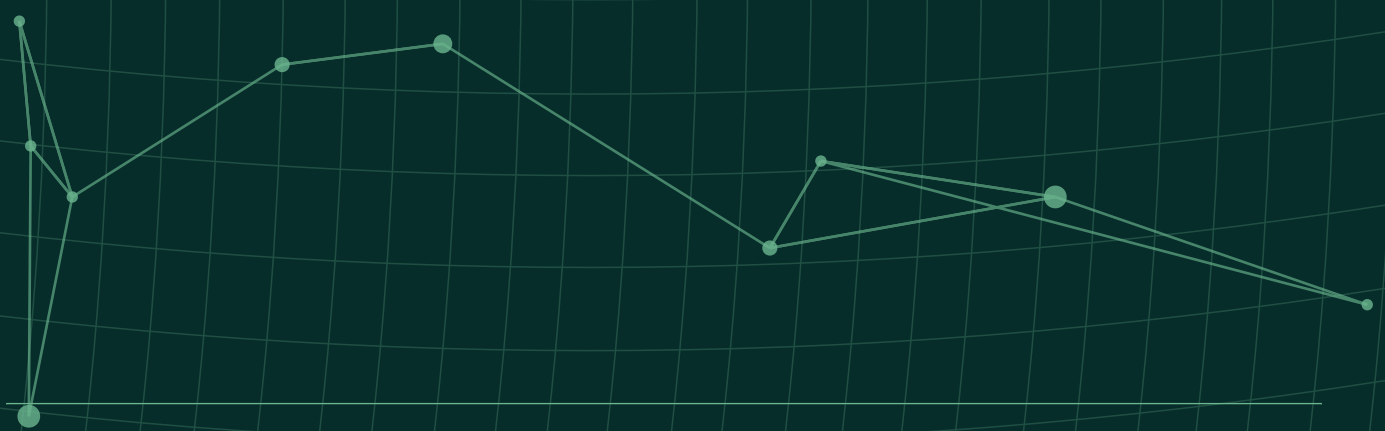
GREEN FUTURE TECH
LIMITED / HONG KONG SAR

GFT RESEARCH / WARP AND SIGNAL

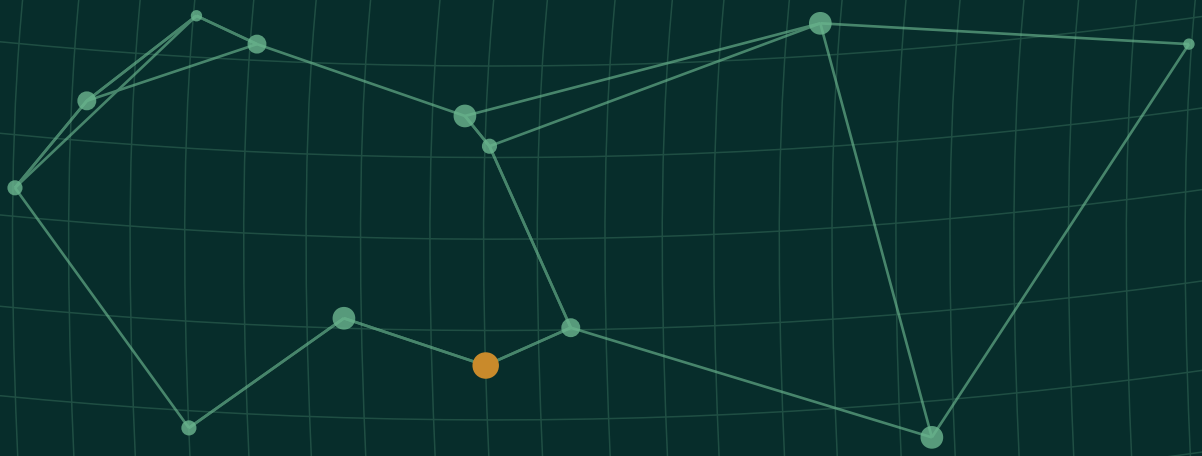
Measure Before You Model

Performance-management systems for greenfield garment factories, from the first shift



wp02
RESEARCH EDITION

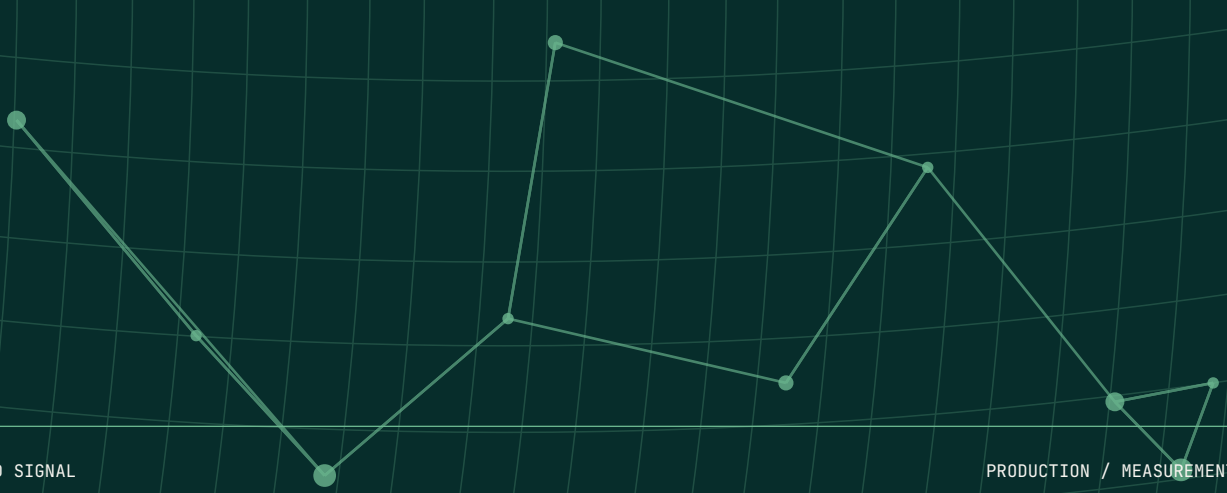
EDITION 2026-10-30
HONG KONG SAR



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.

ISSUER	Green Future Tech Limited, Hong Kong SAR
DOCUMENT	wp02 / Measure Before You Model
EDITION DATE	2026-10-30
AUDIENCE	Sponsors and boards of greenfield garment factories, Plant directors and operations managers, Industrial engineering, production and quality leaders, Human-resources, sustainability and digital teams, Development and technical partners assessing operating readiness
STATUS	Research edition. Generated locally. Publication and operating-performance acceptance are separate decisions.
PROGRAMME	GFT's Cameroon textile programme: feasibility, performance-management system design and digital strategy. Prepared 31 January 2024; source-refresh annotations retained in 2026.

IMPORTANT NOTICE

This document is not investment, legal or tax advice. Proposed controls and illustrative calculations require project-specific validation. Targets and announced third-party projects are not evidence of delivered operating performance.

The confidential programme PDFs are not reproduced or published. No client identity or engagement code is included.

EVIDENCE REMAINS GRADED

A: official. B: institutional or major research. C: trade or local press and market-research vendors. D: unverified; excluded from use. A grade describes the supplied register and does not certify accuracy.

Inherited publication dates unrecorded: R06, R07, R10, R12, R14, R15, R16, R17, R27, R28, R29, R32. Temporal eligibility is unverified; these are inherited source-text checks, not independent source validation.

The operating case runs from fibre to feedback.

01 / The first shift must make evidence as well as garments 15

1.1 / A greenfield line begins with uncertainty, not a stable average 16

1.2 / The local-processing gap raises the cost of weak operating control 19

1.3 / The earliest records become the factory's institutional memory 20

1.4 / Measurement serves decisions rather than reporting volume 22

1.5 / Sustainability claims inherit the quality of factory records 25

1.6 / GFT's position is capture before model 26

1.7 / The paper follows the path from definition to verified value 27

02 / Ramp-up is a learning system, not a reduced steady state 29

2.1 / Yield and speed must be managed as joint outcomes 30

2.4 / A baseline is a dated population, not a single number 32

2.7 / Learning curves need comparable work and explicit resets 34

2.9 / Skill retention belongs on the ramp agenda 36

2.12 / Supervisor practice turns classroom content into line capability 37

2.15 / Training claims require a counterfactual or a cautious label 39

2.18 / Targets should widen where evidence is thin 41

03 / A KPI cascade succeeds only when the line can act on it 46

3.1 / Strategic outcomes determine what not to measure 47

3.2 / Six families prevent one dimension from dominating 49

3.3 / The line receives measures it can influence 50

3.4 / One owner protects definition and action 52

3.5 / Targets need a basis, a horizon and a review rule 54

3.6 / A purely top-down scorecard can miss local knowledge 55

3.7 / Trade-offs belong in the same review 57

04 / A metric is not a measurement until its error is understood 59

4.1 / The data dictionary begins with formula and unit 60

4.2 / Good output needs an unambiguous counting event 62

4.3 / Structured records need explicit quality dimensions 64

4.4 / Time and identity prevent false comparisons 65

4.5 / Measurement variation can mimic process variation 66

4.6 / A control limit is not a specification or a target 69

4.7 / Definition changes require versioned migration 71

05 / Production measures must expose losses, not compress them 73

5.1 / Nameplate capacity is not saleable throughput 74

5.3 / OEE retains its three components 77

5.5 / Aggregated downtime hides the action required 79

5.7 / Performance loss needs a work-content reference 81

5.9 / The quality factor counts only accepted production 82

5.11 / A score without an improvement loop stalls 84

5.13 / Source data can test the manual record 86

06 / Quality improves when defects become structured evidence 89

6.1 / First-pass yield excludes correction 90

6.3 / The denominator determines what yield means 92

6.5 / A defect taxonomy must support action 94

6.7 / Rework is a separate production flow 96

6.9 / SPC separates signals from routine variation 98

6.11 / Inspection itself requires measurement-system checks 100

6.12 / Vision is an input to the quality system, not its replacement 102

07 / Delivery reliability begins with measured work content and flow 105

7.1 / Standard minutes describe a method, not a universal truth 106

7.2 / Capacity must be expressed in comparable work content 107

7.3 / Balancing continues after the plan is issued 109

7.4 / WIP age reveals problems that output totals miss 110

7.5 / OTIF needs a promise and a receipt event 112

7.6 / Lead-time decomposition locates the delay 114

7.7 / S&OP reconciles demand with demonstrated capability 115

08 / Effective labour cost joins productivity with capability and fairness 119

8.1 / Cost per good garment is the controlling labour measure 120

8.4 / The skill matrix records demonstrated operations 123

8.6 / Supervisor capability is a measurable production asset 125

8.8 / Training transfer needs workplace practice 126

8.10 / Attendance and working time constrain sustainable output 128

8.12 / Incentives should reward controllable quality as well as output 130

8.14 / Targets require voice and a correction route 133

09 / Per-unit sustainability starts with boundaries and meters 137

9.1 / The inventory boundary precedes the footprint 138

9.2 / Energy indicators can be absolute, relative or modelled 139

9.3 / Metering follows the energy-use map 141

9.4 / Water withdrawal, discharge and consumption are not interchangeable 143

9.5 / Waste needs composition and destination 144

9.6 / Emissions factors belong to a declared accounting layer 146

9.7 / Normalisation explains intensity without excusing absolute impact 149

10 / One governed record should serve the shift and the model 152

10.1 / The minimum data model follows work events 153

10.2 / Capture at source reduces reconstruction 155

10.3 / Master data keeps history comparable 156

10.4 / The system of record is an accountability before it is software 158

10.5 / Quality controls sit at capture and roll-up 160

10.6 / Shared vocabularies make later integration cheaper 162

10.7 / Local operation must survive weak connectivity 163

11 / A fixed cadence turns measures into owned decisions 166

11.1 / The daily huddle protects the current shift 168

11.5 / Visual control shows exceptions and ownership 171

11.8 / The weekly review closes recurring problems 173

11.11 / Monthly S&OP reconciles families rather than individual tickets 175
11.14 / Escalation follows decision rights, not hierarchy for its own sake 178
11.17 / The action log is the memory between meetings 181
11.19 / Meeting quality itself needs review 183

12 / Improvement closes only when the cause and result are verified 186

12.1 / Problem selection begins with a measurable gap 188
12.4 / Common and special causes require different responses 190
12.7 / A3 makes the reasoning inspectable 191
12.10 / Root causes compete until evidence discriminates 194
12.13 / Countermeasures need an operational owner 196
12.16 / Verification tests effect and unintended consequences 197
12.19 / Standardisation preserves the gain 201

13 / Maturity gates stop digital ambition outrunning discipline 204

13.1 / Maturity spans behaviour as well as technology 205
13.4 / Clean manual capture is the first digital asset 207
13.7 / Active management is a separate gate 208
13.9 / History-dependent models wait for usable history 210
13.11 / MLOps can grow in stages 213
13.13 / Architecture must respect the site's constraints 215
13.15 / Governance persists through platform migration 217

14 / The first eighteen months install a system that can prove value 220

14.1 / Approve the operating contract before the first shift 221
14.3 / Months one to three establish clean capture 224
14.5 / Months four to eight make the cadence routine 225
14.8 / Months nine to twelve prove the improvement loop 227
14.10 / Months thirteen to eighteen connect approved digital uses 229
14.12 / The benefits register separates movement from attribution 231
14.14 / The board measures system health as well as factory output 235

Executive summary 13
Evidence register 239
Glossary 266
Term index 269
Method and imprint 271

Every exhibit states a testable claim.

EXHIBIT 01 / stacked
Accepted output can conceal the work needed to recover quality 18

EXHIBIT 02 / bar
The processing gap makes operating evidence strategically important 19

EXHIBIT 03 / table
The first-shift register joins evidence to an immediate use 21

EXHIBIT 04 / flow
A measure earns its place only when it leads to an owned decision 23

EXHIBIT 05 / matrix
Six families connect the business case to the line 24

EXHIBIT 06 / line
A useful ramp view separates output, yield and competence 31

EXHIBIT 07 / table
Every ramp baseline requires a dated cohort header and a reset rule 35

EXHIBIT 08 / dumbbell
Training evaluation must show the comparison behind the effect 40

EXHIBIT 09 / matrix
Leading learning signals sit beside lagging production results 41

EXHIBIT 10 / range
Review bands narrow only as cohort stability and sample size grow 42

EXHIBIT 11 / flow
A useful cascade ends in a permitted response 48

EXHIBIT 12 / matrix
Signal timing and metric category answer different questions 50

EXHIBIT 13 / hbar
An unchanged gross count can conceal an accepted-output shortfall 52

EXHIBIT 14 / table
The accepted-output charter names the decision and its limits 53

EXHIBIT 15 / layered-architecture
Escalation follows the scope of the decision 57

EXHIBIT 16 / table
The metric contract makes independent calculations reconcilable 61

EXHIBIT 17 / waterfall
A count reconciliation preserves unfinished and corrected work 63

EXHIBIT 18 / heatmap
A control map locates the hand-off that still needs evidence 65

EXHIBIT 19 / range
Equal central results can conceal different observer variation 68

EXHIBIT 20 / flow
Measurement-system evidence gates consequential target use 69

EXHIBIT 21 / bar
Reported plant utilisation in Cameroon shows why headline capacity requires loss decomposition 75

EXHIBIT 22 / waterfall
The path from scheduled time to good output retains every loss 77

EXHIBIT 23 / small-multiples
The OEE composite must travel with its components 78

EXHIBIT 24 / hbar
Downtime causes point to different owners 80

EXHIBIT 25 / table
Each production loss component requires a fixed boundary, denominator and owner 84

EXHIBIT 26 / dumbbell
First-pass yield and flow should be evaluated together 91

EXHIBIT 27 / table
Distinct yield denominators reveal hidden rework that final acceptance conceals 94

EXHIBIT 28 / hbar
A defect ranking should preserve operation and mechanism 96

EXHIBIT 29 / line
Control limits direct attention to unusual variation 99

EXHIBIT 30 / range
Reported inspection accuracy ranges show why human and automated checks need calibration 101

EXHIBIT 31 / table
Piece counts hide a heavier style mix until work content is calculated 107

EXHIBIT 32 / hbar
Operation work content reveals the constraint before pieces move 109

EXHIBIT 33 / waterfall
Queues and rework dominate an illustrative order lead time 111

EXHIBIT 34 / keyfigures
OTIF reconciles the due-order population with fulfilled promises 113

EXHIBIT 35 / flow
Order timestamps separate queue, touch and rework time 114

EXHIBIT 36 / gantt
The monthly plan uses demonstrated rather than nameplate capability 117

EXHIBIT 37 / table
Identical base wages yield different unit costs once losses are reconciled 121

EXHIBIT 38 / heatmap
Skill coverage exposes the next staffing constraint 124

EXHIBIT 39 / dumbbell
Training evidence needs a comparison group and a local retest 127

EXHIBIT 40 / bar
Nominal monthly wage benchmarks span a wide range before productivity is measured 129

EXHIBIT 41 / matrix
Incentive design must test outcome control and side effects 132

EXHIBIT 42 / table
Each textile process needs its own physical denominator 141

EXHIBIT 43 / sankey
Material records must connect accepted product, residual streams and destinations 146

EXHIBIT 44 / keyfigures
An integrated garment-chain result is a case, not a transferable target 148

EXHIBIT 45 / small-multiples
Absolute electricity and electricity per good garment can move differently 150

EXHIBIT 46 / layered-architecture
The data spine separates work events, authoritative records and decisions 154

EXHIBIT 47 / table
Every critical entity has an authoritative record and a change owner 158

EXHIBIT 48 / waterfall
Duplicate retries and invalid records must not inflate the authoritative population 161

EXHIBIT 49 / flow
Offline capture reconciles without duplicating work history 164

EXHIBIT 50 / matrix
Each cadence has a distinct horizon and authority 168

EXHIBIT 51 / keyfigures
The line board pairs results with causes and responses 172

EXHIBIT 52 / waterfall
Monthly S&OP reconciles nameplate time to deliverable family capacity 178

EXHIBIT 53 / table
Every review forum has a fixed charter, input contract and decision boundary 179

EXHIBIT 54 / flow
Escalation ends in a verified decision 181

EXHIBIT 55 / flow
The improvement loop ends at a revised standard 188

EXHIBIT 56 / table
Each improvement link has its own evidence and closure test 193

EXHIBIT 57 / heatmap
Competing root causes are scored against discriminating evidence tests 195

EXHIBIT 58 / line
A before-and-after claim needs comparable populations 198

EXHIBIT 59 / waterfall
Verified benefit reconciles gross movement to operating effect 200

EXHIBIT 60 / matrix
Five domains must advance together 206

EXHIBIT 61 / flow
A use case passes evidence gates before build 211

EXHIBIT 62 / layered-architecture
Initial MLOps controls precede pipeline automation 214

EXHIBIT 63 / table
Build-against-buy includes exit and offline tests 216

EXHIBIT 64 / gantt
Four gated stages sequence the eighteen-month rollout 223

EXHIBIT 65 / flow
Each roadmap stage hands an audited asset to the next gate 227

EXHIBIT 66 / table
The benefits register makes every claim auditable 232

EXHIBIT 67 / keyfigures
The board sees operating results and system health together 236

Build the factory and its evidence as one system.

A greenfield garment factory has no operating history, yet its first shifts create the evidence on which every later forecast, investment case and sustainability claim will depend. This paper argues that the performance-management system must therefore start with production, not arrive after it. GFT's position is simple: capture a small set of well-defined measures at the point of work, review them on a fixed cadence, and add digital models only when the underlying records are complete enough to support them. The paper builds a measurement architecture for a new cut, make, trim and finishing operation. It connects strategic outcomes to six families: production, quality, delivery, cost, people and sustainability. It defines the operational data behind each family, including good output, downtime, first-pass yield, standard minutes, on-time-in-full delivery, effective labour cost, skills, energy, water and waste. It then specifies source capture, data ownership, measurement-system checks, visual control, daily and weekly reviews, monthly sales and operations planning, and a corrective-action loop. The final chapters sequence the first eighteen months from clean manual records to active management, structured improvement and a data-driven floor. The result is not a dashboard project. It is an operating discipline that makes performance visible, protects workers from poorly designed targets, and gives later machine-learning applications a defensible database.

01 Ramp-up must manage learning, yield and production rate together because a new process is initially poorly understood. [S11]

02 A KPI is not ready for a target until its formula, unit, time basis, owner and measurement error are explicit. [S01] [S23] [S40]

03 The scorecard should balance financial, behavioural and core-process measures, with both in-process and end-of-process indicators. [S02]

04 OEE is useful only when availability, performance and quality remain visible and downtime retains its causes. [S06] [S07] [S08]

05 First-pass yield belongs beside flow and lead-time measures because rework consumes capacity as well as quality. [S10]

06 Standard minutes require a specified method and qualified work, while line balancing remains a daily supervisor task. [S03] [S04]

07 Supervisor development and fair incentives are production controls, not peripheral human-resources activities. [S13] [S14] [S16] [S17]

08 Source capture needs governed master data, explicit quality checks and shared vocabularies before it can support later models. [S21] [S22] [S24] [S25]

09 Resource intensity is meaningful only with a declared boundary, a production denominator and separate withdrawal, consumption and disposal records. [S30] [S33] [S34] [S35] [S38]

10 Daily, weekly and monthly routines should reach maturity before history-dependent machine learning is introduced. [S27] [S28] [S42] [S44]

GREEN FUTURE TECH

LIMITED / HONG KONG SAR

01

PART I: THE MEASUREMENT CONTRACT / THE GREENFIELD PROBLEM

The first shift must make evidence as well as garments

A factory without an operating baseline cannot rely on hindsight, so GFT treats measurement as part of production from the outset.

CHAPTER 01
DECISION TEST

A factory without an operating baseline cannot rely on hindsight, so GFT treats measurement as part of production from the outset.

A greenfield garment factory should treat its first shift as the start of both production and evidence generation. The answer is not to postpone management information until output stabilises, nor to buy a model that promises to infer control. It is to record a small set of defined work events, preserve the conditions around them and use the resulting measures in owned decisions. GFT's position is capture before model: the line must learn to describe its own performance before any later analytical system can describe it credibly.

This principle does not require a heavy digital platform. A controlled manual record can be sufficient when its definitions, responsibilities and correction rules are clear. It does require measurement to be designed with the operation rather than added as a reporting burden. The first records will be imperfect and the process will change. Their value lies in making that change visible, comparable and open to challenge.

1.1

A greenfield line begins with uncertainty, not a stable average

A new line has no demonstrated steady state. Methods are still being translated into practice, operators are developing task-specific capability, supervisors are learning where work accumulates and machines are being adjusted to real materials. An average computed across these conditions is not a stable benchmark. It is a mixture of different learning conditions, and its apparent precision can conceal more than it explains.

Research on production ramp-up describes the underlying problem directly: while a new production process is ill understood, low yields and low production rates occur together. The same research analyses learning, capacity utilisation and quality as interacting outcomes rather than independent scores. [S11] Its principal models concern other manufacturing settings, so they do not supply a garment-factory ramp rate. They do support a transferable management caution: early output and early yield must be read as evidence about process understanding, not as two independent verdicts on effort.

The first shift therefore needs context beside quantity. A piece count should retain the style, operation, method revision, line, shift and counting boundary. Where the measure depends on individual or team work, the record should identify the relevant skill assessment and machine condition without turning a broad contextual field into an unsupported claim about personal capability. These attributes allow a later reviewer to ask whether two observations are comparable before calculating a trend.

Consider a daily average that combines a mature method on one style with a newly released method on another. The total may move even when neither cohort changes. A change in style mix can imitate improvement or deterioration. Recording the cohort does not eliminate this problem, but it makes the mixture visible and prevents the factory from treating compositional change as learning. The next chapter develops comparable ramp populations in detail; the requirement here is to preserve their raw material from the outset.

Speed needs the same discipline. Faster completion can coincide with more correction, longer queues or greater fatigue. The first record should therefore distinguish pieces started, pieces completed, first-pass good pieces and pieces requiring correction at a named boundary. A single production total cannot tell management whether the line became more capable or merely pushed more work through a weaker process. This is a measurement distinction, not yet a target-setting rule.

WORKED EXAMPLE: ONE SHIFT, THREE DIFFERENT ANSWERS

An illustrative shift presents a closed cohort of 1,000 distinct garments for end-of-line inspection. Of these, 820 are accepted without correction, 120 are accepted after rework and 60 remain rejected or pending a final disposition at the cut-off. Every garment has a recorded initial inspection outcome. These values are invented solely to demonstrate the counting method; they are not a forecast or an observed GFT result.

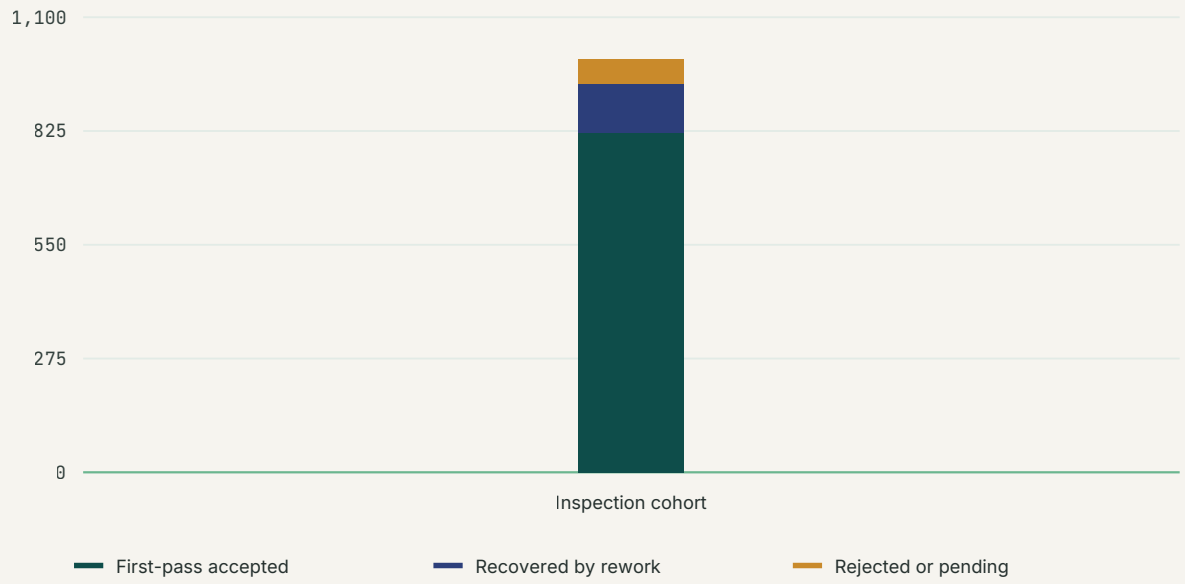
The illustrative first-pass yield is 820 divided by 1,000, or 82 percent. Final accepted output is 820 plus 120, or 940 garments, giving a final acceptance rate of 94 percent against the same starting population. Rework recovery is 120 divided by the 180 garments not accepted first time, approximately 66.7 percent. Each ratio answers a different question, and none should replace the others.

If the illustrative shift report contained only 940 accepted garments, it would hide the 120 garments recovered through rework and the remaining 60 unresolved outcomes. A recovered garment may have required several correction loops, so the recovered-piece count is not a count of rework events. If the report contained only the 82 percent first-pass yield, it would omit final recovery. The useful record retains the starting population, each disposition and the boundary time, so production and quality can reconcile their accounts before discussing causation.

Exhibit 1, p. 18 reconciles the illustrative cohort without treating pending work as scrap. The categories are mutually exclusive at the reporting cut-off; reinspection does not create another garment in the denominator.

EXHIBIT 01 / ILLUSTRATIVE GARMENTS IN A CLOSED INSPECTION COHORT

Accepted output can conceal the work needed to recover quality



ILLUSTRATIVE Assumed cohort: 1,000 distinct garments with recorded initial inspection outcomes. At cut-off, 820 first-pass accepted plus 120 accepted after rework plus 60 rejected or pending equals 1,000. Final accepted output is 940. Recovery counts garments, not correction events. Pending work is not assumed to be scrap.

The exhibit makes an accounting distinction rather than a causal claim. It cannot reveal why a defect arose, how long correction took or whether a pending garment will eventually pass. Those questions need event histories and follow-up. Management should retain the unresolved category until the later outcome is known and preserve the original close when it updates the record.

This reconciliation also protects the interpretation of missing work. A bundle that has not crossed the boundary is not automatically a rejected garment. A missing inspection entry is not evidence of a defect-free garment. The daily close should carry explicit categories for unfinished, uninspected and unrecorded work. Otherwise the denominator changes silently and a clerical gap becomes an apparent operating result.

Early targets should reflect this uncertainty. A target can direct attention to a desired condition, but it should not declare the initial average to be a reliable capacity baseline. During the earliest shifts, the more useful contract is to observe defined cohorts, test the measurement method and state what would count as evidence of learning. Tight comparison against an assumed steady state would reward the wrong behaviour and could discourage the recording of problems precisely when the factory most needs to see them.

1.2

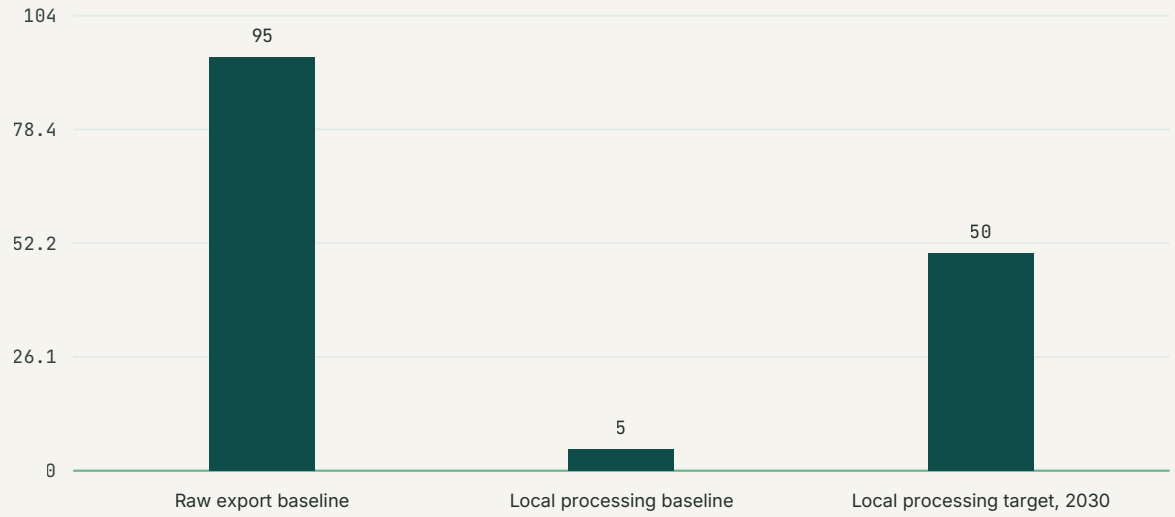
The local-processing gap raises the cost of weak operating control

The inherited evidence register records a substantial difference between Cameroon's cotton production and local transformation: about 95 percent of cotton fibre is exported raw and about 5 percent is processed locally. It also records a national ambition for 50 percent local processing by 2030, restated in the national development strategy. [R06] [R07] These are approximate sector observations and a policy target, with the original publication dates not recorded in the inherited register. They are not current GFT operating measures.

Exhibit 2, p. 19 places the baseline and the target beside one another without treating them as equivalent observations.

EXHIBIT 02 / PERCENT OF COTTON FIBRE

The processing gap makes operating evidence strategically important



SOURCED [R06] [R07] The first two values are approximate inherited baseline shares and sum to 100 percent. The third is a separate policy target for local processing by 2030, not an observed share or a factory sales forecast. Original publication dates were not recorded in the inherited register.

The exhibit shows the scale of the industrial proposition, not its commercial inevitability. Moving from raw export towards local processing requires more than additional equipment. Each added stage must convert inputs into accepted output under conditions that can be repeated, costed and improved. Weak operating control makes the gap harder to close because the organisation cannot locate where material, time and quality are lost.

The figures do not establish demand for any proposed garment factory. They say nothing by themselves about product specification, order size, customer eligibility, delivered cost or the route from national ambition to realised factory utilisation. This paper therefore does not convert the policy target into a sales assumption. It addresses a different question: if a greenfield operation is commissioned, what evidence must exist for its sponsors and managers to understand and govern production?

That distinction changes the design priority. A feasibility model can estimate a future operating condition from assumptions, but only actual records can test whether the condition has occurred. The first shift is where assumed work content meets observed work, where expected quality meets inspection outcomes and where planned resource use meets meter readings. A performance-management system should preserve those comparisons rather than overwrite the plan with an unexplained actual.

The strategic consequence is practical. Local value addition depends on learning that remains inside the operating organisation. If each problem is resolved through informal intervention and no durable record survives, the factory repeats the same uncertainty with each style and shift. If events, causes and responses are recorded consistently, the organisation can turn isolated corrections into reusable method knowledge.

> **GFT NOTE**
>
> GFT recommends that sponsors approve the measurement workstream as a production deliverable before launch. Its acceptance criteria should include defined source records, a counting-boundary reconciliation and named owners, alongside machinery and staffing readiness. The national processing ambition supplies context for this discipline, not evidence that a particular factory will achieve a particular return.

1.3

The earliest records become the factory's institutional memory

A factory remembers through its records or through the recollection of individuals. The second route is fragile during ramp-up. People change roles, methods are revised and the explanation for an unusual shift becomes difficult to reconstruct. A contemporaneous record preserves what was known at the time, including uncertainty. It allows a later team to distinguish an observed event from a story assembled after the result was already known.

Garment-floor research shows that source capture is technically feasible. One study describes RFID systems recording front-line production data every day in varied, small-batch garment production. [S19] Another uses power monitoring attached to sewing machines to collect consumption data remotely and extract working times for sewing tasks. [S20] These studies demonstrate possible sources of operational evidence. They do not establish that either technology is the correct starting point for every new factory, nor that a sensor stream automatically carries the right operational meaning.

The record must precede the capture device. Before selecting RFID, power monitoring or another input, management needs to state which event matters and how it will be used. A machine becoming active is not necessarily a garment becoming good. A tag crossing a reader is not necessarily a unit completing an operation. A power pattern

may support an inferred work interval, but the inference still needs validation against the actual method, product and quality outcome. Source capture reduces reconstruction only when the event definition is sound.

GFT would therefore begin with a disciplined manual record and automate fields where doing so improves timeliness or reduces demonstrated capture error. Manual does not mean informal. The sheet or lightweight application needs controlled identifiers, required fields, explicit cut-offs and a correction history. A blank entry should remain distinguishable from zero. A late entry should retain both event time and entry time. A corrected value should preserve its predecessor and reason rather than silently rewriting the shift.

Exhibit 3, p. 21 defines a practical minimum register. Its purpose is to connect each measure family to a source event and an immediate decision, not to prescribe an exhaustive data model.

EXHIBIT 03 / ILLUSTRATIVE GFT RECORD DESIGN

The first-shift register joins evidence to an immediate use

Family	Source event	Context retained	Immediate use
Production	Pieces cross a named boundary	Style, method, line, shift and disposition	Reconcile flow and locate interruption
Quality	Inspection records an outcome	Operation, defect, first-pass state and correction	Contain and investigate the failure
Delivery	Order reaches a promised milestone	Order, quantity, promise and actual event	Protect or revise the customer plan
Cost	Paid time and accepted output close	Direct work, support, training and rework	Explain cost per accepted garment
People	Competence and attendance are assessed	Method revision, assessor, shift and exception	Staff work fairly and close skill gaps
Sustainability	Meter or waste record closes	Boundary, source, estimate flag and output denominator	Explain absolute use and intensity

ILLUSTRATIVE [S01] [S02] [S30] Illustrative minimum design for a greenfield cut, make, trim and finishing operation. Fields are added only when they support a defined decision. Formula and unit discipline follows S01, metric balance follows S02 and declared boundaries follow S30.

The table is deliberately organised around events. It prevents a common failure in which each function builds a separate report with a different meaning for output. Production, quality, cost and sustainability should be able to reconcile to the same accepted quantity at the same boundary. Where their scopes legitimately differ, the difference should be explicit. A sustainability calculation may use a monthly meter close while a production huddle uses a shift close; neither should borrow the other's denominator without carrying that time basis.

Institutional memory also depends on vocabulary. Defect names, interruption causes and method identifiers should be stable enough to compare, while remaining open to controlled revision. The aim is not a perfect taxonomy on the first day. It is a governed

starting vocabulary whose changes are dated and whose old records remain interpretable. Otherwise a definitional improvement can look like a change in factory performance.

Finally, memory must include unsuccessful responses. If a supervisor changes a work allocation and the problem persists, that test is useful evidence. Recording only apparent successes creates an archive of unjustified confidence. The first-shift system should retain the observed problem, the response and the subsequent result so later improvement work begins with what has already been tried.

1.4

Measurement serves decisions rather than reporting volume

A measure earns its place when it changes a decision. More fields do not automatically create more control; they can increase capture effort, delay the close and diffuse accountability. Garment-sector guidance recommends balance among financial, behavioural and core-process metrics, together with a mixture of in-process and end-of-process measures. [S02] This supports a scorecard that sees causes and consequences together, rather than a dashboard dominated by whatever is easiest to count.

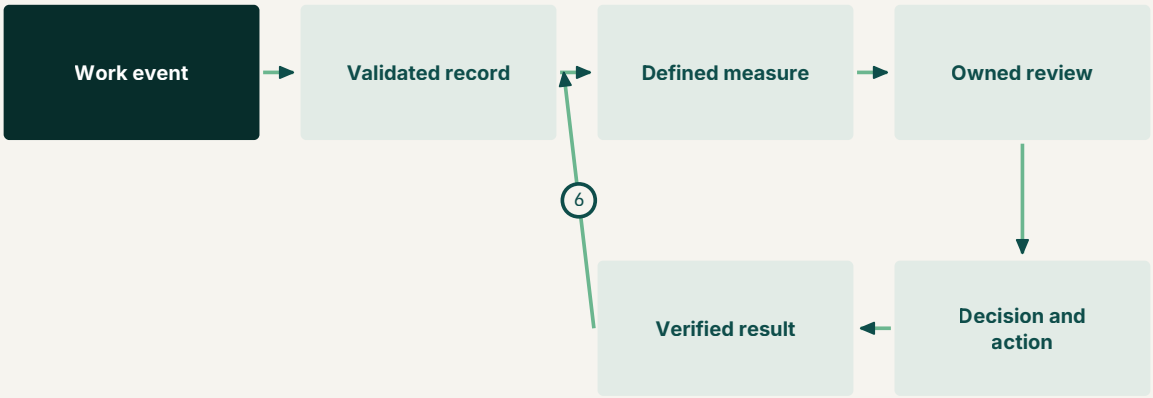
The admission test begins with purpose. ISO 22400 presents manufacturing KPIs through their formulas and corresponding elements, time behaviour, units and other characteristics. [S01] Before a proposed indicator reaches a dashboard, GFT would state the decision it informs, the source event, the calculation, the review cadence and the role with authority to act. A metric that lacks any of these elements is a reporting candidate, not yet an operating control.

The decision must be specific. “Monitor sewing” is too broad to guide record design. “Reallocate work when an operation accumulates beyond its agreed flow condition” identifies a management action and points to the events that must be observed. “Review resource intensity” is similarly incomplete until the team names the boundary, denominator and decision forum. Precision at this stage reduces later disputes about what the number was supposed to mean.

Exhibit 4, p. 23 shows the required chain. It includes a return path because an action whose result is not checked has not completed the management cycle.

EXHIBIT 04 / ILLUSTRATIVE GFT DECISION CHAIN

A measure earns its place only when it leads to an owned decision



6. Retest

ILLUSTRATIVE [S01] [S02] Illustrative design, not an implemented system claim. S01 supports explicit KPI definitions and S02 supports balanced process and outcome measures. The return path makes action verification part of the same chain.

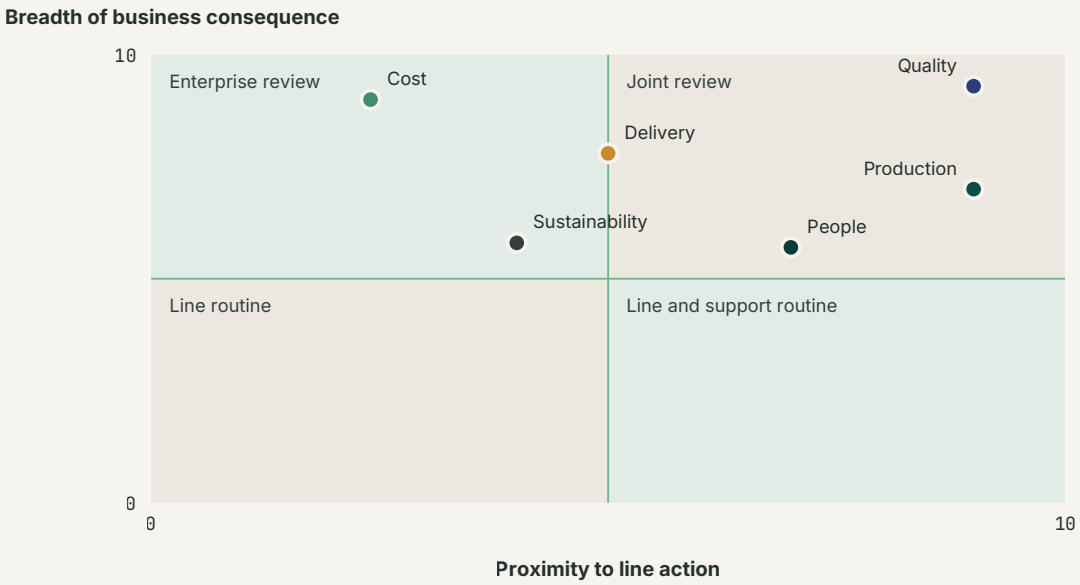
The chain exposes weak links that a visual dashboard can hide. If the source event is ambiguous, validation cannot rescue the measure. If the review has no decision rights, the measure produces escalation without resolution. If the result is never retested, the organisation records activity rather than effectiveness. Each link needs an accountable role, although a small start-up team may combine several roles in one person.

Balance also requires measures that sit at different distances from the work. End-of-process outcomes confirm what happened, but they arrive too late to explain every correction. In-process signals can support intervention, but they can also encourage local optimisation if their consequences are not visible. Output should therefore sit beside first-pass quality; staffing decisions beside demonstrated competence and working-time conditions; resource intensity beside absolute use and accepted production.

Exhibit 5, p. 24 offers an illustrative workshop map of the six GFT families. Its coordinates are not performance data. They are a prompt for testing whether each family has both a line-level action and a wider business consequence.

EXHIBIT 05 / ILLUSTRATIVE SCORE FROM 0 TO 10

Six families connect the business case to the line



ILLUSTRATIVE [S02] Illustrative qualitative positions assigned by GFT for design discussion. Higher x means a decision is closer to direct line action; higher y means broader enterprise consequences. Scores are not measured performance, weights or priorities. S02 supports the underlying balance principle.

The useful output of this map is not the geometry. It is the discussion about where each decision belongs. Production and quality signals may require action close to the shift, while a customer-promise revision or a cost response may require wider authority. Sustainability can involve line practice, engineering investment and reporting policy. A single forum should not pretend to hold every decision right.

Ownership follows the same logic. The business owner protects the measure's purpose and acts on its result. The data steward protects the definition and record quality. The review chair ensures that the decision occurs and its result is revisited. These accountabilities are distinct even when the start-up organisation assigns them to a small team. “Everyone owns the KPI” usually means that no one resolves a disputed definition or an overdue action.

> **GFT NOTE**
>
> GFT recommends removing a proposed first-shift measure when no named decision, owner or verification step can be attached to it. Retain the underlying event if another measure needs it, but do not burden operators with a field whose only purpose is to make a report appear complete.

The result is a shorter and more demanding measurement contract. It asks less about presentation and more about management behaviour: who can act, what evidence they need, when they review it and how the factory will know whether the action worked. Later chapters specify the metric contracts and review cadence. The opening requirement is to admit no measure that cannot complete this chain.

1.5

Sustainability claims inherit the quality of factory records

A per-garment sustainability figure is an accounting result, not an intrinsic label that can be attached to the product by assertion. It depends on a boundary, a numerator, a production denominator and rules for missing or estimated data. The GHG Protocol requires organisations to account for and report emissions sources and activities within their chosen inventory boundary, with specific exclusions disclosed and justified. [S30] The same discipline should shape the factory record before any public claim is drafted.

The first decision is the boundary. A meter inside a cut, make, trim and finishing site can describe activity within that site during a stated period. It does not, on its own, measure upstream fibre, fabric production or downstream distribution. Calling a site-based ratio a complete product footprint would erase precisely the processes that the record did not observe. The boundary must therefore travel with the value wherever it is reported.

The second decision is the denominator. GFT recommends retaining absolute resource totals alongside production-normalised ratios, with both calculated over the same declared period. Both views matter. Intensity can improve because accepted output rises while total resource use remains unchanged; total use can also fall while intensity worsens if production falls faster. These are consequences of dividing resource use by output, not measured effects at a GFT factory. Neither trend should be reported without the other when the decision concerns both operating efficiency and absolute impact.

For a first-shift energy record, the numerator might be electricity read within a declared site and period, while the denominator is accepted garments crossing the same site's completion boundary. The calculation is valid only as that defined ratio. Style mix, operating hours, estimated meter intervals and the acceptance rule remain relevant context. A later comparison should test whether those conditions changed before attributing an intensity movement to better practice.

> **WORKED EXAMPLE: INTENSITY NEEDS ITS BOUNDARY BESIDE IT**
>
> An illustrative site records 10,000 kWh within a declared factory-gate electricity boundary and 8,000 first-pass good garments during the same close. The illustrative ratio is 10,000 divided by 8,000, or 1.25 kWh per first-pass good garment. These assumed values demonstrate the calculation only and are not a benchmark.
>
> If 500 kWh within that illustrative total was allocated rather than metered, the record should carry the estimation method and affected share. If upstream fabric production is outside the boundary, the result should be labelled as site electricity intensity, not as the garment's full energy footprint. A change in the denominator to all accepted garments, including reworked items, would create a different indicator and should not be compared without restatement.

This is why sustainability cannot be deferred to a later reporting exercise. The necessary source events already exist in production, maintenance, quality and waste routines. If they are captured with inconsistent periods or unclear boundaries, the reporting team must reconstruct them under pressure. Reconstruction may be unavoidable in some cases, but it should be labelled and its uncertainty retained rather than presented as equivalent to contemporaneous measurement.

The operating benefit appears before external disclosure. A reconciled record allows the plant to ask where energy, water or material loss occurs and whether a proposed response changes accepted production. It also prevents a narrow efficiency project from shifting impact outside the chosen boundary. Subsequent chapters define the resource measures in full; this chapter fixes their dependence on the same governed evidence created for operating control.

1.6

GFT's position is capture before model

Machine-learning engineering guidance gives a direct warning: if machine learning is not absolutely required, it should not be used before the necessary data exists. [S27] GFT extends that caution to the whole greenfield operating system. The factory should establish the event, measure, decision and response first. Automation and prediction become candidates only after the record can support them and a user can act on their output.

This is not an argument against digital technology. It is an argument for earning complexity. A controlled manual sheet with clear definitions can produce more useful evidence than an automated stream whose identifiers and event meanings are unresolved. Conversely, a validated sensor can be preferable to repetitive manual capture once its error modes are understood. The choice is empirical and operational, not ideological.

Capture before model also separates three tasks that are often confused. Recording an event preserves what happened. Calculating a KPI transforms defined records into a decision-relevant measure. Building a model estimates or predicts something that is not directly recorded. Each task can add value, but the later task inherits weaknesses from the earlier one. A model cannot restore a method revision that was never saved or infer a reliable defect history from inconsistent labels.

Readiness should therefore be tested against the intended decision. The team needs sufficient coverage of the relevant operating conditions, stable or versioned definitions, known missingness and an accountable user. It also needs a simple comparison. If a transparent rule or current supervisor routine performs the decision adequately, a more complex model must demonstrate additional value against that baseline rather than against the absence of any method.

