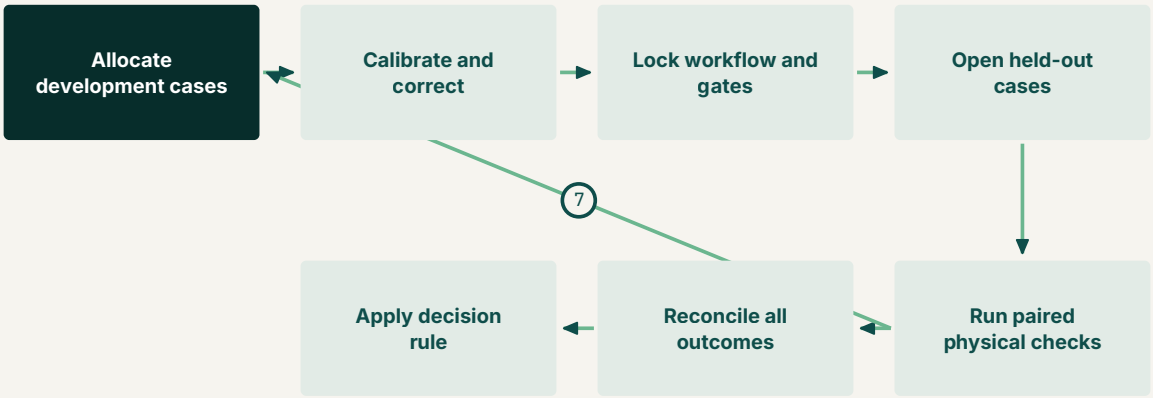
Simulation controls make the reason concrete. The physical-versus-virtual drape study includes a phase examining the effect of particle distances on virtualised fabric. [S04] Resolution can therefore be part of the experimental condition, not an incidental preference. During validation, the team should not change particle distance, collision handling or related settings until a difficult case looks acceptable. Such a change creates a revised candidate and returns that case to development.

Physical comparison remains the check on the calibrated digital decision. The virtual-fit research supports a real fitting gate, while the real-versus-virtual garment study compares distance ease at named bust and waist cross-sections. [S07] [S06] A pilot should define its own corresponding physical and digital observations before seeing the results. Locations, poses, material state and measurement methods must match as closely as possible. Differences should be reported at their locations rather than averaged into a reassuring overall fit score.

Exhibit 53, p. 198 sets out the proposed evidence sequence. The return edge is important: a material or workflow correction does not merely add a note to a failed validation. It creates a new candidate that needs held-out evidence appropriate to the change.

EXHIBIT 53 / ILLUSTRATIVE GFT EVALUATION SEQUENCE

Calibration and validation must remain separate



7. Revision becomes new candidate

ILLUSTRATIVE [S04] [S06] [S07] Illustrative protocol design. Development cases inform calibration; validation cases remain untouched until the workflow and criteria are locked. A change after validation begins creates a new candidate. No software performance, sample size or achieved approval rate is asserted.

GFT NOTE

GFT recommends appointing a protocol custodian who can refuse silent retuning. Keep development and validation identifiers separate, record every attempt, and require a new validation decision after any change that could affect the result. A failed held-out case is evidence about the locked service, not an invitation to improve the record by quietly moving that case into calibration.

The held-out set need not be secret or theatrically concealed. Its integrity comes from not using it to make workflow choices. Buyers and operators can know which cases are included, while the technical team commits to the evaluation settings in advance. Where buyer approval requires a revision, the ledger should show that the evaluation became developmental and identify what new validation is required.

13.4

Acceptance thresholds belong before the results

A gate written after the results tends to fit the preferred answer. Before execution, the buyer and operations leads should agree what must pass, which evidence is acceptable, who decides and what happens after failure. Thresholds should reflect the garment's intended use, the buyer's specification, process capability and the decision's consequence. A supplier demonstration or an unrelated publication cannot supply a universal acceptance limit.

Physical tests need complete protocols rather than method names alone. ISO's laundering scope warns that industrial and hospital articles may require special procedures that are more severe in some aspects. [S10] Its rubbing scope distinguishes dry and wet rubbing cloths. [S11] Its domestic washing and drying scope states that a complete test consists of both washing and drying. [S12] These public catalogue entries help define the questions; they do not provide the pilot's pass grades. A qualified laboratory or competent reviewer must agree the full procedure, specimens, conditions and evaluation before testing.

Fit gates require the same specificity. The small real-versus-virtual garment study provides a warning against transferring study-specific discrepancies into a new operation. [S06] The pilot should instead state the locations, poses, intended wearer coverage, measurement uncertainty and buyer-approved tolerances that matter for this garment. It should record both evaluator observations and relevant wearer feedback. A mean difference cannot compensate for a local failure that prevents use.

Operational gates should cover the original delivery promise, complete retained-order contribution and recovery work. Delivery is measured against the promise made when the order was accepted, with later amendments shown separately. Contribution includes failed work, refunds and remakes rather than only clean output. Recovery includes reprints, repeated tests, additional courier movements and the labour required to correct them. A favourable development result cannot compensate for a service that loses money or arrives late under the agreed criteria.

Exhibit 54, p. 200 provides the gate sheet's minimum structure. Its cells deliberately do not invent numerical thresholds. Each organisation must complete them from its own buyer, process and risk requirements before running the pilot.

EXHIBIT 54 / ILLUSTRATIVE PRE-REGISTERED GATE SHEET

Every acceptance decision needs its evidence and owner

Gate	Required evidence and threshold origin	Accountable role	Failure consequence
Fit and construction	Paired observations at agreed locations and poses; buyer-approved tolerances	Technical and quality leads	Hold affected style or size
Colour and care	Agreed laundering, drying and rubbing protocols; buyer criteria	Quality lead and laboratory	Hold affected material route
Delivery	Original promise, dispatch and buyer acceptance records	Fulfilment lead	Review promise or stop route
Retained contribution	Complete order ledger after the defined return window	Commercial and operations leads	Reject or redesign economics
Resource boundary	Metered or allocated inputs with accepted and retained denominators	Operations and analysis leads	Narrow the supported claim
Recovery and hours	All reprints, remakes, courier work and paid correction hours	Production and people leads	Correct planning before retest
Evidence integrity	Complete identifiers, attempts, revisions and source records	Protocol custodian	Block adoption decision

ILLUSTRATIVE [S06] [S07] [S10] [S11] [S12] [S18] [S28] Illustrative GFT protocol structure. Thresholds, methods, editions, observation windows and named accountable persons must be completed before execution. Public standards scopes do not supply buyer pass grades. No measured pilot result is shown.

Risk assessment should determine which failure can be conditional and which must stop the route. IFC guidance supports using a risk assessment form to prioritise which risks should be addressed first. [S18] Prioritisation does not mean averaging a severe safety or physical failure against commercial success. The gate sheet should identify non-compensable failures explicitly. A lower-priority documentation gap may receive a bounded correction period; an unclosed physical release failure keeps the affected service out of adoption.

Working conditions belong inside the protocol rather than in a later social review. OECD guidance identifies inefficient production planning and poor purchasing practices among common factors associated with excessive working hours. [S28] The pilot should therefore predefine how it records work outside normal shifts, late buyer changes and urgent recovery. Meeting a delivery gate through unrecorded or unacceptable hours is not a pass. Applicable employment obligations require qualified local review rather than inference from international guidance.

Finally, the decision rule should handle missing evidence. An unmeasured gate is not a passed gate, and an incomplete return window is not evidence of retention. The review can postpone a decision, narrow the claim or commission another test. It

should not convert absent data into a favourable assumption. This rule protects the pilot from ending with a precise score whose most important fields were never observed.