Historical depth alone is not readiness. A long archive can contain repeated definitions, unrecorded corrections and systematic gaps. A shorter archive with explicit cohorts and correction history may be more useful. The key question is whether the data represents the decision population, not whether the factory has accumulated an impressive number of rows.

GFT NOTE

GFT would approve a predictive use case only after its owner can demonstrate a governed source record, a defined action, a simple baseline and a verification plan. Failure of any condition returns the use case to measurement design. This gate protects the first shift from becoming a data-collection exercise for a model whose operational user and benefit remain hypothetical.

The same rule protects workers and supervisors from misplaced inference. Early records describe a changing system, not fixed personal capability. Using sparse ramp data to make automated judgements about individuals would confuse process learning with worker performance and could discourage honest recording. The initial purpose of evidence is to improve the production system and its management decisions. Higher-consequence uses require stronger proof and separate governance.

Capture before model thus sets a constructive sequence rather than a permanent refusal. Each well-defined shift record increases the factory's ability to test later sensing, forecasting or decision support. The evidence earns the next step. Digital ambition remains welcome, but it must arrive with a user, a baseline and data whose limitations are visible.

1.7

The paper follows the path from definition to verified value

The argument proceeds in the same order as the operating system should develop. It begins with ramp-up as a learning problem, then translates strategic outcomes into controllable measures and tests whether each metric is defined well enough to support comparison. ISO's formula, element, time-behaviour and unit structure provides a reference point for that definition work. [S01] Only after those foundations does the paper examine the six operating families in detail.

The next movement turns records into management. Production measures retain their losses, quality records retain first-pass outcomes, delivery measures retain work content and order events, labour measures connect cost with capability, and resource measures retain boundaries and denominators. Source capture then becomes a governed record, review routines assign decisions, and corrective actions are tested against results. This sequence prevents the paper from treating data architecture, meetings and analytics as separate programmes.

A later movement addresses maturity and implementation. The question is not how quickly a factory can accumulate digital tools, but whether each stage demonstrates reliable capture, active management and verified improvement. Machine-learning candidates enter only after those conditions are visible. The implementation roadmap therefore treats model readiness as an outcome of operating discipline rather than a substitute for it.

The scope is deliberately bounded. This paper concerns a greenfield cut, make, trim and finishing operation and the performance-management system needed from its first shift. It does not specify detailed vision algorithms, demand-forecasting models

or full product-footprint methods. Those subjects belong to companion papers and should consume the governed records defined here rather than create parallel meanings for the same production events.

For a sponsor, the immediate test is whether measurement readiness appears in the launch approval beside physical readiness. For a plant director, it is whether the first close reconciles output, quality, time and resource records to declared boundaries. For functional leaders, it is whether each proposed measure has a decision and an owner. For development and technical partners, it is whether reported progress can be traced to source events rather than to an unqualified narrative.

A close that exposes uncertainty is more useful than a close that conceals it behind a complete-looking report. The review should record unresolved counts, disputed definitions and late source entries as items for correction. It should not force a false reconciliation merely to meet the reporting timetable. This habit establishes a durable rule: confidence must reflect the condition of the evidence, and an honest exception is preferable to an untraceable adjustment.

The first shift will not produce a finished baseline. It will produce something more important: the initial entries in an inspectable operating memory. If the factory preserves context, admits uncertainty and closes the loop from event to action, later performance claims can be tested. If it does not, later sophistication will only make weak evidence faster to circulate.

Make the garment and the evidence together, then let each improvement stand on a record that can be checked.

CHAPTER SOURCE NOTES

S11 International Journal of Production Economics, Elsevier. 2001.

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

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

S19 The International Journal of Advanced Manufacturing Technology, Springer Nature. 2019-09-03.

S20 Applied Sciences, MDPI. 2020-04-29.

S01 International Organization for Standardization. 2014-01.

S02 International Labour Organization. 2017.

S30 GHG Protocol, WRI and WBCSD. 2004.

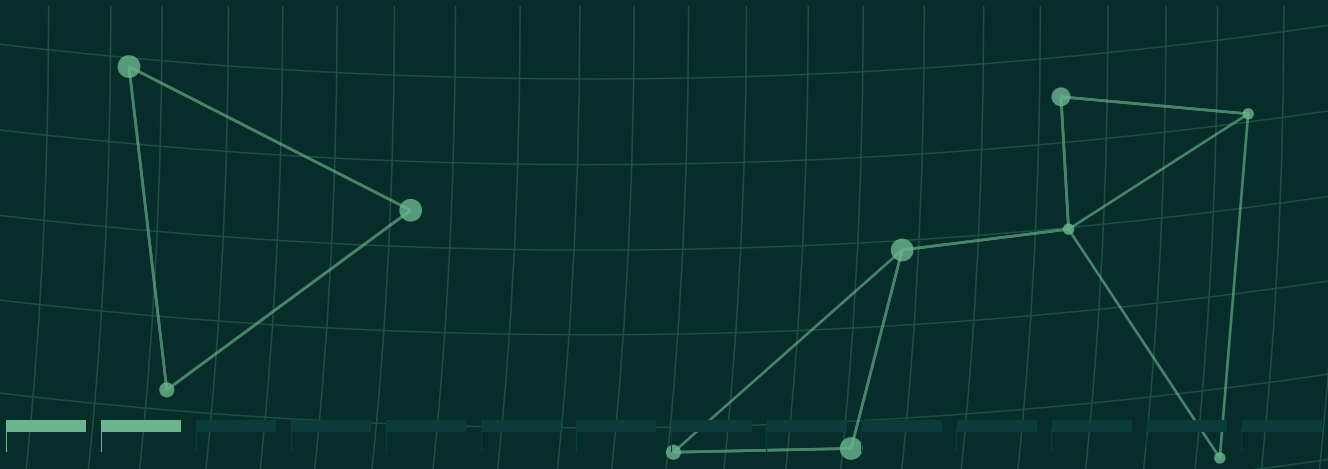
S27 Google for Developers. 2025-08-25.

02

PART I: THE MEASUREMENT CONTRACT / LEARNING BEFORE TARGETS

Ramp-up is a learning system, not a reduced steady state

Early targets should describe a controlled learning trajectory, with yield, rate and capability observed together rather than assumed away.



CHAPTER 02
DECISION TEST

Early targets should describe a controlled learning trajectory, with yield, rate and capability observed together rather than assumed away.

A greenfield garment factory cannot manage its opening months by taking a mature factory's steady-state targets and scaling them down by an arbitrary percentage. Empirical research on production ramp-up demonstrates that a newly introduced manufacturing process is initially poorly understood, which causes low yields and low production rates to appear at the same time. [S11] Treating early shifts as a smaller version of steady-state production confuses two distinct management problems: learning how to execute a repeatable method without defects, and accelerating throughput once that method holds. Green Future Tech Limited (GFT), Hong Kong SAR, designs performance-management systems around a stricter premise. During ramp-up, the line is a structured learning system whose primary output is verified capability alongside saleable garments, and every target must link good output, first-pass yield and demonstrated competence inside a clearly bounded cohort. [S11] [S12]

That distinction carries direct financial and industrial consequences where local processing is expanding from a narrow base. In Cameroon, inherited sector evidence indicates that about 95 percent of cotton fibre is exported raw while about 5 percent is processed locally, against a national target of 50 percent local processing by 2030. [R06] [R07] Separate public reporting on the announced Camtext SA project cites planned processing of 12,000 tonnes a year, about 12,000 jobs at Dibamba and 3,000 at Garoua, an estimated return on investment near 11 years and optimal capacity around 2033, while July 2023 reports on CICAM recorded capacity utilisation of 33.7 percent at Garoua, 48.9 percent at CICAM 1 and 10.83 percent at CICAM 2. [R10] [R12] Those figures describe sector context rather than a GFT operating result or demand forecast, yet they show why capital recovery in textiles depends on disciplined ramp control. When a new cut, make, trim and finishing plant mistakes early volume pressure for maturity, rework and turnover erode the capacity the investment case assumed.

2.1

Yield and speed must be managed as joint outcomes

A ramp-up measurement system fails if a line can report rising piece counts while concealing the defects, repairs and unrecorded overtime used to produce them. Terwiesch and Bohn show that early commercial manufacturing combines incomplete process knowledge, frequent disturbances and simultaneous pressure on production rate and yield. [S11] Because material handling, machine settings and operator motion are still stabilising, pushing speed alone routinely raises fault rates. A sewing line that runs faster by skipping alignment checks or bypassing in-line inspection does not create real capacity; it builds a hidden queue of defective bundles that must be unpicked, recut or downgraded later.

To prevent speed from masquerading as progress, GFT specifies a joint review rule from shift one: good output, first-pass yield and cycle time must be read together on the same board and in the same daily meeting. International Labour Organization (ILO) lean guidance for garment factories stresses balancing financial, behavioural and core-process metrics while combining in-process and end-of-process indicators. [S02] During ramp-up, gross pieces sewn can never stand alone as the headline

metric. A line advances only when completed units pass their first boundary without repair, recut or reinspection-driven correction, and when the bottleneck station holds its pace within the approved method. [S02] [S10]

2.2 WHY GROSS PIECE COUNTS DISTORT EARLY LINE BEHAVIOUR

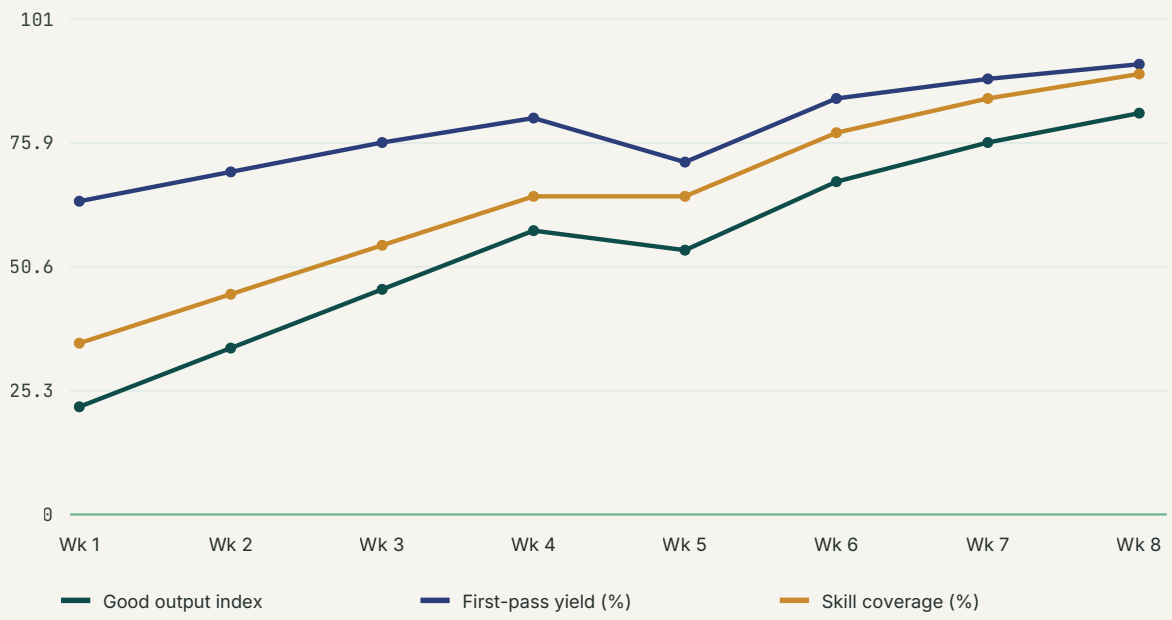
The arithmetic of rework explains why yield and speed cannot be separated. A National Institute of Standards and Technology (NIST) Manufacturing Extension Partnership case documented a process where raising first-pass yield from 10 percent to 90 percent accompanied a reduction in total processing time from 11.8 hours to 3.4 hours. [S10] Although that sourced case comes from a specific manufacturing intervention rather than a garment benchmark, the mechanism applies directly to apparel assembly. Every bundle that fails first-pass inspection consumes sewing minutes twice: once when the fault is sewn, and again when a skilled operator unpicks the seam, re-sews the piece and returns it to inspection. [S10] Diverting scarce skilled operators to repair defects starves the main line of the competence needed to stabilise flow.

2.3 REVIEWING THE TRIAD ON ONE COHORT AXIS

Before a plant director or line supervisor approves an increase in line speed, the performance record must show how output, quality and skill coverage are moving together. The illustrative trajectories in **Exhibit 6**, p. 31 show how GFT structures this joint view across an eight-week cohort for a single garment style and method revision. [S11] [S12]

EXHIBIT 06 / ILLUSTRATIVE COHORT INDEX (0 TO 100)

A useful ramp view separates output, yield and competence



ILLUSTRATIVE [S11] [S12] Illustrative GFT cohort trajectories over eight production weeks for one style and method revision. Good output, first-pass yield and demonstrated skill coverage move at different rates and dip at Week 5 when an unapproved speed push outruns skill and method stability. Rationale from S11 and S12; values are an illustrative model, not a GFT factory observation.

In **Exhibit 6**, p. 31, the illustrative series progress together from Week 1 to Week 4 as operators master the specified method and in-line quality stabilises, moving from an illustrative good-output index of 22 and first-pass yield of 64 percent at Week 1 to an illustrative index of 58 and yield of 81 percent at Week 4. [S11] At Week 5, the chart models a typical ramp failure mode: management demands a higher hourly quota before demonstrated skill coverage has expanded beyond an illustrative 65 percent of stations. [S12] First-pass yield drops from 81 percent to 72 percent in this illustrative sequence, rework absorbs station time, and net good output falls from 58 to 54 even though machines are running faster. Only when the line restores method discipline and completes cross-training in Weeks 6 to 8 does the illustrative good-output index reach 82 alongside a 92 percent first-pass yield. What this exhibit cannot establish is a universal weekly slope for all factories; every product family and workforce starts from its own empirical condition, which is why the underlying cohort baseline must be defined before any curve is plotted.

> **GFT NOTE**
>
> Never sign off a ramp milestone on gross pieces completed or on attendance hours alone. In GFT's performance-management design, a weekly ramp gate requires three concurrent records for the active style cohort: net first-pass good garments per attended hour, in-line and end-of-line defect rates by operation, and the share of bottleneck and critical operations staffed by operators who have demonstrated the current method revision without supervision. [S02] [S11] [S12]

2.4

A baseline is a dated population, not a single number

Credible factory improvement starts by establishing where performance stands before interventions begin, yet greenfield plants often reduce their baseline to a single undated average. In the ILO's Sustainable Competitive and Responsible Enterprises (SCORE) programme in Ethiopia's garment industry, trainers begin at step zero with a baseline assessment to identify operational gaps and measure change through key performance indicators. [S05] Statistical process control (SPC) likewise rests on comparing what is happening today with what happened previously. [S09] Neither approach works if "what happened previously" is an undocumented mix of different styles, shifting rosters, fabric substitutions and provisional sewing methods.

In a greenfield garment factory, the first shifts generate a dated, conditional population of observations rather than a static scalar. If Line A produces a basic crew-neck T-shirt during its first fortnight and switches to a woven work shirt in week three, pooling those two periods into one monthly "baseline efficiency" destroys comparability. Output changes between those windows reflect work content and method novelty, not worker effort. GFT therefore defines a baseline as a governed data object carrying a mandatory cohort header. [S05] [S09]

2.5 SIX ATTRIBUTES THAT BOUND A VALID RAMP BASELINE

No baseline figure may enter a management review or planning tool unless six boundary attributes are recorded alongside the numeric value:

1. **Product style and construction family:** style identifier, fabric weight class, construction type and size ratio, keeping work content comparable. [S03]
2. **Operation and process boundary:** whether capture occurs at a critical sewing operation, an in-line roving check, or end-of-line passage before packing. [S02]
3. **Line, shift and core roster stability:** line identifier, shift, attended operator count and share of operators retained from cohort start, separating learning from turnover. [S04] [S18]
4. **Approved method revision and SMV version:** version identifier of the operation breakdown, attachment setup and standard minute value (SMV) in force. [S03]
5. **Observation window and cumulative volume:** start and end dates, completed shifts and cumulative bundles processed since the cohort opened. [S05] [S11]
6. **Measurement protocol and observer check:** counting rule, defect taxonomy and inspection verification status, confirming that yield shifts reflect process behaviour rather than inspector drift. [S40]

2.6 POPULATION BOUNDARIES IN EXTERNAL AND INTERNAL COMPARISONS

The same discipline applies when sponsors compare early baselines with external benchmarks. In Cameroon, shared evidence records show a statutory minimum wage (SMIG) raised from XAF 41,875 a month in 2023 to XAF 43,969 a month from 23 February 2024 (about US$76, up 5 percent), a 40-hour standard week, a 48-hour maximum and overtime at 1.2 times base pay, with informal employment near 90 percent of the workforce. [R14] [R16] A greenfield plant recruiting first-time industrial operators draws from a distinct labour-market population. [R16] Its initial two-week baseline measures that cohort's starting point; it cannot be compared directly with a mature plant in Cambodia (where the 2024 garment minimum wage was US$204 a month) without adjusting for tenure, style familiarity and supervision. [R17] [S13]

> **METHOD**
>
> **GFT cohort-baseline locking protocol.** When a new line or style cohort launches, GFT's baseline rule separates *proving shifts* from the *reference baseline window*. During the initial proving shifts (typically the first 3 to 5 illustrative shifts while machine folders, thread tensions and bundle tickets are debugged), records are tagged as setup diagnostics. Once the operation breakdown is released and material flow is continuous, the next 5 to 10 illustrative shifts form the locked cohort baseline window, provided at least 50 illustrative or sampled inspection units or subgroup observations are logged for statistical stability. [S05] [S09] [S0201] Any subsequent comparison of efficiency, first-pass yield or cycle time must reference both the cohort ID and the baseline window dates.

2.7

Learning curves need comparable work and explicit resets

Industrial engineers rely on learning curves to plan capacity and pace line targets, yet learning curves are misapplied when factories ignore the assumptions behind standard work. As documented in the ILO's analysis of textiles and clothing in Ghana, the Standard Minute Value (SMV) is the time value arrived at for a task based on the average rate of output that qualified workers naturally achieve without over-exertion, provided they know and adhere to the specified method and are motivated to apply themselves. [S03] Similarly, the IFC and ILO Better Work assessment of Bangladesh garment factories notes that engineers break each style into steps, assign an SMV to each step for a fully efficient operator, multiply the garment SMV by completed pieces to obtain output minutes, and divide by available sewing minutes to calculate line efficiency, which in their factory sample typically ranged between 45 percent and 70 percent on any given day. [S14] [S0204]

Every word in the SMV definition constrains how a learning curve may be read during ramp-up. [S03] When a greenfield line starts, operators are still becoming "qualified workers", the "specified method" is being refined on the floor, and supervisors are still learning daily balancing. [S03] [S04] If an engineer alters the sewing method, adds a folder attachment, or changes seam construction, the task denominator has changed. Plotting output across that change as one uninterrupted learning curve mixes method engineering with human repetition.

2.8 WHAT FORCES A COHORT RESET

To keep learning trajectories honest, GFT enforces explicit reset rules in master data. **Exhibit 7**, p. 35 summarises how GFT derives cohort attributes and reset triggers from garment-engineering and ramp-up principles. [S03] [S04] [S05] [S11]

EXHIBIT 07 / COHORT GOVERNANCE ATTRIBUTES

Every ramp baseline requires a dated cohort header and a reset rule

Cohort attribute	Recorded field	Reset rule when attribute changes	Decision protected
Style and family	Style ID and construction class	Open new cohort; keep family link	Prevents mixing unlike garment complexity
Method and SMV	Approved breakdown and SMV version	Freeze prior series; start new cohort	Separates method redesign from operator speed
Line and shift	Line ID, shift and core roster share	Flag break if turnover exceeds rule	Isolates staffing churn from individual learning
Material and setup	Fabric batch class and machine setup	Split cohort on material spec change	Prevents fabric faults reading as operator error
Observation window	Start date, bundles and shift count	Require sample before narrowing band	Stops single-shift noise setting fixed targets

DERIVED [S03] [S04] [S05] [S11] Derived by GFT from baseline assessment principles in S05, method-based SMV conditions in S03, daily line-balancing practice in S04 and ramp process-learning constraints in S11. No factory values are assumed.

As **Exhibit 7**, p. 35 makes clear, a cohort reset is not an admission of failure; it is an accounting boundary that preserves analytical truth. [S03] [S11] When a line moves to a new garment style, or when industrial engineering issues a revised operation breakdown that alters station work content, the system freezes the prior cohort series and opens a new cohort linked by product family. Because **Exhibit 7**, p. 35 is a governance contract rather than an empirical dataset, it cannot tell a plant manager how many days a specific reset will cost; instead, it ensures that once the reset occurs, the factory measures the true recovery time rather than burying it inside a smoothed monthly average.

WORKED EXAMPLE

Illustrative cohort-efficiency and effective good-output calculation. Consider an illustrative 25-operator sewing line assembling a woven work shirt with an approved garment SMV of 16.0 standard minutes during a standard 480-minute shift, giving 12,000 illustrative available operator-minutes per shift (`25 operators * 480 minutes = 12,000 minutes`). [S03] [S14]

In Shift 4 of Cohort A (method revision v1), the line completes 360 gross shirts, so nominal earned time appears to be 5,760 standard minutes (`360 pieces * 16.0 SMV`), or an illustrative gross efficiency of 48.0 percent (`5,760 / 12,000`). [S03] [S14] However, in-line and end-of-line quality records show an illustrative first-pass yield of only 75.0 percent: 270 shirts pass first time, while 90 shirts require an average of 8.0 illustrative rework minutes each (720 rework minutes total) before 60 are recovered and 30 are rejected as seconds.

Under GFT's ramp accounting rule, only the 270 first-pass good shirts count toward first-pass earned minutes: `270 good pieces * 16.0 SMV = 4,320 first-pass earned standard minutes`, yielding an illustrative **first-pass line efficiency of 36.0 percent** (`4,320 / 12,000`), not 48.0 percent. [S10] [S11] In Shift 9, after industrial engineering introduces a collar-jig attachment (method revision v2, opening Cohort A-v2 with a revised SMV of 15.2 minutes) and supervisors rebalance the bottleneck, the line completes 400 gross shirts at an illustrative 90.0 percent first-pass yield (360 first-pass good shirts). First-pass earned minutes rise to `360 * 15.2 = 5,472 standard minutes`, or an illustrative **45.6 percent first-pass efficiency** (`5,472 / 12,000`), adding 90 more right-first-time garments per shift even though the SMV denominator was tightened. [S03] [S04] These figures are an illustrative arithmetic case demonstrating the method and are not a GFT factory observation or forecast.

2.9

Skill retention belongs on the ramp agenda

A greenfield ramp-up plan typically budgets for pre-launch induction training, yet treats operator competence as permanent once a course ends. Apparel research refutes that assumption. A study in *Applied Sciences* evaluating manual skill degradation in apparel manufacturing shows that sewing skills degrade when operators leave specific manual tasks or when task allocations shift, concluding that capacity-development drills are essential to maintain an efficient required skill set. [S12] During ramp-up, skill decay and partial mastery appear constantly: an operator trained on pocket setting during induction may spend three weeks on simple overlocking while early styles run, then struggle when rotated back to complex top-stitching.

2.10 WHY COURSE ATTENDANCE IS NOT A CAPABILITY MEASURE

Counting training hours or certificates measures an input, not line capability. Supervisors face daily absenteeism, uneven cycle times and style changeovers that require moving operators across operations. [S04] [S18] If the skill matrix only records classroom attendance, the supervisor discovers too late that the operator cannot hold seam tolerance at line speed. Better Work research also shows that using excessive overtime to cover skill gaps leads to poorer worker health, reduced efficiency, higher accident rates, dissatisfaction and turnover, stripping learned skill from the line. [S18]

2.11 STRUCTURING AN EVIDENCE-BASED SKILL MATRIX

GFT replaces attendance logs with an operation-level demonstrated skill matrix connected to the line-balancing board and quality log. [S03] [S04] [S12] For each operator and critical operation, the record tracks four verifiable levels and a recency clock:

- **Level 1 (In training / drill stage):** off-line method instruction completed; practising capacity-development drills on panels, not yet cleared for unassisted bundles. [S12]
- **Level 2 (Method-qualified under supervision):** adheres to the specified method and meets first-pass quality on live bundles within a learning speed band below full SMV pace. [S03]
- **Level 3 (Standard-capable at SMV and FPY):** consistently achieves the approved SMV rate and first-pass yield threshold across a multi-shift window without elevated rework. [S03] [S10]
- **Level 4 (Multi-operation relief and coach):** holds Level 3 capability across multiple bottleneck operations and supports peer drills during rebalancing. [S04] [S12]

Every Level 2, Level 3 and Level 4 entry carries a *last-demonstrated date* and *method revision tag*. If an operator has not performed a complex operation within a defined recency window (such as an illustrative 30 to 45 days) or if the method revision changes, the matrix flags a refresher drill before scheduling that operator as full capacity. [S12]

2.12

Supervisor practice turns classroom content into line capability

Operators do not learn in a vacuum; the line supervisor controls the daily conditions under which operator learning consolidates or breaks down. In garment manufacturing, line balancing is performed systematically by line supervisors before production through planning and daily during production. [S04] When a bundle queue builds up, thread breaks recur, or a seam allowance drifts, the supervisor's response determines whether the event becomes a coaching moment or a confrontation that triggers defects and turnover.

Empirical garment-sector studies confirm both the value of supervisory training and the time required for classroom concepts to become floor habit. In a randomised evaluation of supervisory skills training in Cambodia published by the International Finance Corporation (IFC), training improved workers' perceptions of supervisor relationships and produced moderate improvements in firm productivity. [S13] Similarly, the 2025 IFC and ILO Better Work assessment of the Gender Equality and Returns (GEAR) programme in Bangladesh documented that trainees attended classroom sessions two days a week for five weeks while working as trainee supervisors on remaining days, and then shadowed a supervisor on a production line for another six to eight weeks. [S14]

2.13 WHY SUPERVISORY CAPABILITY LAGS CLASSROOM COMPLETION

Even when supervisor candidates hold strong technical skills, floor performance takes months to stabilise because supervision is both a social and an operational role. In a field experiment across 24 large Bangladesh garment factories published by the National Bureau of Economic Research (NBER), researchers randomly assigned marginal female and male supervisor candidates to manage production lines. [S0202] Baseline diagnostics showed few skill differences between them; initially, however, marginal female candidates had lower line productivity and subordinate evaluations due to negative initial worker beliefs, before those gaps disappeared after four to six months and female supervisor retention rose significantly above baseline. [S0202]

That four-to-six-month convergence window in the NBER study and the six-to-eight-week shadowing period in GEAR carry a direct lesson for ramp planning. [S14] [S0202] A factory cannot run a brief pre-launch workshop and expect mature line balancing on shift one, nor should it treat early transitional friction as proof that trainee supervisors lack capability. [S0202]

2.14 OBSERVABLE GATES FOR SUPERVISORY READINESS

Rather than grading supervisors solely on raw output during early shifts, GFT gates supervisory readiness on four observable behaviours during shadowing and initial line assignment:

- **Structured start-of-shift huddles:** leading a focused five-to-ten-minute illustrative huddle that reviews prior-shift first-pass yield, names the bottleneck operation and sets daily priorities without blame. [S02] [S05]
- **Pre-production and daily line balancing:** checking attendance and the skill matrix at shift start, reallocating tasks to match work content, and rebalancing stations during the shift when WIP queues exceed buffer bands. [S04] [S12]
- **Timely abnormality escalation:** separating issues solvable at the line from constraints requiring immediate escalation to maintenance, cutting or quality assurance. [S02]
- **Constructive, respectful coaching:** correcting method deviations at the needle point through calm demonstration rather than verbal pressure, protecting the relational trust linked to productivity gains. [S13]

> **WARNING**
>
> **Constraint on borrowed training durations.** The five-week classroom plus six-to-eight-week line-shadowing structure in the Bangladesh GEAR study and the four-to-six-month convergence period in the NBER experiment are sourced empirical cases from Bangladesh, not universal constants. [S14] [S0202] A greenfield factory in Cameroon or another emerging industrial hub must log its own supervisor shadowing completion dates, huddle audit scores and line-stability metrics before declaring its supervisory pipeline ready for autonomous multi-shift expansion.

2.15

Training claims require a counterfactual or a cautious label

When sponsors prepare a greenfield business case or evaluate workforce training during ramp-up, it is tempting to paste headline percentage gains from published studies into financial spreadsheets as guaranteed productivity jumps. Rigorous performance management prohibits that shortcut. Published apparel evaluations owe their credibility to explicit counterfactual designs (randomised control groups, matched comparison lines and regression controls for style complexity), and their exact magnitudes belong to the populations studied. [S13] [S15] [S0204]

Consider the controlled apparel training evaluation reported by the World Bank's Development Impact group from a ready-made garment export firm in southern India, where female operators worked in lines of about 70 to 100 workers benchmarked by standard allowable minutes. [S15] Researchers randomised lines and workers within treatment lines to receive an 80-hour soft-skills programme (Personal Advancement and Career Enhancement) over 11 months. [S15] Controlling for garment style fixed effects and tenure, trained workers produced about 6 more garments per hour, or 10 percent more relative to the control group, while efficiency rose by 7 percentage points (12 percent relative to controls) and technical training requests rose by about 15 percentage points. [S15] Overall attrition across 26 months left about 25 to 30 percent of the initial sample, and the productivity gains materialised *after* training completed rather than during the course. [S15]

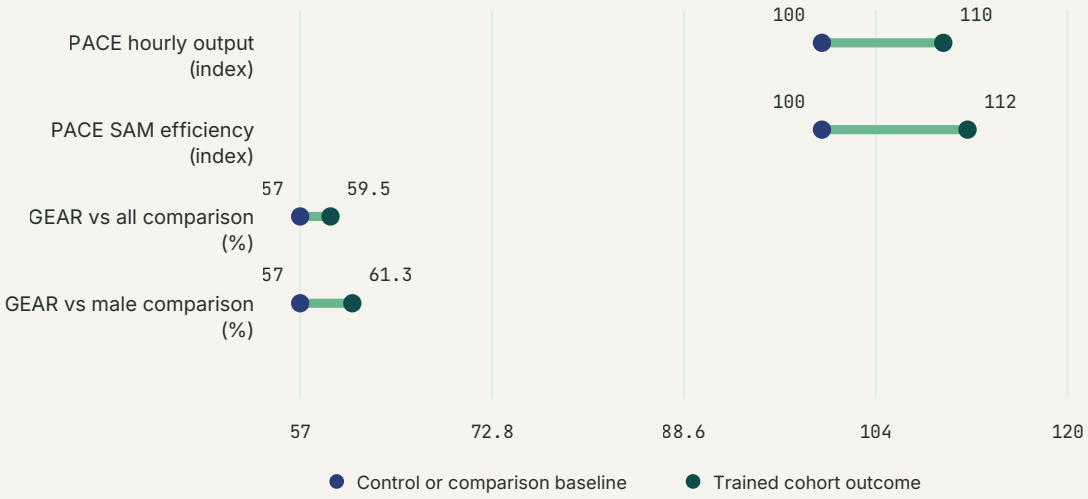
A second controlled case comes from the 2025 IFC and ILO Better Work assessment of the GEAR supervisor programme in Bangladesh. [S14] [S0204] Controlling for garment complexity and factory characteristics, lines managed by GEAR-trained supervisors were 2.5 percentage points more efficient than lines managed by all comparison supervisors (rising from 57.0 percent to 59.5 percent, not statistically significant in the pooled sample), and 4.3 percentage points more efficient than lines managed exclusively by male comparison supervisors (rising from 57.0 percent to 61.3 percent, significant at the 0.05 level). [S0204]

2.16 SHOWING THE COMPARISON BEHIND EVERY TRAINING NUMBER

To show external evidence without turning case results into promises, **Exhibit 8**, p. 40 plots the comparison baselines and trained outcomes from these sourced evaluations alongside the Cambodian supervisory study. [S13] [S14] [S15] [S0204]

EXHIBIT 08 / INDEX (CONTROL = 100) OR LINE EFFICIENCY (%)

Training evaluation must show the comparison behind the effect



SOURCED [S15] [S13] [S14] [S0204] Sourced from controlled evaluations in S15 (Indian apparel PACE study: output +10 percent and efficiency +12 percent relative to control indexed at 100) and S0204/S14 (Bangladesh GEAR study: line efficiency 57.0 percent vs 59.5 percent all comparison lines, and 57.0 percent vs 61.3 percent male-supervised comparison lines). Complemented by S13. Case results are non-transferable.

Inspecting **Exhibit 8**, p. 40 shows why the counterfactual is as important as the treatment outcome. [S15] [S0204] In the Indian PACE study, the 10 percent output gain (100.0 to 110.0) and 12 percent relative efficiency gain (100.0 to 112.0) were identified only by tracking untreated control lines on comparable styles and controlling for tenure. [S15] In the Bangladesh GEAR study, the contrast between the 2.5 percentage-point gap against all comparison supervisors (57.0 percent to 59.5 percent) and the 4.3 percentage-point gap against male comparison supervisors (57.0 percent to 61.3 percent) depended on specifying the comparison group and controlling for style complexity. [S0204] What **Exhibit 8**, p. 40 cannot establish is that a new factory in Cameroon will automatically gain 6 garments an hour or 4.3 percentage points of efficiency by running a similarly named course.

2.17 HOW GFT EVALUATES LOCAL TRAINING WITHOUT A RESEARCH TEAM

A commercial factory does not need an academic team to apply counterfactual discipline during ramp-up, but it needs a structured comparison rule:

1. **Matched-cohort or staggered-line comparison (preferred):** when a drill or supervisory module launches on Line 1, Line 2 (running a complexity-adjusted style family with similar tenure) serves as the contemporaneous comparison line before receiving the module next cycle. [S05] [S15]
2. **Pre-post cohort comparison within a frozen method window (cautious label):** when only one line runs a product family, post-training shifts are compared against the locked baseline window for that exact style and method revision. [S03] [S05] Because repetition learning occurs simultaneously during ramp-up, any gain in a simple before-and-after series must be labelled *combined learning and training movement*, never claimed as the isolated effect of training alone. [S11]

2.18

Targets should widen where evidence is thin

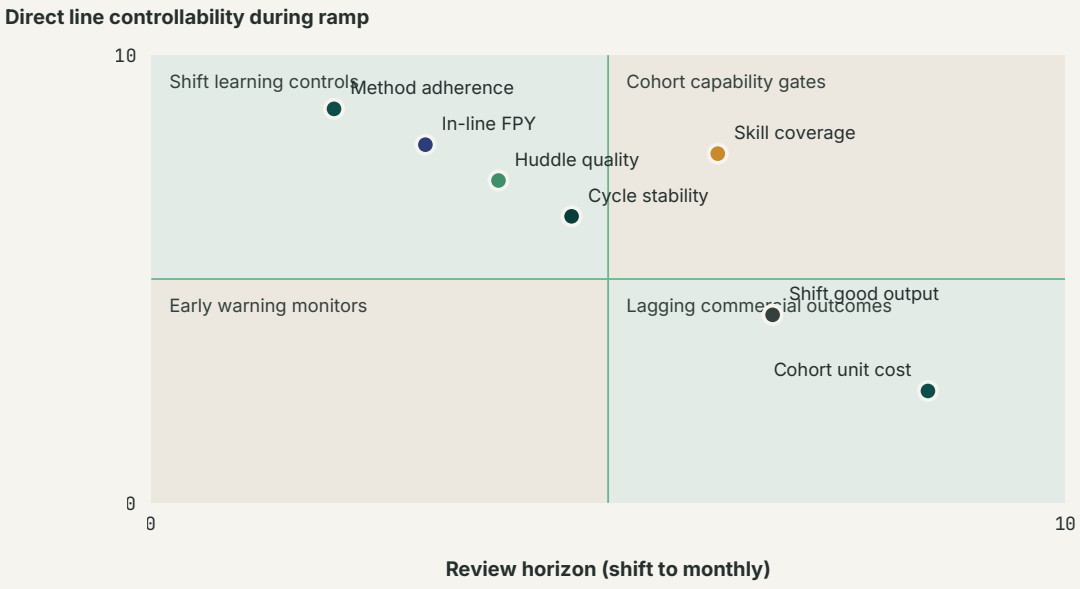
The final requirement of a ramp-as-learning system governs how targets are set and tightened. United States Office of Personnel Management guidance states that performance standards should be measurable, understandable, verifiable, equitable and achievable. [S45] Imposing a narrow steady-state efficiency quota on a greenfield line in Week 2 violates those criteria. When the process is poorly understood, standard minutes are provisional and inspection repeatability is unverified, a single-point quota is neither verifiable nor equitable. [S11] [S40] [S45]

2.19 LEADING LEARNING SIGNALS VERSUS LAGGING PRODUCTION RESULTS

To keep standards equitable and actionable during ramp-up, management must match each indicator to the horizon and controllability appropriate to the line's maturity. Following the ILO principle of combining in-process and end-of-process metrics across behavioural, process and financial dimensions, **Exhibit 9**, p. 41 maps seven ramp indicators across review horizon and direct line controllability. [S02] [S05] [S45]

EXHIBIT 09 / ILLUSTRATIVE HORIZON AND CONTROLLABILITY SCORE (0 TO 10)

Leading learning signals sit beside lagging production results



ILLUSTRATIVE [S02] [S05] [S45] Illustrative GFT classification of ramp indicators across review horizon (x-axis: 0 = immediate shift check to 10 = monthly cohort review) and line controllability (y-axis: 0 = lagging outcome to 10 = direct line control), applying S02, S05 and S45. Coordinates are conceptual placements, not empirical measurements.

In **Exhibit 9**, p. 41, the upper-left quadrant (*Shift learning controls*) holds measures that operators and supervisors influence immediately: method adherence (illustrative coordinates 2.0, 8.8), in-line first-pass yield (3.0, 8.0), supervisor huddle quality (3.8, 7.2) and cycle stability (4.6, 6.4). [S02] [S04] The upper-right quadrant (*Cohort capability gates*) holds demonstrated skill coverage (6.2, 7.8), built through weekly drills. [S12] Shift good output (6.8, 4.2) and cohort unit cost variance (8.5, 2.5) sit in the lower-right quadrant (*Lagging commercial outcomes*) because early ramp output and cost depend heavily on cutting readiness, material batches, machine debugging and

cohort age. [S11] Holding operators accountable for lagging unit cost variance in Week 2 is inequitable; holding line leadership accountable for method adherence, in-line defect capture and daily balancing is both equitable and verifiable. [S04] [S45]

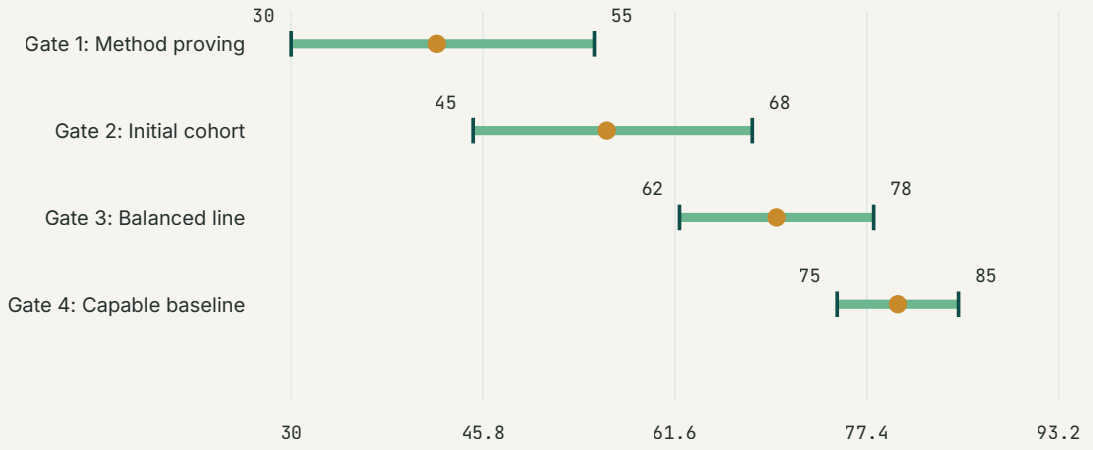
2.20 NARROWING TARGET BANDS THROUGH STATISTICAL AND OPERATIONAL GATES

NIST statistical process control guidance explains that control limits are chosen so almost all points fall within them while the process remains in control, and that capability indices (C_p, C_{pk}) compare an *in-control, stable process* against specification limits using a sample size generally thought to be about 50 independent data values. [S09] [S0201] [S0203] Furthermore, NIST guidance on Gauge R&R studies emphasises characterising gauge and observer errors (repeatability, reproducibility and bias) so measurement error is not mistaken for process variation. [S40]

In the opening shifts of a garment cohort, the process is not yet in statistical control, completed shifts are far below 50 independent observations, and visual inspectors are still calibrating agreement on stitch faults. [S11] [S40] [S0201] Setting a tight point target under those conditions rewards noise and punishes honest defect reporting. Instead, GFT narrows review bands across four capability gates, as illustrated in **Exhibit 10**, p. 42. [S09] [S40] [S45] [S0201]

EXHIBIT 10 / ILLUSTRATIVE REVIEW BAND (% OF APPROVED SMV RATE)

Review bands narrow only as cohort stability and sample size grow



ILLUSTRATIVE [S09] [S40] [S45] [S0201] Illustrative GFT review bands across four capability gates for a single garment cohort. Wide early bands reflect thin sample size and method adjustment; narrowing requires measurement repeatability (S40), in-control stability (S09), adequate sample size (S0201) and achievable standard criteria (S45). Values are illustrative, not a factory forecast.

The four gates in **Exhibit 10**, p. 42 translate statistical and managerial readiness into practical floor governance:

- **Gate 1 (Method proving, illustrative band 30 to 55 percent of SMV rate, midpoint 42 percent):** the operation breakdown and machine setup are being tested on the first bundles. The review checks whether the method is executable without over-exertion and whether inspection definitions are clear; no piece-rate or narrow output quota is permitted. [S03] [S40]

- **Gate 2 (Initial cohort learning, illustrative band 45 to 68 percent, midpoint 56 percent):** the method revision is frozen and the baseline cohort window opens. [S05] Management reviews daily progress inside a wide learning band while tracking whether in-line first-pass yield rises alongside speed and whether supervisors execute daily line balancing. [S04] [S11]
- **Gate 3 (Balanced line, illustrative band 62 to 78 percent, midpoint 70 percent):** demonstrated skill coverage reaches the primary bottleneck stations, supervisor shadowing milestones are verified, and inspector agreement passes repeatability checks. [S12] [S14] [S40] The review band narrows because special-cause startups have been removed.
- **Gate 4 (Capable baseline, illustrative band 75 to 85 percent, midpoint 80 percent):** the cohort has accumulated at least 50 independent subgroup or shift observations under a stable method, variation stays within control limits, and first-pass yield holds above its guardrail. [S09] [S0201] [S0203] Only at Gate 4 does the factory lock a narrow operational target for commercial planning and routine variance management. [S45]

Again, the specific percentages in **Exhibit 10**, p. 42 are illustrative planning bands rather than a universal norm: remember that even across established garment factories in the Bangladesh GEAR sample, typical daily line efficiency ranged widely between 45 percent and 70 percent. [S14] [S0204] The transferable principle is the gating logic itself: a target earns the right to be narrow only when the underlying process, skill matrix, supervisory routine and measurement system have proved they can support it.

GFT NOTE

When implementing GFT's ramp-planner and supervisor-pipeline tools, configure early cohort screens to display a shaded review range paired with a mandatory first-pass yield floor rather than a red-or-green single-number target. Require three system signatures before narrowing a cohort's target band: the industrial engineer confirming SMV and method stability, the quality lead confirming inspection agreement and first-pass yield compliance, and the production manager confirming demonstrated skill coverage across bottleneck stations. [S03] [S12] [S40] [S45]

By treating ramp-up as a governed learning system, the factory protects its earliest shifts from theatrical targets and builds a clean, cohort-indexed record from day one. With that learning contract in place, the next chapter examines how strategic business outcomes cascade into the six KPI families and line-level measures without losing operational control.

A factory that demands steady-state speed before it has measured method, yield and skill does not accelerate its ramp; it only accelerates its rework.

CHAPTER SOURCE NOTES

S11 International Journal of Production Economics, Elsevier. 2001-10-26.

S12 Applied Sciences, MDPI. 2021-11-23.

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

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

R10 Ecofin Agency. Publication date unrecorded; inherited source-text check.

R12 Business in Cameroon. Publication date unrecorded; inherited source-text check.

S02 International Labour Organization. 2017-09-18.

S10 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04.

S05 International Labour Organization. 2022-06-01.

S09 NIST/SEMATECH. 2003-06-01.

S03 International Labour Organization. 2024-01-17.

S04 International Labour Organization. 2023-03-21.

S18 ILO and IFC, Better Work. 2023-03-28.

S40 NIST/SEMATECH. 2003-06-01.

R14 WageIndicator. Publication date unrecorded; inherited source-text check.

R16 WageIndicator. Publication date unrecorded; inherited source-text check.

R17 just-style. Publication date unrecorded; inherited source-text check.

S13 International Finance Corporation. 2009-11-01.

S0201 NIST/SEMATECH. 2003-06-01.

S14 IFC and ILO, Better Work. 2025-07-16.

S0204 IFC and ILO, Better Work. 2025-07-16.

S0202 National Bureau of Economic Research. 2020-08-03.

S15 World Bank. 2017-09-07.

S45 United States Office of Personnel Management. 2019-11-04.

S0203 NIST/SEMATECH. 2003-06-01.

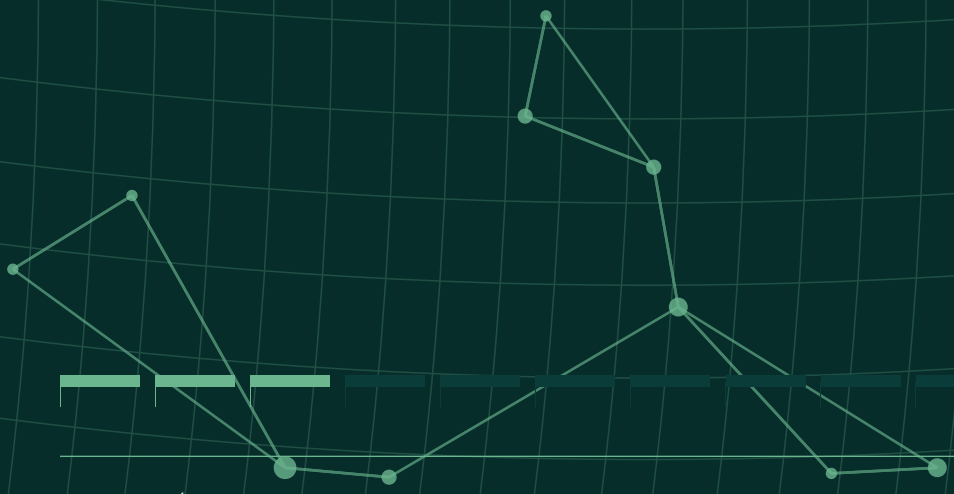
GREEN FUTURE TECH
LIMITED / HONG KONG SAR

03

PART I: THE MEASUREMENT CONTRACT / STRATEGY TO STATION

A KPI cascade succeeds only when the line can act on it

Strategic intent becomes an operating system when each line measure carries a decision, an owner, a feasible record and a guardrail.



CHAPTER 03
DECISION TEST

Strategic intent becomes an operating system when each line measure carries a decision, an owner, a feasible record and a guardrail.

A factory should cascade decisions and responsibilities before it cascades targets. The line needs to know which result matters, which observed condition requires a response, what action it may take and when the problem exceeds its authority. GFT proposes a short scorecard covering production, quality, delivery, cost, people and sustainability, with explicit connections between strategic outcomes and controllable work. The proposed architecture below is a design for a greenfield garment factory, not evidence that a GFT installation has achieved these conditions. Its purpose is to make the operating promise inspectable before that promise becomes a performance judgement.

3.1

Strategic outcomes determine what not to measure

Begin with the factory's operating promise: supply conforming garments against an agreed requirement while controlling cost, protecting people and accounting for resources. Translate each part of that promise into a question management must answer. Can the accepted order be completed with demonstrated capability? Is the current method producing conforming work? Which constraint needs intervention? A measure earns a place when it helps answer a question and changes the next decision. A count that attracts interest but carries no consequence belongs in diagnostic analysis until a useful decision has been identified.

NIST's manufacturing performance-assurance report connects measurement selection to organisational objectives and policies. The ISO manufacturing KPI abstract also describes indicators through their calculation elements, time behaviour and units. These are complementary starting points: purpose determines admission, while operational definition determines whether the resulting signal can be interpreted. Neither source establishes that every available measure should appear on a line board. [S0301] [S01]

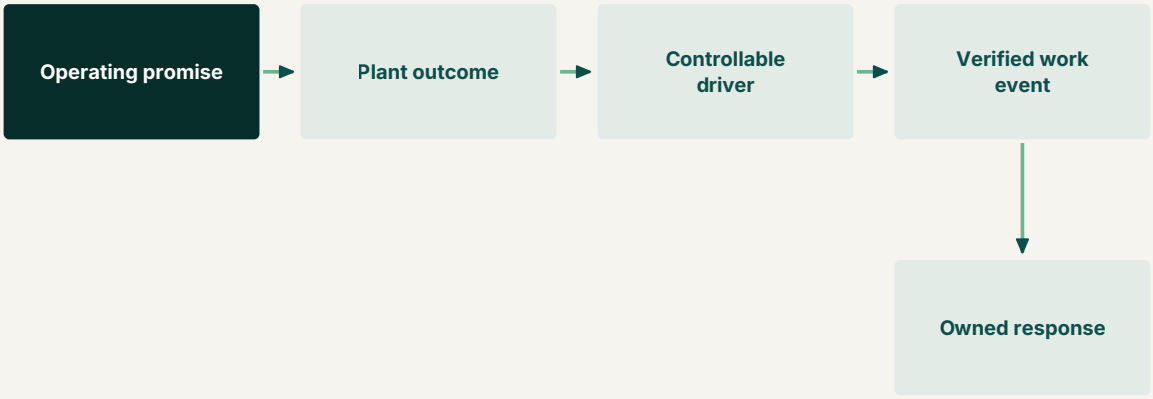
GFT's proposed admission test asks the sponsor of each measure to identify its strategic parent, decision owner, source event and available response. Consider a proposed efficiency tile. The sponsor must explain whether it supports capacity planning, method improvement or immediate line balancing. If nobody can distinguish these uses, the tile is premature. A proposed absenteeism measure must similarly distinguish support planning from individual performance assessment. The same record can support different questions, but those questions require separate permissions, interpretation and routes for challenge.

Collection burden belongs in the admission decision. GFT would ask an operator and a supervisor to demonstrate how a proposed record is completed during ordinary work, including an interruption and a correction. The design should preserve necessary production context without requiring workers to reconstruct the shift from memory. A measure whose capture interrupts the process it is meant to improve needs redesign, a different collection point or a lower reporting frequency. This is a practical design test, not a claim that manual capture is always superior to sensing.

The illustrative cascade in **Exhibit 11**, p. 48 preserves the connection from the operating promise to a permitted response. Information also travels upwards: a station observation can invalidate the assumptions behind the line plan. The arrows describe proposed responsibilities rather than a causal model with verified coefficients.

EXHIBIT 11 / ILLUSTRATIVE DECISION SEQUENCE

A useful cascade ends in a permitted response



ILLUSTRATIVE [S0301] [S01] Illustrative GFT design. NIST supports selection by organisational purpose; ISO supports operational definition. Nodes and links are proposed responsibilities, not an observed implementation.

The cascade needs a retirement rule as well as an admission rule. GFT would remove a routine tile when its decision disappears, its source cannot be maintained or another measure answers the same question more directly. Retain historical records under the applicable retention policy rather than deleting inconvenient evidence. A retired indicator may remain useful for investigation, but its removal from a board should be explicit. This prevents a growing archive of former priorities from becoming an ever larger demand on current production.

An unresolved strategic choice should remain visible instead of being disguised as a missing KPI. If management has not decided which order has priority when capacity is constrained, another output chart cannot resolve the conflict. GFT would ask the accountable manager to approve the priority rule and its exception route. The line can then interpret a local shortfall against an agreed plan. Until that decision exists, performance reporting should describe the constraint and competing requirements without implying that a supervisor has been given a coherent instruction. This separates a measurement problem from an unresolved business decision.

3.2

Six families prevent one dimension from dominating

The ILO's ready-made garment guidance recommends balance across financial, behavioural and core-process metrics, alongside a mixture of in-process and end-of-process measures. It also warns that excessive or insufficient numbers of metrics can impair improvement. GFT uses that principle to organise the proposed scorecard into production, quality, delivery, cost, people and sustainability. These families are the chapter's organising design, not a claim that the ILO prescribes this exact classification. [S02]

Production asks whether available work is becoming accepted output. Quality asks whether the method is producing conformity without correction. Delivery asks whether the remaining work can meet the agreed promise. Cost asks what the conversion consumes relative to the accepted result. People asks whether the work has suitable capability, support and safeguards. Sustainability asks what physical resources and waste cross the declared boundary. Each question has a different decision consequence. Combining them into a single weighted mark would conceal which consequence requires attention.

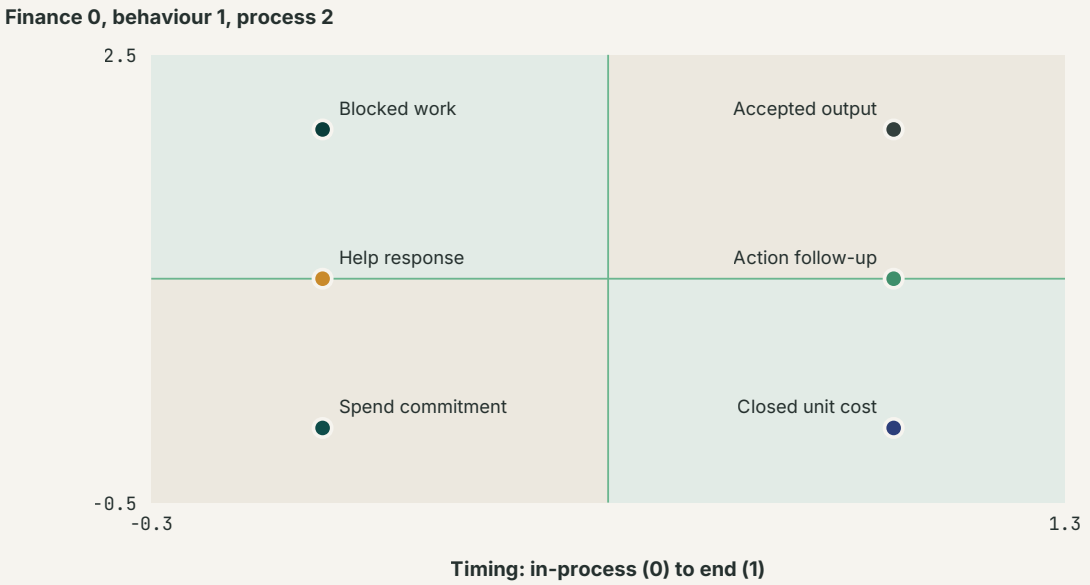
GFT would choose a small active set within these families for each management level. A station may need a clear acceptance condition, a visible abnormality signal and a route for assistance. It need not display the entire plant scorecard. The plant director, however, needs visibility across all the families before approving a recovery plan. Coverage means that a relevant consequence has an accountable review somewhere in the system. It does not mean that every person must calculate every indicator.

Treat relationships between families as hypotheses to test. A method change intended to raise throughput might reduce rework, leave it unchanged or create a new defect. A consolidation of orders might improve machine utilisation while extending the wait for another customer. GFT would record the expected mechanism and watch the affected measures over a comparable production cohort. An improvement claim should identify the boundary at which the gain appears and check whether a queue, rejected unit or resource demand has merely moved elsewhere.

The illustrative classification in **Exhibit 12**, p. 50 distinguishes the timing of a signal from the kind of consequence it describes. The positions are category coordinates. Their distances and areas carry no analytical meaning. This deliberately avoids assigning an invented financial value to behavioural evidence or averaging unlike units into an apparent factory score.

EXHIBIT 12 / ILLUSTRATIVE CATEGORY POSITIONS

Signal timing and metric category answer different questions



ILLUSTRATIVE [S02] Illustrative GFT classification using ILO distinctions. Horizontal coordinate 0 means in-process and 1 end-of-process. Vertical coordinate 0 means financial, 1 behavioural and 2 core-process. Coordinates are category codes, not weights, scores or measured distances.

A family can contain both kinds of timing. Resource use while a line is operating can support immediate investigation; the reconciled resource total supports period reporting. A skill observation during an operation can prompt assistance; a completed competence review supports future assignment. GFT would document these different uses instead of calling a metric inherently leading or lagging. Whether it warns in time depends on the decision deadline, not simply on how frequently a dashboard refreshes.

GFT would also test the completeness of a proposed recovery proposal across families before comparing its headline benefit. A production proposal should state its quality check; a delivery proposal should state the cost and work conditions it assumes; a resource proposal should preserve the required product specification. This does not require assigning an artificial monetary value to every effect. It requires naming an affected consequence and identifying who can judge it. Where the consequence cannot yet be measured reliably, record the uncertainty and choose a bounded trial rather than presenting the gain as settled.

3.3

The line receives measures it can influence

The ILO's Factory Improvement Toolset report describes line supervisors balancing work before production through planning and during daily production. This supports assigning balancing decisions close to the work. It does not justify assigning every plant outcome to a supervisor or treating all missed output as operator underperformance. The line-level cascade must distinguish what can be changed locally from what requires resources or authority elsewhere. [S04]

GFT proposes a controllability map for each important gap. The supervisor can investigate blocked work, confirm the approved method, call technical support and rearrange work within verified competence and authorised practice. A production manager may change the allocation between lines. Purchasing owns the supplier commitment; maintenance owns the technical repair response; commercial management owns renegotiation of a customer promise. The local board should show the dependency and escalation owner even where the local team cannot remove the cause.

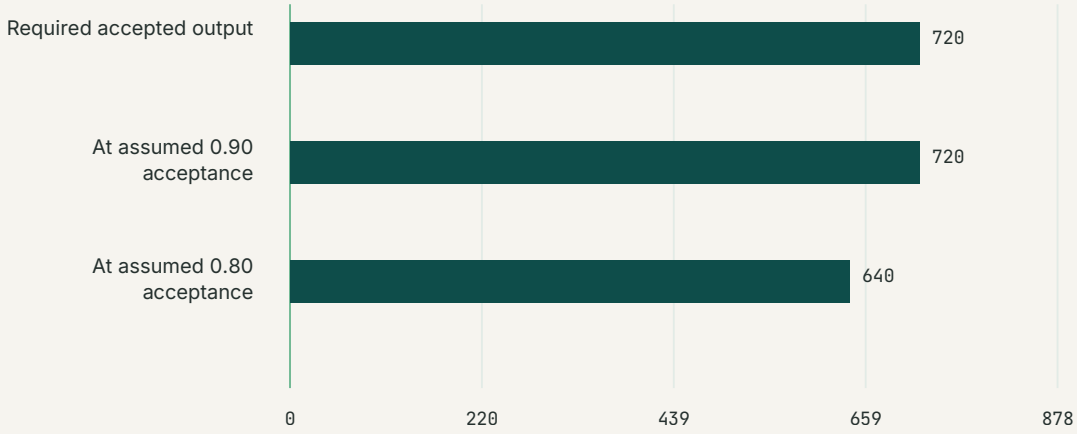
Output must remain connected to the relevant product boundary. A completed operation is not necessarily a completed garment, and an inspected garment may still be awaiting a release decision. GFT would require the line planner to state which boundary the current plan uses before comparing actual performance. The detailed counting contract belongs in the metric-definition chapter. The cascade's task is to ensure that the customer outcome and the operating driver refer to compatible work, rather than assuming a common label makes them equivalent.

> **WORKED EXAMPLE: THE CUSTOMER PROMISE CHANGES THE RELEASE PLAN**
>
> An illustrative line plan requires 720 first-pass accepted garments during 8 scheduled hours. Assume a single unchanged style, adequate materials, compatible inspection timing and no rework recovery inside the planning window. If the illustrative first-pass acceptance fraction is 0.90, the planned gross completion count is 720 / 0.90 = 800 garments. The implied average gross rate is 800 / 8 = 100 garments per scheduled hour. These are planning assumptions, not demonstrated line capability.
>
> If the illustrative acceptance fraction falls to 0.80 while gross completions remain 800, first-pass accepted output becomes 800 multiplied by 0.80 = 640 garments. The shortfall against the promise is 720 minus 640 = 80 accepted garments. Recovering the original promise at that assumed acceptance fraction would require 720 / 0.80 = 900 gross completions, or 112.5 per scheduled hour. Those calculated requirements do not prove that a safe or feasible production response exists.
>
> The illustrative decision is therefore to investigate the loss and test the remaining capacity before authorising a changed plan. Quality confirms the acceptance issue; the supervisor checks the work condition; planning tests the delivery consequence. Any eventual rework release is tracked separately from first-pass acceptance. A gross-output target that remains unchanged while acceptance deteriorates cannot represent the same customer commitment.

The common denominator in **Exhibit 13**, p. 52 is first-pass accepted garments over the same illustrative planning window. The chart compares the promise with alternative outcomes at an unchanged gross completion count. It does not compare gross output and accepted output as if they were the same measure.

EXHIBIT 13 / ILLUSTRATIVE ACCEPTED GARMENTS PER WINDOW

An unchanged gross count can conceal an accepted-output shortfall



ILLUSTRATIVE Illustrative arithmetic, not a factory forecast. Promise assumed 720. At 800 gross completions and acceptance 0.90, accepted output is 800 × 0.90 = 720. At the same gross count and acceptance 0.80, accepted output is 640. Assumptions exclude rework recovery and hold style and boundary constant.

This example also separates responsibility from blame. A supervisor should be responsible for detecting the accepted-output gap and initiating the authorised response. That responsibility does not establish the cause of a quality change. GFT would keep the observation, suspected mechanism and confirmed cause separate. Until the evidence supports attribution, the escalation should describe the condition and assistance required, preserving both accountability for action and fairness in interpretation.

The dependency map should remain useful when the physical line performs exactly as planned but the order still cannot ship. For example, a hypothetical batch may have completed sewing while awaiting an externally supplied trim. GFT would preserve the valid sewing result, show the unfulfilled release condition and route the shortage to its owner. Increasing the sewing target would not resolve that dependency. Conversely, a materials owner should not close the shortage merely because a purchase instruction exists. The completion condition must follow the physical event needed by the next responsible role.

3.4

One owner protects definition and action

The Federal Data Strategy playbook describes governance through priorities, authority, roles, policies and accountability. It addresses public administration rather than garment production. GFT adapts its accountability principle here; the factory roles below are proposed operating arrangements, not a regulatory requirement or a claim of compliance with that playbook. [S22]

Every KPI should have a business owner who answers for its purpose and permitted use. The data steward maintains the record rules, checks completeness and investigates inconsistent submissions. The review chair ensures that a decision is made or escalated. These responsibilities can be held by the same person in a small organisa-

tion, but the charter should keep them distinguishable. Otherwise a correction can be treated as a target revision, or a discussion can be mistaken for a completed operational response.

Ownership should also identify who may change the definition. GFT would let the steward propose a correction to a calculation or source mapping, but require the business owner to approve a material change in meaning. Planning and affected users should confirm how the change alters comparisons. Historical records need their original interpretation preserved, with any restatement made visible. This chapter establishes the decision right; the neighbouring metric-contract chapter specifies the detailed versioning and measurement checks.

The illustrative charter in **Exhibit 14**, p. 53 shows how to attach accountability without creating an unmanageable table. Each row represents a field on the proposed accepted-output charter. The cadence is a proposed management choice. It should be adapted to the time available for a useful response and to the reliability of the source record.

EXHIBIT 14 / ILLUSTRATIVE CHARTER FIELDS

The accepted-output charter names the decision and its limits

Field	Proposed arrangement
Business owner	Production manager
Data steward	Production-record custodian
Review chair	Shift supervisor
Source and rule	Unique first-pass acceptances in shift log
Decision	Rebalance, assist or escalate
Cadence	Within shift, with shift-end reconciliation
Guardrail	Quality, competence and safe work protected
Target basis	Approved order plan and tested capability

ILLUSTRATIVE [S22] [S01] Illustrative GFT charter, adapted from accountability and operational-definition principles. Roles, cadence and guardrails are proposals. Accepted output counts unique first-pass acceptances at the declared end-of-line inspection boundary, with subsequent corrections retained.

A production manager remains accountable for the business interpretation even when software computes the value. GFT would not make the software supplier the default owner of the factory's production promise. Equally, the steward should be able to flag an unreliable signal without being instructed to supply a convenient number. A missing inspection batch should produce an explicit incomplete status, a bounded explanation and a correction route. It should not silently become accepted output or a fabricated zero.

A deputy and an escalation route are part of ownership. Before a shift begins, the line should know who can authorise assistance when the usual owner is absent. A record correction should preserve the reason and the person approving it. A target dispute

should reach someone with authority over the original assumption. These arrangements make the cascade usable under ordinary absences and disagreements, rather than depending on a particular manager being present whenever the data becomes inconvenient.

Approval rights should distinguish ordinary assistance from changes that create new obligations. A supervisor may request help under an agreed staffing arrangement, while the authorisation of additional expenditure belongs to the designated budget owner. A quality release follows the authorised acceptance route even when production is behind plan. GFT would put these distinctions in the charter as practical boundaries, then test them with a simulated exception. If the proposed response depends on authority that nobody actually holds, the measure is not ready for operational use regardless of how accurately its value can be calculated.

3.5

Targets need a basis, a horizon and a review rule

GFT proposes that a target be measurable, understandable, verifiable, equitable and achievable under its stated conditions. These are recommended acceptance criteria for this design. They do not establish an employment rule, a legal standard or a guarantee of factory capability. A target should state the required result, the relevant work population, the decision window and the evidence supporting feasibility. Without those conditions, apparent precision is a management preference written as a number.

Separate the customer requirement from demonstrated capability and the management improvement objective. The customer requirement states what has been agreed. Capability describes what comparable work has actually achieved under recorded conditions. The improvement objective proposes a change and the intervention expected to support it. A gap between requirement and capability needs a planning decision. Relabelling the requirement as a capability target does not supply missing materials, competence, maintenance or time.

GFT would classify each target's basis explicitly. External evidence provides context whose scope and transferability must be checked. Internal arithmetic converts agreed inputs into a requirement, as in the worked example. A planning assumption supports a scenario pending observation. An internal baseline supports comparison only for its declared population. These categories should remain visible in the target register. A sourced ambition is still an ambition; an illustrative scenario remains illustrative even when a plausible formula produces it.

A target should expire when its stated basis no longer holds. A style change, a revised method, a different inspection boundary or a changed staffing condition should trigger a review of comparability. The owner may retain the customer commitment while changing the recovery plan. Alternatively, management may need to renegotiate the commitment. Neither response permits rewriting the old record. The scorecard should show the original requirement, the changed assumption and the authorised revision separately.

THE TARGET REVIEW CHECKS FEASIBILITY BEFORE JUDGEMENT

GFT proposes a target review that first confirms the work boundary and the current requirement. The owner then checks the source record, compares the intended operating conditions with observed conditions and identifies which assumptions remain untested. Planning calculates the required performance, while production and quality confirm whether the proposed method can support it. Worker representatives or an appropriate local challenge route should be able to identify unsafe or impractical assumptions. Approval records both the target and the circumstances requiring reconsideration.

The review rule should avoid both automatic relaxation and automatic tightening. An adverse result may expose a weak method, an unreliable record or a missed dependency; it does not automatically prove that the target was wrong. A favourable result may reflect an easier mix or a temporary support arrangement; it does not automatically justify a permanent increase. GFT would require an explanation of changed conditions before either decision, preserving the distinction between learning from evidence and rewarding a convenient interpretation.

During early production, the target register should also expose uncertainty. A provisional planning band can be useful if its basis is stated, but its edges are not statistical control limits unless a valid analysis establishes them. The cascade should record what observation would narrow the uncertainty and who owns obtaining it. This keeps target setting tied to the development of evidence, while leaving the detailed study of variation to the measurement and improvement chapters.

Target review should preserve the original decision deadline. Revising a plan after the relevant production window has closed cannot improve that completed window; it changes only how the result is presented. GFT would keep any retrospective explanation separate from the prospective instruction for the next comparable work. The owner should record when the changed information became available and what response was still possible at that time. This gives management a fairer basis for judging decisions under uncertainty and prevents later knowledge from being treated as something the line should already have possessed.

3.6

A purely top-down scorecard can miss local knowledge

A review of the Balanced Scorecard identifies criticism of its presumed rational, top-down strategy execution, including its fit with decentralised or adaptive organisations. That is a reported criticism of a framework, not proof that every cascade fails. GFT's design response is to let the people doing and supervising the work test the operational assumptions before measures become fixed performance judgements. [S46]

A station test should ask the worker to explain what event changes the displayed number. The supervisor should explain what can be done when the number is adverse. The steward should explain how a correction reaches the record. If these

explanations conflict, the design has not yet reached a shared operational meaning. GFT would resolve that disagreement at the work location, using the actual record and method, before adding another layer of reporting or a more elaborate visual display.

The feedback route should distinguish a temporary exception from a proposed definition change. A broken machine is an operating event. A counting rule that treats a restarted garment as a new completion is a definition problem. A target that assumes unavailable competence is a planning problem. Routing each issue to the appropriate owner prevents workers from having to invent a local workaround simply to make the scorecard match their experience.

GFT would retain the original observation while a challenge is assessed. The challenge record should describe the work condition, the contested interpretation, supporting evidence and requested decision. The responsible owner acknowledges it, investigates with affected users and publishes the outcome. If the definition changes, the explanation should reach every affected shift. If the definition remains, the reason should be equally visible. A route that merely receives comments without returning decisions cannot correct the cascade.

A hypothetical pressing station illustrates the distinction. Suppose the completion mark is recorded before the garment has cooled enough for the specified inspection. Moving the mark might improve the apparent timing of output while leaving the release delay unchanged. GFT would ask production and quality to agree the counting boundary together, then keep any earlier operation-completion event as a separate diagnostic record. This is a constructed design case, not an observed GFT event or a universal prescription for pressing methods.

Worker voice also requires restraint in how records are displayed. GFT recommends shared line-level problem solving without public individual rankings whose basis workers cannot inspect or challenge. Access to person-level information should follow its necessary use and the applicable local requirements. This chapter offers operating-design recommendations, not legal advice. The practical question for the cascade is whether the proposed display helps authorised assistance and improvement, or merely transfers uncertainty into individual blame.

Local knowledge should test the strategic model as well as the metric. If a recurrent observation shows that an assumed driver does not explain the outcome, GFT would revisit the link. The response may be a better measure, a changed intervention or retirement of an unsupported assumption. The scorecard remains aligned to strategy by correcting its theory of how work produces results. Alignment should not require the line to defend a relationship that the operating evidence repeatedly contradicts.

GFT would test the challenge route during commissioning with an intentionally ambiguous record. Ask the worker to identify the ambiguity, the supervisor to route it and the steward to show how the eventual decision reaches other users. The test passes only when the record can be corrected without destroying its history and the agreed meaning reaches the next shift. Record any failure as an operating-system defect with an owner. This rehearsal does not prove that all future disputes will be resolved, but it establishes whether the proposed route exists beyond the written policy.

3.7

Trade-offs belong in the same review

A decision that changes production should bring its quality, delivery, cost, people and resource consequences into the same review. GFT proposes paired measures and explicit guardrails, rather than a weighted total that lets a favourable output result cancel a breach elsewhere. The organising balance follows the ILO guidance; the particular approval rule and pairings here are GFT's proposed design choices. [S02]

The illustrative responsibility layers in **Exhibit 15**, p. 57 identify where an unresolved trade-off should go. They do not require a new committee at every layer. The relevant distinction is the scope of authority: assistance within an approved method, a cross-functional change to the operating plan, or a change to the business commitment and its resources.

EXHIBIT 15 / ILLUSTRATIVE RESPONSIBILITY LAYERS

Escalation follows the scope of the decision



ILLUSTRATIVE [S22] [S04] Illustrative GFT design, not an implemented reporting structure. Accountability follows governance principles; line balancing remains close to production. A guardrail issue follows the relevant authorised protection procedure at any layer.

Before authorising a recovery action, GFT would require a short statement of its expected benefit, affected families, owner and stopping condition. Reallocating a competent operator may help a constraint but weaken another operation. Increasing release to a line may build work in progress without improving completion. Deferring maintenance may preserve current running time while leaving an unresolved technical risk. These are proposed questions for decision review, not quantified predictions of what any particular factory will experience.

A guardrail must name the response to a breach. If the approved method cannot be maintained, the responsible role follows the authorised protection and escalation procedure. If quality evidence is incomplete, affected output remains in its declared status pending the required decision. If a resource measure deteriorates, the owner

investigates the relevant boundary and absolute use alongside intensity. Each condition needs an accountable response; a red tile on its own does not protect the process or resolve the problem.

The review should also distinguish a decision from its result. Authorising assistance is a recorded action. Observing a subsequent improvement is a separate event. Attributing the improvement to the action requires further evidence, including consideration of product mix and other changed conditions. GFT would keep these stages visible in the action record. The later improvement chapter develops verification in depth; here the cascade must ensure that the follow-up measure is chosen before the intervention loses its original context.

> **GFT NOTE**
>
> Approve the cascade only after a supervisor can trace a strategic requirement to a current line record, explain the authorised response and identify the person who resolves a conflicting guardrail. Test the reverse route as well: a worker's challenge should reach the owner of the underlying assumption and return a recorded decision. Keep the scorecard provisional until both routes work in ordinary production.

The resulting scorecard is ready to become a metric contract when its users can state the outcome, the controllable driver, the counting boundary and the decision right without inventing missing assumptions. It is ready for a management routine when the relevant owners can act within the required window. A later digital tool may assemble that draft and expose incomplete fields, but the owner still approves its meaning. The final test is practical: can the line take a defensible action, and can management see the consequences across the operating promise?

At handover, GFT would ask management to inspect a complete decision path rather than approve a slide of metric names. Select a real order requirement, trace the planned work and locate the underlying source event. Confirm who checks it, who acts and how an adverse consequence reaches the appropriate decision owner. Then test an incomplete record and a disputed assumption. The cascade should preserve uncertainty in both cases while still giving the line a usable next step. That is the acceptance condition for this chapter's design, before more detailed metric contracts and management routines are installed.

Carry the purpose to the line, and carry the evidence back.

CHAPTER SOURCE NOTES

S0301 National Institute of Standards and Technology. 2015-12.

S01 International Organization for Standardization. 2014-01.

S02 International Labour Organization. 2017.

S04 International Labour Organization. 2023.

S22 United States Federal Data Strategy. 2020-07.

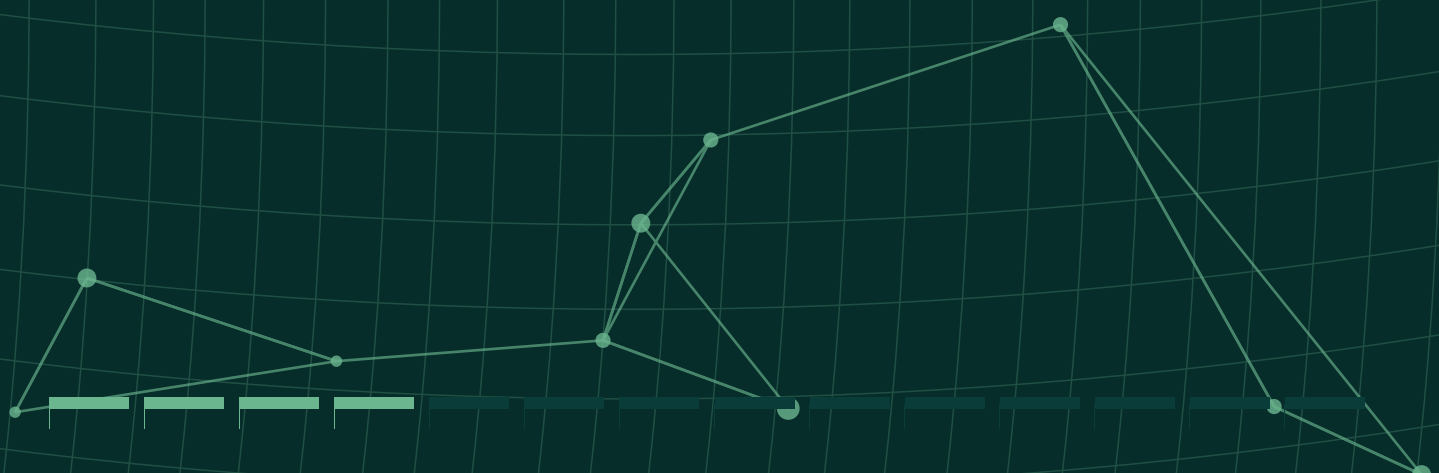
S46 Encyclopedia, MDPI. 2025-03-19.

04

PART I: THE MEASUREMENT CONTRACT / DEFINITIONS AND PROOF

A metric is not a measurement until its error is understood

Operational definitions, data-quality controls and measurement-system analysis must precede target comparisons and automated analytics.



CHAPTER 04
DECISION TEST

Operational definitions, data-quality controls and measurement-system analysis must precede target comparisons and automated analytics.

A factory can calculate a precise percentage from records that do not mean what management thinks they mean. The remedy is a metric contract: a versioned definition of the decision, counting event, formula, unit, time basis, source record and owner, accompanied by evidence that the measurement process is fit for that decision. GFT recommends that no greenfield KPI receive a hard target, a worker consequence or an automated interpretation until those conditions are met. This is not a demand for perfect data. It is a requirement to know where error enters, how large it is relative to the decision, and what remains uncertain after checking.

This discipline separates three questions that dashboards often compress into one tile. What does the number mean? Can the records be trusted for the intended use? Does an observed change exceed the variation created by counting, inspection, timing or meter reading? The chapters on production, quality and management cadence can then use the resulting measures without repeatedly negotiating their meaning.

4.1

The data dictionary begins with formula and unit

ISO 22400 presents manufacturing KPIs through their formulas, corresponding elements, time behaviour, units and other characteristics. That structure is the starting point because a familiar name such as output, availability or yield does not determine a calculation. [S01] A GFT metric contract turns the name into instructions that two people can apply independently to the same events and obtain reconcilable results.

The formula should use operational nouns rather than vague labels. `First-pass good pieces divided by pieces reaching first completion` is more useful than `good divided by total`, because both numerator and denominator now have a counting event. The unit should also survive scrutiny. Pieces, bundles, standard minutes and garments accepted at final inspection are not interchangeable. A ratio may be dimensionless, yet its numerator and denominator still require the same piece basis and process boundary.

Inclusion and exclusion rules finish what the formula starts. The contract states whether samples, training output, interrupted bundles, customer returns and subcontracted work enter the population. It identifies the operation or gate at which completion occurs. It says whether a repaired unit remains a first-pass failure after final acceptance. These are not rare technical exceptions. They are ordinary production events that can otherwise move a KPI without any change in the underlying work.

The time basis needs equal care. A shift total can mean scheduled attendance, planned production time or elapsed time between system timestamps. The contract therefore names the shift calendar, event-time zone, cut-off, late-arrival rule and permitted reporting latency. It also distinguishes event time from entry time. A record entered after the review may be valid for a weekly reconciliation but unavailable for the shift decision that already took place.

Rounding is a presentation rule, not a licence to alter source values. The contract preserves the unrounded numerator and denominator, states when rounding occurs and prevents rounded line ratios from being averaged into a plant ratio. The plant calculation sums compatible numerators and denominators first, then divides. If the populations are not compatible, the correct response is separate reporting rather than a weighted average whose meaning has been lost.

Ownership completes the definition. A business owner approves purpose and use. A data steward maintains validation and resolves record issues. A system custodian controls implementation. One person may hold more than one role in a small factory, but the accountabilities remain visible. Formal data governance supplies the decision rights and enforcement that an informal spreadsheet convention lacks. [S22]

Exhibit 16, p. 61 converts these requirements into a minimum contract. It is deliberately more extensive than a dashboard label because it must support capture, calculation, review and later migration.

EXHIBIT 16 / REQUIRED CONTRACT FIELDS

The metric contract makes independent calculations reconcilable

Contract group	Required entries	Failure prevented
Purpose	Decision, user, owner, review forum	A number without an action
Population	Boundary, inclusions, exclusions, identity	Unlike events counted together
Calculation	Formula, numerator, denominator, unit	Rival formulas under one KPI name
Time	Event, shift calendar, cut-off, latency	False comparison across periods
Capture	Source event, authoritative record, steward	Unowned transcription and correction
Quality	Completeness, validity, consistency, timeliness, uniqueness, accuracy	Clean appearance despite unfit records
Measurement	Repeatability, reproducibility, bias, resolution evidence	Measurement error read as process change
Presentation	Precision, rounding, roll-up and suppression rules	False precision and unstable aggregation
Change	Version, approval, effective date, migration policy	History silently rewritten

DERIVED [S01] [S22] [S23] [S24] Derived field structure. Formula, elements, time behaviour and unit follow S01. Ownership follows S22. Structured quality and fitness-for-use controls follow S23 and S24. No factory performance values are asserted.

The table is a control surface, not administration for its own sake. A field should be removed only when it cannot affect a decision or reconciliation. Conversely, a visually simple KPI may need a substantial contract because its consequences are substantial. The effort belongs where misinterpretation could change staffing, pay, customer promises or investment.

> **GFT NOTE**
>
> Before the first shift, GFT would issue the essential KPI contracts with the source sheets and line board, not after the dashboard. For each measure, the production owner and data steward would independently calculate the same recent sample, reconcile every difference and sign the worked example. A KPI that cannot pass that test remains provisional. It can support learning, but not punishment, incentive payment or an external performance claim.

4.2

Good output needs an unambiguous counting event

Output becomes measurable only when a unit crosses a defined boundary. At a sewing operation, the event may be a completed bundle accepted by the next operation. At end of line, it may be a garment passing inspection without correction. At dispatch, it may be a saleable garment released for shipment. Each event answers a different management question. Combining them produces an apparently convenient total that conceals work in progress, rework and rejection.

First-pass yield makes the distinction especially important. The NIST Manufacturing Extension Partnership case links a first-pass-yield improvement with reduced processing time, but its reported result belongs to that manufacturer's improvement case, not to a garment factory or a universal benchmark. [S10] The transferable lesson is methodological: units accepted only after repair consumed additional processing, so final acceptance cannot replace the first-pass measure.

OEE also retains quality as a component beside availability and performance. Its quality rate is based on processed good amount over processed amount in the formulation reviewed by Ádám and Sebestyén. [S06] That does not make every good-count definition interchangeable. A factory must state whether its production quality component accepts repaired pieces, while its separate first-pass KPI must continue to exclude them. The metric contract prevents a repaired unit from erasing the original loss merely because a later composite needs a final good count.

Five mutually useful records should therefore coexist: pieces started, pieces reaching first completion, first-pass good pieces, pieces entering correction and rejected pieces. Work in progress reconciles starts with completions. Corrected pieces need a disposition such as accepted after rework, still in correction or rejected. A piece count should not be inferred from bundle counts without a reliable pieces-per-bundle record and an exception rule for partial bundles.

The denominator follows the question. First-pass yield at an operation uses pieces reaching their first completion at that operation when management wants to understand the operation's ability to produce correctly. A start-to-date yield uses pieces started when management wants to include the effect of unfinished work. Neither is universally superior. They become misleading when the name remains `yield` while the denominator changes between lines or periods.

WORKED EXAMPLE: ONE POPULATION, THREE DIFFERENT ANSWERS

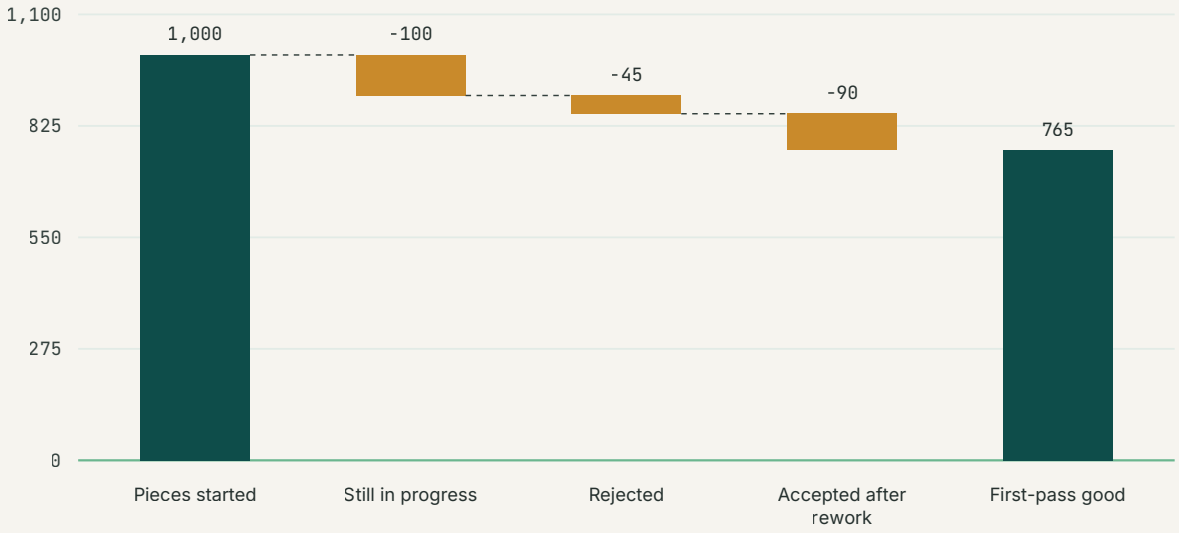
An illustrative sewing operation receives 1,000 pieces in a shift. By the cut-off, 900 have reached first completion and 100 remain in progress. Of the 900 completions, 765 are accepted without correction, 90 are accepted after rework and 45 are rejected. These assumptions are constructed solely to test the counting rules.

First-pass yield is 765 divided by 900, or 85.0 percent. Final acceptance among completed pieces is 765 plus 90, divided by 900, or 95.0 percent. First-pass good pieces per piece started are 765 divided by 1,000, or 76.5 percent. The illustrative results differ because their denominators and purposes differ, not because the process changed. Reporting only 95.0 percent as `yield` would hide both correction and unfinished work.

Exhibit 17, p. 63 shows the same illustrative population as a partition. Every started piece appears once, so the flow can be checked before any ratio is calculated.

EXHIBIT 17 / ILLUSTRATIVE PIECES STARTED

A count reconciliation preserves unfinished and corrected work



ILLUSTRATIVE Illustrative worked example, not factory evidence. Assumed starts are 1,000 pieces. Partition: 100 still in progress, 45 rejected, 90 accepted after rework and 765 first-pass good. Arithmetic: 1,000 - 100 - 45 - 90 = 765. Repaired pieces remain separately visible and are not first-pass good.

The reconciliation must also survive roll-up. Summing first-pass good pieces and completions across operations is valid only when each operation retains its own boundary and no piece is counted twice within the same KPI. A plant end-of-line yield should not be presented as the product of operation yields unless the routing, sampling and unit identity actually support that calculation. The safer daily control is to preserve operation-level counts and a separate end-of-line population, then investigate differences rather than force them into one formula.

Manual counts need practical controls at the point of work. The counter records the boundary, bundle identity where applicable, event time and any partial quantity. A supervisor resolves discrepancies against physical work before the shift closes. Corrections retain the original value, revised value, reason and author. Automation can later capture the same event, but a sensor does not settle the definition. It merely implements the counting rule it has been given.

4.3

Structured records need explicit quality dimensions

A correct formula cannot rescue records that are missing, duplicated, late or detached from reality. ISO/IEC 25012 defines a general quality model for structured data retained in a computer system, which supports treating data quality as a defined evaluation problem rather than a general complaint about spreadsheets. [S23] The model does not make a manual sheet reliable by virtue of being typed into an application. The factory still has to specify intended use, checks and evidence.

The UK Government Data Quality Framework describes quality as fitness for purpose and sets out completeness, uniqueness, consistency, timeliness, validity and accuracy as core dimensions. It also warns that quality needs and trade-offs depend on the user. [S24] This matters on a garment floor. A line interruption record may need to be available immediately even if its cause is provisional, while a monthly cost reconciliation can wait for a complete and reviewed population. One service level should not be imposed on both.

Each dimension needs an operational test. Completeness compares received records with an expected population, such as active lines, shifts or meters, rather than counting rows already present. Validity checks types, allowed codes and feasible ranges. Consistency tests whether related records contradict one another, such as completions exceeding starts without an explained opening balance. Timeliness measures the interval between event and availability for a named decision. Uniqueness detects repeated identities or duplicate events. Accuracy compares a sample with physical work, reference instruments or adjudicated evidence.

These tests belong at capture and again during roll-up. Capture controls prevent avoidable errors and return ambiguous entries to the person who can still inspect the work. Roll-up controls detect failures between systems, incompatible master data and calculations applied to the wrong population. A valid individual record can still produce an invalid plant KPI if the aggregation includes a closed line, repeats a corrected event or mixes different method revisions.

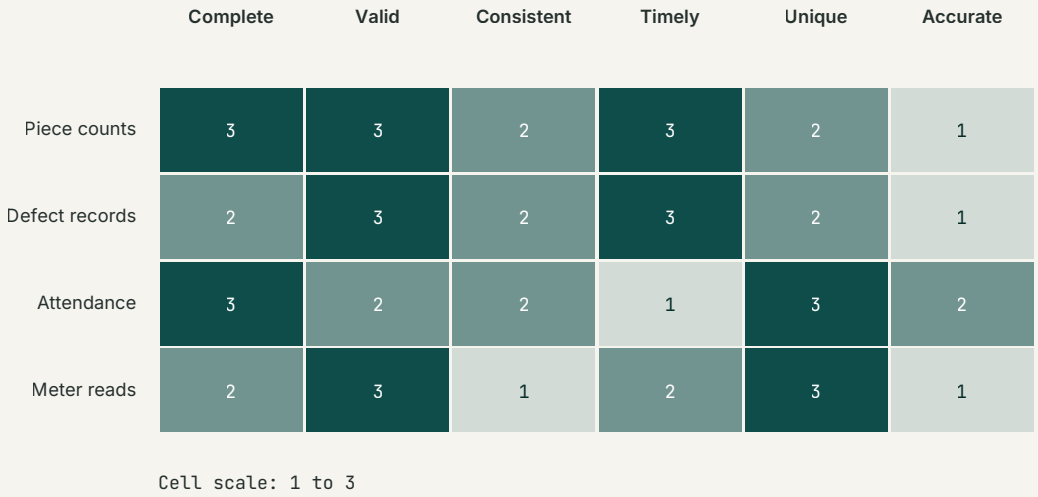
Accuracy deserves separate treatment because a fully populated, valid and timely record may still be wrong. A defect code can belong to the permitted vocabulary yet describe the wrong observable fault. A meter value can have the expected format yet come from the wrong meter. Accuracy checks therefore require an external reference and a sampling procedure. The reference itself needs review, especially when expert judgement is used to adjudicate inspection or defect categories.

Failed checks need disposition rules. Some records can be rejected immediately, such as an impossible timestamp. Others should be quarantined with the source retained, such as a duplicate bundle event whose physical status is unclear. A provisional value may support a shift review only when its status travels with the KPI. Silent imputation, deletion or overwriting removes the evidence needed to diagnose the failed hand-off.

Exhibit 18, p. 65 provides an illustrative control-planning matrix. The scores do not assess a real factory. They show how a team can record whether a control is absent, designed, executed or supported by retained evidence for each log and dimension.

EXHIBIT 18 / ILLUSTRATIVE CONTROL SCORE FROM 0 TO 3

A control map locates the hand-off that still needs evidence



ILLUSTRATIVE [S23] [S24] Illustrative deployment template, not an assessment of GFT or any factory. Score 0 means absent, 1 designed, 2 executed and 3 evidenced by a retained test result. Values are constructed to demonstrate how control coverage can be reviewed. Quality dimensions follow S24 within the structured-data concern framed by S23.

The matrix should lead to a small number of repairs, not a second reporting burden. For each weak cell, the steward records the failing records, decision affected, root hand-off, corrective action and retest result. A high design score means little without retained execution evidence. The control map becomes useful when a reviewer can move from a cell to the actual exception log and see what changed.

4.4

Time and identity prevent false comparisons

Factories compare periods, lines and styles. Those comparisons are valid only when identity survives the comparison. A line code reused after a layout change, an operation code reused after a method revision or a style code attached to a revised routing can make unlike work appear continuous. The result is a clean time series whose meaning has quietly broken.

Shared vocabularies and standards support interoperability among datasets, according to W3C guidance. [S25] GFT would apply that principle before selecting integration technology. The minimum identifiers cover line, operation, style, order,

shift, employee or team where justified, machine, material batch and meter. Each identifier has one authoritative owner and a defined relationship to the production event. Free-text substitutes are permitted only as controlled exceptions, not as parallel master data.

Effective dating is more useful than overwriting. A routing record retains the method revision and the interval during which it applied. A line assignment retains its start and end. A defect code retains its definition and successor if the taxonomy changes. Historical events then resolve against the master-data version in force at event time, while current planning uses the current version. This avoids both dangers: rewriting the past with today's structure and freezing tomorrow's work inside obsolete codes.

Shift identity requires a calendar rather than a date extracted from a timestamp. Work crossing midnight belongs to the shift defined by the operating calendar, not automatically to the calendar date on which the event occurred. The contract records the shift start, end and approved exceptions. Late entries retain both the production shift and the entry timestamp. This allows an operations review to use the intended population and a data-quality review to measure reporting delay.

Comparisons also need population flags. Style, order, routing revision, staffing cohort and machine configuration can explain why two output records are not like for like. These fields should not become an excuse to discard inconvenient results. They define cohorts in advance, so a supervisor can compare similar work and an analyst can state the limitations of a pooled result. A changed routing is a new comparison condition, not a silent edit to old history.

Identity controls extend to people with restraint. A performance system should collect the least personal information needed for the operational decision, restrict access and avoid turning a team process measure into an unsupported individual verdict. This is a design recommendation, not a claim of legal compliance. Where worker identity is necessary for skill, attendance or allocation records, its purpose and permitted use belong in the data contract and governance review.

4.5

Measurement variation can mimic process variation

A KPI observes production through a measurement system. When the observed value changes, the cause may be the work, the instrument, the observer, the recording practice or a combination of them. NIST's Gauge R&R guidance explicitly addresses errors affecting gauges and instruments in production, including repeatability, reproducibility, stability and bias. [S40] The management mistake is to interpret every movement as process performance before separating these sources.

Repeatability asks whether the same method, observer and instrument produce close results on the same item under repeated conditions. Reproducibility asks whether the result remains sufficiently close when observers, gauges or other defined conditions change. Bias concerns systematic difference from a reference. Stability concerns

behaviour over time. Resolution concerns whether the instrument or recording increment can distinguish a difference that matters to the decision. These are distinct failure modes, so a single calibration sticker cannot answer all of them.

Garment-floor measures need the same scepticism even when no conventional gauge is present. Defect grading depends on observers, reference samples, lighting, instructions and the condition presented. Piece counting depends on bundle integrity, boundary discipline and duplicate handling. Timestamp measures depend on clocks, event definitions and when an operator presses a key. Meter reading depends on instrument identity, units, resolution and transcription. A manual process is still a measurement system.

A useful study begins with the decision, not with a generic pass mark. The team states the smallest difference that would trigger action and the consequence of a wrong classification. It then selects items that represent the actual range of work, including difficult borderline cases where inspection agreement matters. Observers perform blinded repeats in a randomised order where practical. The study records raw outcomes and conditions rather than retaining only a final agreement percentage.