13.5

The ledger must include failures and learning costs

A pilot ledger should explain where every hour, material unit and order outcome went. Recording only successful samples would remove precisely the work that determines whether adoption is worthwhile. Each style or order needs a continuous record of attempts, revisions, rejected prints, physical tests, courier movements, approvals, production recovery and final acceptance. The denominator is the full cohort entered into the test, including withdrawals and failures, with reasons attached.

Learning costs need a visible home. Fabric digitisation, pattern conversion, staff training, trial prints, software setup and protocol development may be treated as cohort or period costs rather than assigned arbitrarily to one garment. The ledger should show the chosen allocation and the unallocated period total. It should also distinguish a one-time investigation from a recurring obligation. That distinction aids interpretation, but it must not be used to make inconvenient initial work disappear from the adoption comparison.

The same rule applies to work outside the expected route. A supervisor correcting a file at night, a second supplier visit, a replacement blank and an urgent delivery all belong to the case that caused them. OECD guidance on planning and purchasing risks makes these events relevant to responsible operation as well as cost. [S28] Paid hours should reconcile to work records, while waiting time should be distinguished from active labour. An idle printer and an idle worker are different states and should not share one vague downtime field.

Commercial closure comes after the defined cancellation, refund and return window. Net retained sales must reflect the outcome after that window, while the cost ledger retains everything consumed by cancelled and refunded work. Remakes and replacements belong to the original order, not to new demand. The pilot should reconcile ordered, started, accepted, dispatched, returned, refunded and retained states so that an internally successful print cannot become a successful sale without buyer evidence.

The source records must reconcile to the paper's sampling-cost and unit-economics dictionaries before the review. Development hours, physical iterations, residual samples and courier costs feed the sampling comparison. Materials, direct production labour, energy, delivery, recovery and net retained sales feed order contribution. Shared period costs remain visible in both models without being counted twice in a combined conclusion. A reviewer should be able to move from every summary value to the underlying events.

WORKED EXAMPLE: A SMALL SAVING CAN REVERSE WHEN RESIDUAL APPROVAL CHANGES

Assume an illustrative matched cohort of 12 styles solely to demonstrate the calculation. This is not a recommended sample size. The baseline requires 2 physical samples per style at an assumed 45,000 XAF each, plus 10 development hours per style at an assumed 4,000 XAF per hour. Every price and quantity is an invented model input, not a Cameroon quotation or GFT observation.

The illustrative baseline sample cost is 12 x 2 x 45,000 = 1,080,000 XAF. Baseline labour is 12 x 10 x 4,000 = 480,000 XAF, giving a complete comparison cost of 1,560,000 XAF. The digital route is assumed to need 14 development hours per style, 180,000 XAF of cohort fabric calibration, 420,000 XAF of allocated software and training cost, and 9 residual physical samples. Its central total is therefore (12 x 14 x 4,000) + 180,000 + 420,000 + (9 x 45,000) = 1,677,000 XAF.

In this illustrative comparison, the digital route costs 117,000 XAF more than the baseline. With only 6 residual samples and otherwise unchanged central assumptions, its total becomes 1,542,000 XAF, an apparent saving of 18,000 XAF. With 12 residual samples, its total becomes 1,812,000 XAF, or 252,000 XAF above baseline. The decision reverses within the scenario set even though the digital workflow itself is unchanged. These arithmetic cases say nothing about likely local sample rates or prices. A protocol that recorded only the favourable case would conceal this fragility. Pre-registered scenarios make the reversal visible before the equipment proposal can define the evidence.

The example is useful because it denies the analyst a simple equipment narrative. Fewer physical samples can coexist with higher total cost once digital labour, calibration and period capability are counted. Conversely, a digital route should not be rejected merely because it carries those costs if measured outcomes show sufficient avoided work. The correct response is to observe the actual residual requirement and labour distribution, then test whether the decision remains stable across defensible conditions.

13.6

Uncertainty belongs in the decision

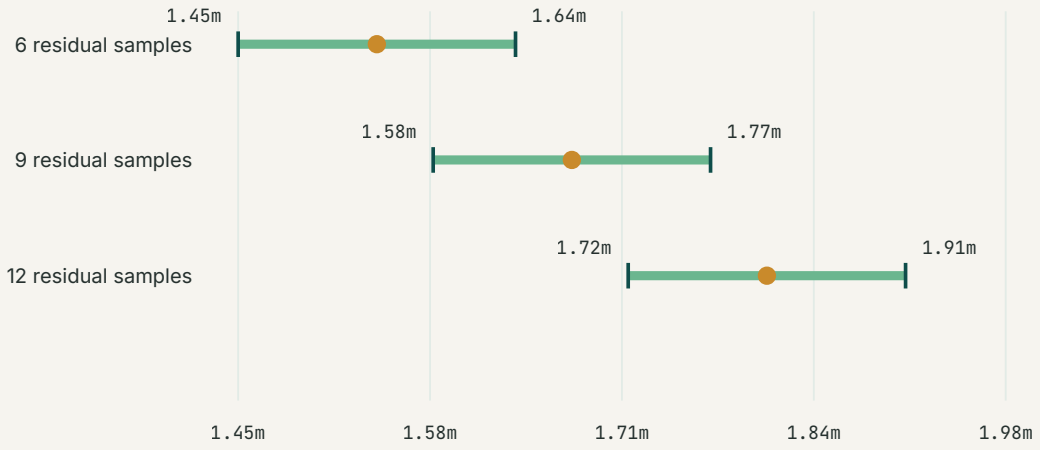
A pilot average can hide the cases that determine adoption. The review should retain pair-level differences, cohort totals and results by material, novelty, size coverage and placement complexity. For each matched pair, the arithmetic difference can be calculated as proposed route minus baseline for development hours, complete cost and other common measures. The sign and unit must remain consistent. A favourable mean accompanied by repeated failures in one intended service cell is not evidence for the whole offer.

Variation should be shown before any summary interval is attempted. A small pilot can reveal the range observed within its cases, but that observed range is not a confidence interval and does not bound every future order. Statistical intervals require a defensible sampling and analysis method. Where those conditions are absent, the report should use descriptive results and explicit scenarios instead. More decimal places cannot compensate for a weak sampling frame.

Exhibit 55, p. 203 extends the worked example by varying both digital labour and residual physical samples. The bars are scenario bounds, not confidence limits or observed outcomes. They show how an apparently close decision can change under assumptions that the pilot needs to measure.

EXHIBIT 55 / ILLUSTRATIVE XAF PER 12-STYLE COHORT

The pilot must expose uncertainty as well as average performance



ILLUSTRATIVE Illustrative scenario arithmetic, not observations or statistical intervals. For each residual-sample case, fixed non-labour cost is 180,000 calibration + 420,000 software and training + residual samples x 45,000. Low and high digital labour bounds are 12 and 16 hours per style x 12 styles x 4,000 XAF; mid uses 14 hours. Baseline comparison and all assumptions appear in the worked example. No local prices, sample rates or forecast are asserted.

The scenario bounds expose two different evidence needs. Residual-sample count is a physical approval outcome that the pilot can observe by style and cause. Development hours require disciplined time capture across pattern, digitisation, simulation, review and correction. If either field is missing, the analyst should not select whichever scenario makes the route attractive. The appropriate conclusion is that the economic gate remains unresolved.

Study-specific discrepancies also need careful handling. The real-versus-virtual garment study compares named cross-sections, but its observations belong to its tested garments and method. [S06] They should motivate paired measurement, not become acceptance tolerances or expected error rates for a new service. Likewise, the on-demand wool-knitting LCA uses environmental measurement and denominator choices for a different product system. [S25] It supports stating boundaries carefully, not transferring its results to printed cotton apparel in Cameroon.

Sensitivity analysis should change one consequential assumption at a time and then examine combinations where dependencies matter. Labour and residual samples may be related: additional digital correction could reduce physical iterations, or could create more of them. The model should not assume a convenient independence if the case records suggest otherwise. Correlation in a handful of cases is still not a proven causal relationship, but it is a reason to inspect mechanism and collect better paired evidence.

Decision uncertainty can justify three bounded responses. More observation is appropriate when the route passes its non-compensable gates but the economic or operational result remains unstable. Narrowing is appropriate when only some cells pass consistently. Stopping is appropriate when the route fails a required physical condition or cannot produce a viable result across reasonable conditions. Uncertainty is not always a reason for another pilot; it can also reveal that the proposed scope was too broad.

13.7

Scale only the service that passed

The final review should choose among stop, repair and retest, outsource, or adoption of a precisely bounded service. Expansion is not the default reward for completing the protocol. Stop is appropriate when the route cannot meet a required condition or its disadvantage is clear. Repair and retest require a named cause and a credible correction. Outsourcing remains a valid service design when an external route provides the better accepted outcome. Adoption applies only to the material, garment, approval and order conditions supported by the evidence.

A pilot review packet should contain the counterfactual sheet, test matrix, locked workflow, held-out register, gate sheet, complete, reconciled cohort ledger, pair-level results, scenarios and deviations from protocol. It should identify which planned cases were not run and which records remain incomplete. Failed cases stay in the evidence register with their original identifiers. Removing them would turn a service evaluation into a marketing selection and would prevent the next reviewer from understanding what was actually learned.

Corrective action should follow risk and cause rather than enthusiasm. IFC guidance supports prioritised risk treatment inside an operating management system. [S18] OECD's more recent garment due-diligence guidance expects each company to identify its priority risks from its individual circumstances, including risks not listed in the guidance. [S29] The pilot owner should therefore record the affected condition, corrective action, accountable role, evidence needed and retest scope. An open safety or physical release failure prevents the affected route from advancing regardless of its commercial score.

The reviewer should also be independent enough to reject the equipment story. A person who approved the purchase can contribute operational evidence, but the gate decision needs a reviewer authorised to accept a negative result. Supplier demonstrations and vendor calculations may inform the protocol, yet they cannot determine its thresholds or replace local observations. This governance condition matters most when the pilot appears close to passing and the organisation has already publicly committed to adoption.

Scope control is the last defence against overgeneralisation. A pass for an exact-repeat, single-material service does not establish custom fit, a new fabric family or automatic production release. A change to material, artwork complexity, size coverage, supplier, care requirement or delivery promise should trigger a documented carry-over decision. Some evidence may remain relevant, but the changed condition needs the tests its new failure modes require.

> **WARNING**
>
> No local demand, supplier support, physical performance, accepted-output cost or resource saving is established by this chapter. Those inputs must come from the proposed pilot and qualified testing. Contracts, employment, privacy, safety and other applicable obligations require qualified review. This is an operational evaluation framework, not investment, legal or tax advice.

GFT's practical recommendation is to approve the smallest validated scope, retain the baseline where it performs better, and treat a rejected route as useful evidence rather than wasted work. The pilot has succeeded when it produces a defensible decision with its failures and uncertainty intact.

Let the held-out garment test the story before the story buys the factory.

CHAPTER SOURCE NOTES

S26 VTT Technical Research Centre of Finland. 2014.

S07 3DBODY.TECH conference proceedings. 2020.

S05 Kaunas University of Technology, Materials Science. 2011-07-04.

S30 Epson America. 2026.

S15 Epson United Kingdom. 2026.

S04 Dongguk University research portal; Taylor & Francis, Journal of the Textile Institute. 2025.

S06 Kaunas University of Technology, Materials Science. 2020.

S10 International Organization for Standardization. 2010.

S11 International Organization for Standardization. 2016.

S12 International Organization for Standardization. 2021.

S18 International Finance Corporation. 2014.

S28 Organisation for Economic Co-operation and Development. 2018.

S25 TU Delft Research Portal; author abstract of Textiles article. 2026.

S29 Organisation for Economic Co-operation and Development. 2026-02-26.

GREEN FUTURE TECH

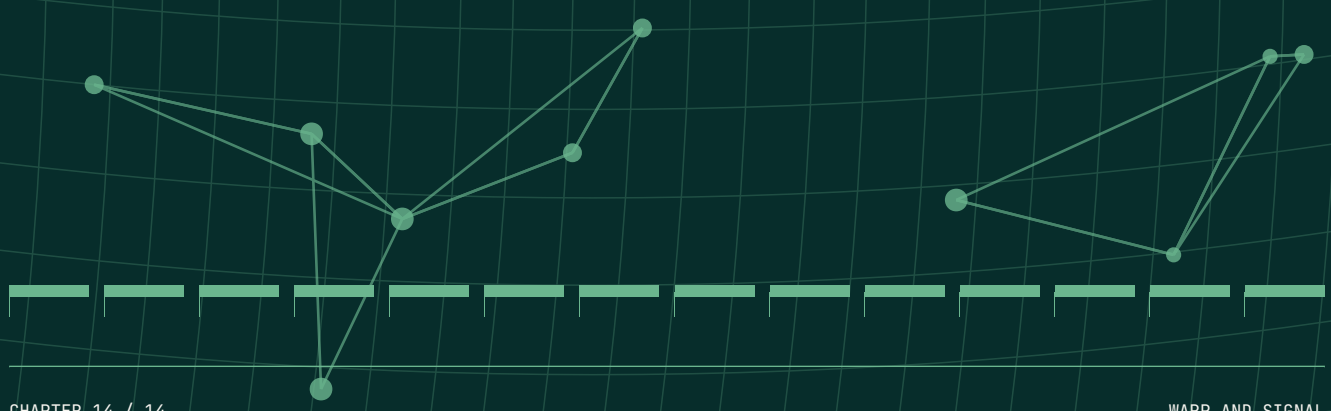
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14

PART IV: BUY, PILOT AND SCALE AGAINST EVIDENCE / ROADMAP AND ACCOUNTABILITY

Scale follows measured repeatability and retained-order economics

GFT recommends staged adoption with named evidence gates and a scorecard that stays inside the factory performance system.



CHAPTER 14
DECISION TEST

GFT recommends staged adoption with named evidence gates and a scorecard that stays inside the factory performance system.

Expansion is justified only after a bounded apparel service has reproduced acceptable garments, fulfilled its original promises and covered the complete cost of retained orders. A successful demonstration, an attractive digital sample or a busy printer does not establish those conditions. GFT therefore recommends a sequence that begins with reversible learning, installs the measurement spine before pilot orders, releases only a physically qualified route and expands one controlled dimension at a time. Advanced customisation remains a separate validation problem. This chapter closes the proposed adoption loop with named evidence, accountable roles and explicit stop, outsource and repair options. It extends GFT's Cameroon textile programme as a decision framework, not as evidence of an installed on-demand factory or achieved commercial result.