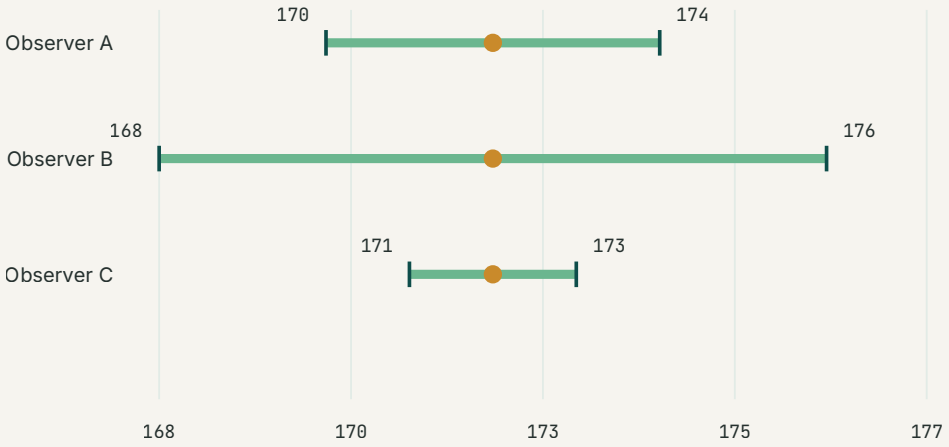
For continuous measures, a simple decomposition can guide the analysis: observed variation contains process variation and measurement variation under stated assumptions. The assumptions matter. If the same item changes between readings, if observers learn the sequence or if gauge error grows with the measured value, the simple decomposition is not enough. The study design should expose those conditions rather than hide them inside a single ratio.

For attribute decisions, agreement statistics must preserve the confusion pattern. An inspector who misses defects creates a different risk from one who rejects good garments, even when total agreement is identical. The review therefore separates false acceptance, false rejection and disagreement on defect type. A reference set needs an adjudication rule and periodic review, because calling one expert's answers `truth` merely relocates the measurement problem.

Exhibit 19, p. 68 illustrates why a central result alone is insufficient. Three constructed observers have the same median accepted count but different ranges across blinded repeats of one reference set. The ranges are observed study outcomes in this example, not confidence intervals and not evidence from a factory.

EXHIBIT 19 / ILLUSTRATIVE ACCEPTED PIECES PER 200-PIECE REFERENCE SET

Equal central results can conceal different observer variation



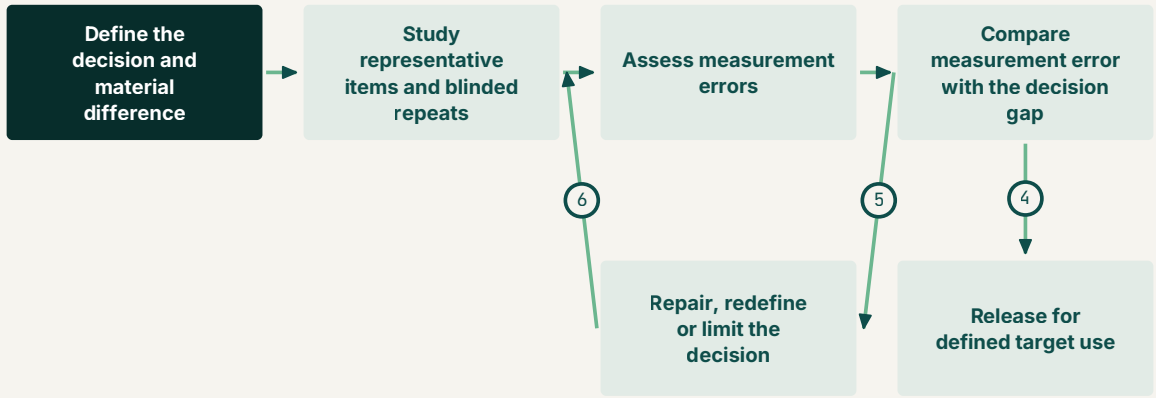
ILLUSTRATIVE Illustrative measurement-system example. Each constructed observer reviews the same 200-piece adjudicated set in five blinded repeats. Low and high are the observed minimum and maximum accepted counts; mid is the median, not a mean or confidence interval. A: 170 to 174 with median 172. B: 168 to 176 with median 172. C: 171 to 173 with median 172. Values demonstrate study interpretation only.

The example does not say which observer is correct. It shows that Observer B's repeat outcomes vary more and that a reference comparison is needed to assess bias. Nor does the range establish a universal acceptance limit. The factory compares the observed measurement error with the decision gap. A small target difference cannot support a confident ranking if routine observer variation is wider than that difference.

Exhibit 20, p. 69 places this evidence before target use. Repair may mean recalibration, a better reference set, clearer defect definitions, a revised counting event, additional observer practice or a coarser but more honest KPI precision. Repeating the same study without changing the measurement system is not repair.

EXHIBIT 20 / DECISION SEQUENCE

Measurement-system evidence gates consequential target use



4. Fit for use
5. Not fit
6. Retest

ILLUSTRATIVE [S40] Illustrative GFT control flow based on the measurement-error categories in S40. Acceptance is relative to the intended decision, not a universal Gauge R&R threshold. A failed gate returns to repair or redefinition before target use.

MINIMUM EVIDENCE PACK

Retain the decision and material difference, study protocol, item selection, reference basis, observer or instrument conditions, raw repeats, calculations, exceptions and acceptance rationale. Record who approved use and which KPI versions rely on the result. Repeat the study after a relevant instrument, method, staffing or product change, and when routine results suggest that measurement behaviour has drifted. The pack should allow another reviewer to reproduce the conclusion, not merely see that a study occurred.

Measurement-system analysis also changes management behaviour. Where error is material, leaders use ranges, longer observation windows or physical verification rather than false precision. They do not rank workers on differences the measurement system cannot resolve. They may continue to collect a provisional measure for learning, provided its limitation is visible and no high-stakes consequence depends on it.

4.6

A control limit is not a specification or a target

Control limits, specifications and targets answer different questions. A control limit describes expected process behaviour under a stated statistical method and baseline. A specification states a requirement that a product or process must satisfy. A target

states the result management wants. Confusing them can make a capable process look unacceptable, make an unacceptable process look stable or provoke intervention whenever ordinary variation occurs.

NIST describes statistical process control as a comparison between what is happening now and what happened previously, using historical data or a process model to calculate limits for expected measurements. [S09] The baseline is therefore part of the result. A limit calculated during an unstable ramp, under a different method or from a mixture of unlike styles does not acquire authority merely because software draws it precisely.

The measurement-system gate comes first. If observer variation or meter error is material, a control chart may signal changes in the measurement process rather than the production process. The team should retain the study evidence beside the chart configuration and state any remaining limitation. This is especially important when inspection standards, reference samples or timestamp practices change, because the apparent process population may no longer be continuous.

A stable baseline is not simply a long sequence of numbers. The reviewer examines the production conditions, exclusions, sampling frequency and missing records, then documents why the baseline population is suitable. Known interventions and method revisions are marked. Points are not removed merely because they are inconvenient. Any exclusion retains its reason and the effect on the calculated limits, so baseline construction does not become an unreviewed route to a preferred answer.

The control method must fit the record. Defect proportions, counts, continuous cycle times and rare events have different statistical needs. Sample size and sampling frequency affect interpretation. Where the factory lacks the conditions for a defensible chart, a run chart with contextual notes and physical investigation is more honest than an elaborate limit calculation. The objective is to direct attention to unusual evidence, not to display statistical vocabulary.

Specifications remain visible on their own terms. A customer requirement is not recalculated from factory history, and a process inside control limits can still produce nonconforming work. Conversely, a process can meet a specification on average while an unusual point warrants investigation. Management review needs both answers: whether behaviour is stable relative to its baseline and whether output satisfies requirements.

Targets sit beside rather than inside this logic. A target can be intentionally beyond current capability, but the gap should prompt resource and method decisions rather than repeated adjustment to routine noise. When a verified intervention changes the process, the team documents the new baseline before adopting new limits. Limits are not reset after every movement, because that would erase the evidence needed to distinguish sustained change from ordinary variation.

A chart therefore needs a contract of its own: measure version, population, sampling rule, baseline period, calculation method, limit version, specification source, target basis and response rule. The reviewer records what action a signal should trigger and who has authority to investigate. Without those fields, the chart is only a picture of variation, not a governed control.

4.7

Definition changes require versioned migration

Metric definitions will change as the factory learns, customer requirements evolve and source capture improves. The risk is not change itself. The risk is an untraceable change that makes a new result look like an improvement or decline against an incompatible history. Data governance is a process of setting and enforcing priorities for managing and using data, which gives definition change an explicit decision right rather than leaving it to whoever edits a spreadsheet first. [S22]

A change request begins with the reason and the decision affected. It distinguishes correction of an implementation error from a deliberate change in operational meaning. Fixing a denominator mapping in code is not the same as deciding that repaired garments now count as first-pass good. The first restores the approved contract. The second creates a new measure version and may invalidate comparisons, incentives and model features built on the old one.

The request records the current definition, proposed definition, source-event implications, owner, approvers and effective date. It identifies every affected surface: source sheet, validation rule, line board, plant report, export, sustainability calculation, incentive rule and analytical dataset. A small factory can keep this register in a controlled workbook. What matters is completeness and accountability, not the sophistication of the tool.

Back-calculation requires evidence, not preference. If the retained raw events contain enough information to calculate both versions, the steward may rebuild history and reconcile the result to the original records. The back-calculation keeps its own version and test evidence. If the old events do not contain the new distinction, history must not be fabricated. The report carries a break, explains the difference and, where useful, presents overlapping old and new measures during a controlled transition.

Parallel operation provides a practical bridge. Both definitions run on the same events for a suitable review window, with differences investigated and explained. The purpose is not to choose the more flattering series. It is to prove that the new rule captures the intended population, that source systems implement it consistently and that users understand the new comparison basis. The transition ends through the same approval route that authorised it.

Migration acceptance uses concrete reconciliation cases. The worked example in the metric contract becomes a test fixture, joined by boundary cases such as partial bundles, repairs, late entries, changed routings and duplicate events. Expected outputs are agreed before release. Source totals reconcile to KPI inputs, KPI outputs reconcile to every report and corrections preserve their history. A visual check of the new dashboard cannot replace these tests.

Historical extracts carry the definition version with the values. This prevents a later analyst from treating differently defined observations as one training population. Models and rules that consume the KPI receive an impact review before migration. If a threshold was learned under one inspection or counting regime, it remains provisional until validated under the new one. The same caution applies to external benchmarks and target commitments.

Retirement is also controlled. When a measure no longer supports a decision, the owner records why it is withdrawn, which reports lose it and how its history remains accessible. Removing an inconvenient KPI without a record damages institutional memory just as surely as redefining it in secret. A useful data dictionary therefore contains active, superseded and retired versions, with their effective intervals and relationships.

GFT's practical rule is that the history of meaning is part of the operating record. The factory does not need a heavy governance bureau to preserve it. It needs one accountable owner, one visible change register, reproducible calculations and the discipline to leave a discontinuity visible when evidence cannot bridge it. That discipline protects every later comparison, from a shift review to an investment model.

A number earns authority from the integrity of its definition, its evidence and its error, not from the precision of its display.

CHAPTER SOURCE NOTES

S01 International Organization for Standardization. 2014-01.

S22 United States Federal Data Strategy. 2020.

S23 ISO/IEC. 2008.

S24 UK Government Data Quality Hub. 2020-12-03.

S10 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04.

S06 Diamond Congress, Creative Construction Conference. 2023.

S25 W3C. 2017-01-31.

S40 NIST/SEMATECH. 2003.

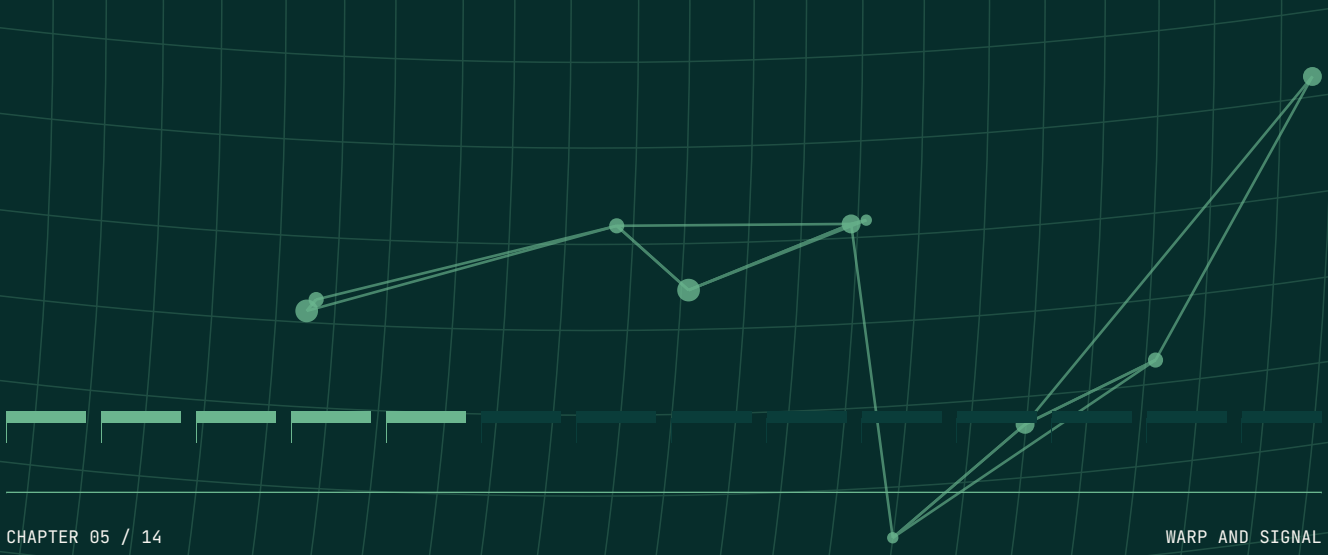
S09 NIST/SEMATECH. 2003.

05

PART II: MEASURE THE OPERATING SYSTEM / OUTPUT AND UTILISATION

Production measures must expose losses, not compress them

Good output is the result, while the production system must retain the component losses that explain why the result occurred.



CHAPTER 05
DECISION TEST

Good output is the result, while the production system must retain the component losses that explain why the result occurred.

A greenfield garment factory cannot manage production through a headline output total or a compressed efficiency ratio. Good garments completed on the first pass are the commercial result of the shift, yet that result is the residual of a chain of distinct time, speed and quality losses. [S06] When a system reports only pieces packed at day's end, or collapses line performance into one composite Overall Equipment Effectiveness (OEE) percentage without its components, management sees the symptom after the shift closes but loses the cause. [S07] In GFT's Cameroon textile programme, prepared on 31 January 2024 with source refreshes flagged in 2026, the production measurement contract requires every shift record to reconcile scheduled time, attended time, planned production time, actual run time, standard minutes earned, total pieces completed and first-pass good pieces on one auditable ledger. [S01]

The context in Cameroon raises the cost of opaque reporting. Sector evidence indicates that about 95 percent of Cameroon's cotton fibre is exported raw while about 5 percent is processed locally, against a target of 50 percent local processing by 2030 under the National Development Strategy (SND30). [R06] [R07] Those figures describe the raw-material boundary rather than a guaranteed market share for any plant, and nothing in this chapter constitutes investment, legal or tax advice. Yet they explain why new cut, make, trim and finishing operations cannot afford the underutilisation documented in legacy domestic plants, where a July 2023 report recorded capacity utilisation of 33.7 percent at Garoua, 48.9 percent at CICAM 1 and 10.83 percent at CICAM 2, costing about CFAF 2 billion in 2020. [R12] Moving from fibre export to competitive garment manufacturing requires line-level operating evidence from the first shift, separating order gaps from starvation, breakdown, changeover delay, learning pace and rework loops. [S11]

5.1

Nameplate capacity is not saleable throughput

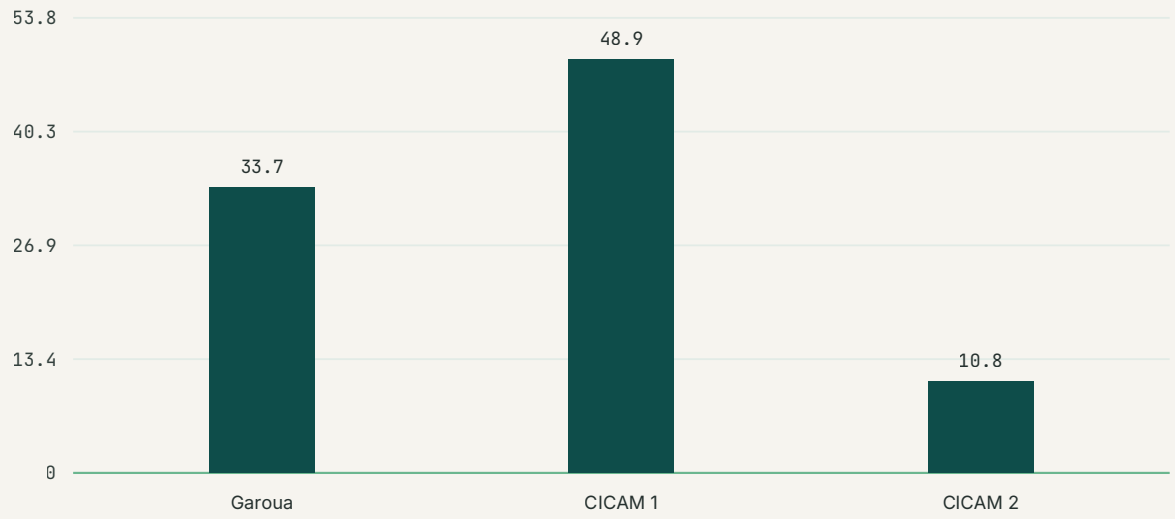
Sponsors often evaluate a new garment factory by multiplying installed sewing stations by annual working hours and dividing by an assumed garment work content. That calculation describes theoretical nameplate capacity under uninterrupted steady-state conditions, not saleable throughput. [S11] Production ramp-up research shows that a newly launched process is initially poorly understood, simultaneously causing low production rates and low yields. [S11] In an apparel sewing line, where thirty to forty interdependent stations pass bundles sequentially, a gap between theoretical capacity and saleable output arises at four boundaries before a carton enters the warehouse: calendar time lost to unscheduled shifts, planned time lost to stoppages, running time lost to sub-standard speed or imbalance, and completed pieces lost to rework or rejection. [S06] [S07]

Historical evidence from Cameroon's existing textile sector illustrates the risk of treating installed capacity as an undifferentiated block. As shown in **Exhibit 21**, p. 75, the inherited sector baseline from July 2023 records wide variation across domestic facilities, with Garoua operating at 33.7 percent of capacity, CICAM 1 at 48.9 percent and CICAM 2 at 10.83 percent. [R12] While those figures are Grade-C sector observations of an established enterprise rather than GFT operating results, a single plant-level utilisation percentage cannot tell an operations director whether missing output

resulted from power interruptions, spare-parts shortages, unbalanced work allocation or quality rejects. [R12] [S07] Reporting one aggregate utilisation number compresses distinct engineering and commercial problems into an unactionable figure. [S0501]

EXHIBIT 21 / PERCENT OF INSTALLED CAPACITY

Reported plant utilisation in Cameroon shows why headline capacity requires loss decomposition



SOURCED [R12] Reported capacity utilisation from a July 2023 report cited in Business in Cameroon (R12): Garoua 33.7 percent, CICAM 1 48.9 percent, CICAM 2 10.83 percent. Inherited Grade-C sector observation; original publication day not recorded. Not a GFT operating result.

Exhibit 21, p. 75 establishes only that wide gaps between installed capacity and actual utilisation have been observed in the national industry and associated with financial loss, reported at about CFAF 2 billion in 2020. [R12] It cannot establish root causes inside each plant, because an aggregate utilisation ratio merges demand deficits, supply delays, breakdowns and efficiency losses into one denominator. [S07] To prevent that ambiguity, GFT separates the time and piece accounting hierarchy into non-overlapping layers aligned with ISO 22400-2. [S01]

5.2 TIME ACCOUNTING MUST PRECEDE EFFICIENCY CALCULATION

Before any efficiency or OEE percentage is calculated, the shift ledger must account for every minute of the working day. In Cameroon, labour regulations establish a standard 40-hour working week and a 48-hour maximum week, with overtime compensated at 1.2 times the regular rate. [R16] Under an illustrative five-day schedule of eight-hour shifts, each line begins with 480 scheduled calendar minutes per shift (2,400 minutes per week). [R16] Unscheduled shift time due to unreleased orders is a capacity-allocation variance owned by commercial planning, not an operating loss owned by the line supervisor. [S22]

Once a shift is scheduled and attended, three subtractions convert calendar time into productive-equivalent time: [S01] [S06]

1. **Scheduled shift time to planned production time**: Scheduled shift time minus authorised non-production windows, such as statutory breaks, planned maintenance or safety briefings, yields *planned production time*. [S01] [S06] Supervisors cannot extend planned time by skipping breaks or adding unapproved overtime, which degrades health and efficiency. [R16]
2. **Planned production time to actual run time**: Planned production time minus all unplanned and changeover stoppages, including breakdowns, setups, folder adjustments, panel starvation, trim shortages and power interruptions, yields *actual run time* (operating time). [S06] [S07]
3. **Actual run time to standard minutes earned and good time**: Multiplying completed garments by the approved Standard Minute Value (SMV) yields total standard minutes produced, revealing run time lost to slow pace, micro-stoppages and balancing friction. [S03] [S06] Multiplying by the proportion of pieces accepted on the first pass without rework yields productive-equivalent minutes spent creating saleable, first-pass good output. [S06] [S10]

METHOD

Reconciling the production time and piece boundary

To ensure that two analysts never calculate different utilisation or OEE figures from the same shift, the GFT measurement contract enforces four conservation identities across every shift record: [S01] [S0501]

- $\text{Scheduled Shift Time} = \text{Authorised Non-Production Time} + \text{Planned Production Time}$ (minutes).
- $\text{Planned Production Time} = \text{Total Downtime} + \text{Actual Run Time}$ (minutes), where $\text{Total Downtime} = \sum_{k} d_k$ across logged stoppage events k.
- $\text{Total Pieces Completed} = \text{First-Pass Good Pieces} + \text{Reworked Pieces} + \text{Scrap Pieces}$ (units crossing end-of-line inspection on initial completion).
- $\text{Good Standard Minutes} = \text{First-Pass Good Pieces} \times \text{SMV}$, where SMV is the approved standard minute value for the active style and method revision. [S03]

Locking these conservation rules into the shift record prevents the failure identified by NIST's manufacturing diagnostics subcommittee, which warned that multiple competing definitions and calculations of OEE circulate across industry and make unstandardised figures incomparable. [S0501]

5.3

OEE retains its three components

Overall Equipment Effectiveness detects production losses and maximises equipment effectiveness by decomposing performance into three multiplicative components: availability, performance efficiency and quality rate. [S06] Applied to a sewing line or cutting room, the composite score equals the product of those three sub-KPIs: [S06]

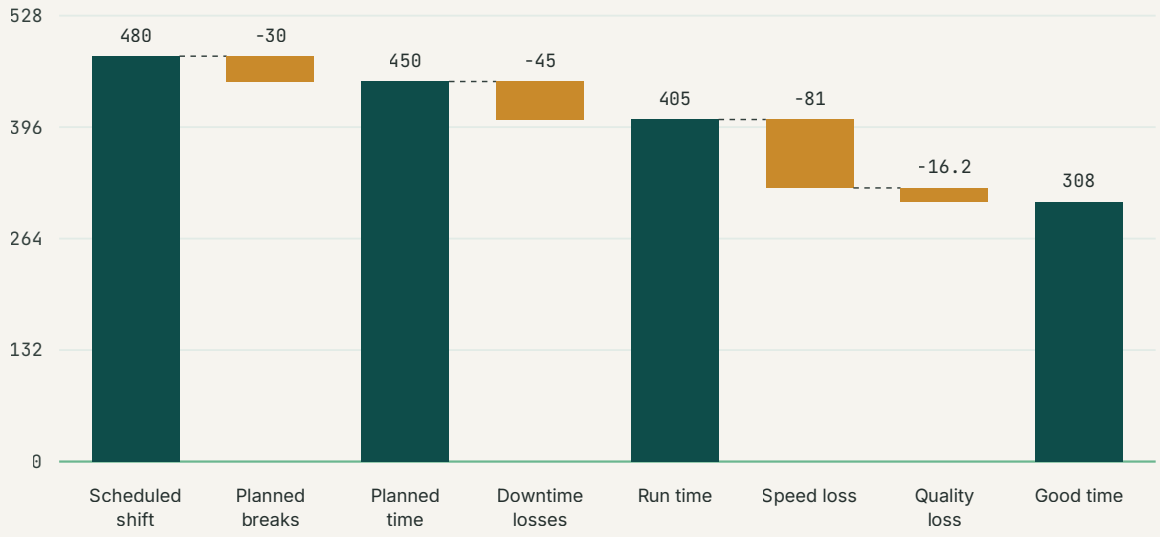
$$\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality}$$

When availability is $\text{Actual Run Time} / \text{Planned Production Time}$, performance is $(\text{Total Pieces Completed} \times \text{SMV}) / \text{Actual Run Time}$, and quality is $\text{First-Pass Good Pieces} / \text{Total Pieces Completed}$, intermediate terms cancel upon multiplication. [S06] The product simplifies to $(\text{First-Pass Good Pieces} \times \text{SMV}) / \text{Planned Production Time}$, the ratio of good standard minutes earned to planned production minutes. [S06] [S0501] That cancellation guarantees an exact conservation measure of productive time, but displaying only the cancelled product hides whether time vanished into stops, slow pace or defective stitching. [S06] [S07]

Exhibit 22, p. 77 shows how GFT structures the shift bridge so every loss category remains visible between the opening 480-minute scheduled shift and closing productive-equivalent time. [R16] [S06]

EXHIBIT 22 / PRODUCTIVE-EQUIVALENT MINUTES PER 480-MINUTE SHIFT

The path from scheduled time to good output retains every loss



DERIVED [S06] [S07] [R16] Derived from an illustrative 480-minute shift (40-hour five-day week in R16) using OEE components in S06 and unmerged downtime in S07: 480 scheduled less 30 break minutes = 450 planned minutes; less 45 downtime minutes (20 failure, 15 changeover, 10 waiting) = 405 run minutes; less 81 speed-loss minutes (80 percent performance) = 324 standard minutes; less 16.2 quality-loss minutes (95 percent first-pass yield) = 307.8 good minutes (68.4 percent OEE).

In **Exhibit 22**, p. 77, starting with 480 scheduled minutes per station and deducting 30 break minutes leaves 450 planned production minutes. [R16] [S06] Deducting 45 minutes of illustrative availability losses leaves 405 run minutes ($405 / 450 =

90.0\text{ percent}$ availability). [S06] An illustrative 80.0 percent performance rate deducts 81 minutes of speed loss, leaving 324 standard-earned minutes, and an illustrative 95.0 percent first-pass quality rate deducts 16.2 minutes spent on defective garments, leaving 307.8 minutes of good time ($307.8 / 450 = 68.4\text{ percent}$ OEE). [S06] [S10] While this waterfall reconciles shift arithmetic, it cannot by itself identify which station acted as the constraint or whether speed losses came from skill gaps or starvation; those questions require component drill-downs. [S04] [S07]

5.4 IDENTICAL COMPOSITE SCORES MASK OPPOSITE OPERATIONAL FAILURES

Because multiplication is commutative, a line with 90.0 percent availability, 80.0 percent performance and 95.0 percent quality achieves the same 68.4 percent OEE as a line with 80.0 percent availability, 95.0 percent performance and 90.0 percent quality, yet needs intervention from different teams. [S06] [S22] **Exhibit 23**, p. 78 illustrates three garment lines in an illustrative plant review that all report a composite OEE near 68 percent (68.4 percent, 68.0 percent and 68.3 percent), with diverging component profiles. [S06] [S0501]

EXHIBIT 23 / ILLUSTRATIVE PERCENT

The OEE composite must travel with its components



ILLUSTRATIVE [S06] [S0501] Illustrative comparison of three garment lines that all report approximately 68 percent composite OEE (68.4, 68.0 and 68.3 percent) under the multiplicative definition in S06 and S0501, yet require completely different interventions: Line A is constrained by performance during ramp (80 percent), Line B by availability losses (75 percent), and Line C by first-pass quality defects (78.1 percent).

In **Exhibit 23**, p. 78, Line A runs reliably (90.0 percent availability) with clean work (95.0 percent quality), but operates at an illustrative 80.0 percent performance rate during ramp-up, requiring line balancing and coaching. [S04] [S11] Line B runs near standard pace when active (95.0 percent performance) with 95.5 percent quality, but loses 25.0 percent of planned time to stoppages (75.0 percent availability), requiring maintenance, cutting coordination or setup reduction. [S06] [S07] Line C maintains 92.0 percent availability and 95.0 percent performance, but loses 21.9 percent of output to defects (78.1 percent quality), pointing to machine tension, pattern faults or speed-biased incentives. [S10] [S0503] **Exhibit 23**, p. 78 is an illustrative comparison rather than an empirical benchmark and cannot replace event logs, but it shows why GFT never prints a composite OEE figure without its three constituent ratios and denominators. [S01] [S06]

> **GFT NOTE**
>
> **Never set a single composite OEE target for a garment sewing line during ramp-up.** Because OEE multiplies availability, performance and quality, a supervisor pressured to meet an arbitrary composite percentage can temporarily inflate the score by pushing defective bundles through to the end of the line or by misclassifying material starvation as unscheduled time. [S06] [S0501] In GFT's design, the line board displays availability minutes, standard minutes earned and first-pass yield side by side, each with its own guardrail and owner. [S02] [S22]

5.5

Aggregated downtime hides the action required

Even when availability is separated from performance and quality, the availability ratio is still an aggregate. Empirical research analysing real-time manufacturing efficiency warns that standard OEE loss categorisation merges all downtime events into a single availability deduction, obstructing the identification of specific operational losses and representing a significant limitation of conventional OEE reporting. [S07] Knowing that a sewing line stopped for 45 minutes in an eight-hour shift tells the manager that 10.0 percent of planned time was lost, without indicating whether the plant needs a mechanic, a changeover cart, earlier fabric relaxation or a generator check. [S07]

In a multi-station sewing line, downtime accounting requires a distinction between *station stoppage* and *line stoppage*. [S04] [S0502] If one non-bottleneck overlock breaks down for 12 minutes while an upstream buffer holds bundles and a floater steps in at a spare station, packing-table throughput suffers no immediate interruption. Conversely, if the bottleneck collar station stops for 15 minutes with no buffer, the thirty-operator line is starved downstream and blocked upstream. [S04] GFT records downtime at two linked levels: station-level stoppage minutes (machine-minutes or operator-minutes lost) and line-level stoppage minutes (line-minutes lost to total flow). [S01] [S07]

5.6 A CONTROLLED TAXONOMY ROUTES EACH STOPPAGE TO ITS FUNCTIONAL OWNER

To prevent vague free-text notes that cannot be aggregated across shifts, structured data-quality governance requires a mutually exclusive controlled vocabulary for downtime causes. [S23] [S25] Every downtime event exceeding a defined threshold (such as an illustrative two-minute threshold on manual logs, or thirty seconds on power-sensing logs) records six mandatory attributes: line and station identifier, operation code, start timestamp, end timestamp, controlled cause code and immediate response. [S01] [S20]

GFT organises the controlled cause taxonomy around the functional owner who holds authority to eliminate the stoppage: [S07] [S22]

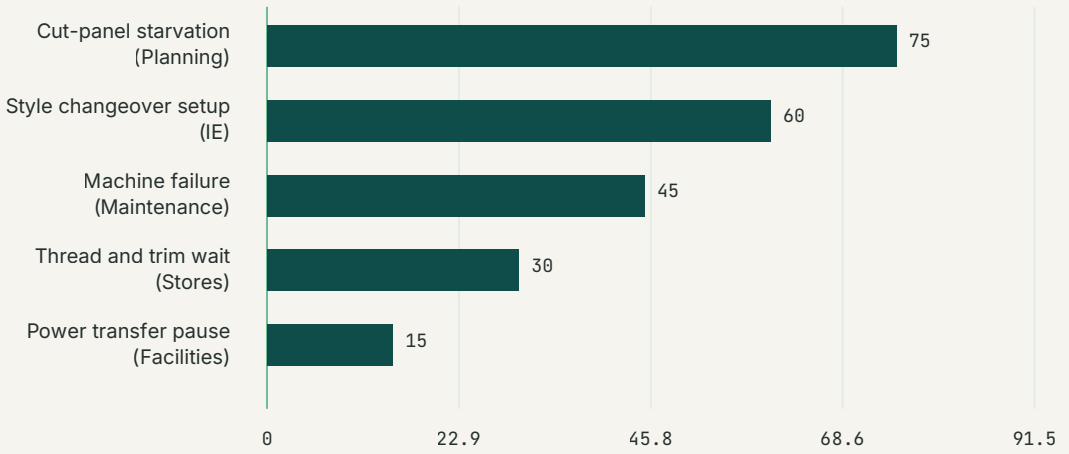
- **Upstream starvation (Production Planning and Cutting)**: Waiting for cut panels, mismatched bundles, missing shade-lot tickets or delayed cutting release. [S04] [S07]
- **Material and trim shortage (Stores and Purchasing)**: Waiting for thread, zippers, buttons, labels, interlining or cartons after bundles are loaded. [S07]

- **Changeover and setup delay (Industrial Engineering and Line Supervision)**: Changing folders, presser feet, needle gauges and thread colours between styles, plus bundle loading before the first good garment exits. [S04] [S06]
- **Equipment breakdown (Maintenance)**: Unplanned mechanical or electrical failure, split between *mechanic response time* (call to arrival) and *active repair or swap time* (arrival to restart). [S06] [S07]
- **Quality hold or method clarification (Quality Assurance and Technical Design)**: Station or line stopped for a defect outbreak, spec discrepancy or unsewable construction step. [S03] [S10]
- **Utility and facility interruption (Facilities Engineering)**: Grid outages, voltage sags, generator transfer delays, compressed-air drops or steam interruptions. [S07]
- **Staffing or rebalancing pause (Line Supervision and Human Resources)**: Station unstaffed at shift start before a floater is assigned through daily line balancing. [S04]

Exhibit 24, p. 80 shows an illustrative weekly Pareto ranking of 225 downtime minutes across five shifts on one sewing line, routing accountability across plant functions. [S07] [S22]

EXHIBIT 24 / ILLUSTRATIVE DOWNTIME MINUTES PER LINE-WEEK

Downtime causes point to different owners



ILLUSTRATIVE [S07] Illustrative weekly downtime Pareto for one 30-operator sewing line (225 total downtime minutes across five shifts) showing why merged downtime obstructs diagnosis (S07). Each bar maps to a distinct operational owner: cut-panel waiting (planning/cutting), style changeover (industrial engineering/supervision), lockstitch/overlock failure (maintenance), trim/thread shortage (stores), and utility interruption (facilities).

In **Exhibit 24**, p. 80, the line lost 225 minutes out of 2,250 planned production minutes across the week (90.0 percent availability). [S06] Merged into one availability-loss bar, those 225 minutes might prompt management to blame the line supervisor or maintenance team. [S07] Disaggregated by cause and owner, only 45 minutes (20.0 percent of illustrative downtime) came from machine failure, whereas 75 minutes (33.3 percent) came from waiting for cut panels and 60 minutes (26.7 percent) from style changeover setup. [S07] **Exhibit 24**, p. 80 is an illustrative taxonomy model

rather than an empirical survey of Cameroon factories, so its numbers are not benchmarks, but it proves that availability measurement cannot direct corrective action unless downtime retains its cause, duration and owner. [S07] [S08]

5.7

Performance loss needs a work-content reference

Once availability losses are subtracted to yield actual run time, the second OEE pillar evaluates whether the line produces at its reference rate while running. [S06] In a garment factory producing shirts, trousers, uniforms and workwear across the same month, raw piece counts per running hour are meaningless unless normalised for work content. [S03] Completing 120 simple t-shirts an hour can represent a lower performance rate than completing 55 tailored trousers an hour when the trousers require nearly three times the stitching work per unit. [S03]

The International Labour Organization defines the Standard Minute Value (SMV) as the time value for a task based on the average output rate that qualified workers naturally achieve without over-exertion, provided they know and adhere to the specified method and are motivated to apply themselves. [S03] That definition imposes four conditions on performance-loss measurement: [S03]

1. **Method specificity**: An SMV belongs to a documented operation breakdown, stitch density, attachment and station layout. [S03] Sewing a placket without its specified folder attachment changes the method, making the slower cycle a tooling variance rather than an operator effort deficit. [S03]
2. **Worker qualification**: The standard assumes qualified operators. [S03] During ramp-up or style introduction, operators are still acquiring coordination, which ramp-up research links to lower initial production rates. [S11]
3. **Absence of over-exertion**: Standard minutes include relaxation, personal-needs and contingency allowances so 100 percent performance represents sustainable work. [S03]
4. **Denominator clarity**: NIST research notes that Worker Efficiency, Allocation Ratio and Throughput Ratio must be calculated from defined quantitative shop-floor records. [S0502] In OEE accounting, *performance rate* compares standard minutes produced to *actual run time* (excluding downtime), whereas gross *line efficiency* compares standard minutes produced to *total attended time* (including downtime). [S06] [S0501] Mixing those denominators destroys the boundary between availability and performance. [S0501]

5.8 DECOMPOSING THE PERFORMANCE GAP DURING RUNNING TIME

When the performance component falls below 100 percent (such as the illustrative 80.0 percent rate in **Exhibit 22**, p. 77, or 81 lost minutes out of 405 running minutes), the loss stems from three mechanisms in garment assembly: [S03] [S04]

- **Line-balancing loss (Pitch and bottleneck friction)**: Because sequential stations depend on one another, line cycle time is governed by the slowest station. ILO guidance states that line balancing must be performed by line supervisors sys-

tematically before production through planning and daily during production. [S04] If the bottleneck operation takes 0.95 minutes per piece while average station allocation is 0.80 minutes, layout balancing efficiency is capped at $0.80 / 0.95 = 84.2\text{ percent}$ before any operator slows down. [S04]

- **Unlogged micro-stoppages**: Interruptions lasting twenty to ninety seconds, such as re-threading a broken thread, changing a bobbin or clearing a pucker, fall below the manual downtime threshold and are absorbed into run time as performance loss. [S06] [S20] High micro-stoppage rates indicate poor thread quality, tension errors or worn hooks. [S20]
- **Learning and skill-pace variance**: When a greenfield cohort works on a critical-path operation, cycle time exceeds the qualified-worker SMV until handling rhythm stabilises. [S03] [S11] GFT flags cohorts under a *provisional ramp standard* so monthly reviews separate expected learning loss from steady-state speed loss. [S03] [S11]

5.9

The quality factor counts only accepted production

The third component of OEE, and the final filter between activity and saleable throughput, is the quality rate. [S06] In the multiplicative OEE structure, the quality component isolates the share of running output that meets specification without consuming secondary correction capacity. [S06] First Pass Yield (FPY), or throughput yield, measures quality units produced as a percentage of total units that began or completed the process on the first attempt without rework or scrap. [S0503]

A common failure in apparel factories is substituting *final packing yield* (after repair tables have unstitched, re-sewn, spot-cleaned and re-pressed defective garments) for *first-pass yield* inside OEE. [S10] [S0503] If a line completes 400 shirts during a shift, of which 360 pass end-of-line inspection on the first attempt, 35 fail with skipped stitches and go to repair, and 5 are scrapped for oil stains, true first-pass yield is $360 / 400 = 90.0\text{ percent}$. [S0503] If repair operators fix all 35 shirts before shift close and the supervisor records 395 good shirts ($395 / 400 = 98.75\text{ percent}$), the report hides 8.75 percentage points of defect generation and ignores the repair labour spent rescuing those 35 garments. [S06] [S10]

Empirical evidence from the NIST Manufacturing Extension Partnership shows why first-pass yield belongs inside flow and capacity measurement: in a documented improvement case, raising first-pass yield from 10 percent to 90 percent accompanied a reduction in total processing time from 11.8 hours to 3.4 hours. [S10] While that case comes from discrete manufacturing rather than a Cameroonian garment plant and is not a transferable forecast, the physical mechanism applies directly to apparel bundles. [S10] Every garment pulled from a bundle for rework breaks bundle integrity, holds matching pieces in work-in-progress queues, and consumes sewing capacity a second time without earning an additional standard minute of saleable output. [S03] [S10]

WORKED EXAMPLE

Shift loss reconciliation for an illustrative 30-operator garment line

Consider an illustrative shift record for Line 02 sewing a work shirt with an approved SMV of $12.0\text{ standard minutes}$ (Method Revision B). [S03] All figures are illustrative to demonstrate the GFT method.

1. **Scheduled and planned time**: Scheduled shift time is $8.0\text{ hours} = 480\text{ minutes}$ per station (40-hour five-day workweek in Cameroon), or $30 \times 480 = 14,400\text{ station-minutes}$. [R16] Deducting a 30-minute break and huddle window per operator ($900\text{ station-minutes}$) leaves 450 line-minutes ($13,500\text{ planned station-minutes}$), equal to $13,500 / 12.0 = 1,125.0\text{ shirts}$ of theoretical planned capacity. [S01] [S03] [S06]
2. **Availability**: Three line-stopping events occur (15-minute changeover adjustment, 10-minute panel wait, 20-minute overlock breakdown), totalling 45 line-minutes ($1,350\text{ station-minutes}$) of downtime. [S07] Run time is $450 - 45 = 405\text{ line-minutes}$ ($12,150\text{ station-minutes}$), giving $\text{Availability} = 405 / 450 = 90.00\text{ percent}$ and costing $1,350 / 12.0 = 112.5\text{ potential shirts}$. [S06]
3. **Performance**: During 405 running minutes ($12,150\text{ running station-minutes}$), the line completes 810 shirts, earning $810 \times 12.0 = 9,720\text{ standard minutes}$. [S03] [S06] This gives $\text{Performance} = 9,720 / 12,150 = 80.00\text{ percent}$, with $2,430\text{ lost station-minutes}$ (81.0 line-minutes) costing $2,430 / 12.0 = 202.5\text{ potential shirts}$. [S06]
4. **Quality (First-Pass Yield)**: Inspection checks all $810\text{ completed shirts}$: 769 shirts pass first time, 36 shirts enter rework, and 5 shirts are rejected as seconds, giving $\text{Quality (FPY)} = 769 / 810 = 94.94\text{ percent}$. [S10] [S0503] Those $41\text{ defective shirts}$ represent $492\text{ standard minutes}$ (16.4 line-minutes) that failed to yield first-pass output. [S06] [S0503]
5. **Composite OEE and reconciliation**: Multiplying the factors gives $\text{OEE} = 0.9000 \times 0.8000 \times 0.94938 = 68.36\text{ percent}$, matching $(769 \times 12.0) / 13,500 = 9,228 / 13,500 = 68.36\text{ percent}$. [S06] Even if 33 reworked shirts are repaired before shift close (for 802 packed shirts), they sit in the *rework recovery log*, never in the OEE numerator. [S10] Every shirt reconciles: $1,125.0 - 112.5\text{ (availability)} - 202.5\text{ (performance)} - 41.0\text{ (quality)} = 769.0\text{ first-pass good shirts}$.

5.10 RECONCILING THE OEE QUALITY FACTOR WITH THE QUALITY LEDGER

To prevent discrepancies between production and quality reports, GFT enforces a cross-field validation rule at shift close, applying the consistency and accuracy dimensions of ISO/IEC 25012 and the UK Government Data Quality Framework. [S23] [S24] The denominator of the OEE quality component ($\text{Total Pieces Completed}$) must equal the garments inspected at the end-of-line boundary on their initial pass, and the numerator ($\text{First-Pass Good Pieces}$) must equal that total minus the garments logged with defect tickets in the quality ledger. [S06] [S24]

Exhibit 25, p. 84 summarises the production-loss accounting contract across all five levels of the hierarchy, linking each component to its formula, exposed loss and accountable owner. [S01] [S06] [S22]

EXHIBIT 25 /

Each production loss component requires a fixed boundary, denominator and owner

Component	Numerator and denominator	Primary loss exposed	Accountable owner
Schedule utilisation	Planned production time / Scheduled shift time	Planned stops and no-order time	Plant planning
Availability	Actual run time / Planned production time	Breakdowns, changeovers, material wait	Line supervisor & maintenance
Performance rate	Standard minutes produced / Actual run time	Micro-stops, imbalance, skill pace gap	Industrial engineering & line
First-pass quality	First-pass good pieces / Total pieces completed	Rework loops, seconds and scrap	Quality & line supervisor
Composite OEE	Availability x Performance x First-pass quality	Total productive-time conversion loss	Plant operations manager

DERIVED [S01] [S03] [S06] [S07] [S10] [S22] Derived synthesis of the production-loss measurement contract combining ISO 22400 formula-and-unit structure (S01), SMV method-based time norms (S03), OEE component decomposition (S06), unmerged downtime taxonomy (S07), first-pass yield boundary (S10) and role accountability (S22).