14.1

Start with the least irreversible capability

The first capability to qualify is not a printer. It is the ability to define a garment, obtain a physical result against that definition and learn from the difference. A controlled technical pack, a supplier sample and a small outsourced run can test much of that ability before the business commits to an integrated production stack. This starting point preserves options. It allows the team to reject a material, revise a service boundary or change a fulfilment partner without also defending an equipment purchase. On-demand manufacturing concerns a structural change in the production system rather than a simple technological upgrade, so equipment ownership cannot substitute for that operating work. [S03]

Least irreversible does not mean cheapest or permanently outsourced. It means that the next commitment should buy information whose absence currently blocks a decision. If pattern quality is uncertain, pattern and physical sampling work has priority. If supplier print quality is uncertain, a matched strike-off and care test has priority. If buyers will not accept the proposed delivery promise, an order trial has priority. Purchasing machinery before answering those questions can make the unresolved work harder to see because the organisation now has an asset that appears to demand use.

GFT proposes an explicit capability ladder. The first rung controls specifications, material identity and approvals. The second qualifies suppliers through samples and short runs. The third operates a bounded service using the smallest practical combination of owned and outsourced stages. A later rung adds equipment only where observed volume, accepted output, support and retained-order economics justify it. Advanced parametric or image-derived customisation sits beyond that, with its own release protocol. A rung is not a calendar milestone. It is a scope that can be entered, retained, narrowed or left.

An outsourced comparator should remain visible even after equipment is acquired. It shows whether internal production improves the complete accepted-order outcome rather than merely shifting cost from a supplier invoice into labour, maintenance, idle capacity and recovery. Model-specific printer guidance, for example, includes routine ink-handling tasks that continue on a schedule, which demonstrates why intermittent use does not remove every operating obligation. [S31] That example applies only to the

documented machine. The general lesson is to cost the actual chosen equipment's maintenance and support duties rather than assuming that low utilisation makes them disappear.

> **METHOD**
>
> Maintain an option register beside the procurement register. For each candidate stage, record the decision still blocked, the cheapest reliable way to obtain evidence, the commitment created, the exit route and the evidence that would justify the next commitment. Compare own, outsource and hybrid routes against the same approved article, accepted quantity and physical tests. A quotation without support scope, exclusions and acceptance conditions is not a complete basis for moving along the ladder.

The least irreversible route also protects the quality of the counterfactual. If the pilot compares a new internal route with an unrealistically weak baseline, later expansion will rest on a manufactured advantage. The baseline should be the route that could genuinely deliver the same garment service, with its actual outsourcing, transport, approval and recovery work recorded. A decision to retain that baseline can be a successful pilot outcome when it prevents a poor commitment. The objective is a defensible service, not a predetermined purchase.

14.2

Set up the measurement spine before taking pilot orders

A pilot cannot reconstruct reliable evidence after the orders have passed through an informal process. Before accepting them, GFT would freeze the product scope, approval states, metric definitions, material identifiers, cost fields and accountable roles. This is the illustrative Phase 0 extension of the programme's performance-management design: capture source events at their origin, preserve stable denominators and connect operating records to a regular management review. The measurement system is part of the service being tested. It is not a reporting layer to be added once adoption looks favourable.

The product-scope record names the garment family, construction route, material or blank, print process, size coverage, artwork limits, intended care and permitted customisation. It also states what is excluded. An exact repeat, a revised artwork and a new style should not enter one undifferentiated style count. Their development work and approval obligations differ. The record should assign each a stable identifier so that later evidence can show which version actually passed and which buyer promise it supported.

The order record follows commitment, approval, release, production, dispatch, acceptance, cancellation, refund and subsequent purchase as distinct events. A print job identifier cannot replace an order identifier, and a dispatch scan cannot replace buyer acceptance. The material record links fabric or blank lots, inks, pretreatment and other relevant consumables to the released specification. The cost record cap-

tures development labour, setup, failed work, production labour, energy, packaging, delivery, recovery and period capability in fields whose boundaries match the economic model.

Responsibility needs to be assigned at the event, not only at the dashboard. A technical role approves the specification. A production role releases and reconciles physical work. A quality role records holds and acceptance evidence. A fulfilment role closes delivery and return events. A commercial role confirms net retained sales and subsequent commitments. A management reviewer checks that the same definitions survive the weekly and monthly reviews. Small teams may combine roles, but the record should still show which accountable person performed each decision.

The illustrative Phase 0 is ready for pilot orders only when two practical demonstrations pass. First, a sample record must reconcile the approved design, pattern, material, process route, physical tests and decision history without relying on memory. Second, a trial order must survive an interruption test. The team should be able to stop and restart the record, identify what has already been produced, prevent duplicate release and recover the commercial and physical state. This does not require simulating every possible failure. It requires proving that the minimum control system works before real orders make omissions costly.

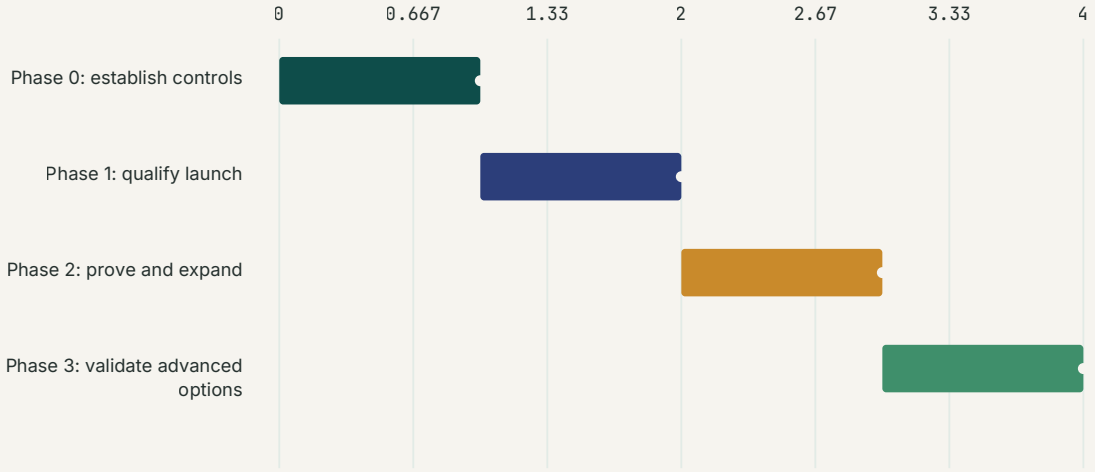
> **GFT NOTE**
>
> GFT recommends treating an incomplete ledger as a failed launch gate, not as an administrative inconvenience. Do not fill missing order outcomes, labour hours or meter intervals with favourable assumptions. Mark the evidence gap, name its owner and prevent the affected metric from supporting expansion. A small number of fully reconciled pilot records is more useful than a larger collection whose denominators cannot be checked.

The management-control literature supports placing risk assessment and corrective action inside the operating system rather than treating them as a separate compliance exercise. [S18] For this service, that means every failed test, late order, unsupported release or unresolved record receives a cause, an action, an owner and a review state. The measurement spine should make those failures visible while they can still change the decision. A pilot that hides its exceptions has not established repeatability; it has established only that the summary was easier to produce than the evidence.

Exhibit 56, p. 210 expresses the proposed sequence as a dependency map. The illustrative numeric positions are symbolic stages, not months, promised dates or resource-loaded scheduling. Each later phase begins only after the preceding evidence gate opens, and a failed gate can return the work to an earlier phase or end the route.

EXHIBIT 56 / ILLUSTRATIVE EVIDENCE SEQUENCE, NOT ELAPSED TIME

Capability should advance when evidence gates open



ILLUSTRATIVE [S03] [S18] Illustrative GFT adoption sequence extending the staged logic of the Cameroon textile programme. Positions 0 to 4 are symbolic phase boundaries, not calendar commitments. Phase 0 requires reconciled records and recoverable order states; Phase 1 requires physical and operational release; Phase 2 requires repeatability and retained-order economics; Phase 3 requires separate advanced-customisation validation.