As **Exhibit 25**, p. 84 establishes, no single manager owns all five rows: plant planning owns schedule utilisation, line supervision and maintenance share availability by cause code, industrial engineering and line supervision share performance rate, quality assurance and line supervision share first-pass quality, and the plant operations manager owns the composite. [S04] [S06] [S22] To eliminate a loss once exposed, this measurement contract must connect directly to an improvement routine. [S08]

5.11

A score without an improvement loop stalls

Collecting availability, performance and quality losses achieves nothing if the numbers merely populate a slideshow. A review of Overall Equipment Effectiveness implementation found a lack of improvement frameworks with systematic steps specifically developed for OEE implementation. [S08] Factories frequently calculate OEE, post percentages on walls, and exhort supervisors to raise the score without providing a diagnostic routine to remove physical losses. [S08]

In a garment factory, exhorting a line supervisor to raise an aggregate OEE score is counterproductive because the largest losses cross functional boundaries. [S04] [S07] A sewing supervisor cannot unilaterally rebuild a worn overlock mechanism, force the

cutting room to deliver shade bundles earlier, or rewrite a faulty pattern marker. [S04] Demanding a higher score without a systematic loss-elimination loop produces frustration or denominator manipulation. [S08] [S0501]

5.12 EVERY LOSS BUCKET LINKS TO A SPECIFIC COUNTERMEASURE ROUTINE

To address that gap, GFT embeds a four-step loss-to-action routine into the daily and weekly cadence (detailed in Chapters 11 and 12): [S02] [S08]

1. **Stratify losses in standard minutes lost**: At shift and week close, availability, performance and quality losses are converted into *lost standard minutes* (or *lost good garment equivalents*), ranking problems objectively across a 45-minute cutting delay, an 81-minute balancing loss and a 16.4-minute defect outbreak. [S01] [S06] [S07]
2. **Assign the top loss in each bucket to its technical discipline**: Rather than requesting a generic OEE increase, the weekly review routes the top loss in each component to its engineering method: [S08] [S22]
3. *Chronic changeover losses* trigger setup-reduction staging of folders, cones, needle plates and sample garments on a changeover cart before the prior order finishes. [S04] [S06]
4. *Repeated mechanical breakdowns* trigger preventive maintenance checks, spare-parts buffer adjustments and machine-history reviews. [S06] [S07]
5. *Running-time performance losses* trigger a pitch-diagram check and daily line rebalancing by the supervisor and industrial engineer, splitting bottleneck tasks or deploying floaters. [S03] [S04]
6. *First-pass quality losses* trigger at-station checks on machine tension, needle condition, method adherence and cut-panel accuracy. [S10]
7. **Record an expected mechanism and verification window**: Every countermeasure in the action log states the targeted loss code, the physical mechanism of improvement, the owner and the verification date. [S08] [S22]
8. **Verify movement in the targeted component while checking guardrails**: When the verification window closes, the team checks whether the targeted loss code fell on comparable work and confirms that guardrails such as startup first-pass yield did not deteriorate. [S02] [S06]

WARNING

Goodhart's law on the sewing floor: four failure modes of badly governed OEE targets

Linking supervisor bonuses or disciplinary reviews to a raw OEE percentage without auditing component boundaries creates four distortions: [S23] [S0501]

- **Reclassifying unplanned downtime as planned non-production**: Logging material waiting or extended changeovers as "unscheduled line time" shrinks the planned-production-time denominator to inflate availability. [S07] [S0501]
- **Inflating SMVs to flatter the performance rate**: Leaving loose time standards in the master table after method changes overstates earned standard minutes and masks micro-stoppages. [S03] [S22]
- **Counting reworked garments as first-pass good output**: Entering end-of-day packed quantities after repair instead of initial inspection passes erases rework loops from the quality factor. [S10] [S0503]
- **Running unneeded WIP on simple operations**: Sewing non-bottleneck bundles ahead of the constraint inflates earned standard minutes on shift sheets while building excess work-in-progress piles. [S04] [S10]

Each distortion is prevented by enforcing the conservation checks in **Exhibit 25**, p. 84, auditing downtime logs against cutting and maintenance records, and separating loss tracking from punitive targets. [S22] [S24]

5.13

Source data can test the manual record

In the opening months of a greenfield factory, GFT starts with a disciplined manual and barcode-assisted shift record so supervisors and engineers master operational definitions before relying on hardware. [S01] [S24] Yet manual logs have physical limits when capturing high-frequency losses. A supervisor coaching an operator or rebalancing a bottleneck cannot hold a stopwatch on every two-minute thread break or log the exact minute a mechanic arrives. [S04] [S07] When downtime sheets are filled in from memory at shift end, timestamps are rounded, short stops vanish into performance loss, and causes such as cut-panel waiting are under-reported. [S07] [S24]

Empirical research in apparel manufacturing demonstrates two shop-floor sensing methods that capture production events and working times at the point of work, testing the manual record: [S19] [S20]

- **Radio-Frequency Identification (RFID) bundle and station tracking**: A garment-factory study in *The International Journal of Advanced Manufacturing Technology* showed that front-line worker production data can be recorded daily by an RFID system across multi-variety, small-batch production. [S19] Reusable RFID tags on bundles and workstation readers log arrival and completion timestamps automatically, separating active cycle time from queue time and starvation. [S19]
- **Sewing-machine electrical power monitoring**: A study in *Applied Sciences* attached a power monitoring system to a sewing machine to collect electrical power consumption data and extract working times across sewing tasks. [S20]

Because a sewing motor draws distinct current profiles during active stitching, idle standby and power-off states, non-intrusive current sensors on bottleneck machines measure actual run time, stitch-burst duration and stoppage intervals automatically. [S20]

5.14 SEQUENCING SENSING AS A VERIFICATION LAYER, NOT AN UNMAPPED DATA DUMP

Installing sensors before the factory has governed master data and loss definitions produces noisy telemetry rather than insight. [S21] [S22] A current clamp on a lockstitch machine can prove that the motor drew zero sewing current between 10:12 and 10:29 (a 17-minute stoppage), and an RFID reader can prove that no bundle crossed station 14 during that window, but neither sensor knows by itself whether the operator was waiting for cut panels, changing a folder or waiting for a mechanic. [S07] [S20]

GFT sequences automated source capture through three verification rules that connect sensor signals to the human loss taxonomy: [S19] [S20] [S24]

1. **Instrument bottleneck and end-of-line boundaries first**: Power monitoring is attached to designated bottleneck stations on pilot lines, while RFID or barcode gates are placed at cutting release, line loading, end-of-line inspection and rework return to cross-check run time, completed pieces and first-pass yield against manual sheets. [S06] [S19] [S20]
2. **Use sensor timestamps to detect unlogged stops and trigger human cause coding**: When power telemetry detects a bottleneck stoppage exceeding an illustrative three-minute idle threshold during planned production time, the system logs start and end timestamps automatically and prompts the supervisor to select the cause code. [S07] [S20]
3. **Audit manual-versus-sensor variance before retiring manual tallying**: Following structured data-quality governance, GFT compares manual shift totals against RFID bundle counts and power-monitored run time across a validation window, retiring manual counting only after identifiers, rework loops and exception rules reconcile. [S22] [S23] [S24]

> **GFT NOTE**
>
> **Keep machine-run time distinct from task work time.** Extracting task working times from electrical power traces requires analysing the full sewing task cycle, including panel positioning, seam alignment, trimming and bundle handling alongside motor-on needle bursts. [S20] Mistaking raw motor-on seconds for total running time misclassifies manual fabric handling as machine downtime. [S03] [S20] GFT calibrates power-monitoring windows against the full operation cycle in the SMV breakdown so handling and stitching time remain paired. [S03] [S20]

By anchoring production measurement in explicit time boundaries, keeping OEE's three components open to inspection, disaggregating downtime by cause and owner, tying performance to method-based standard minutes, restricting quality credit to first-pass good output, and verifying manual records with targeted sensing, a greenfield garment factory turns daily production into a self-diagnosing system. [S03] [S06]

[S07] The next chapter applies the same rigour to the quality family, showing how first-pass defects, rework flows and inspection checks become structured preventive evidence. [S10]

A single efficiency number tells a factory what it lost after the shift is over; decomposed losses tell the floor where to act while the shift can still be saved.

CHAPTER SOURCE NOTES

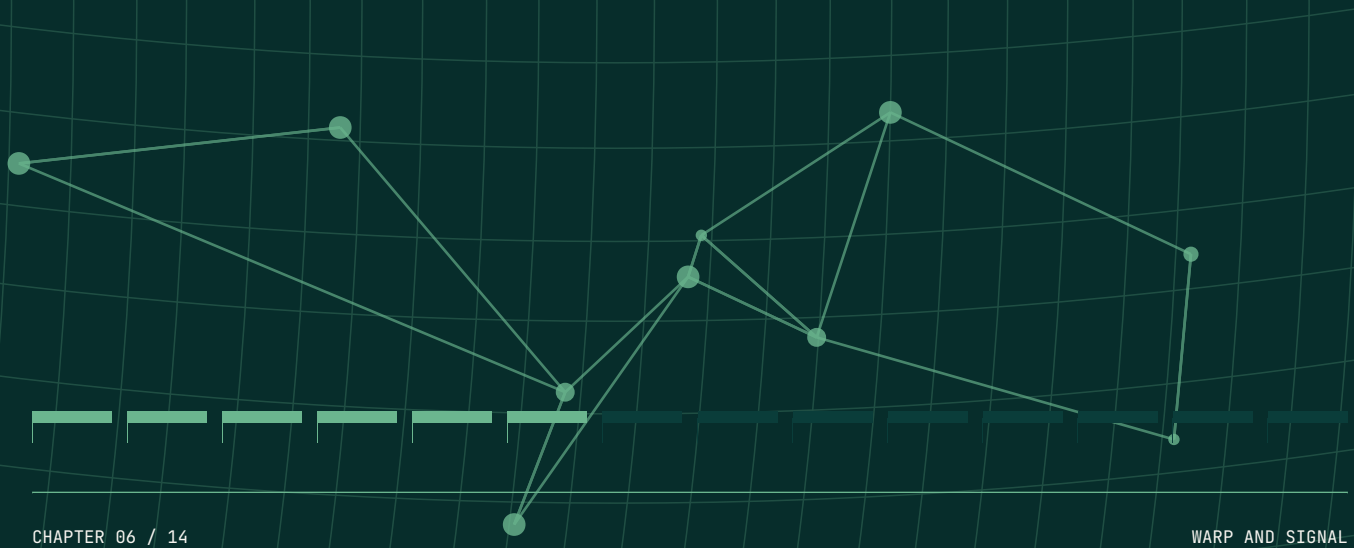
S06 Diamond Congress, Creative Construction Conference. 2023.
S07 Scientific Reports, Springer Nature. 2025.
S01 International Organization for Standardization. 2014.
R06 Cameroon Trade Hub. Publication date unrecorded; inherited source-text check.
R07 Ecofin Agency. Publication date unrecorded; inherited source-text check.
R12 Business in Cameroon. Publication date unrecorded; inherited source-text check.
S11 International Journal of Production Economics, Elsevier. 2001.
S0501 US National Institute of Standards and Technology. 2020-03.
R16 WageIndicator. Publication date unrecorded; inherited source-text check.
S22 United States Federal Data Strategy. 2020.
S03 International Labour Organization. 2023.
S10 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04.
S04 International Labour Organization. 2023.
S0503 MachineMetrics. 2021-09-22.
S02 International Labour Organization. 2017.
S0502 US National Institute of Standards and Technology. 2013-04.
S23 ISO/IEC. 2008.
S25 W3C. 2017-01-31.
S20 Applied Sciences, MDPI. 2020-04-29.
S08 International Journal of Productivity and Quality Management, Inderscience. 2020-05-11.
S24 UK Government Data Quality Hub. 2020-12-03.
S19 The International Journal of Advanced Manufacturing Technology, Springer Nature. 2019-09-03.
S21 National Institute of Standards and Technology. 2016.

06

PART II: MEASURE THE OPERATING SYSTEM / FIRST-PASS QUALITY

Quality improves when defects become structured evidence

The quality system should connect first-pass yield, defect causes and variation so that inspection leads to prevention rather than sorting alone.



CHAPTER 06
DECISION TEST

The quality system should connect first-pass yield, defect causes and variation so that inspection leads to prevention rather than sorting alone.

A greenfield garment factory cannot inspect quality into a product at the packing table. When an operating system treats inspection merely as a sorting gate before carton sealing, defects are discovered only after fabric, machine time and operator effort have been spent, turning the finishing room into a hidden repair shop. [S02] [S10] Quality improves only when every detected nonconformity is captured at source as structured operational evidence linking the observable fault to the originating operation, method revision, machine setting and material batch. [S23] [S25] Under the performance-management system design prepared in Green Future Tech Limited's (GFT) three-part Cameroon textile programme on 31 January 2024, with source refreshes noted in 2026, quality measurement rests on four rules: count a unit as first-pass good only when it passes without correction, state the exact population denominator on every yield figure, separate symptom from mechanism in the defect taxonomy, and verify the accuracy of human inspectors and computer-vision models before treating their outputs as process shifts. [S01] [S40]

The industrial context in Cameroon makes disciplined quality control at source an immediate commercial necessity. Sector records indicate that about 95 percent of Cameroon's cotton fibre is exported raw while about 5 percent is processed locally, against a public target of 50 percent local processing by 2030 under the National Development Strategy (SND30). [R06] [R07] Those figures establish the national value-chain boundary rather than a guaranteed market share for any plant, and nothing in this chapter constitutes investment, legal or tax advice. Yet any new cut, make, trim and finishing plant seeking to convert local cotton into competitive apparel faces strict buyer acceptance rules alongside the operating challenges documented in legacy enterprise records, where a July 2023 report recorded capacity utilisation of 33.7 percent at Garoua, 48.9 percent at CICAM 1 and 10.83 percent at CICAM 2, with underutilisation costing about CFAF 2 billion in 2020. [R12] If a greenfield facility adds high rework rates onto its ramp-up learning curve, effective capacity falls further and order lead times stretch. [S10] [S11]

6.1

First-pass yield excludes correction

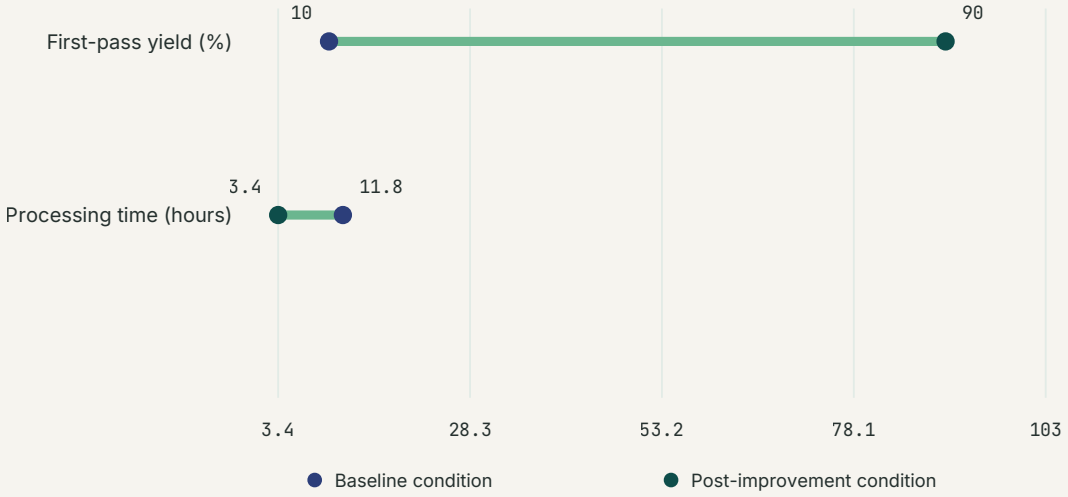
First-pass yield (FPY), often called right first time on the sewing floor, measures the proportion of units that complete a defined process and satisfy all specification requirements on their initial pass without rework, repair, recutting, stain removal or re-pressing. [S06] [S10] Many garment factories obscure this measure by reporting only final packing acceptance at order close. A shipment leaving dispatch with 98 percent illustrative final acceptance may have achieved that figure only after 20 percent illustrative of its garments cycled through unpicking, panel replacement and secondary pressing. Counting repaired garments as equivalent to first-pass good units conceals a secondary production system running inside the primary line. [S06] [S10]

External industrial evidence demonstrates why first-pass quality and production flow must be evaluated together. In a documented case from the National Institute of Standards and Technology (NIST) Manufacturing Extension Partnership concerning a returned-material process, improvements raised first-pass yield from 10 percent to 90 percent while reducing total processing time from 11.8 hours to 3.4 hours. [S10] As

shown in **Exhibit 26**, p. 91, the 80-percentage-point gain in first-pass yield occurred alongside a 71.2 percent reduction in processing time, derived from dividing the 8.4-hour saving by the 11.8-hour baseline. [S10]

EXHIBIT 26 / PERCENT OR PROCESSING HOURS (NIST MEP CASE S10)

First-pass yield and flow should be evaluated together



SOURCED [S10] Sourced from the NIST MEP returned-material process case (S10): first-pass yield moved from 10 percent to 90 percent, and total processing time moved from 11.8 hours to 3.4 hours. Presented strictly as that external case, not as a garment benchmark or GFT target.

Exhibit 26, p. 91 records an external non-apparel case and cannot establish an expected improvement ratio, baseline yield or cycle-time target for a garment line. [S10] What it establishes is the mechanism: whenever a unit fails its first pass, correction consumes touch time, interrupts batch flow, adds waiting queues and requires re-inspection. [S10] During a greenfield ramp-up, when the process is poorly understood and exhibits low production rates and low yields, treating reworked garments as ordinary output hides the learning bottleneck until delivery promises fail. [S11]

6.2 THE COUNTING BOUNDARY SEPARATES FIRST COMPLETION FROM FINAL RECOVERY

To make first-pass yield auditable under ISO 22400-2 rules for formula, unit and time behaviour, the shift ledger must lock the counting event to a specific inspection boundary and state whether a unit is entering for the first time or returning from repair. [S01] When a bundle of 20 illustrative garment pieces arrives at an inspection station for initial evaluation, each piece is classified into one of three mutually exclusive states: [S01] [S0601]

- **First-pass good**: The garment meets all dimensional, construction, appearance and labelling specifications at initial completion without repair, trimming or spot-cleaning intervention. [S10] [S0601]
- **First-pass rework**: The garment exhibits one or more repairable nonconformities, such as a skipped stitch, uneven topstitch, uncut thread tail or removable oil mark, and is routed to a rectification loop. [S10] [S0601]

- **First-pass scrap or reject**: The garment exhibits an unrepairable nonconformity, such as a miscut panel, needle tear, shade mismatch or permanent dye stain, and is removed from primary order fulfilment. [S0601]

Once a garment is classified as rework on initial inspection, its first-pass status remains nonconforming for that boundary, even if an operator repairs the seam within 5 illustrative minutes and the garment passes re-inspection as a recovered piece. [S06] [S10] Recording recovered pieces increases shippable garments and reduces scrap cost, but never alters the numerator of first-pass yield. [S06] [S10]

> **GFT NOTE**
>
> GFT recommends that every line board and shift ledger display two acceptance figures side by side: **First-Pass Yield** (first-pass good units divided by initial units inspected) and **Final Recovery Yield** (first-pass good plus recovered reworked units, divided by initial units inspected). [S06] [S10] When Final Recovery Yield is 98 percent illustrative while First-Pass Yield is 82 percent illustrative, 16 percent of the line's output is being manufactured twice. Rewarding supervisors solely on Final Recovery Yield encourages informal repair tables rather than fixing the station that generates the fault. [S02] [S16]

6.3

The denominator determines what yield means

Overall Equipment Effectiveness (OEE) incorporates quality as one of three multiplicative components alongside availability and performance efficiency to detect production losses. [S06] However, quality ratios become incomparable when teams divide by different populations or confuse nonconforming units with total defect counts. [S01] [S0601] Statistical quality literature differentiates between a *defect* (an individual nonconformity at a specific point) and a *defective* (a nonconforming unit containing at least one nonconformity). [S0601] A rejected shirt with a crooked collar, two skipped buttonholes and an oil stain represents 4 illustrative defects in total but 1 nonconforming garment. [S0601]

If an analyst subtracts 4 defects from 100 inspected garments and reports a 96 percent yield, when all 4 faults occurred on the same garment and 99 garments passed without fault, the calculation mixes incompatible units. [S01] [S0601] Conversely, if 4 separate garments each contain 1 fault out of 100 inspected garments, the defect count is 4, the Defects Per Hundred Units (DHU) is 4.0, and the proportion of nonconforming units is 4.0 percent, giving a 96.0 percent first-pass yield. [S0601] [S0602]

6.4 FOUR YIELD DENOMINATORS SERVE DISTINCT OPERATIONAL DECISIONS

Even when numerator and denominator are restricted to physical garments, a cut, make, trim and finishing plant operates across sequential stages, and a yield ratio changes meaning depending on where its boundary is drawn. [S01] [S02] GFT requires every quality metric contract to specify which of four denominators governs the calculation: [S01] [S06]

1. **Gate or Operation First-Pass Yield**: The ratio of units passing a specific inspection gate on the first attempt without correction to total units inspected for the first time at that gate, owned by the supervisor of the preceding operations. [S02] [S10] [S0602]
2. **End-of-Line Sewing First-Pass Yield**: The ratio of garments accepted on initial inspection at the end of the sewing line to total garments reaching the end of the line for the first time during the shift, feeding the quality component of sewing-line OEE. [S06] [S10]
3. **Rolled Throughput Yield (RTY)**: The product of gate-level first-pass yields across all sequential gates from cutting through finishing, measuring the probability that a cut bundle traverses the factory without any repair or recutting stop. [S06] [S10]
4. **Order Cut-to-Shipped Yield**: The ratio of total first-quality garments packed for shipment (including recovered pieces) to total garment equivalents cut at order release, capturing net material utilisation while hiding in-process rework loops. [S01] [S02] [S10]

METHOD

Reconciling sequential gate yields with rolled throughput yield

For a batch of garments released across sequential process gates, every gate record must satisfy five accounting rules: [S01] [S06] [S10] [S0601]

- `Gate First-Pass Yield` equals first-pass good pieces at the gate divided by pieces entering the gate for initial inspection. [S10] [S0602]
- `Gate Recovery Yield` equals first-pass good plus successfully repaired pieces at the gate, divided by pieces entering for initial inspection. [S06] [S10]
- `Next-Gate Entry Population` equals first-pass good plus successfully repaired pieces from the preceding gate, matching entering pieces minus scrap. [S01]
- `Rolled Throughput Yield (RTY)` equals the product of the individual `Gate First-Pass Yield` ratios across all sequential gates. [S06] [S10]
- `Cumulative Shipped Yield` equals final packed good garments leaving the last gate divided by initial garment equivalents cut at Gate 1. [S01] [S02]

Exhibit 27, p. 94 applies these conservation rules to a derived 1,000-piece garment batch moving across four sequential gates: cutting inspection, in-line sub-assembly inspection, end-of-line sewing inspection and finishing inspection. [S01] [S06] [S10] [S0601]

EXHIBIT 27 / PIECES AND PERCENT ACROSS A 1,000-PIECE ILLUSTRATIVE LOT

Distinct yield denominators reveal hidden rework that final acceptance conceals

Process gate	Entering (pcs)	First-pass good	Repaired good	Gate FPY (%)	Recovery (%)
1. Cutting panel check	1,000	990	6	99	99.6
2. In-line collar/cuff	996	946	42	95	99.2
3. End-of-line sewing	988	909	68	92	98.9
4. Finishing and press	977	956	15	97.9	99.4
Cumulative lot summary	1,000	847 (RTY eq.)	131	84.7	97.1

DERIVED [S01] [S06] [S10] [S0601] Derived arithmetic applying ISO 22400-2 (S01), OEE quality rules (S06), first-pass definitions (S10) and nonconforming-unit rules (S0601) to an illustrative 1,000-piece cut lot. Gate FPYs multiply to 84.7% RTY, whereas final shipped yield after 131 repairs and 29 scrapped pieces is 97.1%.

As **Exhibit 27**, p. 94 demonstrates, each gate in this illustrative lot appears to perform well in isolation, with gate first-pass yields between 92.0 percent and 99.0 percent, and 971 first-quality garments packed out of 1,000 cut pieces (97.1 percent shipped yield after 29 pieces are scrapped). [S06] [S10] Yet multiplying the four gate first-pass yields (0.990 times 0.950 times 0.920 times 0.979) reveals a Rolled Throughput Yield of only 84.7 percent. [S06] [S10] More than 15 percent of the initial illustrative lot required manual repair or scrapping along the routing, generating 131 repair transactions. While **Exhibit 27**, p. 94 uses assumed piece counts to illustrate the accounting structure rather than an observed GFT factory result, it proves why reading only the 97.1 percent shipped yield conceals the 110 repairs occurring inside sewing stations. [S02] [S07]

A second denominator failure occurs when factories combine records from 100 percent in-line or end-of-line inspection with statistical lot acceptance sampling at pre-shipment audit. [S0603] NIST guidance emphasises that acceptance sampling decides whether a lot is acceptable for disposition, not to estimate the quality of the lot. [S0603] When an auditor inspects an illustrative random sample of 80 garments out of a 1,200-piece packed lot under an Acceptable Quality Limit (AQL) plan and finds 2 defective garments (2.5 percent), that result governs lot release and must never be pooled with the sewing line's 100 percent inspection log. [S01] [S0603]

6.5

A defect taxonomy must support action

Capturing an accurate denominator tells management *how often* quality fails, but cannot tell a supervisor *what to change* unless the defect record is structured for causal diagnosis. [S07] [S23] Just as merged downtime categories obstruct the identification of specific equipment losses in OEE, vague defect buckets such as "sewing fault" or

"bad workmanship" obstruct root-cause elimination. [S07] ISO/IEC 25012 establishes a formal data-quality model for structured records, while the UK Government Data Quality Framework defines six core dimensions (completeness, validity, consistency, timeliness, uniqueness and accuracy) and W3C guidance requires shared vocabularies and standards for dataset interoperability. [S23] [S24] [S25]

Applied to garment quality control, these standards prohibit free-text notes or local shorthand on paper tally sheets. [S23] [S25] If Line 1 records a loose lower thread as "looping", Line 2 records it as "tension fault", and finishing records it as "bad seam", no weekly review or machine-learning model can aggregate the pattern without manual cleansing. [S21] [S25]

6.6 A THREE-PART DEFECT CODE SEPARATES SYMPTOM, MECHANISM AND ACTION

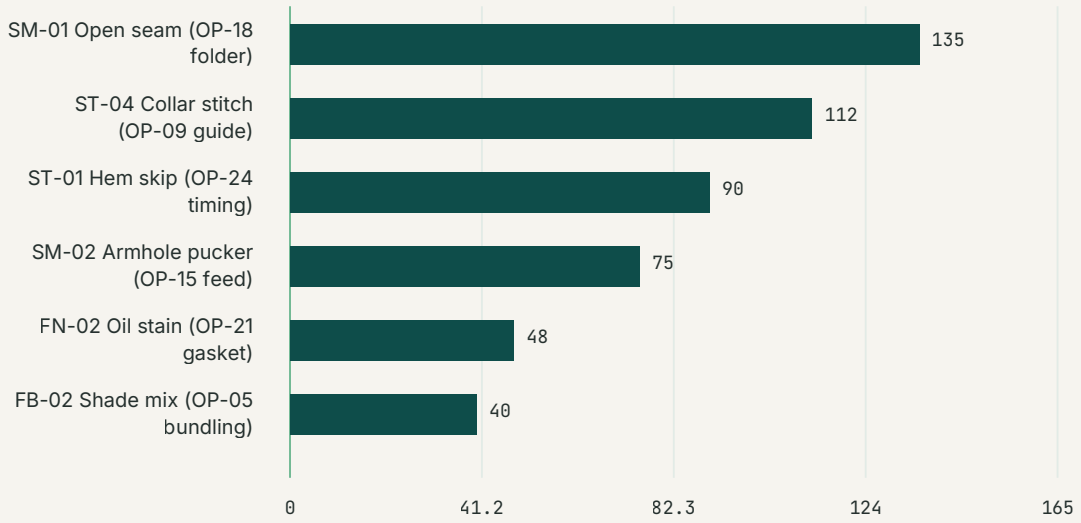
To prevent ambiguity while keeping shop-floor entry fast enough for an inspector checking a garment every 20 to 40 illustrative seconds, GFT structures the defect taxonomy around three fields, bound to master-data context from the bundle or station record: [S19] [S23] [S25]

1. **Observable fault code (What the inspector sees)**: A controlled two-level code identifying the defect family and physical manifestation, such as `ST-01` (Skipped stitch), `ST-02` (Broken stitch), `SM-01` (Open seam), `SM-02` (Seam pucker), `MS-01` (Measurement out of tolerance), `FN-02` (Oil stain), or `FB-02` (Shade mismatch). [S23] [S25] The inspector logs only what is physically observable without guessing who caused it. [S24] [S40]
2. **Location and operation context (Where it occurred)**: Linked from the bundle routing table and garment zone map, recording the component (collar stand, side seam, bottom hem) and the operation number in the operation breakdown, alongside style ID, method revision, station ID, machine asset ID, shift and fabric roll batch ID. [S03] [S19] [S21]
3. **Verified mechanism and action code (Why it occurred and what changed)**: Assigned by the supervisor, quality technician or mechanic when investigating a repeat fault, distinguishing machine settings (bobbin tension, burred needle, feed timing), method and skill factors (missing edge guide, improper curve feeding), or material inputs (shade variation between rolls, miscut notches). [S12] [S25] [S41]

Separating the inspector's *observable fault code* from the technician's *verified mechanism code* protects data accuracy and prevents inspectors from guessing root causes or blaming operators for mechanical or material faults. [S23] [S24] [S45]

EXHIBIT 28 / ILLUSTRATIVE REWORK MINUTES PER SHIFT

A defect ranking should preserve operation and mechanism



ILLUSTRATIVE [S23] [S25] [S10] Illustrative shift Pareto ranked by rework burden (fault count x repair minutes) with operation and mechanism codes following S23, S25 and S10: SM-01 Open seam (45 pcs x 3.0 min = 135 min), ST-04 Collar stitch (28 pcs x 4.0 min = 112 min), ST-01 Hem skip (60 pcs x 1.5 min = 90 min), SM-02 Armhole pucker (75 min), FN-02 Oil stain (48 min), FB-02 Shade mix (40 min).

Exhibit 28, p. 96 illustrates how a structured taxonomy transforms a shift quality review. In this illustrative dataset, ST-01 (Skipped stitch at bottom hem OP-24) has the highest raw frequency at 60 occurrences, whereas SM-01 (Open seam at side join OP-18) has 45 occurrences and ST-04 (Uneven collar topstitch at OP-09) has 28 occurrences. Because GFT's record links each fault code to its repair work content, **Exhibit 28**, p. 96 ranks faults by *rework minutes consumed*: repairing 45 open side seams requires 3.0 illustrative minutes per garment (135 rework minutes), and unpicking and restitching 28 collar topstitches requires 4.0 illustrative minutes per garment (112 rework minutes), both exceeding the 90 rework minutes consumed by 60 bottom-hem stitch repairs at 1.5 illustrative minutes each. [S10] [S23] Because each bar retains its operation code and verified mechanism, corrective action splits cleanly across owners: the mechanic resets folder alignment on OP-18 and looper timing on OP-24, industrial engineering fits an edge-guide foot on OP-09 and conducts operator drills, and the cutting room enforces roll-shade ticketing at OP-05. [S12] [S22] [S25]

6.7

Rework is a separate production flow

The relationship between first-pass yield and processing time in the NIST returned-material case explains why repaired garments cannot be treated as free recovery. [S10] Every garment diverted into a rework loop leaves the primary assembly sequence, consumes direct labour minutes to unpick and re-sew, occupies work-in-

progress (WIP) buffers, risks secondary fabric damage during unpicking, and requires re-inspection before rejoining its bundle. [S10] [S19] Failing to measure rework as a separate flow causes three distortions: [S03] [S10] [S36]

- **Inflated operator efficiency**: Crediting standard minutes when a garment first crosses a station and again during repair detaches apparent output from saleable production. [S03] [S06]
- **Stranded bundles**: Holding back 3 illustrative defective pieces from a 25-piece bundle prevents bundle closure at packing, delaying On-Time-In-Full (OTIF) shipment even when 95 percent illustrative of the order is complete. [S10] [S19]
- **Unaccounted labour and resource cost**: Rework consumes paid hours, electricity, needles, thread and spot-cleaning resources without adding a net garment to the denominator of cost or sustainability intensity. [S11] [S36]

6.8 RECONCILING REWORK LABOUR, WIP AGE AND EFFECTIVE COST PER GOOD GARMENT

GFT requires the quality log to reconcile every rework event back to the originating operation, active bundle and shift labour ledger by logging the flag timestamp, repair touch minutes, a repeat-defect flag if a garment fails re-inspection after first repair, and the final disposition timestamp. [S01] [S02] [S23]

WORKED EXAMPLE: HOW HIDDEN REWORK ERODES EFFECTIVE CAPACITY AND RAISES UNIT LABOUR COST

Consider an illustrative sewing line in Cameroon staffed by 32 direct operators and 3 quality inspectors (35 line workers) working an 8-hour shift (480 scheduled minutes, 450 planned production minutes after a 30-minute break) under Cameroon's 40-hour standard week. [R16] Assume an illustrative monthly payroll cost of XAF 75,000 per worker across 21.67 illustrative working days (above the statutory minimum wage, SMIG, of XAF 43,969 a month effective 23 February 2024 in the inherited register), giving a shift labour cost of XAF 3,461 per worker, or XAF 121,135 for the 35-person line. [R14] [R16] These values are assumed solely to demonstrate the method and are not a GFT forecast.

Suppose the line makes a woven shirt with an approved Standard Minute Value (SMV) of 15.0 illustrative standard minutes. [S03] During the shift, the 32 operators complete 600 illustrative shirts (9,000 gross standard minutes). At end-of-line inspection:

1. **First-pass classification**: Of 600 completed shirts, 480 pass without fault, giving an illustrative First-Pass Yield of 80.0 percent. [S06] [S10] Exactly 105 shirts enter rework, and 15 are rejected as unrepairable scrap (2.5 percent initial scrap).
2. **Rework loop consumption**: Each of the 105 reworked shirts requires an illustrative 6.0 minutes of unpicking, restitching and re-pressing, consuming 630 direct rework minutes (42.0 shirt equivalents at 15.0 minutes per shirt, or 1.4 operators working the full 450-minute shift on repair). [S03] [S10]
3. **Re-inspection outcome**: Upon re-inspection, 96 repaired shirts pass and rejoin their bundles, while 9 suffer unpicking damage and are scrapped, bringing total scrap to 24 shirts (4.0 percent) and shippable output to 576 shirts, an illustrative Final Recovery Yield of 96.0 percent. [S06] [S10]
4. **Labour cost across denominators**: Dividing XAF 121,135 by 600 gross pieces gives XAF 201.89 per piece. Dividing by 576 shipped pieces gives XAF 210.30 per piece (or XAF 220.40 per piece if the 630 rework minutes are worked at Cameroon's 1.2 times overtime rate, adding XAF 5,814 illustrative overtime pay). [R16] Dividing by 480 first-pass good pieces reveals XAF 252.36 per first-pass good garment, a 25.0 percent premium over the gross figure. [S06] [S10]

Apparel compensation research in PLOS ONE shows that when compensation and management systems are well designed, workers focus effort on reducing quality defects and tardiness, two behaviours largely under individual control. [S16] Better Work research cautions that partial piece-rate pay is associated with reduced emotional and physical health when workers chase volume under pressure. [S17] Charging rework to its true operational cause and rewarding first-pass quality aligns worker wellbeing, flow and unit cost. [S10] [S16] [S17]

6.9

SPC separates signals from routine variation

Every process exhibits natural variation even when operators follow standard work on calibrated machines. [S09] Readjusting a sewing machine every time the shift defect rate moves from 3.5 percent illustrative to 4.2 percent illustrative tampers with routine common-cause noise and increases instability, whereas dismissing a jump to 12.5 percent illustrative as normal ramp variation delays needed intervention. [S09] [S11]

As defined in the NIST/SEMATECH e-Handbook, statistical process control (SPC) compares current behaviour with previous behaviour from a stable baseline, establishing control limits that separate common-cause variation from assignable-cause signals. [S09] For garment inspection, attribute control charts apply: [S0601] [S0602]

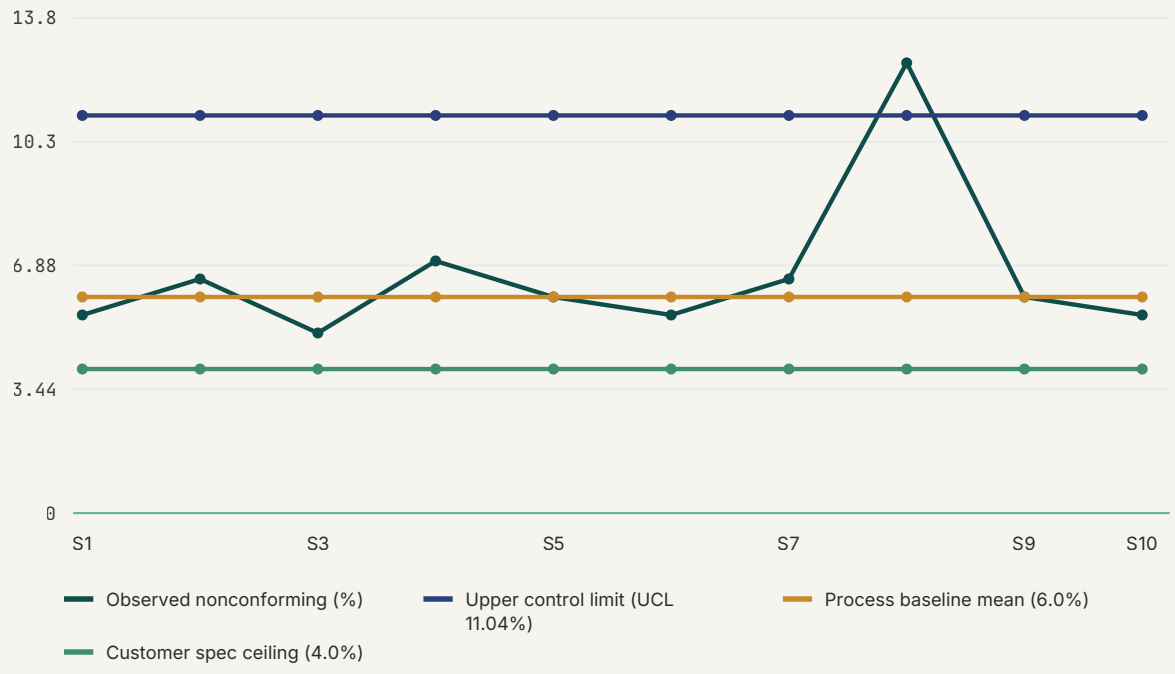
- **Proportions control chart (p-chart)**: Plots the fraction of nonconforming units in each subgroup using the binomial distribution, with three-sigma control limits set three standard errors above and below the baseline centre line. [S0602]
- **Counts control chart (c-chart or u-chart)**: Plots total nonconformities (c-chart) or average nonconformities per unit (u-chart) using the Poisson approximation where multiple defects can occur on one garment. [S0601]

6.10 CONTROL LIMITS, CUSTOMER SPECIFICATIONS AND TARGETS MUST NEVER BE CONFUSED

Plotting a customer's Acceptable Quality Limit (such as a 4.0 percent illustrative AQL ceiling) on a trend chart and calling it a control limit confuses voice-of-the-customer requirements with voice-of-the-process variation. [S09] [S45] [S0602] **Exhibit 29**, p. 99 displays these boundaries separately on a shift p-chart for a post-ramp cohort inspecting 200 illustrative garments per shift. [S09] [S0602] [S0604]

EXHIBIT 29 / PERCENT NONCONFORMING (N = 200)

Control limits direct attention to unusual variation



ILLUSTRATIVE [S09] [S0602] [S0604] Illustrative binomial p-chart for n = 200 inspected garments per shift across 10 shifts, applying S09 and S0602. Baseline mean p = 6.0 percent; 3-sigma UCL = 11.04 percent. Customer specification (4.0 percent) is shown separately to distinguish chronic capability gaps (Shifts 1 to 7, 9 to 10) from assignable-cause spikes (Shift 8 at 12.5 percent, triggering OCAP per S0604).

In **Exhibit 29**, p. 99, the illustrative process operates around a baseline mean of 6.0 percent nonconforming units across 200 garments per shift, giving a three-sigma Upper Control Limit of 11.04 percent and a Lower Control Limit of 0.96 percent. [S0602] Two diagnostic conclusions follow:

1. **Shifts 1 to 7 and 9 to 10 (In statistical control, out of specification)**: Observed proportions fluctuate between 5.0 percent and 7.0 percent, inside the 11.04 percent UCL, showing common-cause stability, yet every shift exceeds the 4.0 percent customer specification. [S09] [S0602] Closing the chronic gap between 6.0 percent and 4.0 percent requires management-owned work aids, method revisions or sewing skill drills rather than operator reprimands. [S05] [S12] [S45]
2. **Shift 8 (Out of statistical control, assignable cause)**: On Shift 8, the illustrative nonconforming rate jumps to 12.5 percent (25 of 200 garments), breaching the 11.04 percent UCL and triggering an Out-of-Control Action Plan (OCAP) to contain and fix the specific mechanical or material fault before Shift 9. [S0602] [S0604]

> **WARNING**
>
> **Small sample sizes and greenfield ramp-up invalidate unadjusted control limits**
>
> NIST guidelines note that the Poisson approximation requires a sample size of at least 20 units with a defect probability of 0.05 or less (performing best when sample size is at least 100 and expected count is 10 or less), while during early ramp-up the process mean is non-stationary as operators learn. [S11] [S0601] [S0602] During initial ramp cohorts or lots below 50 illustrative units, GFT suppresses automated three-sigma alarms and uses cohort-indexed run charts paired with deterministic triggers, such as halting an operation if 3 consecutive illustrative pieces show the same critical fault. [S09] [S11] [S19]

6.11

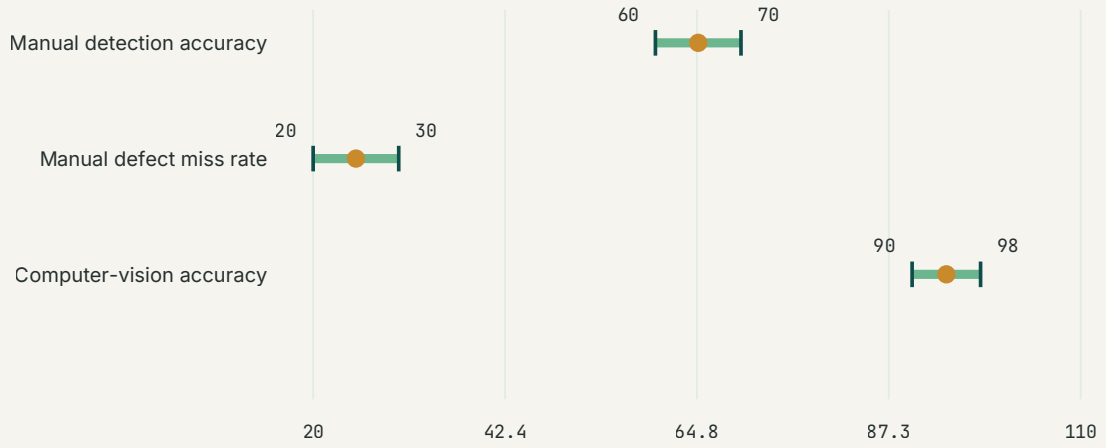
Inspection itself requires measurement-system checks

Every yield calculation and control chart assumes that an inspector's label reflects the garment rather than fatigue, lighting or subjective interpretation. [S40] Gauge Repeatability and Reproducibility (Gauge R&R) studies characterise measurement errors in production settings across repeatability, reproducibility, stability and bias. [S40]

Sector literature in the inherited register reports that manual defect inspection is only 60 to 70 percent accurate, missing 20 to 30 percent of defects, whereas computer-vision inspection is reported above 90 percent accuracy across more than 40 defect types at line-scan speeds up to 60 metres a minute (Grade C, original publication date not recorded). [R29] **Exhibit 30**, p. 101 shows the implication: if manual inspection misses 20 to 30 percent of defects, an apparent 5-percentage-point illustrative yield shift can arise from inspector drift rather than cleaner sewing. [R29] [S40]

EXHIBIT 30 / PERCENT OF DEFECTS

Reported inspection accuracy ranges show why human and automated checks need calibration



SOURCED [R29] [S40] Sourced from inherited register R29 (MDPI and industry inspection literature, Grade C, original date unrecorded): manual inspection accuracy 60 to 70 percent (mid 65%), manual miss rate 20 to 30 percent (mid 25%), and computer vision above 90 percent across >40 defect types (plotted 90% floor to 98% illustrative upper reference). Local Gauge R&R checks required per S40.

Exhibit 30, p. 101 establishes that inspection error can distort KPIs if unmeasured, though local detection rates require local testing. [R29] [S40] Applying Gauge R&R to visual grading tests four properties before KPI targets or machine-learning training rely on the log: [S27] [S40]

- **Master Gold Set (Bias control)**: A calibration rack of 30 illustrative numbered garments (15 conforming including borderline stitches, and 15 nonconforming across critical, major and minor faults) with locked master classifications. [S40]
- **Repeatability (Within-inspector)**: Grading the 30 illustrative blind-coded garments twice on separate days to check self-agreement across Trial 1 and Trial 2. [S40]
- **Reproducibility (Between-inspector)**: Checking agreement across Day Shift, Night Shift and audit inspectors on the same 30 illustrative garments. [S40]
- **Accuracy against Master Standard**: Quantifying false acceptance (missed defects) and false rejection (conforming garments sent to rework). [S40] [S45]

METHOD

Attribute Agreement Gate before KPI target or ML training activation

An inspection station's log remains `provisional` until its inspectors complete a 30-garment illustrative blind calibration trial and meet three illustrative thresholds: [S23] [S40]

1. **Within-inspector repeatability**: At least 90 percent illustrative exact match across blind repeat trials on conformance disposition. [S40]
2. **Between-inspector reproducibility**: At least 85 percent illustrative agreement across shifts on conformance disposition and primary defect family code. [S40]
3. **Critical-fault miss rate**: Zero percent illustrative false acceptance on safety or critical structural defects, and 10 percent or lower illustrative false acceptance or rejection on major visual defects, supported by standardised table lighting and physical limit swatches. [S12] [S40]

6.12

Vision is an input to the quality system, not its replacement

Inherited market records project the global fabric-defect-detection AI market to grow from US$523.4 million in 2024 to US$6,522.1 million by 2033 at 33.8 percent a year, with Asia-Pacific at about 46 percent in 2024 (Grade C, original date unrecorded). [R28] Alongside the computer-vision figures in R29 (above 90 percent accuracy across more than 40 defect types and line-scan speeds up to 60 metres a minute), McKinsey's *The State of Fashion 2025* reports broader AI potential in fashion, including inventory cost reductions of 35 to 40 percent and forecast-error cuts of 20 to 50 percent. [R27] [R28] [R29]

GFT applies strict boundary discipline to these figures. R28 and R29 are Grade-C records describing flat fabric-roll line-scan inspection and general vision benchmarks rather than three-dimensional sewn garment inspection. [R28] [R29] Furthermore, machine-learning engineering guidance advises against deploying machine learning before governed data exists when a simpler operational baseline has not yet been established. [S27]

6.13 AUTOMATED DETECTIONS MUST WRITE TO THE SAME GOVERNED DEFECT CONTRACT

While a companion paper evaluates vision hardware and algorithms in detail, within this performance-management system a vision model is a sensor whose output must obey the same governance rules as a human inspector: [R29] [S19] [S21] [S27]

- **Shared vocabulary and entity binding**: Every detection must map to the governed defect taxonomy and bind to the fabric roll ID, dye lot, cut bundle ID, style and timestamp in the system of record. [S21] [S23] [S25]
- **Human-in-the-loop adjudication**: Human confirmations or overrides are logged alongside model confidence scores to monitor precision, recall and drift across local cotton weaves and dye shades. [S09] [S23] [S27] [S40]

- **Corrective-action integration**: Detecting 40 illustrative weave defects a minute on a fabric roll creates value only when connected to cutting-room splice maps and supplier claims, just as sewing-floor defect logs must feed daily huddles, A3 root-cause reviews and skill drills. [S08] [S12] [S19] [S41]

> **GFT NOTE**
>
> In GFT's eighteen-month rollout, months one to three establish the defect taxonomy, first-pass denominators and human Attribute Agreement calibration using clean manual or tablet logs. [S05] [S23] [S40] Only after demonstrating above 98 percent illustrative log completeness, verified inspector reproducibility and an active A3 loop in months four to twelve does the factory connect computer-vision classifiers in months thirteen to eighteen. [S27] [S41]

By binding first-pass counting rules, explicit denominators, three-part defect taxonomies, rework accounting, statistical control limits and inspector calibration into one governed record, the factory turns quality from a sorting cost into an engineering signal. [S01] [S09] [S23] The next chapter extends this discipline to line balancing, work-in-progress age and On-Time-In-Full delivery promises. [S03] [S04]

Inspection sorts the past; structured defect evidence engineers the next shift.

CHAPTER SOURCE NOTES

S02 International Labour Organization. 2017.

S10 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04.

S23 ISO/IEC. 2008.

S25 W3C. 2017-01-31.

S01 International Organization for Standardization. 2014.

S40 NIST/SEMATECH. 2003.

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

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

R12 Business in Cameroon. Publication date unrecorded; inherited source-text check.

S11 International Journal of Production Economics, Elsevier. 2001.

S06 Diamond Congress, Creative Construction Conference. 2023.

S0601 NIST/SEMATECH. 2003.

S16 PLOS ONE. 2020-02-05.

S0602 NIST/SEMATECH. 2003.

S07 Scientific Reports, Springer Nature. 2025.

S0603 NIST/SEMATECH. 2003.

S24 UK Government Data Quality Hub. 2020-12-03.

S21 National Institute of Standards and Technology. 2016.

S19 The International Journal of Advanced Manufacturing Technology, Springer Nature. 2019-09-03.

S03 International Labour Organization. 2023.

S12 Applied Sciences, MDPI. 2021-11-23.

S41 Lean Enterprise Institute. 2022-08-10.

S45 United States Office of Personnel Management. 2019-11-04.

S22 United States Federal Data Strategy. 2020.

S36 UNIDO and UNEP. 2015.