The roadmap deliberately leaves duration open. Evidence may accumulate at different rates for a stable repeat product and a difficult new material. It also prevents a common misunderstanding of phased adoption: passing time does not open a gate. Only the recorded result does. If the service changes its material, route or order promise, the reviewer must decide which earlier evidence remains valid and which phase the change has reopened.

14.3

Launch only the route that meets physical requirements

The illustrative Phase 1 authorises a bounded service, not a general claim about digital production. Its launch candidate must name the exact garment family, material route, print process, size coverage, customisation limits, approval bundle and delivery promise that passed. Fit, colour, care, safety and order recovery are separate gates. A favourable result in one cannot compensate for an unresolved failure in another. The launch record should show both the passed conditions and the failed or untested conditions so that nobody mistakes a narrow release for a universal capability.

Physical fitting remains necessary where the intended digital workflow cannot resolve every technical issue. The virtual-versus-physical fitting study supports that bounded role for simulation rather than automatic replacement of a real fitting. [S07] GFT would therefore specify which fit decisions the digital sample may inform, which wearer or form checks remain required and who interprets disagreement. The launch package should include the pattern revision, material state, avatar or body basis, poses, physical observations and approval decision. Changing any of those inputs may require a new comparison rather than reuse of the earlier pass.

Care evidence needs equal precision. ISO's public catalogue scope notes that industrial and hospital articles can require special laundering procedures that are more severe in some respects, so the intended use must shape the test route. [S10] The rubbing scope distinguishes dry and wet tests, which prevents one visual assessment from carrying both decisions. [S11] The domestic washing and drying scope states that a complete test consists of both procedures, making the drying route part of the evidence rather than an omitted detail. [S12] These catalogue entries define method scope. They do not provide a buyer's acceptance grade or prove that the proposed garment passed anything.

The launch dossier should consequently identify the laboratory or competent reviewer, exact procedure edition, specimens, conditions, observations and agreed acceptance criteria. It should distinguish a booked test from a completed test, and a completed test from a passed requirement. Where a public catalogue scope is all the team has accessed, the full protocol still needs to be agreed with the qualified testing party. GFT's recommendation is to keep those limitations beside the release signature rather than in a general annex that nobody reads when an order is waiting.

Safety and process recovery sit in the same launch decision. IFC textile guidance identifies heat consumption in drying and curing and addresses occupational risks across textile operations. [S17] The proposed service should therefore qualify its actual thermal, chemical and moving-equipment controls using the selected process documents and site conditions. It should also test the order-recovery procedure after an interruption: what material was consumed, which stage is safe to resume, whether a release retry could duplicate work and how the buyer promise will be reviewed. A route that produces a good sample but cannot recover its records and physical state is not ready for repeatable orders.

A launch gate can have four outcomes. A full pass releases only the stated scope. A conditional pass narrows that scope, for example by excluding an unqualified size or material, and records the condition in the offer. A failed but repairable gate returns to development with a named cause and retest requirement. An unacceptable physical or safety result stops the affected route regardless of apparent demand or contribution. Conditional release must never become a quiet permission to sell the excluded condition.

The launch reviewer should sign a gate sheet that identifies each evidence object, its source, its owner, the decision and the remaining limitation. The sheet should also list the changes that automatically reopen review: material or blank substitution, ink or pretreatment change, pattern revision beyond an approved parameter, new care requirement, altered print placement, different subcontractor or a changed delivery promise. This change control protects the meaning of the word proven. The service that expands must be the service that passed.

14.4

Expand only after repeat-order evidence accumulates

The illustrative Phase 2 joins two different kinds of evidence. Operational repeatability asks whether the controlled process can reproduce accepted garments and reliable fulfilment without exceptional recovery. Commercial retention asks whether orders survive the defined cancellation, refund and return window and cover their complete costs. A later buyer commitment adds evidence of continuing usefulness, but it does not repair a negative contribution or a failed physical gate. Expansion requires the relevant measures to hold together for the qualified scope over a pre-agreed observation window.

Repeat purchase needs a denominator that cannot be confused with production output. The eligible population is the set of earlier buyers whose orders reached the defined retained state and whose subsequent-purchase observation window has closed. Returning-buyer incidence counts eligible buyers who place a new commitment, while repeat-order frequency can count their subsequent orders. A remake, replacement or correction belongs to the original order, not to either repeat measure. These definitions should be fixed before the cohort is reviewed and retained when later cohorts are compared.

Operational evidence should include new and exact-repeat work separately. An exact repeat against an unchanged package tests whether the released process can reproduce its result. A new style within the qualified family tests whether the control system transfers to bounded variation. A new material, construction or care requirement may fall outside the qualified family altogether. Counting all three as equivalent expansion evidence would hide where the process actually learned. The expansion register should identify which dimension changed and which evidence carried over.

Retained-order economics must reconcile more than print revenue. Net retained sales should absorb discounts, cancellations and refunds under the agreed definitions. Costs should include materials, consumables, direct labour, process energy, packaging, payment, delivery, setup and recovery, with period capability and added capacity shown in the period result. Accepted output and retained orders need separate denominators because an internally accepted garment can still be returned, while a refunded order can still have consumed material and labour. The economic review should include failed orders in its numerator rather than calculating margin only on the clean cases.

WORKED EXAMPLE: AN EXPANSION SURPLUS CAN DISAPPEAR WITH ORDER COVERAGE

Assume an illustrative expansion review in which the qualified service has `44` retained orders in the observation period. Each retained order contributes `25,000 XAF` after its defined order-specific costs and recovery, but before the proposed additional period cost of equipment, support and retained capacity. That additional period cost is `960,000 XAF`. Every value is an invented model input in CFA franc (XAF), not a quotation, demand forecast or GFT result.

The illustrative contribution pool is `44 x 25,000 = 1,100,000 XAF`. After the additional period cost, the residual is `1,100,000 - 960,000 = 140,000 XAF`. The arithmetic coverage point is `960,000 / 25,000 = 38.4` retained orders, so the model requires at least `39` whole retained orders to avoid a negative incremental period result. If only `32` retained orders occur under otherwise identical assumptions, the residual becomes `32 x 25,000 - 960,000 = -160,000 XAF`.

This example tests only one economic condition. It does not establish a reasonable order target, a return on capital or a financing decision. Even the positive case cannot justify expansion if physical release, delivery, working-hour or evidence-reconciliation gates fail. The downside case should remain in the decision record because it shows how little order coverage can change the result.

The worked example shows why a scale gate needs both an observed result and a sensitivity. A point estimate above the arithmetic coverage point may still be fragile when order mix, recovery or utilisation changes. The reviewer should ask which measured variation is plausible within the tested scope, then show whether the decision survives it. Where the sample is too small to support that variation, the correct scope is a longer or repeated bounded trial, not a confident extrapolation. Manual planning remains appropriate while order history is insufficient for more elaborate forecasting.

Expansion should proceed along one principal dimension at a time where practical. Adding styles tests product-development transfer. Adding sizes tests pattern, avatar and physical-fit coverage. Adding order volume tests practical capacity, support and working capital. Adding equipment changes fixed cost, process control and maintenance obligations. Combining all four makes it difficult to attribute the next failure or improvement. If commercial pressure requires several changes together, the review should treat the bundle as a new validation candidate with a fresh baseline.

Volume incentives must not erase the conditions that made the pilot acceptable. OECD guidance identifies inefficient production planning and poor purchasing practices among common factors associated with excessive working hours in garment supply chains. [S28] The scale review should therefore examine overtime, unplanned subcontracting, late specification changes and recovery hours beside delivery and contribution. An increase in accepted output achieved by transferring hidden strain to workers or suppliers is not evidence that the original service promise can be repeated responsibly.