R16 WageIndicator. Publication date unrecorded; inherited source-text check.

R14 WageIndicator. Publication date unrecorded; inherited source-text check.

S17 ILO and IFC, Better Work. 2018-12-20.

S09 NIST/SEMATECH. 2003.

S0604 NIST/SEMATECH. 2003.

S05 International Labour Organization. 2022-06-01.

R29 MDPI; industry inspection literature. Publication date unrecorded; inherited source-text check.

S27 Google for Developers. 2025-08-25.

R28 DataIntelo. Publication date unrecorded; inherited source-text check.

R27 McKinsey, The State of Fashion 2025. Publication date unrecorded; inherited source-text check.

S08 International Journal of Productivity and Quality Management, Inderscience. 2020-05-11.

S04 International Labour Organization. 2023.

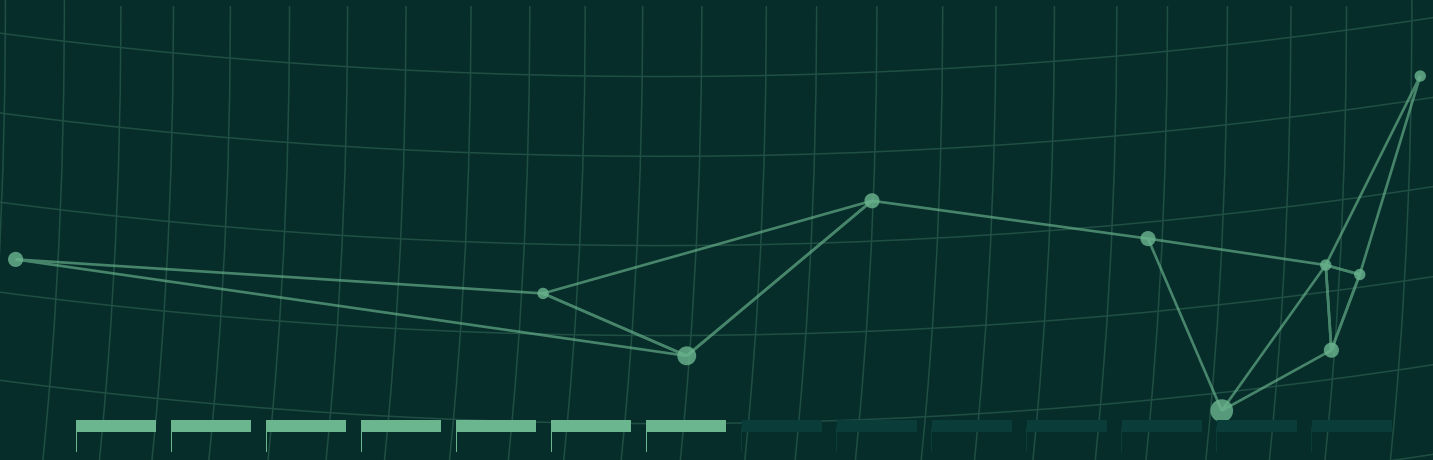
GREEN FUTURE TECH
LIMITED / HONG KONG SAR

07

PART II: MEASURE THE OPERATING SYSTEM / FLOW TO CUSTOMER

Delivery reliability begins with measured work content and flow

Standard work, balanced capacity and order-level flow records must support the delivery promise before expediting becomes routine.



CHAPTER 07
DECISION TEST

Standard work, balanced capacity and order-level flow records must support the delivery promise before expediting becomes routine.

Delivery reliability is an operating result, not a dispatch-room behaviour. A factory can make a defensible promise only when it can translate each order into method-based work content, compare that load with demonstrated capacity by operation and skill, and follow the order through queue, touch, rework and receipt events. Standard minutes supply the common unit, daily balancing protects flow, and monthly sales and operations planning reconciles demand with capability. [S03] [S04] [S42] Expediting may rescue an individual order. It cannot repair an ambiguous routing, an overloaded operation or a missing receipt record.

This chapter therefore treats the customer promise as the final link in a measured chain. Industrial engineering defines the work. Production establishes the capacity that has actually been demonstrated. Supervisors remove imbalances as conditions change. Commercial and logistics teams preserve the agreed date, quantity and proof of receipt. The measures remain useful only when each one leads to a decision before the promise is at risk.

7.1

Standard minutes describe a method, not a universal truth

The standard minute value, or SMV, is a work-content reference with conditions attached. The ILO defines it through the output that qualified workers can achieve without overexertion when they know and follow a specified method and are motivated to apply themselves. [S03] An SMV is therefore not the raw average of whatever happened on a shift. It is not transferable between different operation sequences, machine settings, material behaviours or quality requirements merely because the garment name is unchanged.

Industrial engineering should start with an operation breakdown that describes the work in executable terms. Each operation needs a sequence number, a clear start and finish, the machine or workstation, the attachment or folder, the material and trim condition, the quality criterion and the disposition of the completed bundle. The method release should also identify the style, product family, routing revision and effective date. Without those attributes, a time value cannot be audited against the work that was actually performed.

The observed time and the released standard serve different purposes. Observations describe a particular worker, method and period. The released SMV provides the planning reference for a defined method and qualified performance. The ILO discussion also distinguishes allowances within the calculation, including personal time and machinery-related allowances, before the aggregate SMV is formed. [S03] GFT would retain the observed samples, rating basis and allowance rationale beside the result rather than leaving only a final number in a routing table.

A provisional standard is legitimate during ramp, but it must be labelled as such. Its status should state the evidence still missing, such as a stable method, enough qualified observations or confirmation of the allowance basis. The planner can use that provisional value with an explicit uncertainty allowance. The reviewer should not

present the resulting capacity as settled. Once the method changes, the old value remains attached to its historical orders and a new revision becomes effective for future comparisons.

Method control also protects workers. A standard developed for one sequence should not become a personal output target for a worker who has been given a different machine, an incomplete bundle or an unapproved material substitution. Before a variance is attributed to performance, the supervisor should be able to confirm that the released method was available, the operator was qualified for it and the required inputs were present. A work-content measure is credible only when those conditions are visible.

Finally, the SMV does not measure every form of time. It does not replace records of waiting for material, machine stoppage, changeover, absence, rework or dispatch queues. Those events belong in their own logs. Keeping them separate prevents a planner from hiding an operating loss inside an inflated standard and prevents an engineer from treating a necessary allowance as an unexplained delay.

7.2

Capacity must be expressed in comparable work content

Piece counts are a poor common denominator when styles have different work content. GFT would calculate required standard minutes for each order, operation and method revision by multiplying the order quantity by the applicable SMV, then sum those requirements by product family and planning period. The calculation is simple, but the master data must be precise: quantity, operation, style, routing revision and SMV status all affect the result.

The illustrative mix in **Exhibit 31**, p. 107 shows why a total piece count cannot establish the load. The values are constructed only to demonstrate the arithmetic and do not describe a GFT factory or a forecast.

EXHIBIT 31 / ILLUSTRATIVE PIECES AND STANDARD MINUTES

Piece counts hide a heavier style mix until work content is calculated

Style	Order pieces	SMV per piece	Required standard minutes
Style A	600	6	3,600
Style B	400	14	5,600
Total	1,000	Mixed	9,200

ILLUSTRATIVE [S03] Illustrative model. Style A requires 600 pieces x 6 standard minutes = 3,600 standard minutes. Style B requires 400 pieces x 14 standard minutes = 5,600 standard minutes. Total load is 9,200 standard minutes. SMV interpretation follows S03; all order values are assumed.

In this illustrative case, the order contains 1,000 pieces and 9,200 standard minutes, giving a mix-weighted work content of 9.2 standard minutes per piece. Style B supplies only 400 pieces but carries 5,600 of the 9,200 required standard minutes. A plan that treated all pieces as equivalent would understate the effect of changing the mix. The same arithmetic should be applied at operation level, where a style may add work to one constraint without changing the total by the same proportion.

Available capacity needs an equally explicit basis. For each operation and skill group, the factory should identify scheduled attendance, planned meetings or maintenance, approved non-production time and the number of qualified workers or compatible workstations. Available minutes are a time supply, not yet a promise of good output. The plan must then account for demonstrated rate, stoppages, learning and first-pass quality using records from comparable work.

OEE provides a useful discipline here because it retains availability, performance and quality as separate loss components rather than treating output as an unqualified equipment result. [S06] The capacity model should not multiply a general efficiency assumption through every operation without checking what that factor contains. If attended minutes have already been reduced by a recorded stoppage, applying the same availability loss again would understate capacity. If repaired pieces are counted as first-pass good, the quality factor would overstate it.

METHOD

For a planning period, reconcile four quantities by operation: required standard minutes from released orders; attended minutes from the skills roster; demonstrated standard minutes produced per attended minute for comparable work; and first-pass good output from the quality record. State every conversion and its period. Keep provisional ramp factors separate from stable-method references. The capacity review should explain any residual gap through named losses, not through an unexplained global percentage.

WORKED EXAMPLE: OPERATION LOADING EXPOSES A SHORTFALL

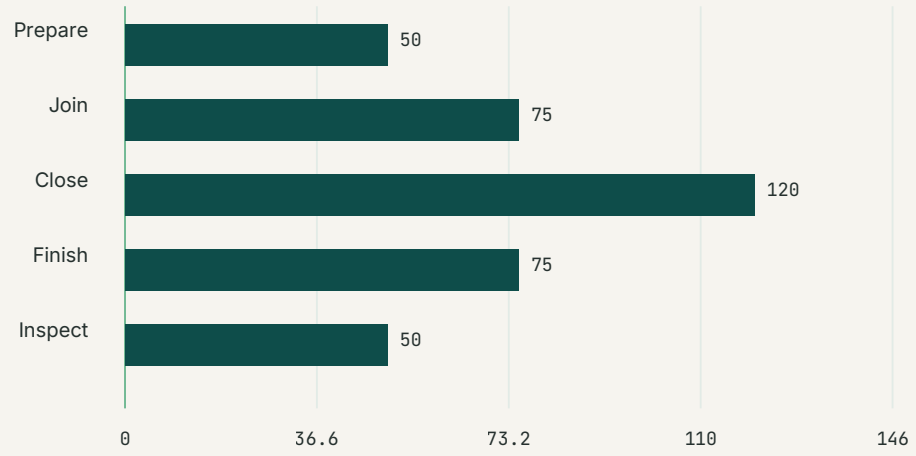
An illustrative order for 1,000 garments has five operations with SMVs of 1.2, 1.8, 2.4, 1.5 and 1.1 minutes. Required work is therefore 1,200, 1,800, 2,400, 1,500 and 1,100 standard minutes respectively. These values are assumed to demonstrate the method, not to represent a real garment.

Assume that the same illustrative operations have 2,400, 2,400, 2,000, 2,000 and 2,200 compatible attended minutes available in the planning window. Their loading ratios are required minutes divided by available minutes: 50 percent, 75 percent, 120 percent, 75 percent and 50 percent. The third operation has a 400-minute shortfall. The other operations have spare time, but that time can be transferred only where skill, machine and method conditions permit.

The illustrative loading pattern appears in **Exhibit 32**, p. 109. It locates the first capacity question before the order is released, but it does not prove that the longest operation will remain the constraint in production.

EXHIBIT 32 / PERCENT OF AVAILABLE MINUTES

Operation work content reveals the constraint before pieces move



ILLUSTRATIVE [S03] [S04] Illustrative model for 1,000 garments. Required minutes are 1,200, 1,800, 2,400, 1,500 and 1,100. Available minutes are 2,400, 2,400, 2,000, 2,000 and 2,200. Loading equals required divided by available, multiplied by 100. No realised line performance is asserted.

The response to the illustrative 400-minute deficit is a choice, not an instruction to work faster. The supervisor and industrial engineer can test a rebalance from an operation with spare compatible capacity, a method improvement that removes work, additional qualified time, a different order sequence or a revised promise. Each option has a different mechanism and verification record. The capacity statement becomes useful when it makes those choices visible while there is still time to act.

7.3

Balancing continues after the plan is issued

A feasible plan can still become an unbalanced line. The ILO garment-sector report assigns line balancing to supervisors systematically before production through planning and daily during production. It also describes regular in-production checks using recorded output and work in progress to identify bottlenecks and their causes. [S04] The important point is the management rhythm: balancing is not a one-time industrial-engineering calculation handed down with the style file.

The pre-production balance begins with the released operation bulletin, the expected order quantity, the available skills and the machine layout. Work is allocated so that each station has a coherent assignment and the planned load is feasible at the constraint. The supervisor should also know which operations are method-sensitive, which workers can cover them and where bundles will be counted. A balance that depends on an unnamed person arriving with an unrecorded skill is not yet an executable plan.

During production, the line board should show planned and actual good output by interval, WIP at agreed boundaries, operation-level stoppages, quality interruptions and skill absences. The purpose is to see a forming queue before the end-of-line

total falls. A station can meet its own local target while starving the next station or building an excessive buffer. The review therefore concerns the whole sequence, not isolated operator utilisation.

A rebalance should follow diagnosis. If the cause is a wrong work allocation, the supervisor can move a compatible operation or share work across qualified stations. If the cause is a machine fault, maintenance owns the response and the plan must reflect the interrupted capacity. If the cause is missing material, the shortage remains visible rather than being converted into an operator performance loss. If a method change is required, industrial engineering must release it before new time comparisons are made.

WIP limits support this review, but they should not be treated as proof of flow by themselves. A line can remain below a WIP ceiling while one order waits untouched and another is repeatedly prioritised. The board therefore needs order or bundle age as well as quantity. It also needs the reason for any deliberate sequence exception, especially when an urgent order displaces work that was already promised.

> **GFT NOTE**
>
> GFT would give the supervisor a short rebalance record: observed constraint, affected order, work-content revision, skill or machine constraint, action taken, owner and next check. The action is accepted only after good output, first-pass quality and WIP age respond as expected. This keeps daily balancing inside the operating system and prevents repeated informal transfers from becoming an unrecorded method change.

The review should close with demonstrated capability, not with the act of rebalancing itself. Did the constraint move? Did good output increase without creating more rework? Did the oldest WIP fall? Did the new allocation remain within qualified skill coverage? Those questions connect the supervisor's intervention to delivery reliability. They also produce the evidence that the next monthly capacity review should use in place of nameplate assumptions.

7.4

WIP age reveals problems that output totals miss

Output is a count at a boundary. Flow is the experience of an identified order between boundaries. Two lines can report the same daily output while one advances orders predictably and the other leaves a small population stranded for long periods. An end-of-day total cannot distinguish those conditions. Order and bundle timestamps can.

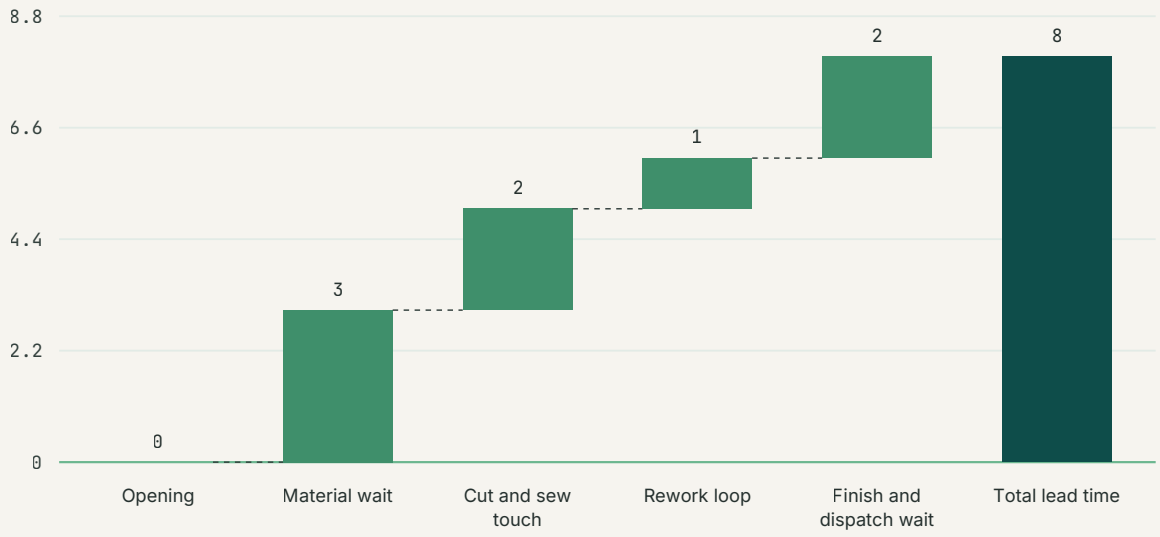
Quality is part of this flow record. A NIST Manufacturing Extension Partnership case concerning a manufacturer's returned-material process reports a large reduction in processing time alongside an increase in first-pass yield. [S10] It is not a garment-factory benchmark and its values should not be transferred as targets. The mechanism is nevertheless relevant: correction consumes touch time, repeats handling and delays the order, so repaired output cannot be treated as equivalent to work completed correctly at the first pass.

Each WIP record should identify the order, style, bundle, quantity, current operation and last completed event. A timestamp at entry to a queue and another at the start of work allow queue time to be separated from touch time. A return to an earlier operation should open a rework interval with its defect or correction reason, not overwrite the original history. The final disposition should reconcile the quantity that entered, was accepted, was repaired, was rejected or remains open.

The illustrative order in **Exhibit 33**, p. 111 makes this decomposition visible. Its eight-day total is constructed from assumed durations to demonstrate the accounting, not from an observed factory.

EXHIBIT 33 / ILLUSTRATIVE CALENDAR DAYS

Queues and rework dominate an illustrative order lead time



ILLUSTRATIVE [S10] Illustrative model. Material wait 3 days + cutting and sewing touch time 2 days + rework loop 1 day + finishing and dispatch wait 2 days = total lead time 8 days. S10 supports the general connection between correction and flow, not these assumed durations.

In that illustrative case, only two of the eight days are recorded as cutting and sewing touch time. Five days sit in material, finishing or dispatch queues and one day is a rework loop. An output review focused only on sewing speed would miss most of the elapsed time. The corrective agenda would instead begin with the causes and ownership of the material wait, the repeated correction and the final queue.

Not every waiting interval is avoidable. A planned consolidation, a customer-approved hold or a required quality quarantine can be legitimate. The record should therefore distinguish planned waiting from an unmanaged queue and retain the authorisation where the order was deliberately stopped. The analytical error is not simply to count waiting. It is to classify every minute as waste before its purpose is known, or to hide every delay beneath a generic production label.

Ageing also needs a defined clock. Calendar time measures the customer's elapsed experience, while working time explains how much scheduled operating opportunity passed. Both can be useful, but they should not be mixed silently. The oldest-order age, the share of WIP beyond an agreed review threshold and the number of

reopened loops provide different prompts. The threshold itself should trigger investigation rather than automatic blame, particularly during ramp or a customer-caused hold.

7.5

OTIF needs a promise and a receipt event

On-time-in-full delivery, or OTIF, is meaningful only when the commercial promise and the fulfilment event are defined together. Monthly sales and operations planning is conducted at an aggregate product-family level, which is necessary for management reconciliation but too coarse to diagnose an individual customer order. [S42] The order-level OTIF record must retain the agreed date, required quantity, quantity tolerance, partial-shipment rule, receipt location and evidence that the customer received the goods.

GFT would calculate order-level OTIF as the share of orders due in the period that meet both the date and quantity conditions, expressed as a percentage of all orders due. An order-line measure may answer a different service question, but it should not be mixed with the order-level result. A single late line can make an entire order fail under one definition while barely changing a line-count measure under another. The data dictionary must state which population is being reported.

The date rule deserves equal care. The original customer promise, any factory acknowledgement and any customer-agreed revision should be separate fields. Performance against the current agreed promise may be commercially useful, while performance against the first promise exposes how often replanning occurred. Neither should silently replace the other. Dispatch is also not receipt. A shipment can leave the factory on the agreed day and still arrive late, which is why the selected proof-of-receipt event matters.

> **WORKED EXAMPLE: OTIF COUNTS FULFILLED PROMISES, NOT DISPATCHES**
>
> Consider an illustrative period with 80 orders due. Of these, 64 are received by the agreed date and in full. Six arrive on time but short, four arrive complete but late, two are dispatched on time but received late, and four fail for other recorded reasons. The illustrative OTIF numerator is 64 and the denominator is 80, so OTIF is 64 divided by 80, multiplied by 100, or 80 percent. The values demonstrate the formula and are not a service benchmark.

Exhibit 34, p. 113 summarises that illustrative population. The important control is the reconciliation between due orders, fulfilled orders and the reasons for failure.

EXHIBIT 34 / ILLUSTRATIVE ORDERS AND PERCENT

OTIF reconciles the due-order population with fulfilled promises

80	64
Orders due	**Received on time and in full**
Illustrative denominator	Illustrative numerator
16	80%
Not OTIF	**OTIF**
Six short, four late, two received late after dispatch, four other	64 divided by 80, multiplied by 100

ILLUSTRATIVE Illustrative worked example. 64 OTIF orders + 16 orders not OTIF = 80 orders due. OTIF rate = 64 / 80 × 100 = 80 percent. These are assumed values used to demonstrate the calculation.

The failure reason should point to the earliest controllable break in the chain, while preserving later events. Material release, cutting, sewing, finishing, inspection, documentation, transport and customer-receipt causes can coexist. A primary reason supports accountability, but a secondary-cause field prevents the record from hiding a sequence of problems. Free text can explain the event; a controlled reason code makes the repeated pattern reviewable.

Finally, OTIF should not be improved by narrowing the denominator after the fact. Cancelled orders, customer holds and agreed revisions need explicit inclusion rules and an audit trail. Commercial teams should be able to explain movement in the due population as carefully as movement in the numerator. A reliable service measure is one whose exceptions are visible enough to survive challenge from production, sales and the customer.

7.6

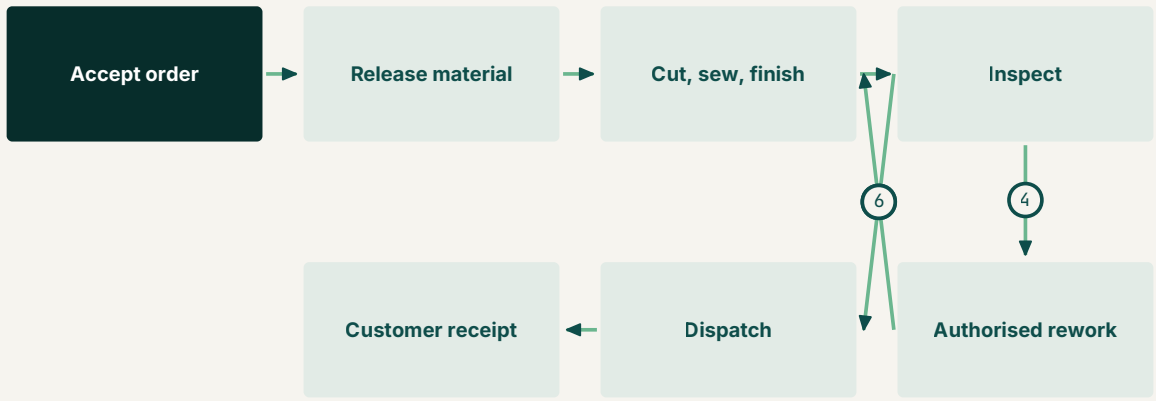
Lead-time decomposition locates the delay

A lead-time total becomes actionable only when its component events share an identity across commercial and production records. NIST states that the ability of different systems to exchange, understand and use product, production and business data depends critically on information standards. [S21] A garment factory does not need to adopt every possible standard before it can measure flow. It does need one governed order identifier, consistent style and routing identifiers, and agreed meanings for the events through which an order passes.

The illustrative event chain in **Exhibit 35**, p. 114 joins the commercial promise to production and receipt. The rework branch is explicit because a corrected unit repeats part of the flow rather than creating a new, unrelated order.

EXHIBIT 35 /

Order timestamps separate queue, touch and rework time



4. Correction
5. Return
6. Accepted

ILLUSTRATIVE [S21] Illustrative process design. Shared order, style and routing identifiers connect the events. The rework branch returns authorised correction to production; accepted work proceeds to dispatch. S21 supports information interoperability, not this specific factory design.

Every event needs more than a timestamp. The record should carry the order and, where relevant, bundle identifier; the event code; the quantity; the operation or location; the event time; the time entered into the system; and the person or device supplying it. Event time and entry time answer different questions. A late entry can make a timely physical event appear delayed, while an overwritten timestamp can erase the evidence needed to investigate capture latency.

The boundary of each lead-time measure must be declared. Customer lead time may run from order acceptance to receipt. Factory production lead time may run from material release to dispatch. Manufacturing touch time may include only intervals in

which an identified operation is being performed. These measures can coexist because they answer different questions. They become misleading when a shorter internal interval is presented as the customer's full experience.

Duration arithmetic should respect that boundary. Queue time is the interval between completion at one defined state and the start of the next eligible state, subject to the site's calendar convention. Touch time sums the relevant work intervals without silently including intervening queues. Rework time is recorded on the repeated path and linked to the originating inspection. If a bundle splits or merges, quantity reconciliation must accompany the event so that the flow record does not invent or lose pieces.

A small manual event set is preferable to a large set of unreliable timestamps. At the first shift, order acceptance, material release, cutting completion, sewing completion, finishing completion, final inspection disposition, dispatch and receipt provide a useful skeleton. Additional operation-level events can be added where they change a decision. The capture test is whether two people reviewing the same order would assign the same event, quantity and time.

> **METHOD**
>
> Reconcile each order from the outside in. Start with promised date and proof of receipt, then test dispatch, final acceptance, production completion, material release and order acceptance. For every interval, state the start event, end event, calendar rule and owner. Investigate missing or negative durations before calculating averages. A median and an oldest-order view can then locate delay without allowing a few extreme records to define every order's experience.

The review output should be a specific intervention. A long material-release queue calls for material and planning decisions. Repeated inspection returns call for quality prevention at the originating operation. A dispatch queue after accepted production calls for documentation or transport action. Lead-time decomposition earns its place by directing the right function to the interval it can change, while leaving the order's complete history intact.

7.7

S&OP reconciles demand with demonstrated capability

Sales and operations planning supplies the management forum in which demand and supply are brought into one plan. The source definition used here calls for performance at least monthly and management review at aggregate product-family level. It also requires detailed and aggregate plans to be reconciled. [S42] For a garment factory, that reconciliation should occur in standard minutes as well as pieces, with order-level promises rolling into product families rather than disappearing into a plant-wide average.

The supply input should be demonstrated capability by operation and skill. Industrial engineering brings current and provisional SMVs, method releases and known routing changes. Production brings attended time, stoppages and recent output for

comparable cohorts. Quality brings first-pass performance and rework demand. Human resources brings demonstrated skill coverage and approved attendance plans. Materials and logistics bring release constraints and transport events. Sales brings the order book, forecast assumptions and the exact basis of each requested promise.

The roll-up should preserve the constraints beneath the family total. Required standard minutes can be summed across styles only after each quantity has been tied to the correct routing revision. Available minutes can be summed only where the relevant skills and workstations are genuinely interchangeable. A family-level surplus may therefore coexist with an operation-level shortage. When that happens, the meeting should see both positions and should not use the surplus to conceal the incompatible constraint.

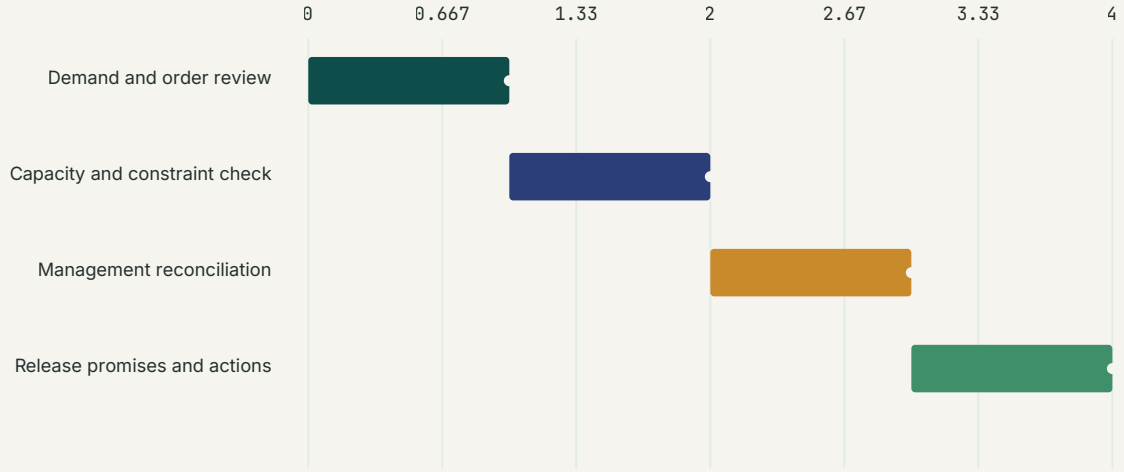
The same discipline applies to the planning horizon. Near-term orders deserve a reconciliation against released methods, confirmed materials and demonstrated skill coverage. Later periods can carry wider assumptions about recruitment, training, method improvement or demand, provided those assumptions have owners and review dates. This separates a commitment that must be executed now from a capability that still has to be created. It also shows when a sales opportunity depends on an operational change rather than on spare capacity already present.

This is deliberately different from nameplate capacity. A machine or headcount total cannot show whether the required operations can be performed to the current method by qualified people, nor whether correction and changeover will consume part of the available time. During ramp, the review should retain a range where the evidence is thin and identify what must be learned before the range can narrow. A single apparent capacity number would hide precisely the uncertainty that the meeting needs to govern.

The illustrative monthly sequence in **Exhibit 36**, p. 117 puts work-content and constraint reconciliation before management releases the plan. The monthly cadence comes from the S&OP source; the weekly placement is a GFT planning illustration, not a universal timetable.

EXHIBIT 36 / WEEKS IN MONTHLY CYCLE

The monthly plan uses demonstrated rather than nameplate capability



ILLUSTRATIVE [S42] Illustrative planning sequence. S42 supports at-least-monthly management review at product-family level. The four weekly windows are assumed to show a possible sequence, not required deadlines or realised milestones.

The meeting should test a small number of explicit choices. If demand exceeds demonstrated work-content capacity, management can resequence orders, add qualified time, approve a feasible method or layout change, adjust the product mix, or revise customer promises. If demand is below available capacity, the same review can consider training, maintenance or a different release pattern without pretending that idle time is a production failure. Each scenario should show its assumptions and the constraint it relieves.

Promise governance belongs inside this process. Sales should not create a new date from an unvalidated piece-rate assumption, and production should not accept an overload silently and recover it through routine expediting. Where a customer request cannot be met under the demonstrated plan, the response should state the earliest feasible alternative and the conditions that could change it. That answer is more useful than a hopeful date supported only by aggregate nameplate capacity.

Expediting should remain an exception with a visible mechanism. The expedite record should name the order, the missed planning condition, the work displaced, the additional handling or transport required and the authority approving the exception. The next review should ask why the normal chain did not protect the promise. Repeated expedites around the same operation are evidence for capacity, method or material action, not proof that the factory has a reliable recovery capability.

The management scorecard should connect outcomes to their earlier signals. OTIF and customer lead time describe the result. Work-content coverage, constraint loading, oldest WIP, rework-loop age and order-event completeness show whether future promises are exposed. None of these measures should be used alone. A low WIP total can conceal starvation, a high output total can conceal late orders, and an attractive OTIF result can conceal a narrowed denominator.

WARNING

The principal unresolved risk is not analytical technique but record comparability. A capacity model built on an old routing, an OTIF result tied to dispatch rather than receipt, or a lead-time average containing missing events will support a confident but wrong decision. The mitigation is a monthly sample audit from physical order to source record, with definition corrections versioned before performance trends are interpreted.

GFT's practical sequence is therefore direct. Release a method-based routing. Convert orders to work content. Reconcile compatible time and skill. Balance daily against observed flow. Preserve order events through receipt. Let the monthly plan learn from that evidence. Delivery reliability then becomes a property of the operating system, rather than a recurring act of recovery at the end of the chain.

A promise is reliable when the work, the flow and the receipt all tell the same story.

CHAPTER SOURCE NOTES

S03 International Labour Organization. 2023.

S04 International Labour Organization. 2023.

S42 Production, SciELO. 2017.

S06 Diamond Congress, Creative Construction Conference. 2023.

S10 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04.

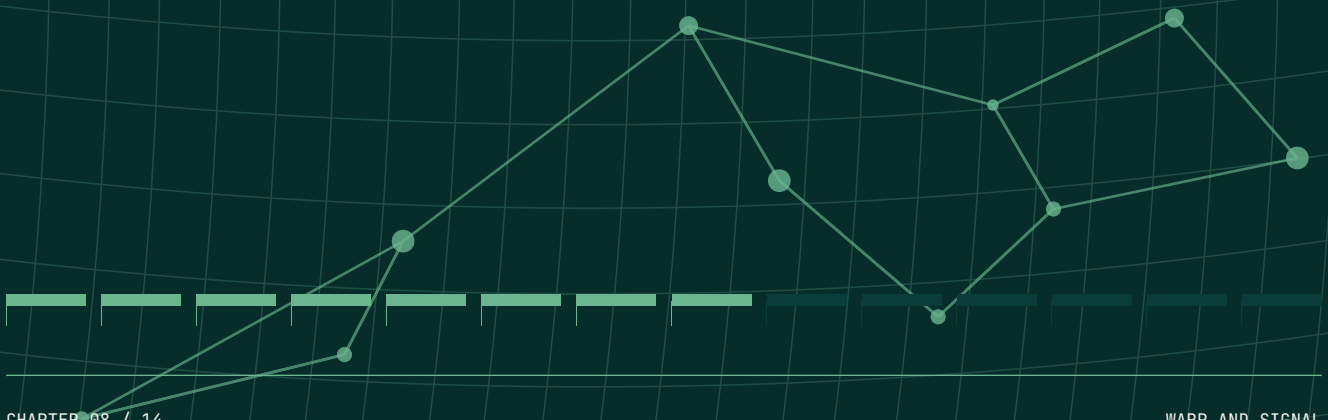
S21 National Institute of Standards and Technology. 2016.

08

PART II: MEASURE THE OPERATING SYSTEM / PEOPLE AND INCENTIVES

Effective labour cost joins productivity with capability and fairness

A low nominal wage does not establish a low cost per good garment, so the people scorecard must include skill, supervision, attendance and working-time effects.



CHAPTER 08
DECISION TEST

A low nominal wage does not establish a low cost per good garment, so the people scorecard must include skill, supervision, attendance and working-time effects.

A greenfield garment factory cannot establish a competitive unit cost simply by locating in a low-wage jurisdiction. The controlling labour measure on the factory floor is effective labour cost per first-pass good garment, not the statutory monthly wage or the hourly payroll rate. [S10] [S11] When a newly commissioned sewing line operates with unverified operator skills, untrained supervision, high absenteeism, excessive overtime and poorly engineered piece-rate incentives, the resulting defects, rework loops, line imbalances and worker turnover multiply the paid minutes required to produce each saleable piece. [S12] [S17] [S18] Green Future Tech Limited (GFT), Hong Kong SAR, therefore designs the people and cost families of the factory scorecard as one connected control system: payroll expenditure must be reconciled to first-pass good output, demonstrated operation competence, supervisory behaviour, working-time stability and equitable incentive design from the first shift. [S01] [S02] [S16]

This accounting discipline is essential for industrial sponsors evaluating garment manufacturing in emerging cotton-producing economies. In Cameroon, inherited sector evidence records that about 95 percent of cotton fibre is exported raw while about 5 percent is processed locally, against a national policy target of 50 percent local processing by 2030. [R06] [R07] Separate public reporting on the announced Camtext SA project cites planned processing of 12,000 tonnes a year and projected creation of about 12,000 jobs at Dibamba and 3,000 at Garoua, while July 2023 reporting on CICAM recorded capacity utilisation of 33.7 percent at Garoua, 48.9 percent at CICAM 1 and 10.83 percent at CICAM 2, with underutilisation costing about CFAF 2 billion in 2020. [R10] [R12] Those third-party figures describe industrial context rather than a GFT operating result or commercial forecast, and this chapter provides operational engineering guidance rather than investment, legal or tax advice. They show, however, that converting raw fibre into viable apparel manufacturing requires a workforce system whose productivity, quality and retention are measured alongside payroll from day one.

8.1

Cost per good garment is the controlling labour measure

Financial feasibility models often compare garment locations by placing monthly minimum wages side by side and assuming a fixed output rate per operator. Operational reality on a greenfield floor invalidates that shortcut. Empirical research on production ramp-up demonstrates that a new manufacturing process is initially poorly understood, causing low yields and low production rates to appear simultaneously. [S11] When yield and production rate are both depressed, the factory pays for full shift attendance while receiving only a fraction of its planned saleable output. A plant with a low nominal wage and weak process control can incur a higher labour cost per accepted garment than a plant paying higher wages to a stable, well-supervised and method-qualified workforce. [S11] [S16]

Following the ISO 22400 requirement that manufacturing key performance indicators specify their formula, corresponding elements, time behaviour and unit of measure, GFT separates hours paid from hours worked on accepted output. [S01] Total paid hours include direct sewing and finishing attendance, indirect floor support (helpers,

bundle handlers, mechanics, quality inspectors and line supervisors), off-line training and drill time, paid absence or statutory leave, and overtime hours carrying statutory premium rates. [R16] [S01] [S12]

8.2 HOW INDIRECT RATIOS, REWORK AND OVERTIME INFLATE UNIT LABOUR COST

A garment that fails end-of-line inspection and returns for unpicking and re-sewing consumes direct operator time twice while delaying bundle completion. [S10] Dividing payroll by gross pieces sewn credits the line for defective work and hides the labour spent on correction. Under GFT's metric contract, the primary denominator for unit labour cost is *first-pass good garments* crossing the completion boundary without repair, recut or reinspection-driven correction, complemented by *first-pass earned standard minutes* so lines assembling styles of different complexity can be compared fairly. [S01] [S03] [S10]

The illustrative comparison in **Exhibit 37**, p. 121 shows how two lines operating under identical statutory wage rates in Cameroon generate sharply different unit labour costs when their supervision, quality and working-time controls diverge. [R14] [R16] [S03] [S10] [S11]

EXHIBIT 37 / ILLUSTRATIVE WEEKLY ROSTER AND XAF COST RECONCILIATION

Identical base wages yield different unit costs once losses are reconciled

Reconciliation element	Line A: unmeasured push	Line B: governed flow	Operational mechanism
Regular hours paid (30 staff)	1,200	1,200	40-hour week across 24 direct and 6 indirect staff
Overtime hours paid (at 1.2x rate)	240	30	Line A pushes 8 hours overtime; Line B caps overtime
Weekly payroll cost (illustrative XAF)	522,000	427,500	Regular hours at XAF 346/hr plus overtime at XAF 415/hr
Gross garments completed	1,500	1,600	Line A suffers waiting and fatigue; Line B holds balance
First-pass yield (%)	72	92	Line A generates 420 defective units; Line B generates 128
First-pass good garments	1,080	1,472	Units accepted at completion boundary without repair
Effective cost per good garment (XAF)	483	290	Weekly payroll divided by first-pass good garments

ILLUSTRATIVE [R14] [R16] [S03] [S10] [S11] Illustrative GFT cost-reconciliation model for two 30-worker rosters (24 direct operators, 6 indirect support staff) assembling a 15.0 SMV garment over a 40-hour standard week with up to 8 overtime hours at 1.2x base pay (R16) and an illustrative base wage of XAF 60,000 a month above the XAF 43,969 SMIG (R14). Values are illustrative arithmetic to demonstrate the method, not a GFT factory observation.

In **Exhibit 37**, p. 121, both illustrative rosters employ 24 direct operators and 6 indirect floor workers at an illustrative base wage of XAF 346.25 per regular hour (corresponding to XAF 60,000 across a 173.3-hour illustrative monthly reference, above the XAF 43,969 statutory minimum wage effective 23 February 2024), with overtime paid at 1.2 times the regular rate under Cameroon's 40-hour standard week and 48-hour maximum framework. [R14] [R16] Line A runs 8 illustrative overtime hours per worker (`240 overtime hours`) while tolerating poor line balance and a 72 percent illustrative first-pass yield. [S11] [S18] Line B uses daily supervisor balancing and in-line quality checks to limit overtime to 30 illustrative hours and hold a 92 percent illustrative first-pass yield. [S04] [S10] Although both lines pay the same base tariff, Line A's illustrative effective labour cost is XAF 483 per first-pass good garment against XAF 290 on Line B. What **Exhibit 37**, p. 121 cannot establish is an empirical cost norm for any specific plant; it proves how overtime premiums and rework erase nominal wage advantages.

WORKED EXAMPLE

Illustrative decomposition of cost per standard minute and cost per good garment. Consider the arithmetic behind the two illustrative lines in **Exhibit 37**, p. 121 for a woven shirt carrying an approved Standard Minute Value (SMV) of 15.0 standard minutes. [S03]

1. **Payroll input:** At an illustrative regular rate of XAF 346.25 per hour (`1,200 * XAF 346.25 = XAF 415,500`) and an illustrative 1.2x overtime rate of XAF 415.50 per hour (`R16`), Line A's 240 illustrative overtime hours plus XAF 6,780 in meal allowances bring weekly payroll to an illustrative **XAF 522,000**, whereas Line B's 30 illustrative overtime hours bring weekly payroll to an illustrative **XAF 427,500**. [R14] [R16]
2. **Gross versus first-pass unit cost:** On gross pieces completed, Line A reports an illustrative `XAF 348.00 per gross piece` (`522,000 / 1,500`) against Line B's `XAF 267.19` (`427,500 / 1,600`), concealing the 420 garments on Line A that failed first-pass inspection (`1,500 * 0.28 = 420`). [S10]
3. **First-pass good garment and standard-minute cost:** Dividing by first-pass good garments (`1,080` on Line A versus `1,472` on Line B) yields **XAF 483.33 per first-pass good garment** on Line A against **XAF 290.42** on Line B. Per first-pass earned standard minute (`16,200 SMVs` on Line A versus `22,080 SMVs` on Line B), Line A costs an illustrative **XAF 32.22** against **XAF 19.36** on Line B. [S01] [S03] All figures are illustrative calculations demonstrating the method, not an observed GFT factory result.

8.3 SEPARATING DIRECT, INDIRECT AND TRAINING HOURS IN THE LEDGER

Pooling all floor hours into a single undifferentiated bucket, or excluding indirect and training hours so direct sewing efficiency looks artificially high, distorts management decisions. [S01] [S02] GFT's chart of operational time accounts mandates four daily hour buckets reconciled to the attendance gate:

- **Direct production hours:** attended time spent by assigned line operators on released order operations, forming the denominator for direct operator efficiency. [S01] [S03]

- **Indirect line and floor support hours:** attended time of supervisors, inspectors, bundle handlers, mechanics and rework operators, tracked as an explicit ratio to direct hours. [S02] [S04]
- **Structured capability-development hours:** scheduled time in induction, off-line drills or supervised line shadowing, tagged as skill investment rather than hidden downtime. [S12] [S14]
- **Non-productive waiting and overtime hours:** paid time lost to material starvation, machine breakdown or unbalanced queues, alongside overtime hours flagged by cause code and premium tier. [R16] [S18]

8.4

The skill matrix records demonstrated operations

Effective labour cost cannot be stabilised if the factory does not know which operators can perform which operations to the current quality and time standard. A study in *Applied Sciences* examining manual skill degradation in apparel production demonstrates that sewing operators lose task proficiency when they are away from specific manual operations or when task structures shift, concluding that ongoing capacity-development drills are essential to maintain an efficient required skill set. [S12] At the same time, the ILO definition of the Standard Minute Value rests explicitly on qualified workers who know and adhere to the specified method without over-exertion. [S03] Assigning an unqualified operator to a critical operation to cover an absence lengthens cycle time, builds upstream queues and raises downstream seam defects. [S04] [S12]

8.5 WHAT A GOVERNED SKILL RECORD MUST CAPTURE

GFT replaces attendance-based training logs with an operation-level demonstrated skill matrix. Each cell links an identified operator to an operation code, machine type and method revision, recording a verified competence grade from 0 to 4 alongside the assessment date and assessor identifier. [S03] [S12] [S22] **Exhibit 38**, p. 124 illustrates this matrix for a six-operation sequence so supervisors and engineers can spot single-point staffing vulnerabilities before an absence stops the line. [S03] [S04] [S12]

EXHIBIT 38 / DEMONSTRATED COMPETENCE LEVEL (0 TO 4)

Skill coverage exposes the next staffing constraint

	Collar attach	Placket set	Shoulder join	Sleeve set	Side seam	Buttonhole
Operator A	4	3	3	2	3	1
Operator B	3	4	3	1	2	2
Operator C	1	2	4	2	3	3
Operator D	0	1	3	3	4	2
Operator E	0	1	2	1	3	4
Operator F	0	0	2	0	2	3

Cell scale: 0 to 4

ILLUSTRATIVE [S03] [S04] [S12] Illustrative GFT operator-by-operation demonstrated-skill matrix for method revision v1.2, informed by capacity-development drill requirements in S12, method-qualified SMV conditions in S03 and daily supervisor line balancing in S04. Scale: 0 = untrained, 1 = off-line drill stage, 2 = method-qualified under supervision, 3 = standard-capable at SMV and FPY, 4 = multi-operation relief and coach. Values are illustrative and not a GFT factory record.

Inspecting **Exhibit 38**, p. 124 reveals an operational risk that headcount totals conceal. [S04] [S12] While the illustrative six-operator team has ample depth on `Shoulder join` and `Side seam` (four operators each at Level 3 or Level 4), `Sleeve set` has only one operator at Level 3 (`Operator D`), while `Collar attach` and `Placket set` rely on `Operator A` and `Operator B`. If `Operator D` is absent, the supervisor must drop to a Level 2 operator (`Operator A` or `Operator C`), slowing the bottleneck and pulling `Operator A` away from `Collar attach`. [S03] [S04] Because **Exhibit 38**, p. 124 is an illustrative structural view, it does not prescribe how many operators a factory must cross-train; it defines the query that triggers preventive drills before a bottleneck materialises while giving operators an audited pathway to higher skill bands. [S12] [S16] [S45] [S0803]

METHOD

GFT skill-verification and recency-decay protocol. An operator advances to **Level 2 (Method-qualified)** only when an engineer or trainer verifies adherence to the specified method breakdown on live panels with zero critical defects, and advances to **Level 3 (Standard-capable)** only when production and quality logs confirm that the operator held the approved SMV pace and first-pass yield floor across at least five consecutive illustrative shifts. [S03] [S10] [S22] Because manual sewing proficiency decays without practice, every Level 3 and Level 4 record carries an automated recency check: if an operator has not worked on a designated complex operation within an illustrative 30-to-45-day window, or if industrial engineering releases a new method revision, the qualification reverts to *provisional* until a refresher drill and first-bundle quality check are completed. [S12]

8.6

Supervisor capability is a measurable production asset

In a cut, make, trim and finishing plant, the first-line supervisor sits at the exact crossing of warp and signal: translating the production plan into station assignments, coaching operator motion, resolving bundle queues and setting the interpersonal climate of the line. [S04] [S13] Empirical evidence from the global garment sector shows that supervisory capability governs both worker well-being and line productivity. [S13] [S14] [S0804]

A randomized impact evaluation conducted by the International Finance Corporation (IFC) in the Cambodian garment industry found that structured supervisory skills training improved workers' perceptions of their relationships with supervisors and led to moderate improvements in overall firm productivity. [S13] Across seven garment-manufacturing countries where more than 5,850 supervisors completed a three-day interactive Better Work Supervisory Skills Training programme covering worker rights, supervisor responsibilities and workplace professionalism, independent assessment by Tufts University found that production lines overseen by trained female line supervisors increased factory productivity by 22 percent compared with lines overseen by untrained supervisors. [S0804] [S0805]

8.7 WHY FLOOR ACCEPTANCE AND DIAGNOSTIC TESTING MUST BOTH BE TRACKED

Supervisory effectiveness also depends on organisational beliefs and floor adaptation over time. In a field experiment across 24 large garment factories in Bangladesh published by the National Bureau of Economic Research (NBER), researchers identified marginal female and male supervisor candidates and randomly assigned them to manage production lines. [S0802] Extensive diagnostic testing at baseline revealed few skill differences between them; initially, however, the marginal female supervisors experienced lower line productivity and lower subordinate evaluations due to negative initial worker beliefs about female supervisors. [S0802] After four to six months of managing lines, those productivity and evaluation gaps disappeared completely, and the share of female candidates retained as line supervisors after the trial remained significantly higher than the factory baseline. [S0802]

Early reviews must therefore avoid confusing transitional friction on a newly formed line with permanent supervisory incapacity. [S13] [S0802] [S0804] Evaluating line supervisors solely on daily gross piece output incentivises shouting at operators, hiding defects, hoarding skilled workers to block cross-training, and forcing unrecorded overtime. [S17] [S18] Following the ILO principle that garment scorecards must balance financial, behavioural and core-process measures across in-process and end-of-process indicators, GFT evaluates line supervisors across four dimensions: [S02]

1. **Flow and quality execution (core-process):** net first-pass good output against demonstrated cohort capability, daily pre-production and in-shift line balancing, and timely escalation of stoppages. [S04] [S10]
2. **Capability building and cross-training (in-process people):** completion of scheduled capacity-development drills and expansion of Level 3 skill coverage across bottleneck stations. [S12]

3. **Attendance stability and working-time discipline (behavioural and fairness):** line absenteeism, tardiness, operator retention across the cohort window, and compliance with regular-hour schedules. [S16] [S18]
4. **Relational climate and corrective-action quality (behavioural and governance):** anonymised worker perception checks on respectful treatment and approachability, paired with audit scores on huddle clarity and root-cause follow-through. [S13] [S17] [S0805]

> **GFT NOTE**
>
> GFT recommends prohibiting supervisor bonus schemes that pay exclusively on gross line output or short-term efficiency spikes. In GFT's `supervisor-pipeline` and scorecard design, a supervisor's review weights first-pass quality compliance, operator retention, skill-matrix coverage expansion and respectful huddle execution alongside line output, ensuring that a supervisor cannot earn a bonus by burning out operators or passing defective bundles downstream. [S02] [S13] [S18]

8.8

Training transfer needs workplace practice

Counting classroom seats or workshop hours measures an input cost; it says nothing about whether a new method or supervisory habit survived contact with the production line. Both operator and supervisor studies in the apparel industry show that workplace practice, structured shadowing and post-training time on the job are the mechanisms through which training translates into productivity. [S12] [S14] [S15]

In the 2025 IFC and ILO Better Work assessment of the Gender Equality and Returns (GEAR) programme in Bangladesh, female sewing operators selected for supervisory development attended classroom training two days a week for five weeks while working as trainee supervisors on remaining days, and then shadowed a supervisor on a production line for another six to eight weeks while receiving coaching during line visits. [S14] That six-to-eight-week line-shadowing phase was the operational transfer period during which trainees practised balancing live lines, managing bottlenecks and communicating with operators under real production pressure. [S04] [S14]

8.9 POST-TRAINING LAGS AND SPILLOVER MECHANISMS IN OPERATOR TRAINING

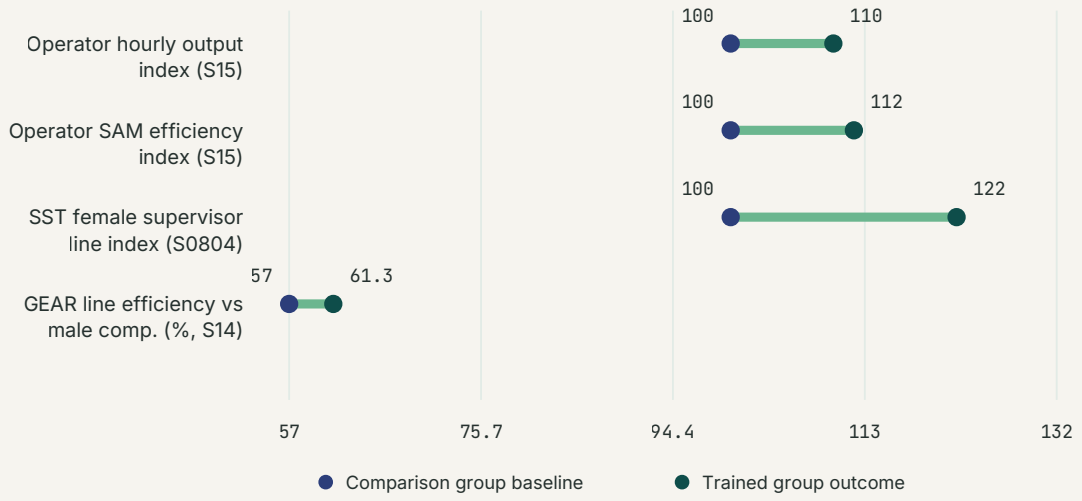
In the controlled evaluation of the Personal Advancement and Career Enhancement (PACE) soft-skills programme at a large ready-made garment export firm in southern India reported by the World Bank, female operators participated in an 80-hour curriculum covering time management, effective communication, problem solving and financial literacy over 11 months. [S15] Controlling for garment style complexity through standard allowable minutes (SAM) and time on the job, trained workers produced about 6 more garments per hour (10 percent more relative to the control group), achieved a 7 percentage-point higher efficiency rate (12 percent relative to controls), were assigned to more complex tasks, and were about 15 percentage points more likely to request technical hard-skills training. [S15] Crucially, the output

and efficiency gains materialised *after* the training concluded rather than while classes were running, and untaught co-workers on the same randomised treatment lines showed positive productivity spillovers. [S15]

Exhibit 39, p. 127 compares the untreated comparison baselines and post-training outcomes from the sourced Indian operator evaluation, the Bangladesh GEAR supervisor assessment, and the Better Work multi-country supervisory evaluation. [S13] [S14] [S15] [S0804]

EXHIBIT 39 / INDEX (COMPARISON = 100) OR EFFICIENCY (%)

Training evidence needs a comparison group and a local retest



SOURCED [S13] [S14] [S15] [S0804] Sourced comparative outcomes: S15 reports about 6 additional garments an hour (+10 percent output, 100 to 110) and +12 percent relative SAM efficiency (100 to 112) vs control group; S0804 reports +22 percent productivity on lines overseen by SST-trained female supervisors vs untrained comparison lines (100 to 122), complementing S13; S14 reports GEAR-trained female supervisor lines at 61.3 percent efficiency vs 57.0 percent on male-supervised comparison lines. Direct transfer as a GFT forecast is prohibited.

As **Exhibit 39**, p. 127 demonstrates, every credible training effect rests on an explicit comparison group: untreated control lines and workers in India (100.0 to 110.0 on hourly output and 100.0 to 112.0 on relative SAM efficiency), untrained supervisor comparison lines across Better Work countries (100.0 to 122.0), and comparison supervisor lines in Bangladesh (57.0 percent to 61.3 percent against male comparison supervisors, or 57.0 percent to 59.5 percent against all comparison supervisors). [S14] [S15] [S0804] What **Exhibit 39**, p. 127 cannot establish is that a greenfield factory in Cameroon will automatically replicate a 10 percent operator jump or a 22 percent supervisory jump by purchasing a curriculum. In the Indian PACE study, overall attrition across 26 months left only about 25 to 30 percent of the initial sample, and post-training wages for trained workers rose by only 0.5 percent, meaning nearly all the productivity gain was captured by the firm. [S15] Rather than logging course attendance as a finished achievement, GFT tracks a four-stage transfer funnel:

- **Stage 1 (Instruction completed):** classroom or off-line drill attendance recorded as an input cost and time allocation. [S12] [S14]
- **Stage 2 (Workplace shadowing and coaching verified):** completion of the line-shadowing window (such as the six-to-eight-week model in GEAR) with coaching logs, or supervised operator execution on live bundles. [S12] [S14]

- **Stage 3 (Behavioural and method adoption on the line):** verified execution of daily line balancing, start-of-shift huddles and standard-method adherence without trainer intervention. [S03] [S04]
- **Stage 4 (Retested cohort outcome):** complexity-adjusted comparison of first-pass good output, defect rate and attendance against the pre-training cohort baseline or a matched comparison line. [S05] [S15]

> **WARNING**
>
> **Prohibition on transferring external training effect sizes as financial forecasts.** While the sourced evaluations in **Exhibit 39**, p. 127 prove that structured operator and supervisor training can raise garment line performance, their exact percentages belong to specific populations in India, Cambodia, Bangladesh and other Better Work jurisdictions. [S13] [S14] [S15] [S0804] Sponsors and engineers using GFT's `supervisor-pipeline` and `labour-cost` tools must treat pre-launch training parameters as illustrative planning scenarios until local Stage 4 cohort retests establish empirical transfer rates on the factory's own lines.

8.10

Attendance and working time constrain sustainable output

A production schedule is only as reliable as the attendance and physical stamina of the people executing it. Two opposite errors routinely undermine working-time management: planners assume 100 percent operator attendance when calculating capacity, and management resorts to chronic overtime when poor planning, material delays or low first-pass yield cause orders to slip. [S04] [S18]

Research by the ILO and IFC Better Work programme on excessive overtime in the garment sector documents why overtime-driven recovery is self-defeating: excessive overtime leads to poorer worker health, reduced efficiency, high rates of workplace accidents and worker dissatisfaction, resulting in high worker turnover. [S18] Fair Labor Association (FLA) case studies across apparel supplier factories in China and Vietnam similarly identify excessive overtime as a persistent violation rooted in low base wages, outdated piece-rate structures and weak production planning. [S0803] When fatigued operators work late, hourly sewing speed drops, seam defects multiply, and next-morning absenteeism rises. [S18] [S0803]

8.11 GROUNDING THE SCORECARD IN CAMEROON WAGE AND WORKING-TIME EVIDENCE

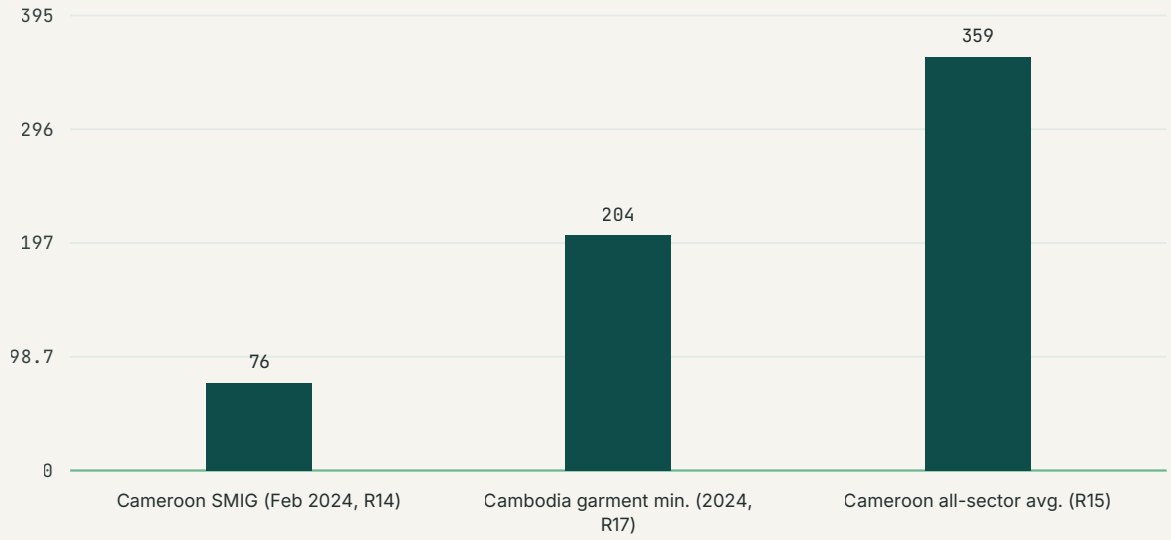
For a greenfield garment programme in Cameroon, the people and cost scorecard must record attendance, working hours and compensation against the country's statutory and labour-market context, keeping source dates explicit. Shared evidence from WageIndicator records that Cameroon's statutory minimum wage (SMIG) stood at XAF 41,875 a month in 2023 and was raised to XAF 43,969 a month from 23 February 2024 (about US$76, a rise of 5 percent), while the labour framework sets a standard 40-hour working week, a 48-hour maximum and overtime compensation starting at 1.2 times normal pay, in an economy where informal employment accounts for about 90 percent of the workforce. [R14] [R16] Separate inherited register entries

cite an average salary across all formal sectors in Cameroon of about US$359 a month (publication date unrecorded in the inherited register) and a 2024 garment-sector minimum wage in Cambodia of US$204 a month as an international benchmark. [R15] [R17] Reference exchange rates note that the CFA franc (XAF) is pegged to the euro at 655.957 XAF per euro. [R32]

Exhibit 40, p. 129 places these sourced monthly reference points side by side to show the spread between statutory floors, international garment minimums and cross-sector formal averages. [R14] [R15] [R17]

EXHIBIT 40 / US DOLLARS PER MONTH (SOURCED BENCHMARKS)

Nominal monthly wage benchmarks span a wide range before productivity is measured



SOURCED [R14] [R15] [R17] Sourced from the inherited evidence register: Cameroon minimum wage (SMIG) raised from XAF 41,875 in 2023 to XAF 43,969 a month from 23 February 2024, about US$76 (R14); Cambodia garment-sector minimum wage of US$204 a month for 2024 (R17); and Cameroon cross-sector average salary of about US$359 a month, original publication date unrecorded (R15). Figures are external macro benchmarks, not GFT wage rates or unit labour costs.

Reading **Exhibit 40**, p. 129 requires strict caution. [R14] [R15] [R17] The US$76 monthly equivalent for Cameroon's February 2024 SMIG (XAF 43,969) is a statutory floor, whereas the US$359 cross-sector figure reflects an aggregate average whose sample and publication date were not recorded in the inherited register. [R14] [R15] Moreover, where about 90 percent of employment is informal, workers entering a greenfield factory are transitioning into structured 40-hour industrial shift routines for the first time. [R16] Setting base pay too close to a survival floor forces workers to seek excessive overtime or leave for informal alternatives, driving up the turnover and tardiness that inflate cost per good garment. [S16] [S0803] What **Exhibit 40**, p. 129 cannot establish is an optimal wage schedule for a specific Cameroon factory; it shows why payroll planning must model base pay, attendance stability, skill progres-

sion and working-time compliance together rather than anchoring on the raw SMIG alone. [R14] [R16] GFT therefore pairs daily production logs with four working-time indicators reviewed at shift and weekly cadences:

- **Start-of-shift attendance and tardiness rate by line:** unexpected absences and late arrivals recorded within the first 15 illustrative minutes of the shift so supervisors can execute immediate skill-matrix rebalancing. [S04] [S16]
- **Regular versus overtime hours by line and cause:** every overtime hour logged against the 40-hour standard week and 48-hour ceiling (R16), tagged by root cause (cutting delay, machine stoppage, rework recovery or order surge). [R16] [S18]
- **Consecutive workdays and rest-window compliance:** automated checks flagging any operator approaching statutory weekly hour limits or lacking mandatory rest days, protecting against fatigue-induced accidents and efficiency drops. [R16] [S18]
- **Cohort turnover and early-attrition rate:** monthly separation tracking segmented by tenure cohort and supervisor line, distinguishing onboarding mismatches from supervision or compensation failures. [S15] [S16] [S18]

8.12

Incentives should reward controllable quality as well as output

Compensation architecture is one of the most consequential controls in a garment factory, yet it is frequently designed without testing what behaviours workers actually control or what side effects an incentive formula creates. Empirical research across multiple garment-producing countries shows that poorly structured piece rates frequently degrade worker health, undermine trust in supervision and fail to lift line productivity unless quality, waste and team coordination are built into the reward design. [S16] [S17] [S0801]

A major ILO and IFC Better Work study examining data from around 6,000 garment workers across Vietnam, Indonesia, Jordan, Haiti and Nicaragua distinguished between hourly pay, full piece-rate pay and *partial piece-rate pay* (where workers receive a low hourly base salary and earn an output bonus only after crossing a quota threshold). [S17] Workers on partial piece-rate pay were more likely to report reduced emotional and physical health than workers paid by the hour, driven by wage variability, lack of transparency in how pay was calculated, and strenuous pressure to reach uncertain thresholds. [S17] Equally important for floor management, workers in partial piece-rate systems reported being less comfortable seeking help from their supervisors and less likely to feel treated with respect and fairness. [S17]

8.13 QUASI-EXPERIMENTAL EVIDENCE ON QUALITY-INCLUSIVE GROUP INCENTIVES

When compensation systems are redesigned around controllable behaviours, transparent thresholds and quality guardrails, both workers and factories benefit. In a two-year quasi-experimental study inside an operating apparel factory published in *PLOS ONE*, Lollo and O'Rourke tested three redesigned group compensation treatments

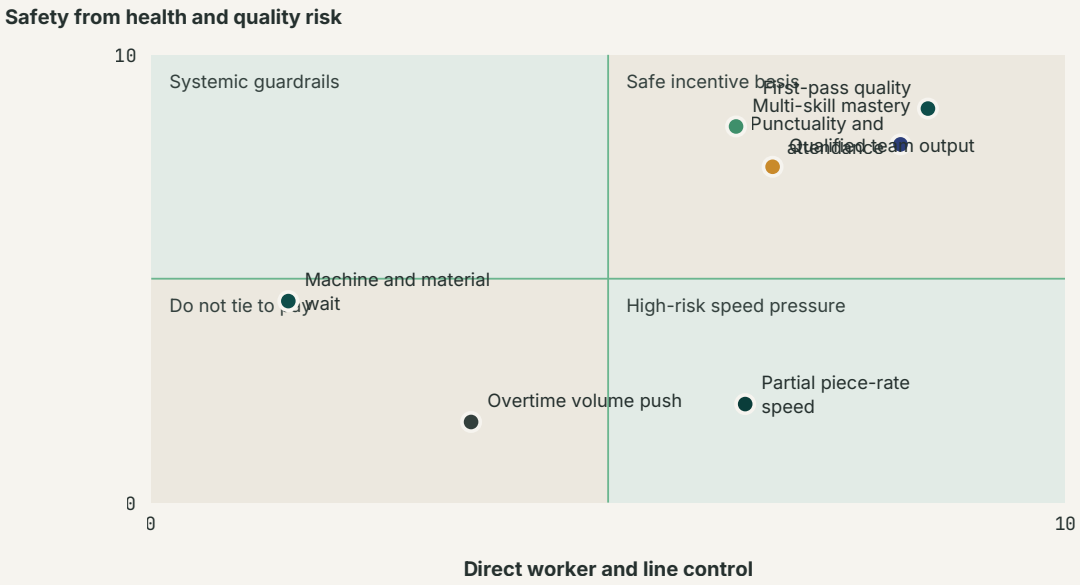
against comparison lines: (1) an accelerating group-rate scheme based purely on output (*Productivity*); (2) an accelerating group-rate scheme combining output with explicit *Productivity, Quality, and Waste Reduction* incentives (*PQWR*); and (3) a *Target Wage* scheme allowing lines to elect to go home once they achieved a pre-specified target wage. [S16] [S0801]

Using a difference-in-difference identification strategy over a two-year panel, the researchers found that the *PQWR* and *Target Wage* treatments increased line productivity by about 8 percentage points and 10 percentage points respectively, raised the quality rate by about 1.8 percentage points, increased daily wages by 4.2 to 9.7 percent, decreased turnover markedly and raised factory profits on five of the six treatment lines, whereas the pure *Productivity* bonus treatment saw no effect on productivity or quality. [S16] [S0801] Newly motivated workers focused their increased effort on reducing quality defects and tardiness, two behaviours that individual workers largely control, whereas line workers lacked the skills and authority to remove systemic constraints such as material and machine downtime, and free-rider tensions among differently skilled team members constrained ad-hoc peer helping. [S16] [S0801] Complementing those findings, Fair Labor Association case studies in China and Vietnam documented that replacing outdated piece-rate systems with higher base wages and diversified bonuses rewarding both quality and efficiency helped increase net regular-workweek wages by 29 to 57 percent over a three-year period (with productivity and quality bonuses rising by 89 to 330 percent during regular hours) while reducing excessive overtime. [S0803]

Synthesising the evidence from *PLOS ONE*, Better Work and the Fair Labor Association, **Exhibit 41**, p. 132 maps seven candidate performance dimensions across two design axes: how directly operators and line teams control the metric (x-axis), and how well tying pay to that metric protects against adverse health, safety and quality side effects (y-axis). [S16] [S17] [S18] [S0801]

EXHIBIT 41 / DERIVED GFT DESIGN SCORE (0 TO 10)

Incentive design must test outcome control and side effects



DERIVED [S16] [S17] [S18] [S0801] Derived by GFT from the controllability and difference-in-difference findings in S16 and S0801 (where workers controlled defects and tardiness under PQWR and Target Wage schemes, raising quality by about 1.8 percentage points and productivity by 8 to 10 percentage points, but lacked authority over machine and material downtime) and the partial piece-rate health and supervisor-trust cautions in S17 and overtime risks in S18. Coordinates are qualitative design placements on a 0 to 10 scale, not statistical measurements.

The quadrants of **Exhibit 41**, p. 132 define GFT's rules for variable compensation design: [S16] [S17] [S18] [S0801]

- **Upper-right quadrant (*Safe incentive basis*):** `First-pass quality` (derived coordinates 8.5, 8.8), `Punctuality and attendance` (8.2, 8.0), `Qualified team output` within regular hours (6.8, 7.5) and demonstrated `Multi-skill mastery` (6.4, 8.4) sit where worker control is high and side-effect risk is low, aligning with the *PQWR* evidence in *PLOS ONE* and the diversified bonus structures documented by the Fair Labor Association. [S16] [S0801] [S0803]
- **Lower-right quadrant (*High-risk speed pressure*):** `Partial piece-rate speed` above opaque thresholds (6.5, 2.2) is controllable in the short run only through self-exploitation, skipping breaks, hiding defects and avoiding supervisor help, producing the health damage documented by Better Work. [S17]
- **Lower-left quadrant (*Do not tie to pay*):** `Overtime volume push` (3.5, 1.8) and `Machine and material wait` (1.5, 4.5) reflect management planning, cutting supply and maintenance reliability rather than operator effort. [S16] [S18] Penalising operator pay when a machine breaks or bundles arrive late violates equity and destroys trust in the measurement system. [S45] [S0801]

WORKED EXAMPLE

Illustrative comparison of a partial piece-rate rule versus a GFT quality-gated team incentive. Suppose an illustrative 20-operator garment line pays a regular weekly base wage of XAF 15,000 per operator for a 40-hour week (R14, R16), with an illustrative 15 percent variable incentive pool (up to XAF 2,250 per operator) above a Gate 3 baseline of 1,200 first-pass good garments per week. [R14] [R16] [S16]

Under a **flawed partial piece-rate design**, each operator is promised XAF 1.50 per gross piece sewn above 1,200 pieces, with zero adjustment for defects or external downtime. [S17] If a cutting delay starves the line for 4 illustrative hours in Week 1, gross output reaches only 1,180 pieces and operators earn zero bonus despite full effort. [S17] [S0801] In Week 2, operators rush to sew 1,500 gross pieces (`XAF 450` bonus), but first-pass yield drops to 76 percent (`1,140 first-pass good pieces`), so the factory pays a bonus while receiving *fewer* saleable garments than its 1,200 baseline. [S10] [S17]

Under **GFT's quality-and-availability-adjusted team incentive**, external stoppages exceeding 15 illustrative minutes are credited at standard pace, and the bonus pays only on *first-pass good garments* above the adjusted baseline, gated by a 90 percent first-pass yield floor. [S16] [S17] [S0801] In Week 2, producing 1,400 gross garments at a 93 percent first-pass yield (`1,302 first-pass good garments`, or 102 above baseline) within the 40-hour regular week earns each operator an illustrative XAF 1,530 team bonus (`102 * XAF 15.00`) plus an illustrative XAF 500 punctuality and zero-rework credit (`XAF 2,030` total), funded by saved rework and lower overhead per good garment. [S16] [S0801] [S0803] All figures are illustrative to show the calculation method, not a GFT payroll record.

8.14

Targets require voice and a correction route

Even a carefully engineered standard minute value, skill matrix or bonus formula will fail if operators and supervisors have no legitimate channel to challenge an inaccurate standard or report an uncontrollable constraint. Literature on the Balanced Scorecard warns that a purely rational, top-down approach to strategy execution can fit decentralised or adaptive organisational structures poorly when front-line realities shift faster than central assumptions. [S46] United States Office of Personnel Management guidance similarly emphasises that performance standards must be measurable, understandable, verifiable, equitable and achievable. [S45]

On a garment floor, three operational conditions routinely invalidate a top-down target during a shift:

1. **Unrecorded material or cut variation:** fabric shade-lot stiffness, defective fusible interlining or inaccurate cutting patterns increase handling time beyond the conditions under which the SMV was timed. [S03] [S0801]
2. **Provisional or outdated method standards:** an operation breakdown released during early ramp-up may omit a required trim alignment step or assume a folder attachment that is unavailable at the station. [S03] [S11]

3. **Upstream starvation and machine downtime:** as documented in the *PLOS ONE* apparel compensation study, line workers lack the authority and technical skills to resolve material shortages and machine breakdowns on their own. [S16] [S0801]

8.15 DESIGNING THE NON-PUNITIVE STANDARD CHALLENGE AND DOWNTIME CLOCK

If an operator or line supervisor who encounters these conditions is forced to absorb the lost minutes as personal "low efficiency", workers feel mistreated and alienated from supervision (echoing the Better Work piece-rate findings), and supervisors falsify bundle counts or downtime logs to protect their line score. [S17] [S22] To keep the performance-management system equitable and auditable, GFT builds a formal *challenge and clock-separation route* directly into the daily line board and data-governance rules: [S22] [S45] [S46]

- **Immediate downtime clock separation:** when a station stops because of machine failure, missing cut panels or trim defects, the operator triggers an Andon or station flag, and the supervisor logs the start timestamp under an external cause code owned by maintenance, cutting or quality assurance. [S02] [S22] Those minutes are excluded from the operator's direct efficiency denominator and charged to the responsible support function's service-level indicator. [S01] [S0801]
- **Method and SMV challenge ticket:** any operator or supervisor can flag a released SMV or operation breakdown for re-timing when actual material or construction conditions diverge from the method specification. [S03] [S45] Industrial engineering must observe the station on the floor within a defined response window (such as 24 to 48 illustrative operating hours), verify whether the method conditions hold, and either restore the specified machine and material setup or issue a versioned SMV revision. [S03] [S22]
- **Pay-calculation transparency and pre-close review:** before weekly or monthly payroll closes, each line board displays the exact count of first-pass good pieces, credited external stoppages and resulting bonus tiers in plain arithmetic so workers can verify their earnings and raise discrepancies before payment is finalised. [S17] [S45] [S0803]
- **Observer agreement on defect attribution:** because quality-gated incentives depend on honest inspection, quality stewards run periodic repeatability and reproducibility checks across in-line and end-of-line inspectors, applying NIST Gauge R&R principles so an overly harsh or inconsistent inspector cannot unfairly penalise a line's quality rate. [S40]

GFT NOTE

GFT recommends auditing the volume and resolution time of worker and supervisor challenge tickets as a positive indicator of system health. A greenfield factory that records zero SMV challenges or zero external material-wait claims during its opening months is almost certainly suppressing floor feedback rather than running a flawless process. In GFT's `labour-cost` and `supervisor-pipeline` tools, any incentive scheme must pass a four-gate pre-deployment check: verified SMV method stability, inspector agreement compliance, an active downtime clock-separation rule, and a tested worker pay-explanation walkthrough. [S03] [S17] [S40] [S45]

By joining productivity with demonstrated skill, trained supervision, sustainable working hours and fair incentives, the people and cost families reinforce every other part of the factory scorecard. First-pass good garments and standard minutes connect directly to the production losses in Chapter 5, the quality-at-source logs in Chapter 6 and the delivery promises in Chapter 7, while master-data identifiers and challenge tickets feed the governed data spine and review cadence in Chapters 10 and 11. [S01] [S03] [S10] [S22] Workforce development is examined at sector scale in companion paper `wp09`, while GFT's interactive `labour-cost` and `supervisor-pipeline` tools implement the exact reconciliation and gating rules specified here. The next chapter applies the same boundary-and-denominator discipline to energy, water, waste and emissions per good garment.

Cheap time is not cheap production; unit labour cost falls durably only when skill, supervision and fair reward make every paid hour count towards a garment accepted first time.

CHAPTER SOURCE NOTES

S10 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04.

S11 International Journal of Production Economics, Elsevier. 2001-10-26.

S12 Applied Sciences, MDPI. 2021-11-23.

S17 ILO and IFC, Better Work. 2018-12-20.

S18 ILO and IFC, Better Work. 2023-03-28.

S01 International Organization for Standardization. 2014-01-15.

S02 International Labour Organization. 2017-02-26.

S16 PLOS ONE. 2020-02-05.

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

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

R10 Ecofin Agency. Publication date unrecorded; inherited source-text check.

R12 Business in Cameroon. Publication date unrecorded; inherited source-text check.

R16 WageIndicator. Publication date unrecorded; inherited source-text check.

S03 International Labour Organization. 2024-01-17.

R14 WageIndicator. Publication date unrecorded; inherited source-text check.

S04 International Labour Organization. 2023-02-14.

S14 IFC and ILO, Better Work. 2025-07-16.

S22 United States Federal Data Strategy. 2020-07-01.

S45 United States Office of Personnel Management. 2019-11-04.

S0803 Fair Labor Association. 2021-08-13.

S13 International Finance Corporation. 2009-11-01.

S0804 International Labour Organization. 2016-09-26.

S0805 ILO and IFC, Better Work. 2016-09-26.

S0802 National Bureau of Economic Research. 2020-08-03.

S15 World Bank. 2017-09-07.

S05 International Labour Organization. 2022-06-01.

R15 wage.is. Publication date unrecorded; inherited source-text check.

R17 just-style. Publication date unrecorded; inherited source-text check.

R32 Wise; XE. Publication date unrecorded; inherited source-text check.

S0801 PLOS ONE. 2020-02-05.

S46 Encyclopedia, MDPI. 2025-03-19.

S40 NIST/SEMATECH. 2003-06-01.

GREEN FUTURE TECH

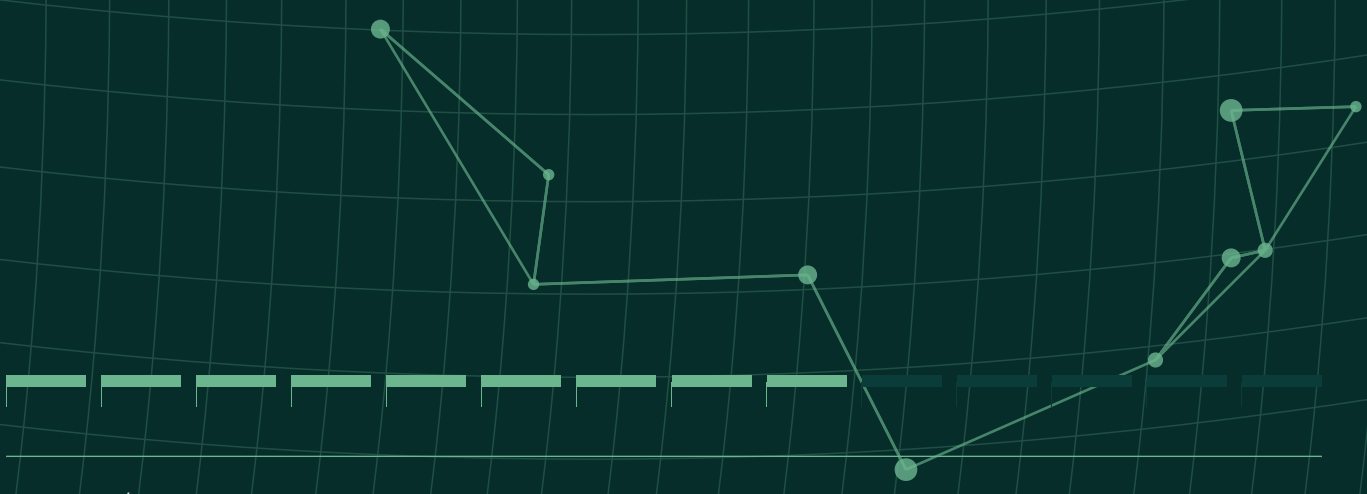
LIMITED / HONG KONG SAR

09

PART II: MEASURE THE OPERATING SYSTEM / RESOURCES AND EMISSIONS

Per-unit sustainability starts with boundaries and meters

Energy, water, waste and emissions become manageable only when each quantity has a declared boundary, source record and production denominator.



CHAPTER 09
DECISION TEST

Energy, water, waste and emissions become manageable only when each quantity has a declared boundary, source record and production denominator.

A per-garment sustainability figure is an accounting result, not a direct property of the garment. It becomes meaningful only when the reader can inspect what entered the calculation, which processes were included, over what period, and which production quantity forms the denominator. GFT's answer is therefore to build the resource record before setting the resource target: declare the boundary, map meters and source documents to that boundary, retain absolute quantities, and calculate intensity with a defined output. A site indicator can guide factory action without pretending to be a full product footprint.

This discipline matters especially in a greenfield cut, make, trim and finishing operation. The first utility invoice, meter reading, waste ticket and production report create the initial accounting structure. If their scopes differ, later precision will not repair the mismatch. Energy, water and waste also need different physical treatments, while emissions add a further conversion layer. The common control is not one universal ratio. It is a chain from physical event to source record, declared method, numerator, denominator and owned decision.

9.1

The inventory boundary precedes the footprint

The GHG Protocol requires all emission sources and activities within the chosen inventory boundary to be accounted for and reported, with exclusions disclosed and justified. [S30] The practical sequence follows directly. Choose and document the boundary first, then populate it. A factory cannot demonstrate completeness by adding up whichever records happen to be available. Availability is a data-quality issue, not a reason to redraw the physical or organisational scope without saying so.

Three questions should remain separate. Which sites and activities belong to the operating review? Which sources belong to the organisation's emissions inventory? Which life-cycle stages belong to a product assessment? A cut, make, trim and finishing site can answer the first with a gate-to-gate operating account. That account may feed the other two, but it does not answer them by itself. Upstream yarn and fabric production, outbound transport, garment use and end-of-life treatment do not become factory observations merely because the factory makes the garment.

Product accounting makes the additional definition explicit. The GHG Protocol Product Standard requires the studied product, unit of analysis and reference flow to be defined. [S32] A reference flow might describe the quantity of product needed to fulfil the chosen unit of analysis. That is different from a plant KPI denominator, which might be good garments accepted during a shift. Confusing them can produce a numerically plausible but materially false claim.

GFT would maintain a boundary register for every resource account. It names the sites, buildings, production processes, ancillary services, energy carriers, water uses and waste streams included. It records outsourced operations, shared utilities, on-site generation, storage, transfer points and any interface where another organisation holds the source evidence. It also identifies exclusions and their rationale. An unknown item remains an unresolved item, not a silent zero.

The period belongs to the same register. A meter interval, invoice period, production shift and reporting month rarely align by accident. The accounting rule should state how readings are assigned to the operating calendar, how opening and closing readings are obtained, and how late invoices or waste tickets are treated. A monthly intensity figure should not combine a billing-period numerator with a calendar-month denominator without disclosing and testing the effect of that choice.

Boundary changes need version control. Installing a compressor, outsourcing garment washing, adding a canteen or bringing a previously shared boiler inside the account can change resource use without any change in process efficiency. The register should retain the effective date, reason, responsible approver and policy for historical comparison. Earlier results should not be silently recalculated under a new scope. Where a like-for-like restatement is possible, both the original and restated bases should remain visible.

The production boundary must match the resource boundary as closely as the decision requires. If a meter serves both sewing and an unrelated tenant, total site output is not an adequate denominator until the shared load is resolved. If a boiler serves a process that is outside the garment account, its fuel cannot simply be divided by garment output. Allocation may be necessary, but it needs a documented physical or operational basis and an uncertainty statement.

> **GFT NOTE**
>
> GFT would require a one-page boundary certificate before the first resource KPI is published. Operations, engineering, finance and sustainability reviewers would sign the included processes, meter list, source documents, production denominator, reporting period, exclusions and known shared loads. The certificate would carry a version and effective date. Any later footprint, target or savings claim would name the certificate version it used, so a change in scope cannot masquerade as a change in performance.

This is not bureaucracy around an otherwise simple ratio. It is the control that makes the ratio interpretable. A narrow, well-declared account is useful. A broad claim with an unknown boundary is not.

9.2

Energy indicators can be absolute, relative or modelled

ISO 50001 permits an energy-performance indicator to take the form of a simple metric, a ratio or a model, depending on the activity measured. [S29] That permission is useful because no single representation answers every factory question. Total electricity supports bill reconciliation and absolute-load management. Energy per good garment supports comparison at a defined output condition. A model may be needed when operating hours, product mix or another relevant variable materially changes the expected load.

The absolute account comes first. Electricity, fuels, steam, heat and other energy carriers should remain in their native source units until a controlled conversion is applied. The record identifies whether a quantity was metered, invoiced, calculated or estimated. Conversion to a common energy unit requires a named conversion-factor source, version and unit convention. Self-generated energy needs an explicit rule so the fuel input and the resulting electricity are not counted as two separate consumption events in the same total.

An intensity numerator must then state which energy types and uses it contains. Electricity alone is not total energy where fuel is also consumed. Production electricity alone is not site electricity where compressors, lighting or environmental control sit inside the declared boundary. GRI 302 defines energy intensity as energy per unit of activity, output or another organisation-specific metric, and requires the denominator and included energy types to be identified. [S33] The formula is simple only after those decisions are made.

The denominator deserves equal care. Pieces started, pieces completed and first-pass good garments describe different populations. A resource account intended to reflect useful production should normally reconcile to good output at a named boundary, while retaining started and completed quantities for diagnosis. Standard minutes can provide a work-content denominator when styles differ, but the applicable method revision and provisional status during ramp must travel with the result. Neither denominator removes the need to show absolute use.

Product mix and operating conditions belong beside the ratio. A style change can alter work content and machine demand. Longer operating hours can change the relationship between fixed ancillary loads and productive output. These are reasons to retain relevant variables, not excuses to adjust every inconvenient result. A model should be introduced only when its variables have an operational rationale and its predictions can be checked against observations.

Textile evidence also warns against borrowing a denominator from another process. The sector study in S38 reports energy and water per kilogram for spinning, per square metre for weaving and wet processing, and per piece for knitting and garmenting. [S38] **Exhibit 42**, p. 141 preserves those distinctions as units, without turning the study's case values into universal benchmarks.

EXHIBIT 42 / REPORTED ENERGY AND WATER UNITS BY TEXTILE STAGE

Each textile process needs its own physical denominator

Textile stage	Energy numerator per	Water numerator per	Accounting consequence
Spinning	Kilogram of yarn	Kilogram of yarn	Use a mass-based output
Weaving	Square metre of fabric	Square metre of fabric	Use an area-based output
Processing	Square metre of fabric	Square metre of fabric	Retain the wet-process context
Knitting	Piece	Piece	Define the piece and acceptance event
Garmenting	Piece	Piece	Define good output and process scope

SOURCED [S38] Sourced reporting units from the opened Pakistan textile-sector study. These are denominator conventions, not factory benchmarks, conversion factors or GFT results. Processing here refers to the study's textile-processing stage, not every possible finishing activity.

The exhibit does not say that one unit is always superior. It shows why a per-piece garment KPI cannot be compared naively with a per-kilogram spinning result or a per-square-metre dyeing result. Even two garment figures need compatible style, acceptance and boundary definitions. Conversion between unlike physical outputs would require a separate, declared reference flow rather than a spreadsheet unit swap.

A practical energy scorecard therefore holds three views together: absolute consumption by carrier and significant use, intensity against an approved denominator, and the conditions needed to interpret both. Management can then distinguish more production at the same intensity from less energy at unchanged output. Those are different outcomes, and the records should not collapse them into one coloured tile.

9.3

Metering follows the energy-use map

The IEA links energy-indicator design with the data required to produce those indicators and with surveying, metering and modelling practice. [S39] For a new factory, this means the metering plan should follow the energy-use map rather than a procurement catalogue. The main incomer establishes the site account. Additional meters are justified where they separate a significant use, test a suspected loss, allocate a shared load or verify an improvement action.

The energy-use map begins with physical inspection. It traces electricity, fuel and any purchased thermal energy from receipt to the systems that consume them. Production equipment, compressed air, boilers, HVAC, lighting, pressing and other loads are included where they actually exist. The map distinguishes a measured branch from an inferred branch and records loads that serve more than one process. It should be possible to walk from a line on the map to a meter, invoice, calculation or explicit estimate.

Each meter then needs an operational register. The register names the meter identifier, physical location, boundary served, energy carrier, reading unit, multiplier, reading convention and responsible owner. It states whether the display is cumulative or interval-based, how often the value is captured, and which review uses it. Calibration or verification status, access constraints and the treatment of an unavailable reading belong there as well. A device number alone does not establish what the reading means.

Read frequency should follow the decision. A monthly main-meter close can support absolute reconciliation and a plant KPI. A daily compressor reading may support investigation of an abnormal load. Interval data may be warranted where the timing of demand matters. Capturing frequent values without a review question creates storage and checking work but little control. Conversely, a monthly total cannot prove when a short-lived abnormal load occurred.

Cumulative meters require particular care at replacement and rollover. The record should retain the final reading of the removed device, the initial reading of its successor, the change timestamp and any multiplier change. Consumption for the interval is calculated only after those events are reconciled. Treating the new display as a continuation of the old one can create an apparent negative or an implausible surge. Such corrections are normal accounting controls, not analytical embellishment.

Submeters should reconcile to the main boundary without being forced to match it exactly. The close identifies metered uses, explicitly estimated unmetered uses and the residual. The residual is investigated when it exceeds a defined review threshold or changes unexpectedly. It should not be distributed across departments merely to make the schedule balance. A visible residual tells the factory where its energy map remains incomplete.

Utility invoices provide an independent commercial reconciliation, but they do not replace physical readings. Invoice quantity, tariff period, estimated-billing status and any correction should be compared with the meter account. Differences can arise from period cut-offs, multipliers, estimated bills or meter identity. Finance and engineering should resolve the same exceptions rather than maintain separate totals for external payment and internal management.

Missing data need a status, not just a substitute number. An estimated interval should identify the reason, method, author and evidence used, such as adjacent validated readings or a documented operating relationship. The replacement value remains distinguishable from a measurement in every later KPI. When the actual reading arrives, the correction is versioned and the affected results are restated under a controlled rule.

THE MONTHLY ENERGY CLOSE

Freeze the production population and boundary version before calculating intensity. Read or extract every registered meter at the declared cut-off. Validate identifiers, units, multipliers and cumulative-reading continuity. Reconcile the main account to the invoice and submeter schedule. Record estimated and missing intervals separately. Investigate the residual and material exceptions. Only then calculate absolute consumption, intensity and any approved normalised comparison, retaining the source and correction status with the released result.

Meter ownership should end in action. Engineering maintains the energy-use map and meter register. Operations explains changes in production conditions. Finance reconciles purchased quantities. The sustainability or performance owner checks that the published KPI uses the approved boundary and denominator. A small team can hold several of these roles, but the review should still show who can accept an estimate, approve a correction and authorise an operating response.

9.4

Water withdrawal, discharge and consumption are not interchangeable

Water accounting begins by separating three quantities. GRI 303 defines consumption as water used by an organisation so that it is no longer available for use by the ecosystem or local community during the reporting period. [S34] Withdrawal describes water entering the organisation from a source. Discharge describes water leaving to a destination. Treating all three as the same number hides both the physical flow and the impacts that need separate management.

A site water map should therefore show sources, uses, storage, return flows and discharge destinations. It identifies municipal or other third-party supply, groundwater or other sources only where present. It then traces water to sanitary use, canteen services, cleaning, humidification, boilers, garment washing or any other actual site use. The map is deliberately based on the installed process, not on a generic textile flow diagram.

This distinction is crucial for a cut, make, trim and finishing factory. A site without dyeing or wet processing should not adopt a wet-processing water denominator or footprint as its own operating result. The textile-stage units in **Exhibit 42**, p. 141 show that the underlying products and processes differ. [S38] If garment washing or another water-using operation is installed, its meters and production population enter the boundary through an explicit revision.

Withdrawal records should preserve source and quality categories where the reporting method requires them. Discharge records should identify destination and treatment, with quality evidence kept beside volume. A larger discharge volume does not by itself establish a larger environmental impact, because the receiving context and discharge quality matter. Equally, a small volume does not excuse an unrecorded or unmanaged release. The account should support the applicable operating and compliance review rather than reduce water to one total.

Consumption may be calculated from withdrawal and discharge where direct measurement is not available, with significant storage changes considered under the chosen method. That calculation needs compatible periods and boundaries. A tank reading at the start of one month and a supply reading at the end of another cannot produce a reliable balance. Where an unmeasured leak, evaporation or process retention is suspected, the factory should investigate and document the mechanism rather than rename the whole residual as consumption.

Water intensity needs the same denominator discipline as energy. Litres per good garment may be useful for a defined garmenting operation, while litres per occupied shift may help interpret sanitary demand. A site with substantial domestic water use should not assume that production volume alone explains every movement. Showing absolute withdrawal, discharge and consumption beside the chosen ratios prevents an output increase from being mistaken for improved water management.

The local context remains visible. GRI 303 treats water as a shared resource and connects impacts with catchments and water stress. [S34] A factory should not claim that a site ratio proves local water benefit or harm without that context. The operating account identifies what the site used and released. Catchment assessment, legal obligations and community effects require their own evidence and competent review.

> **A DEFENSIBLE WATER BALANCE**
>
> Start with opening storage and withdrawals for the declared period. Allocate measured or estimated quantities to actual uses. Reconcile closing storage and all recorded discharges to named destinations. Present the unexplained residual separately, then calculate consumption under the declared method. Check that every numerator and the production denominator share the same cut-off. Mark estimates and retain supporting calculations. Repeat the balance after a material process, storage or discharge change rather than assuming the old map still holds.

The first target may consequently be better evidence rather than lower intensity. A factory with unmetered discharge, estimated storage or an unresolved residual cannot yet attribute a change to operating improvement. Closing those gaps creates the basis for a later reduction programme and prevents a neat ratio from overstating what the site knows.

9.5

Waste needs composition and destination

GRI 306 addresses the processes used to collect and monitor waste-related data, including source measurement and external evidence. [S35] A useful factory record therefore begins with the physical stream, not the disposal claim. Fabric, trims, packaging and general waste should be identified separately, weighed where practicable and followed to an evidenced destination. A single monthly total cannot show which material was lost, which process created it or whether recovery actually occurred.

Composition should reflect the decisions the factory needs to take. Cutting offcuts may be separated by fabric type, colour or contamination where those attributes affect reuse or recycling. Trims and packaging need their own categories when their

destinations differ. General and hazardous streams should not be mixed for convenience. Categories remain meaningless, however, if operators cannot recognise them at the collection point, so the taxonomy needs clear labels, examples and periodic checks.

The generation event should stay connected to production. Cutting records can link offcuts to style, marker, material batch and shift. Packaging records can link receipts and removal to the relevant delivery or dispatch activity. This context allows a waste measure to support prevention, not merely report removal. A higher waste total may reflect more production, a changed material mix, a different collection period or a real deterioration in yield. Those explanations require different evidence.

Direct weighing is preferable where it is feasible, but the record should still describe the weighing point, container treatment and instrument status. Where estimates are unavoidable, their basis must be visible. A container-count method, for example, needs an assumed fill level and a calibrated density or sampled weight, with the date and population of that calibration. Multiplying every later container by an unexamined factor produces apparent precision without establishing accuracy.