14.5

Advanced customisation needs its own validation

The illustrative Phase 3 is not an automatic consequence of earlier sales. It is a separate technical and operational pilot for capabilities whose failure modes differ from a stable repeat service. Parametric patterns can make selected dimensions and construction relationships programmable, while image-to-pattern research explores the recovery of sewing structure from visual input. Neither result authorises automatic production. The earlier service evidence remains useful only where the material, pattern logic, construction, customer specification and physical approval route remain equivalent.

GarmentCode makes valid sewing patterns central to accurate digital simulation and eventual fabrication. [S32] That supports a controlled investigation of parametric components, not a presumption that every parameter combination is manufacturable. A supervised pilot should define which dimensions may vary, their permitted relationships, the construction details that must remain fixed and the patternmaker's review obligations. Each generated candidate needs dimensional readback, seam compatibility, grain and notch checks, and the physical evidence required by its risk. An out-of-range request should stop rather than force the software to produce an answer.

Image-derived patterns create an additional provenance problem. Sewformer research proposes a two-level Transformer network for sewing-pattern prediction from a single image. [S33] A source image does not, by itself, reveal every hidden seam, internal component, material property or construction intention. The research candidate therefore needs human reconstruction of missing design decisions before it can become a technical pack. The validation record should separate what the image showed, what the system inferred and what a patternmaker or buyer approved. Those are different evidence objects with different failure responsibility.

The illustrative Phase 3 test set should include held-out cases rather than only examples used to configure the model. It should cover the intended range of shapes, sizes, artwork and construction complexity, with failures retained in the denominator. Evaluation should compare the generated package with a competent conventional route on equivalent approved outcomes, including correction labour and residual physical iterations. A visually plausible result that requires extensive silent repair has not reduced development work. Its repair belongs in the measured workflow.

Automatic release should remain prohibited in this proposed framework. A responsible technical role must reconcile the generated pattern, customer specification, material route and physical garment evidence before production. The system should also provide a usable manual fallback and preserve the prior approved version. If a model or software update changes outputs, the team needs a recorded revalidation decision rather than allowing the update to rewrite the production baseline unnoticed.

Commercial permission is equally specific. The service must know whether it may reproduce an uploaded image, retain body or garment measurements and reuse a generated design. Those questions require clear customer terms and qualified review of applicable obligations; they cannot be solved by a model confidence score. The

illustrative Phase 3 expands only when its technical, physical, information and permission gates all pass. Otherwise the proven Phase 2 service should continue without the advanced option.

14.6

GFT would measure the same outcomes across every phase

The scorecard in this illustrative roadmap should change in use, not in definition, as the service advances. During Phase 0 it exposes missing records and baseline uncertainty. During Phase 1 it shows whether the physical route and fulfilment controls hold. During Phase 2 it reveals repeatability, retained-order economics and capacity strain. During Phase 3 it makes correction work and new failure modes visible. Stable definitions allow those comparisons; different review questions prevent one summary metric from carrying every decision.

Exhibit 57, p. 216 defines the illustrative measurement dictionary. Each measure needs a numerator, denominator, source record, accountable role and observation window. Baseline fields and acceptance thresholds remain deliberately unfilled because no local pilot observations have been established. A threshold should be agreed against buyer requirements, process variability and the decision at stake, not borrowed from a vendor demonstration or an unrelated study.

EXHIBIT 57 / ILLUSTRATIVE METRIC DICTIONARY

The adoption scorecard must show numerator and denominator

Measure	Numerator and denominator	Accountable role	Review and gate use
Physical iterations per approved style	All physical iterations, including failures, divided by approved styles	Technical development	Style cohort; compare complete development routes
Development hours per approved style	End-to-end development and correction hours divided by approved styles	Product development	Weekly and cohort; include digital and physical work
First physical approval incidence	Styles passing at first physical review divided by styles physically reviewed	Quality and pattern review	Cohort; diagnose by cause, never pursue as a quota
Retained-order contribution	Net retained sales less defined order costs, summed and shown per retained order	Commercial and operations	After return window; economic scale gate
Accepted units per staffed hour	Accepted garments divided by staffed hours on the complete route	Production	Daily and weekly; practical-capacity review
Delivery against original promise	Orders delivered by original promise divided by orders due	Fulfilment	Weekly; report approved amendments separately
Reprints and returns	Reprints divided by starts; returned orders divided by dispatched orders	Quality and fulfilment	Weekly and monthly; keep causes separate
Water per accepted garment	Allocated process water divided by accepted garments	Operations and sustainability	Defined period and process boundary; reconcile meters

ILLUSTRATIVE [S17] [S18] [S26] [S28] Illustrative GFT scorecard extending the programme's stable-definition, source-capture and review discipline. Baselines and thresholds must be agreed from local requirements and observations. Resource intensities are operational measures within stated boundaries, not product-footprint claims. No measured values or universal pass grades are supplied.

EXHIBIT 58 / ILLUSTRATIVE METRIC DICTIONARY

The adoption scorecard must show numerator and denominator, continued

Measure	Numerator and denominator	Accountable role	Review and gate use
Energy per accepted garment	Allocated process energy divided by accepted garments	Operations and maintenance	Include startup, idle and recovery states
Evidence reconciliation	Orders with complete required records divided by orders due for review	Performance-system owner	Every gate; incomplete evidence blocks expansion

ILLUSTRATIVE [S17] [S18] [S26] [S28] Illustrative GFT scorecard extending the programme's stable-definition, source-capture and review discipline. Baselines and thresholds must be agreed from local requirements and observations. Resource intensities are operational measures within stated boundaries, not product-footprint claims. No measured values or universal pass grades are supplied.

Physical iterations and development hours belong together. A falling sample count can conceal growing digital correction, repeated buyer review or downstream remakes. First physical approval adds diagnostic value, but it should not become a target that pressures reviewers to accept weak work. The useful reading is by material, construction, style novelty and failure cause. A low incidence may identify a correctable preparation problem; an unusually high incidence with little recorded revision may identify missing evidence rather than excellent development.

Accepted units per staffed hour must use the complete route and a consistent staffing boundary. Printer runtime alone would omit preparation, curing, cutting, sewing, inspection and recovery. The staffing denominator should say whether indirect quality, maintenance and fulfilment hours are included, then keep that rule across compared periods. Delivery against the original promise should not be rewritten after a missed date. If the buyer agrees to an amendment, the original and amended outcomes can both be reported, but they remain different events.

Reprints and returns also need separate denominators and cause codes. A reprint concerns production recovery before the order closes; a return concerns the buyer or service outcome after dispatch. Both can consume material and capacity, and neither should disappear inside a general yield percentage. The review should connect their causes to a controlled change in specification, process, supplier or service terms. Resource measures need the same connection to physical work. IFC guidance supports attention to drying, curing and unsettled operating conditions, so startup, idle and recovery states should not be trimmed from the observed energy boundary. [S17]

Water and energy per accepted garment are operational intensities, not complete environmental conclusions. The historical Printscorpio case shows that batch and lifetime conditions can change a printing comparison and that its results belong to a particular system boundary. [S26] The scorecard should therefore publish the meter or allocation origin, process stages, accepted-output denominator and observation period beside every intensity. It should not turn those fields into a claim of national savings, low total impact or improved garment service life.

Review cadence should follow the decision. Source records are checked as events occur. Production, quality and recovery exceptions belong in short operational reviews. Cohort development, retained-order economics, resource reconciliation and working-hour risks belong in period and gate reviews. IFC's management-system guidance supports prioritised risk treatment, while OECD guidance keeps planning and purchasing consequences inside the responsible-operation review. [S18] [S28] A dashboard supports that cadence only when every displayed number can be traced to its source rows.

The performance-system owner should issue a metric dictionary version whenever a definition changes. Historical results must retain the old definition or be recalculated transparently where source data permit. If a denominator cannot be reconstructed, the series break should be visible. GFT would rather show a missing baseline than populate it with a target borrowed from another operation. Evidence maturity is itself a pilot result: the team learns whether its proposed measures are collectible, intelligible and capable of changing a decision.

14.7

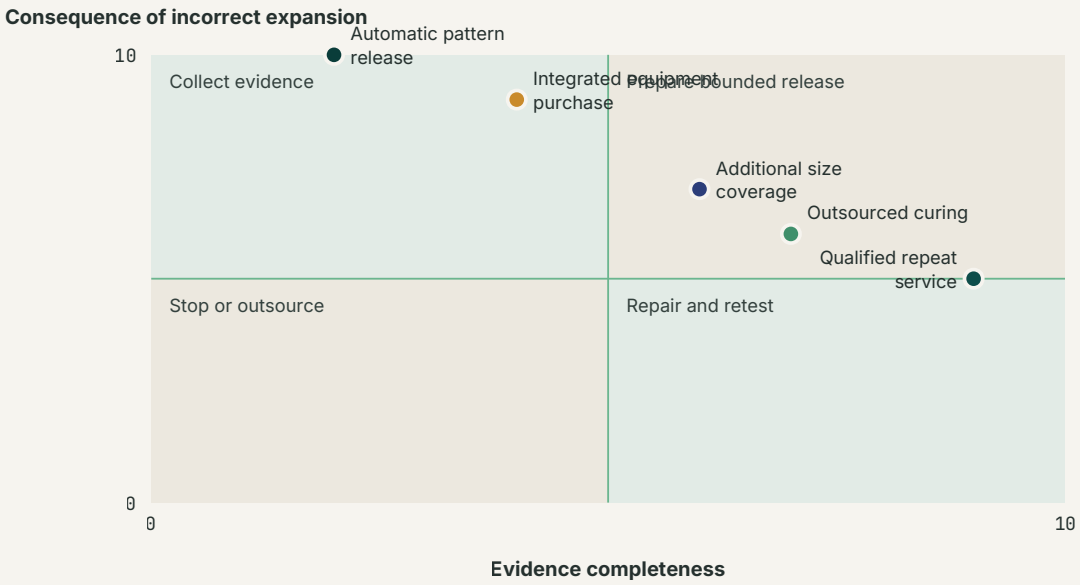
A bounded decision is the final recommendation

The gate review should choose among proceed, narrow, repair and retest, outsource and stop. These are different decisions with different evidence. A fit or care failure blocks the affected physical route even when its economics appear favourable. [S07] A support gap may justify outsourcing while internal capability is repaired. Negative retained-order contribution calls for price, product, process or service-boundary diagnosis. Delivery failure calls for capacity and purchasing review, not a larger sales target. Missing or irreconcilable evidence blocks every expansion claim. Risk prioritisation should direct corrective action rather than determine how much uncertainty to hide. [S18]

Exhibit 59, p. 219 is an illustrative screening device, not a calculated risk score. It positions candidate decisions by the completeness of their evidence and the consequence of expanding without it. The detailed gate record remains decisive: no coordinate can override a failed physical, safety or working-condition requirement.

EXHIBIT 59 / ILLUSTRATIVE REVIEW POSITIONS FROM 0 TO 10

A failed gate changes the decision



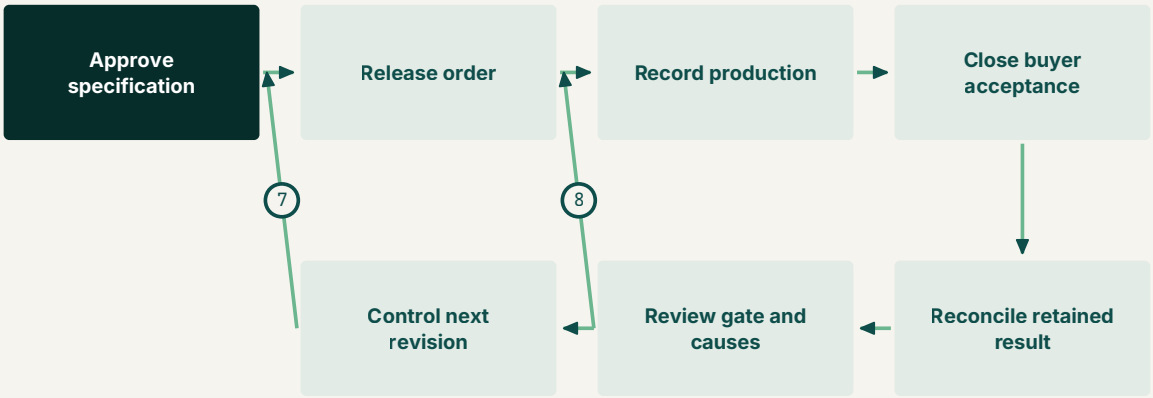
ILLUSTRATIVE [S07] [S18] [S28] Illustrative GFT review positions, not measurements or probabilities. Horizontal position is completeness of the required evidence, where 0 is absent and 10 is complete. Vertical position is the consequence of an incorrect expansion decision, where 0 is low and 10 is high. Actual proceed, narrow, repair, outsource or stop choices require the named gate records.

The final recommendation is a decision record tied to one qualified product family. It should state the approved scope, baseline, evidence period, gate results, contribution and cash boundaries, unresolved risks, named owner and next review trigger. It should also preserve the option to stop or outsource without treating that outcome as failure. Material, supplier, order-mix or service-promise changes reopen the relevant evidence rather than inheriting the previous approval automatically.

Exhibit 60, p. 220 closes the illustrative operating loop. The next order uses a controlled revision, not an informal collection of lessons. Buyer acceptance and retained-order results return to the same specification and performance records that authorised production.

EXHIBIT 60 / ILLUSTRATIVE GFT CONTROL SEQUENCE

The next order closes the learning loop



7. Next order

8. Repeat only if unchanged

ILLUSTRATIVE [S03] [S18] Illustrative GFT learning and corrective-action loop extending the programme's source-capture and staged-adoption discipline. No deployed software, elapsed time or achieved result is asserted.

WARNING

Local quotations, demand, supplier support, physical performance, accepted-output costs and resource readings remain to be collected through the proposed protocols. Financing, legal, tax, employment, privacy, customs, contract and compliance questions require qualified advisers. This chapter is an operational decision framework, not investment, legal or tax advice.

GFT would proceed only with the smallest service whose physical quality, fulfilment, retained-order economics and evidence reconciliation pass together. Expansion then follows measured repeatability, one bounded change at a time. If those conditions fail, the accountable decision is to narrow, repair, outsource or stop before commitment grows.

Scale the evidence that survives the next order, not the promise made before it.

CHAPTER SOURCE NOTES

S03 The Korean Fashion and Textile Research Journal. 2025-12-31.

S31 Epson America. 2026.
S18 International Finance Corporation. 2014.
S07 3DBODY.TECH conference proceedings. 2020.
S10 International Organization for Standardization. 2010.
S11 International Organization for Standardization. 2016.
S12 International Organization for Standardization. 2021.
S17 International Finance Corporation, World Bank Group. 2007-04-30.
S28 Organisation for Economic Co-operation and Development. 2018.
S32 arXiv, Korosteleva and Sorkine-Hornung. 2023-06-06.
S33 arXiv, Liu and co-authors. 2023.
S26 VTT Technical Research Centre of Finland. 2014.

Provenance travels with the claim.

Available inherited records and all chapter-local source records are graded below. Identical source identities are consolidated without losing citation aliases. Missing annex references are excluded. Unrecorded dates are disclosed rather than invented.

R01 Inherited evidence R01 GRADE C

Business in Cameroon. Publication date unrecorded. businessincameroon.com

Source metadata retained for traceability. This entry is not cited in the chapter text.

Inherited source-text check; original source not independently re-opened for this edition.

R02 Inherited evidence R02 GRADE C

Fibre2Fashion; Business in Cameroon. Publication date unrecorded. fibre2fashion.com; businessincameroon.com

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Inherited source-text check; original source not independently re-opened for this edition.

R03 Inherited evidence R03 GRADE C

SODECOTON. Publication date unrecorded. sodecoton.cm

Company profile: more than 220,000 cotton producers supported in northern Cameroon; nine ginning plants; two oil mills.

Inherited source-text check; original source not independently re-opened for this edition.

R04 Inherited evidence R04 GRADE C

Financial Fortune Media. Publication date unrecorded. financialfortunemedia.com

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R05 Inherited evidence R05 GRADE C

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R06 Inherited evidence R06 GRADE C

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About 95 percent of cotton fibre exported raw against 5 percent processed locally; industrialisation target of 50 percent local processing.

Inherited source-text check; original source not independently re-opened for this edition.

R07 Inherited evidence R07 GRADE C

Ecofin Agency. Publication date unrecorded. ecofinagency.com

SND30 restates the 50 percent local-processing target by 2030.

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R08 Inherited evidence R08 GRADE C

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R14 Inherited evidence R14 GRADE C

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Cameroon minimum wage (SMIG) XAF 41,875 a month in 2023, raised to XAF 43,969 a month from 23 February 2024, about US$76, a rise of 5 percent.

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R15 Inherited evidence R15 GRADE C

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Average salary across sectors in Cameroon about US$359 a month.

Inherited source-text check; original source not independently re-opened for this edition.

R16 Inherited evidence R16 GRADE C

WageIndicator. Publication date unrecorded. wageindicator.org

Informal share of employment about 90 percent; standard 40-hour week, 48-hour maximum, overtime at 1.2 times.

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R17 Inherited evidence R17 GRADE C

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Africa textile market about US$37.3 billion in 2025, projected US$49.41 billion by 2030 at 4.73 percent a year.

Inherited source-text check; original source not independently re-opened for this edition.

R25 Inherited evidence R25 GRADE C

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Africa textile market to about US$72.7 billion by 2035 at 6.9 percent a year; fashion and apparel 48.1 percent of the market in 2024.

Inherited source-text check; original source not independently re-opened for this edition.

R26 Inherited evidence R26 GRADE C

Statista. Publication date unrecorded. statista.com

Cameroon clothing and footwear spend about US$94.70 a person in 2024 and about 8.0 pieces a person; apparel eCommerce revenue US$20.32 million (2023) to US$33.61 million (2027) at 13.41 percent a year; user penetration 18.0 percent (2023) to 22.7 percent (2027).

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R27 Inherited evidence R27 GRADE B

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R28 Inherited evidence R28 GRADE C

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R31 Inherited evidence R31 GRADE C

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c02-S09 Same source record as c01-S09.

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c03-S02 Same source record as c02-S02.

c03-S03 Same source record as c02-S03.

c03-S09 Same source record as c01-S09.

c03-S10 Same source record as c01-S10.

c03-S11 Same source record as c02-S11.

c03-S12 Same source record as c02-S12.

c03-S15 Same source record as c01-S15.

c03-S17 Same source record as c01-S17.

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Stable definitions make comparisons useful.

Accepted output

Garments that meet the agreed release or acceptance definition; distinguish internal release from buyer acceptance.

Anthropometry

Measurement of human body dimensions using stated landmarks and procedures.

Approval bundle

Controlled collection of design, pattern, material, fit, colour and test decisions used to release an order.

Avatar

Digital body representation used for garment simulation; its dimensions and shape coverage must be stated.

Bias

Fabric direction oblique to the principal yarn directions, with potentially different deformation behaviour.

Bill of materials

Versioned list of the materials, trims and consumables specified for an article.

Blank

Unprinted ready-made garment held for subsequent decoration or finishing.

Colour fastness

Resistance of a textile colour to a specified treatment or use condition; the method and assessment must be named.

Colour gamut

Range of colours reproducible by a stated device and material process under defined conditions.

Contribution

Net retained revenue less the variable and order-specific costs defined by the chosen model.

Cure

Process used to achieve the required ink, binder or adhesive state; conditions depend on the specified system.

Customer-order decoupling point

Point at which production becomes committed to a particular customer order rather than a forecast.

Digital material

Software representation of a physical fabric, including visual and mechanical properties relevant to its intended use.

Digital sample

Virtual garment used for a stated review task, with known inputs and limits.

Direct-to-film printing

Decoration route that prints onto film and transfers the prepared design onto a garment using an appropriate adhesive and heat process.

Direct-to-garment printing

Inkjet deposition directly onto a garment, with preparation and curing appropriate to the selected system.

Distance ease

Separation between a garment and the underlying body at specified locations and poses.

Drape

Configuration assumed by a fabric under gravity and other stated boundary conditions.

Engineered print

Artwork positioned in relation to specific garment panels, seams or body locations.

Fabric grain

Principal direction of a fabric used to orient pattern pieces and control behaviour.

First physical approval

Acceptance of the initial physical sample against the pre-agreed criteria, without concealing revisions.

Functional unit

Quantified service or output against which an environmental comparison is expressed.

Grading

Development of related garment pattern sizes according to a defined rule set and intended fit.

Hand feel

Tactile perception of fabric or print, which requires an appropriate physical assessment.

Held-out validation

Evaluation using cases excluded from calibration and workflow adjustment.

ICC profile

Colour-management data describing a device or colour-space transform for a stated workflow.

Idempotent job release

Proposed control in which retrying a release request does not create an additional production job.

Marker

Arrangement of pattern pieces on fabric for cutting, including direction and placement constraints.

Mass customisation

Delivery of bounded product variations through a repeatable production system.

Manufacturing restricted substances list

List governing specified substances in chemical formulations used during manufacture; distinguish it from finished-product restrictions.

On-demand manufacturing

Production triggered by confirmed demand under an explicitly defined order-commitment policy.

Particle distance

Simulation-resolution setting whose meaning and effect depend on the software implementation.

Physical sample

Material garment or swatch used to test defined construction, fit, appearance or performance requirements.

Pigment printing

Colouration route that attaches insoluble colourants through an appropriate binding system.

Postponement

Delaying a product-specific production commitment until additional demand or specification information is available.

Pre-treatment

Preparation applied before printing to achieve required process and print behaviour.

Reactive printing

Use of reactive dyes with a compatible fibre and fixation and washing process.

Raster image processor

Software that converts artwork into the data and process instructions required by the printing system.

Retained order

Order whose net commercial outcome is measured after the defined cancellation, refund and return window.

Strike-off

Printed material sample used to assess and approve an artwork and process combination.

Sublimation transfer

Transfer printing route in which a suitable disperse dye moves under heat into a compatible substrate.

Technical pack

Controlled production specification including patterns, dimensions, construction, materials, artwork and approvals.

Warp and weft

Principal yarn systems of a woven fabric; their distinct properties must not be lost in simulation inputs.

Yield

Accepted output divided by starts or another expressly stated input denominator; different yield definitions must remain separate.

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Production is the warp. Measurement is the weft.

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