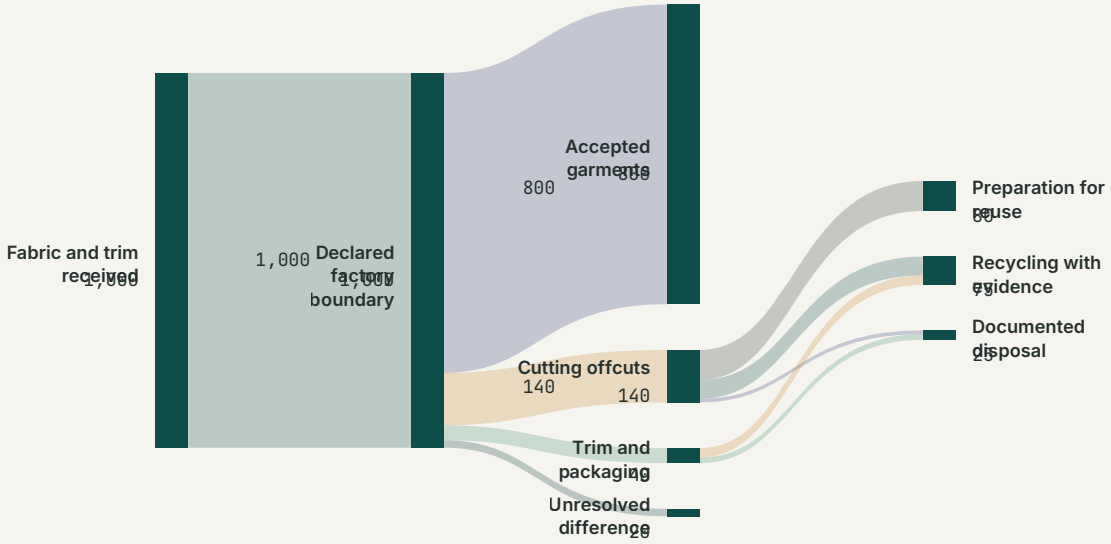
Waste generated, diverted from disposal and directed to disposal are related but distinct accounts. GRI 306 separates composition, recovery operations and disposal operations. [S35] Collection by a contractor is not itself proof of recycling. The evidence should identify the receiving organisation, transfer document, stated operation and any subsequent information needed to support the destination claim. Unknown or mixed destinations remain labelled as such.

The mass balance should retain differences rather than allocate them arbitrarily. Material received, material in accepted product, measured waste streams, stocks and unexplained differences answer different parts of the account. Moisture, handling losses, unrecorded movement or timing can create a residual. The residual prompts investigation and may bound what the factory can claim. It is not a hidden category that can be renamed as recycled content or process waste.

Exhibit 43, p. 146 shows an illustrative material account for one period. The values are constructed to demonstrate conservation and destination tracking, not to represent a factory's yield or recycling performance. The source distinctions and destination records follow the waste-monitoring logic in S35.

EXHIBIT 43 / ILLUSTRATIVE KILOGRAMS OF FABRIC AND TRIM IN ONE PERIOD

Material records must connect accepted product, residual streams and destinations



ILLUSTRATIVE [S35] Illustrative mass balance, not a GFT or factory result. Assumed input is 1,000 kg. Factory outputs are 800 kg in accepted garments, 140 kg of cutting offcuts, 40 kg of trim and packaging, and a 20 kg unresolved difference, totalling 1,000 kg. Offcut destinations are 80 kg reuse, 50 kg recycling and 10 kg disposal. Trim and packaging destinations are 25 kg recycling and 15 kg disposal. Every real link would require a source record and destination evidence; the unresolved difference cannot be allocated silently.

The unresolved difference is the important part of the illustration. A report that shows only accepted product and named destinations may look complete while omitting the weakest evidence. GFT would carry that difference into review, assign its investigation and report progress in resolving it. Prevention can then focus on measured material losses, while destination claims remain limited to what transfer and recovery evidence supports.

Waste intensity should accompany, not replace, this balance. Kilograms of a defined waste stream per good garment can reveal a process relationship. Total waste generated and total fabric input show the absolute scale. Comparing unlike waste streams in one ratio can conceal a shift towards a more difficult destination, so composition and destination remain visible beside every normalised trend.

9.6

Emissions factors belong to a declared accounting layer

An emissions calculation adds a conversion layer to the physical account. Activity data, such as electricity consumed or fuel used, are multiplied by an appropriate factor under a declared method. The activity record and the factor record must therefore be separable. Changing a grid factor is not the same event as reducing electricity use, and improving meter coverage is not the same as reducing emissions.

Scope 2 guidance covers emissions from purchased or acquired electricity, steam, heat and cooling. [S31] Those purchased-energy quantities should reconcile to the energy account before a factor is applied. Fuels burned in owned or controlled equipment require their own activity records and accounting treatment. Other value-chain sources should not be quietly added to a site KPI or silently omitted from a claim that appears to cover the full value chain.

The factor register names the publisher, exact factor, unit, geography, applicable energy source, publication or data year, access date and intended accounting method. It records any conversion needed to make the factor unit compatible with the activity unit. A factor without these attributes may produce a number, but another reviewer cannot reproduce or assess the choice. Superseded factors remain in the history used for earlier calculations rather than being overwritten across every period.

The accounting layer also determines what the result can be called. A site electricity-emissions KPI is not a full corporate inventory. A gate-to-gate factory result is not a life-cycle product footprint. The Product Standard's requirements for a studied product, unit of analysis and reference flow apply when the claim moves to product level. [S32] GFT would state the included gases and scopes, and would distinguish carbon dioxide alone from carbon-dioxide equivalent wherever the source does so.

A published garment case demonstrates why this qualification matters. S37 reports specific energy of 12 MJ per piece and specific carbon-dioxide emissions of 0.94 kg per piece for an integrated Bangladeshi T-shirt production case. [S37] The study's gate-to-gate boundary spans in-factory yarn and fabric operations as well as garment operations, using natural gas, oil and grid electricity. These are case observations, not a cut, make, trim benchmark and not GFT performance.

Exhibit 44, p. 148 retains both absolute and per-piece results from that study. The absolute daily quantities provide scale, while the ratios describe the reported output relationship. Neither establishes what another factory should achieve.

EXHIBIT 44 / REPORTED CASE VALUES FOR THE BANGLADESHI T-SHIRT STUDY

An integrated garment-chain result is a case, not a transferable target

12 MJ/piece

Specific energy

Integrated gate-to-gate case

0.94 kg/piece

Specific CO2

CO2 only, not CO2e

36,265 kWh/day

Grid electricity

Reported absolute daily consumption

56.65 tonnes/day

Total CO2

Reported absolute daily emissions

SOURCED [S37] Sourced case values from the article abstract, published 3 December 2024. The gate-to-gate boundary includes in-factory yarn production, knitting, grey-fabric storage, pretreatment, dyeing, finishing and inspection, followed by cutting, sewing, garment washing, dyeing, pressing and finishing. Energy inputs include natural gas, oil and grid electricity. The 0.94 kg/piece and 56.65 tonnes/day figures are CO2 only, not CO2e. Do not use these integrated yarn, fabric and garment results as cut-make-trim-only benchmarks or GFT claims.

The case can help a reader understand how absolute activity and intensity coexist. It cannot supply a target for a factory with a different boundary, energy mix, product, process or denominator. A responsible benchmark review would first test those conditions, then decide whether any comparison is meaningful. In many operating reviews, the factory's own reconciled baseline will be the more useful reference.

Emissions results should inherit the quality flags of their inputs. An estimated fuel quantity produces an estimated activity-based result even when the factor itself is exact. A factor update should be disclosed as a method change, with the effect distinguished from operational movement. The emissions account can then support decisions without obscuring which part came from measurement, which came from conversion and which remains uncertain.

9.7

Normalisation explains intensity without excusing absolute impact

Normalisation relates resource use or pollution to production output. GRI defines energy intensity through an organisation-specific denominator, while UNIDO and UNEP distinguish relative indicators from absolute changes in resource use and pollution. [S33] [S36] The two views must travel together. Intensity can explain efficiency at a defined output condition. Absolute use shows the scale that remains after that efficiency result.

A good denominator is linked to the physical account and the decision. Good garments can represent accepted output at a named boundary. Standard minutes can represent work content where style differences make pieces less comparable. Operating hours may explain ancillary loads. None is universally correct. The factory should choose deliberately, retain alternative diagnostic views and prohibit a change of denominator during a claim without a disclosed recalculation.

The comparison population also needs stability. Style, method revision, operating calendar, meter coverage and acceptance rules should be recorded beside the baseline. Where these conditions change, the review separates volume, mix, boundary and measurement effects before attributing the residual to an action. A lower ratio caused by producing more against an unchanged fixed load is not the same mechanism as reducing energy at unchanged output.

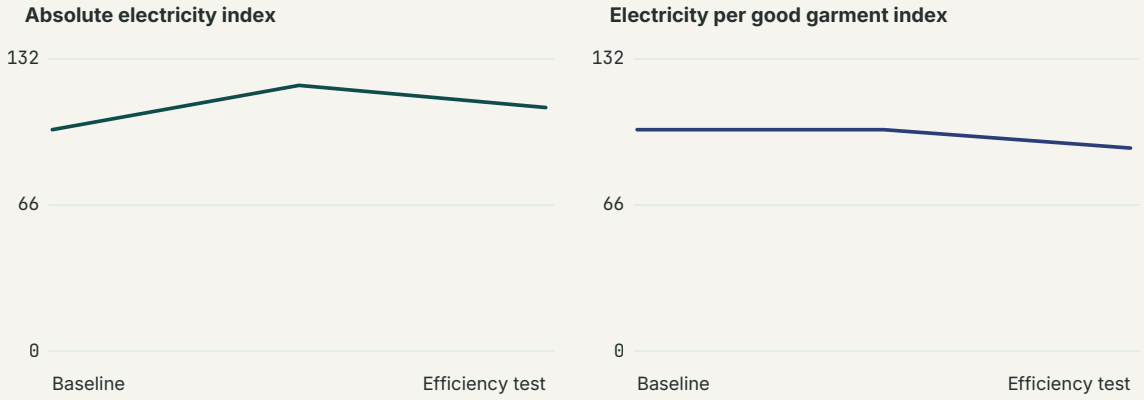
> **WORKED EXAMPLE: INTENSITY CAN IMPROVE WHILE ABSOLUTE USE RISES**
>
> An illustrative factory account starts with 120,000 kWh and 100,000 good garments in one period, giving 1.20 kWh per good garment. A second period has 144,000 kWh and 120,000 good garments, so intensity remains 1.20 kWh per garment while absolute electricity rises by 20 percent. A later efficiency test records 132,000 kWh for the same 120,000 good garments, giving 1.10 kWh per garment. Every value is constructed to demonstrate the arithmetic, not to report an operating result.

The illustrative third period uses about 8.3 percent less electricity per garment than the baseline, yet its absolute electricity remains 10 percent above the baseline. Both statements are true because they answer different questions. GFT would show the underlying kilowatt-hours and good-output counts beside the indexed view, rather than publish a single improvement percentage.

Exhibit 45, p. 150 converts the same illustrative quantities to a baseline index so the two panels share one scale. The index is derived arithmetic, not a target or a statistical forecast.

EXHIBIT 45 / INDEX, ILLUSTRATIVE BASELINE = 100

Absolute electricity and electricity per good garment can move differently



DERIVED [S33] [S36] Derived from an explicitly illustrative scenario, not factory evidence. Baseline: 120,000 kWh / 100,000 good garments = 1.20 kWh/garment. Volume rise: 144,000 kWh / 120,000 good garments = 1.20 kWh/garment. Efficiency test: 132,000 kWh / 120,000 good garments = 1.10 kWh/garment. Absolute indices are 100, 120 and 110. Intensity indices are 100, 100 and 91.7 after rounding. Absolute and relative indicator roles follow S33 and S36.

Savings claims need an additional guardrail. GRI 302 says reductions from reduced production capacity or outsourcing are excluded from its energy-reduction disclosure. [S33] The operating review should likewise ask whether less resource use reflects an efficiency action, less activity, a transferred process or a corrected measurement. Otherwise, a factory can appear to improve by moving the load beyond the chart.

Daily reviews can address visible meter exceptions and missing records. Weekly reviews can assign recurring losses and verify actions. Monthly reconciliation can release absolute and normalised trends after the boundary, denominator, factor and estimate statuses are closed. These routines use the same governed production record as the wider performance system, but they do not require every resource measure to become a shop-floor target.

> **WARNING**
>
> No external case in this chapter supplies a Cameroon factory target. The appropriate initial baseline is the site's own reconciled account, with source quality and operating context retained. Public claims, product comparisons and regulatory submissions may require further methods and assurance. This chapter provides operating measurement guidance, not investment, legal or tax advice.

A credible ratio carries its boundary, its meter and its denominator with it.

CHAPTER SOURCE NOTES

S30 GHG Protocol, WRI and WBCSD. 2004.

S32 GHG Protocol, WRI and WBCSD. 2011.

S29 International Organization for Standardization. 2018.

S33 Global Reporting Initiative. 2016.

S38 Heliyon, Elsevier. 2023-11-17.

S39 International Energy Agency. 2014.

S34 Global Reporting Initiative. 2018.

S35 Global Reporting Initiative. 2020.

S31 GHG Protocol, WRI and WBCSD. 2015.

S37 Energy Efficiency, Springer Nature. 2024-12-03.

S36 UNIDO and UNEP. 2015.

GREEN FUTURE TECH

LIMITED / HONG KONG SAR

10

PART III: TURN RECORDS INTO DECISIONS / THE DATA SPINE

One governed record should serve the shift and the model

Source capture, master data and explicit stewardship turn daily logs into an operational asset without requiring a heavy platform on day one.

CHAPTER 10
DECISION TEST

Source capture, master data and explicit stewardship turn daily logs into an operational asset without requiring a heavy platform on day one.

The shift and the model should read the same governed account of work, not rival extracts assembled for different audiences. GFT's answer is a minimum data spine: identified work events, controlled master data, an authoritative record for each entity, validation at capture and roll-up, and a correction history that survives every export. A paper sheet, a workbook, a machine interface or a manufacturing execution system can implement parts of that spine. None is exempt from its definitions. The operating record comes first, so a supervisor can act during the shift and an analyst can later reproduce what the supervisor knew.

This is deliberately not a proposal to capture everything. Each field must serve a measure, reconciliation or operating decision. ISO 22400 presents KPIs through formulas, elements, time behaviour and units, which makes the source event part of the measure rather than a technical detail beneath it. [S01] The same discipline protects later analysis. A model receives not merely columns of values but a population whose identity, timing, definitions and unresolved exceptions remain visible. Where those conditions are absent, additional storage only preserves ambiguity at greater scale.

10.1

The minimum data model follows work events

The useful starting point is the event that changes the state of work. A bundle reaches an operation. A garment crosses an inspection boundary. A machine stops for a recorded reason. A meter is read at a declared boundary. An operator is assessed against a method revision. Each event has a subject, an action or observation, a time, a source and a relevant operating context. The data model begins with these occurrences, then adds only the reference entities needed to interpret them.

That order prevents two common designs. The first starts with dashboard tiles and works backwards to whatever fields are easiest to obtain. The second starts with a comprehensive enterprise schema and asks the floor to maintain fields whose purpose nobody can explain. GFT would instead trace each KPI element to the event that supplies it. If good output requires accepted pieces at final inspection, the model needs an inspection-completion event and its acceptance rule. It does not need every imaginable attribute of the garment.

A small set of entities usually provides the necessary context: order, style, routing, operation, line, station, shift, machine, material batch and resource meter. Employee or team identity belongs only where allocation, competence, attendance or another justified decision requires it. The factory should prefer the least personal granularity that supports the decision. A team-level production measure should not acquire worker identifiers merely because the capture application makes them available.

Every entity needs a reason to exist and an owner. `Style` may support product identity and work content. `Routing revision` may establish the approved sequence and method in force when the event occurred. `Material batch` may explain a defect pattern. If none of these relationships affects a current measure or investigation, the field can wait. This restraint reduces capture burden and makes missing information easier to interpret.

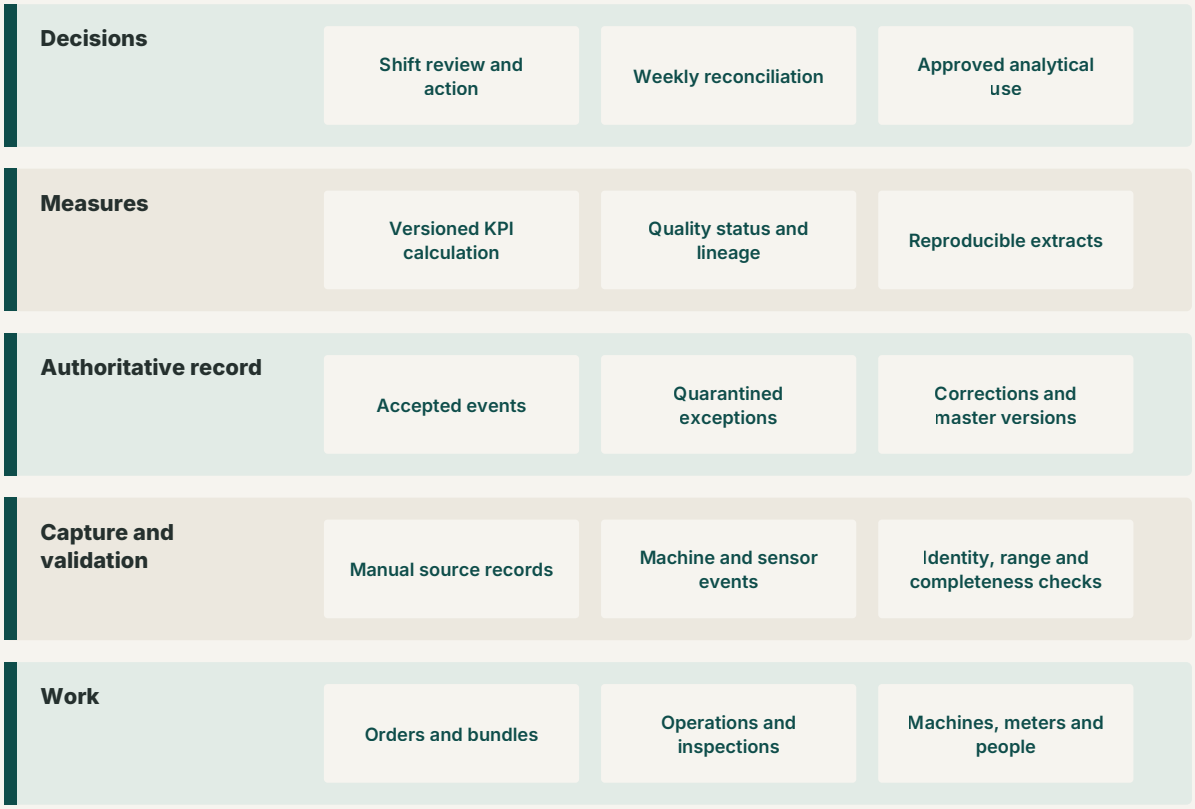
The grain of each record must also be explicit. A row might represent one bundle completing one operation, one machine interruption from start to restart, or one meter reading at one timestamp. Combining several grains in one table invites double counting. A production-event table should not also contain daily meter totals repeated on every garment row. Resource readings, defects, interruptions and labour allocations need their own records and controlled relationships to the shared identifiers.

Event identity is the hinge between operational capture and later reconciliation. The source assigns a stable identifier that survives retries, correction and export. The record retains event time, entry time, source device or sheet, production shift and the entity identifiers in force at capture. A correction creates a new version linked to the original rather than silently changing the past. These fields allow the factory to distinguish a real repeated event from a repeated transmission of the same event.

Exhibit 46, p. 154 shows the resulting separation. Source events describe work. Validation tests fitness. The authoritative record preserves accepted events and exceptions. KPI services calculate under versioned definitions. Review surfaces support decisions, while analytical extracts carry the same lineage. A dashboard never becomes a second, unaccountable source of production truth.

EXHIBIT 46 /

The data spine separates work events, authoritative records and decisions



ILLUSTRATIVE [S01] [S21] [S25] Illustrative GFT architecture, not a deployed system claim. KPI elements and time behaviour follow S01. Shared product, production and business meaning follows S21. Common vocabularies follow S25. Manual and sensed inputs enter the same event and validation contract.

The architecture is logical, not a shopping list. A small factory can keep the layers in controlled worksheets with locked formulas and a visible exception register. A later platform can implement them in separate services. The acceptance test remains the same: trace a reported KPI to the authoritative events, the definitions in force and every excluded or corrected record. If that path breaks at a spreadsheet export or an interface queue, the record is not yet governed.

> **GFT NOTE**
>
> GFT would issue a one-page event contract beside each essential source sheet before selecting software. The contract names the work occurrence, record grain, stable event identifier, required context, event and entry timestamps, authoritative owner, validation rules and correction route. Production, quality, industrial engineering and the data steward test it against real shift scenarios, including partial bundles, rework, late entry and a changed routing. A field that cannot change a decision or reconciliation is removed.

10.2

Capture at source reduces reconstruction

A record created beside the work preserves evidence that later reconstruction cannot reliably recover. The supervisor can inspect a partial bundle, confirm a stop cause or resolve a meter identity while the physical condition still exists. An end-of-week clerk sees only totals and memories. Capture at source therefore means capturing at the responsible point of work, not merely typing an old sheet into a computer sooner.

Garment research demonstrates that detailed source capture is technically possible. One study describes RFID recording front-line production data in varied, small-batch garment production. [S19] Another uses sewing-machine power monitoring to collect consumption data and extract working times for sewing tasks. [S20] These are capture methods, not automatic proof of operational meaning. An RFID read still needs a defined bundle and boundary. A power-derived interval still needs validation against the work event it is intended to represent.

Manual and sensed capture should consequently share the same event contract. A handwritten completion sheet and a machine message can both supply an operation-completion record if both preserve identity, quantity, event time and source. The manual route may carry a later entry time. The sensed route may carry device health and signal-quality flags. Neither route should invent missing context to make the row look complete.

Four timestamps or time attributes answer different questions. Event time records when work occurred. Entry time records when the account was created. Receipt time records when an authoritative service received it. Availability time records when it became eligible for a named review or calculation. A lightweight manual system may not need all four as separate fields, but it must not pretend that entry time is always event time. Late and backdated entries remain visible rather than being silently absorbed into an apparently contemporaneous history.

The shift calendar supplies another essential boundary. Work crossing midnight belongs to the shift defined by the operating calendar, not to whichever calendar date a device happens to print. The source record retains that shift identity alongside the raw timestamp. The review cut-off then determines whether a valid late record belongs to the next operational review, a later reconciliation or both, with each use labelled accordingly.

Source capture should also make correction possible without making falsification easy. The person closest to the work can request a correction and state the reason. The authorised reviewer accepts it where the operating procedure requires separation. The original value, revised value, author, approval and timestamp remain linked. Overwriting a count because the shift total looks wrong destroys the evidence needed to discover why it was wrong.

Good capture design reduces decisions at the point of work. Controlled lists replace free-text defect and downtime codes. Default values are limited to facts the system can know, not assumptions about production. Partial entries are marked unfinished rather than coerced into valid rows. The operator sees a clear route for an unusual event, while the steward sees an exception queue instead of discovering a problem only after the plant report changes.

Automation earns its place through a measured failure or burden. If manual transcription repeatedly loses event time, a station terminal may help. If bundle identity is unreliable, RFID may merit a controlled trial. If stop causes are missing, machine states may support but not replace supervisor classification. Each trial compares the captured record with physical work and tests exception handling. The source technology changes only after the event contract remains intact under both routes.

10.3

Master data keeps history comparable

Production events acquire meaning through the reference records attached to them. A style code identifies a product only if its definition is stable. An operation code supports comparison only if the underlying method and routing remain distinguishable. NIST's smart-manufacturing review states that the exchange, understanding and use of product, production and business data depend critically on information standards. [S21] In a greenfield factory, the practical expression of that principle is a small, owned master-data register with effective dates.

Master data differs from transaction data. The order, style, operation, defect, downtime cause, machine and meter registers change through controlled releases. Production, inspection, interruption and resource events then reference the versions in force when work occurred. A revised routing does not rewrite the events recorded under its predecessor. A retired defect code remains readable in historical records even though new entries cannot select it.

Effective dating is more useful than overwriting. Each master version carries a start, an end where applicable, an approver and a reason for change. The routing register links style, operation sequence, work-content basis and method revision. The line

register preserves changes in physical layout or organisational assignment. The meter register identifies boundary, unit, reading convention and successor where hardware changes. History resolves against the applicable version rather than today's labels.

Identifiers should not be reused after their meaning changes. If an operation is split, renamed or given a materially different method, the owner decides whether this is a new version or a new entity and records the relationship. A code that meant one operation last month cannot quietly mean another this month. Such reuse creates a continuous time series from discontinuous work and can contaminate both operator comparisons and model features.

Taxonomies need the same discipline. Defect codes describe observable conditions before suspected causes are assigned. Downtime codes separate waiting, changeover, failure and no-work conditions where those distinctions lead to different responses. Meter and resource-factor registers preserve units and accounting boundaries. Adding a code requires an operational definition, examples where useful and an owner. Merging codes requires a migration rule that does not pretend the original detail never existed.

Exhibit 47, p. 158 assigns the minimum register to accountable roles. The roles are illustrative and may be combined in a small organisation, but the accountabilities should not disappear. The table also distinguishes the authoritative record from the many reports that may read it.

EXHIBIT 47 /

Every critical entity has an authoritative record and a change owner

Entity or record	Authoritative owner	Essential control
Order and style	Commercial or planning owner	Identity, version and approved inclusion rules
Routing and operation	Industrial-engineering owner	Effective method revision and work-content basis
Defect and downtime codes	Quality or production owner	Definitions, examples, succession and permitted use
Line, station and machine	Production or maintenance owner	Physical identity, assignment interval and retirement
Shift and calendar	Production owner	Cut-off, cross-midnight rule and approved exception
Employee or team reference	Authorised people-process owner	Purpose, access, retention and minimum necessary granularity
Material batch	Materials or quality owner	Receipt identity, traceable issue and disposition
Meter and resource factor	Resource-accounting owner	Boundary, unit, factor version and evidence date
KPI definition	Business owner with data steward	Formula, source events, version and reconciliation test

ILLUSTRATIVE [S21] [S22] [S24] Illustrative GFT stewardship register, not a description of existing GFT staff or systems. Information standards motivate common meaning (S21), governance supplies decision rights (S22), and quality controls support fitness for use (S24). Role combinations are permitted if accountability remains explicit.

The register is a working control, not a documentation annex reviewed once a year. Capture forms draw their allowed values from it. Validation rejects inactive codes at event time while allowing historical reads. Reviewers can see when a method or organisational change interrupts comparability. A migration team can map old identifiers without guessing from free text. These uses justify the maintenance effort.

Stewardship should sit near operational knowledge. Industrial engineering understands routing and method revisions. Quality understands defect meaning. Production understands shift and line boundaries. The data steward coordinates the rules and tests, but should not be expected to invent operational definitions alone. Escalation resolves conflicts between convenience and meaning, such as a request to reuse a code to avoid changing a report.

10.4

The system of record is an accountability before it is software

A system of record is the authoritative account for a defined entity or transaction, together with its correction and reconciliation rules. It is not whichever database holds the most rows. Data governance supplies the management discipline: the Federal Data

Strategy defines it as setting and enforcing priorities for managing and using data. [S22] GFT would make that authority explicit for each critical record before debating a platform.

Authority can be distributed without becoming ambiguous. The order register may be authoritative in a commercial system, the routing register in an industrial-engineering workbook, and production events in a line application. Each domain names its owner and permitted consumers. The plant KPI service reads those authorities rather than maintaining a private copy with local edits. A data store may hold replicas for analysis, but its role and refresh status remain visible.

Parallel reports create risk when they apply different rules to the same event. One shift sheet may count repaired garments as good, another may exclude them, and a plant workbook may remove late records without saying so. Reconciliation then becomes a debate between files rather than an inspection of definitions. The remedy is not to ban extracts. It is to make every extract identify its source version, query or inclusion rule, calculation version and creation time.

The authoritative record also retains exceptions. A rejected message, a missing shift form and an unresolved duplicate are facts about the observation process. Deleting them produces a clean table and a misleading account of reliability. Accepted, quarantined, corrected and superseded states should remain distinguishable. Consumers can then decide whether their intended use tolerates the unresolved portion.

Correction rights need operational boundaries. The source can annotate an error while work is current. The steward can resolve format or identity failures under a documented rule. The business owner approves a definition change, not a convenient alteration of history. System custodians control technical release and access. Separation may be light in a small team, yet no role should be able to change a value, hide the original and alter the KPI definition without another accountable person seeing the action.

A useful audit trail answers plain questions. What was first recorded, by which source, and when? What failed validation? Who changed which field, under which reason and approval? Which reports consumed the earlier version? When did the corrected value become available? These questions matter during the shift and much later. The shift needs to know whether an urgent number is provisional. The model needs to know whether its training rows reflect information that would actually have been available at the decision time.

KPI lineage connects this accountability to a reproducible calculation. The result carries the KPI version, source population, master-data versions, quality status and calculation run. Re-running the same version against the same preserved inputs should reconcile. Where a late event legitimately changes a restated result, both the original release and the restatement remain available with their cut-offs. Restatement is a governed event, not a silent refresh.

MINIMUM AUTHORITATIVE-RECORD TEST

Select one ordinary event, one late entry, one duplicate transmission and one correction. Trace each from source to exception or acceptance, then to the KPI and every consuming report. Confirm that identities and definitions remain unchanged, duplicates do not increase production, and corrections retain their predecessors. Repeat the test after a master-data release and after any migration. Failure blocks consequential use until the break is repaired.

This approach also clarifies procurement. A vendor demonstration should be judged against the factory's event contracts, master versions, exception paths and reconciliation cases, not against a polished screen. The factory should be able to export its authoritative history with definitions and corrections intact. If a platform cannot preserve those controls, adding it would create another reporting silo rather than a system of record.

10.5

Quality controls sit at capture and roll-up

Validation should protect the decision without concealing the source. ISO/IEC 25012 provides a general quality model for structured data, while the UK Government Data Quality Framework identifies core dimensions and treats quality in relation to intended use. [S23] [S24] GFT would turn those dimensions into executable checks at two boundaries: when a record enters, and when records combine into a KPI or analytical population.

Capture checks address what the source can still repair. Required identifiers must be present and active at event time. Quantities and readings must use the declared unit and feasible range. Event and entry times must have a defensible order, with a controlled route for clock exceptions. Cross-field rules test whether the combination makes operational sense, such as first-pass good pieces exceeding pieces inspected. A failed record goes to a visible queue with its original content intact.

Roll-up checks address failures that an individual row cannot reveal. Completeness compares the received population with an expected population of active lines, shifts, forms or meters. Uniqueness detects repeated event identifiers across devices, retries and manual entry. Consistency reconciles starts, completions, corrections and opening balances. Timeliness measures availability against the review cut-off. Accuracy requires comparison with physical counts, reference instruments or adjudicated samples rather than another field in the same possibly wrong record.

The expected population deserves particular care. Counting rows already received cannot measure completeness, because missing rows are absent from that denominator. The factory therefore needs an independent expectation, such as the active shift calendar or scheduled meter-reading register. Where no valid expectation exists, the report should say that completeness is unknown rather than display a reassuring ratio.

Quality status must travel with the result. A shift KPI may be released provisionally with an unresolved exception count, while a monthly claim waits for reconciliation. An analytical extract may include quarantined rows for data-quality investigation but

exclude them from a performance-training population under a documented rule. The exclusion remains reproducible. Silent deletion, interpolation or acceptance would make the later dataset easier to use and less truthful.

WORKED EXAMPLE: RETRIES MUST NOT BECOME PRODUCTION

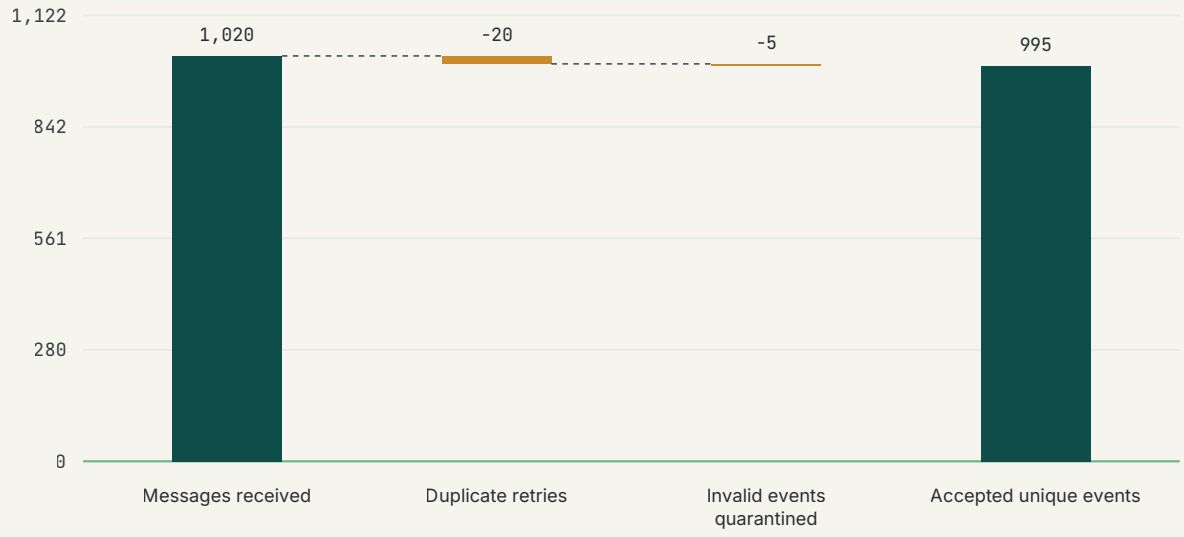
An illustrative source queue contains 1,000 distinct bundle-completion events expected for export. The receiving interface gets 1,020 messages because connectivity retries repeat 20 event identifiers. Duplicate detection removes those 20 repeated transmissions without deleting their audit trail, leaving 1,000 distinct source events. Cross-field validation then quarantines five events whose quantities conflict with their bundle references. The remaining 995 events are accepted for the current KPI population. All values are constructed to demonstrate reconciliation, not to report factory performance.

The illustrative arithmetic is 1,020 minus 20 duplicates, leaving 1,000 unique events, then minus five invalid events, leaving 995 accepted. Accepted-event completeness against the independent source expectation is 995 divided by 1,000, or 99.5 percent. The five quarantined events remain visible, and the twenty retries do not increase output. The result describes record completeness, not first-pass yield or production performance.

Exhibit 48, p. 161 presents that illustrative reconciliation. The closing balance is accepted records, not garments. Its purpose is to show why raw message counts and accepted operational events are different quantities.

EXHIBIT 48 / ILLUSTRATIVE SOURCE MESSAGES AND EVENTS

Duplicate retries and invalid records must not inflate the authoritative population



ILLUSTRATIVE Illustrative worked example, not factory evidence. Assumptions: 1,020 received messages represent 1,000 expected distinct source events plus 20 duplicate retries. Arithmetic: 1,020 - 20 duplicate transmissions = 1,000 unique events; 1,000 - 5 quarantined invalid events = 995 accepted. Accepted-event completeness is 995 / 1,000 = 99.5 percent. This is not a quality-yield measure.

The example also shows why a single green quality badge is inadequate. Management needs the accepted population, the expected denominator, unresolved exceptions, lateness and the rule applied to duplicates. A model dataset needs the same information plus the exact extraction version. A high accepted share does not prove accuracy, and a low share does not justify inventing replacements. Both conditions direct the steward to a specific repair.

Control effectiveness needs review as well as control execution. If the same code fails every shift, the team should repair the form, master data or work instruction rather than normalise a growing quarantine. If a validation rule rejects legitimate exceptions, the owner revises it through version control. The exception log therefore serves both immediate reconciliation and longer-term improvement of the measurement system.

10.6

Shared vocabularies make later integration cheaper

Migration becomes expensive when every historical row depends on a private abbreviation, a local spreadsheet formula or an undocumented code. W3C guidance recommends data vocabularies and standards to promote interoperability among datasets. [S25] The factory can apply that guidance in its first workbook. The sheet names, column names, identifiers and metric contracts used for manual capture should be the same ones a later execution system or data store is expected to preserve.

A practical canonical workbook separates reference registers, source events, validation exceptions, KPI definitions and review outputs. Each table states its grain and keys. Controlled vocabularies supply codes and plain-language definitions. Units are explicit in field contracts rather than inferred from column position. Derived cells identify their formula version. These choices cost little compared with later manual translation, yet they make the workbook a genuine predecessor of the digital record.

Vocabulary does not mean forcing every system to use identical internal names. It means maintaining governed mappings between names that refer to the same operational thing and refusing mappings where meanings differ. A supplier's `operation` field may represent a routing step, a machine state or an inspection activity. The steward verifies the semantics before mapping. Technical connectivity cannot resolve a conceptual mismatch.

Migration acceptance should use preserved cases rather than aggregate totals alone. Ordinary events, corrections, superseded master versions, quarantined records and duplicate retries must arrive with their history and produce reconciled KPI results. Where the new platform cannot represent an old distinction, the owner records the limitation and any discontinuity. A matching daily total can still conceal changed detail.

Later models consume dataset versions, not an unlabelled view of the latest tables. The extract records event and master-data versions, quality filters, cut-off, feature definitions and the authoritative source from which it came. That discipline lets a

reviewer reproduce a result and prevents a corrected or redefined history from changing training data without notice. The vocabulary thus serves operational continuity before it serves analytical sophistication.

10.7

Local operation must survive weak connectivity

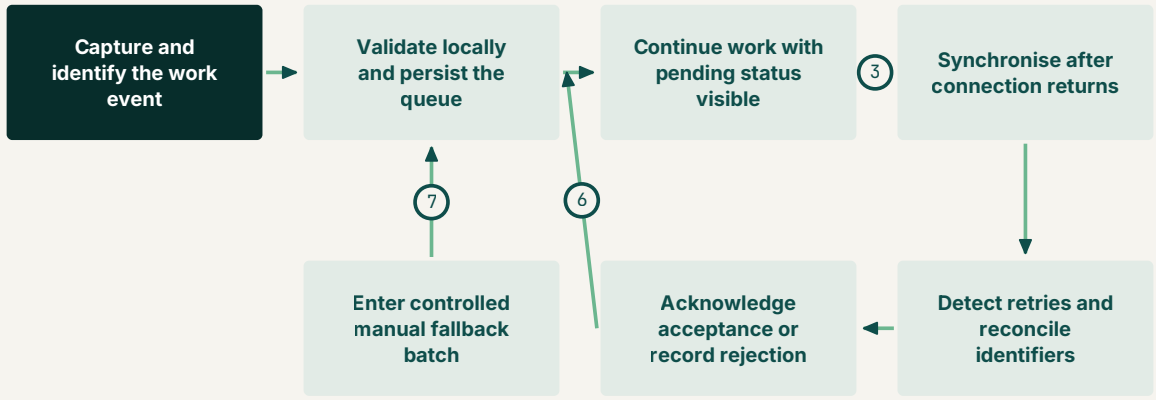
A line should not lose its operating record because a remote service is unavailable. NIST's fog-computing conceptual model describes distributing applications, management and analytics into the network. [S26] For a garment floor, the restrained application is local validation and persistent buffering near the source, followed by controlled synchronisation. This is a resilience pattern, not a requirement to deploy a particular edge product.

The local queue stores each event under its stable identifier before attempting transmission. Validation that does not require remote reference data runs immediately. The source receives a clear pending state, so an operator does not create a second manual event merely because acknowledgement is slow. When connectivity returns, the receiver applies duplicate detection, returns acknowledgement and preserves any rejection reason. Retrying delivery must never create another production occurrence.

Exhibit 49, p. 164 shows the required sequence. The design distinguishes local acceptance for continued work from authoritative acceptance after reconciliation. A manual fallback enters the same queue discipline through a controlled batch rather than forming a separate history.

EXHIBIT 49 / DECISION SEQUENCE

Offline capture reconciles without duplicating work history



3. Connection restored

6. Close pending state

7. Same event contract

ILLUSTRATIVE [S26] [S24] Illustrative GFT continuity flow. Distributed local processing follows the conceptual principle in S26. Duplicate detection, quarantine and visible quality status apply the fitness-for-use controls in S24. It is not a claim that a particular network or platform has been implemented.

Conflict handling needs rules before an outage. If two sources claim the same event identifier, the system quarantines the pair rather than selecting the newest by default. If clock drift makes event order uncertain, the record retains both device and receipt evidence and receives a quality flag. If a master-data update arrives while events are queued, validation uses the version applicable at event time. These are reconciliation problems, not reasons to discard the offline record.

The manual fallback remains deliberately small. Pre-numbered source sheets or another controlled identity scheme preserve uniqueness. The shift owner records when fallback begins and ends. Later entry uses the original event time, actual entry time and fallback reason. Reconciliation checks both missing sheets and duplicates between paper and device capture. A fallback that bypasses these rules may keep production moving, but it does not preserve a governed record.

Local buffering also needs operating limits. The custodian monitors queue age, storage capacity, failed authentication and device clock health. Access to buffered information follows the same purpose and permission rules as online access. Recovery tests use realistic interruptions and verify that no events vanish or multiply. Backups and export routes are tested against the authoritative record, not assumed from a running screen.

The implementation sequence follows operational risk. First establish identifiers, event contracts and a controlled manual queue. Then automate repetitive capture where trials show a benefit. Add local synchronisation only with duplicate, conflict and

acknowledgement tests. Finally permit analytical consumers to read versioned extracts. At every stage, the shift continues from the same definitions and the model inherits the same exceptions and corrections.

GFT's practical recommendation is to judge the data spine by reconstruction, not appearance. Ask a supervisor to explain which records supported the last shift decision. Ask a steward to reconcile a late correction and an offline retry. Ask an analyst to reproduce the source population behind a KPI extract. If all three reach the same authoritative events, the factory has one record that can serve operations now and modelling later without pretending their needs are identical.

The factory should record work once, govern its meaning always, and let every decision carry the same evidence forward.

CHAPTER SOURCE NOTES

S01 International Organization for Standardization. 2014.

S21 National Institute of Standards and Technology. 2016.

S25 W3C. 2017-01-31.

S19 The International Journal of Advanced Manufacturing Technology, Springer Nature. 2019-09-03.

S20 Applied Sciences, MDPI. 2020-04-29.

S22 United States Federal Data Strategy. 2020.

S24 UK Government Data Quality Hub. 2020-12-03.

S23 ISO/IEC. 2008.

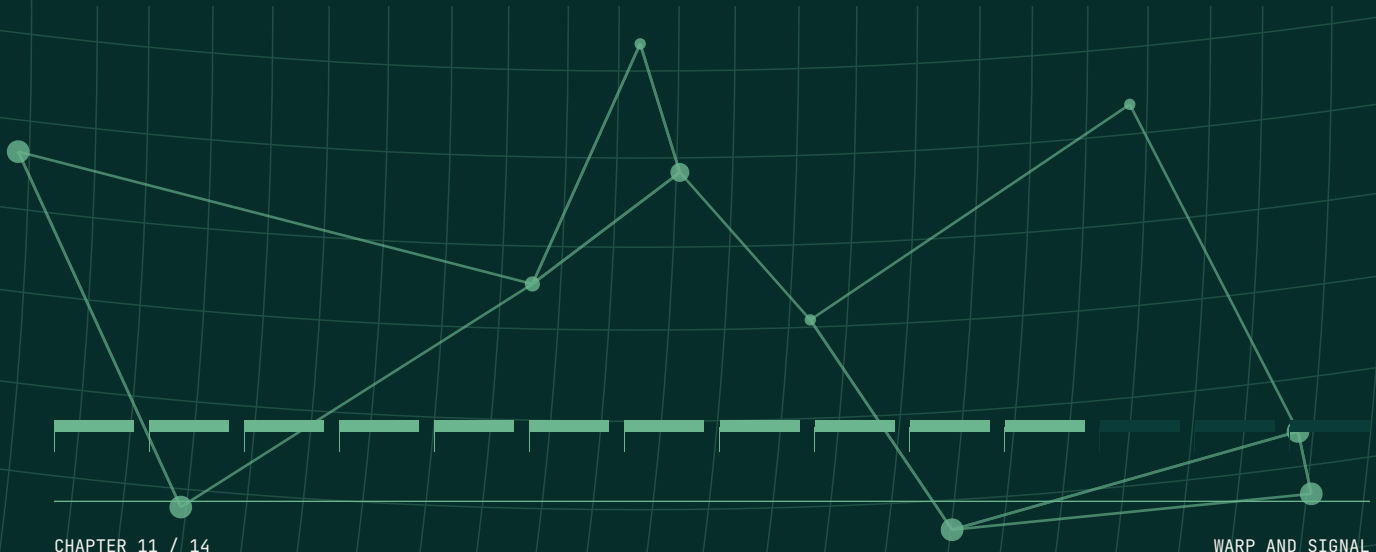
S26 National Institute of Standards and Technology. 2018-03-14.

11

PART III: TURN RECORDS INTO DECISIONS / DAILY TO MONTHLY

A fixed cadence turns measures into owned decisions

Daily correction, weekly problem solving and monthly reconciliation give each signal a forum, an authority level and a recorded response.



CHAPTER 11
DECISION TEST

Daily correction, weekly problem solving and monthly reconciliation give each signal a forum, an authority level and a recorded response.

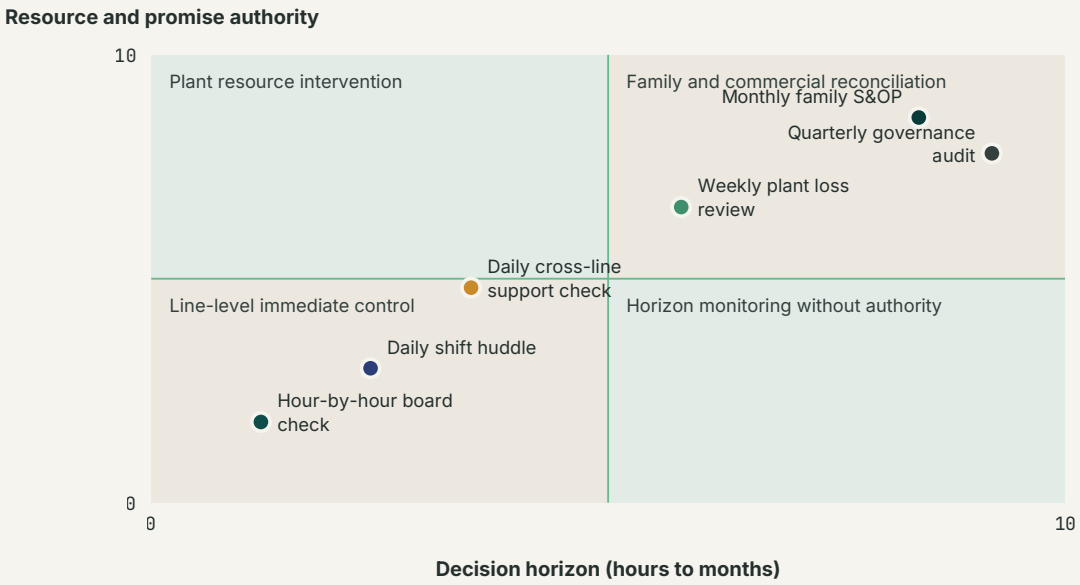
A performance measure changes factory behaviour only when it arrives at a scheduled forum where a named role holds both the authority and the resources to act on it. [S02] [S22] Chapter 10 established that a greenfield cut, make, trim and finishing plant needs one governed record linking source events, master data and quality controls. Yet even a complete operational record remains passive if managers inspect it only when a shipment is already late or an accounting period has closed. In GFT's operating design, the management cadence is the active mechanism that converts validated records into owned decisions. Daily shift huddles protect current-day flow within the sewing line's authority, weekly plant reviews remove recurring cross-functional constraints, and monthly sales and operations planning (S&OP) reconciles aggregate product-family demand against demonstrated capability rather than nameplate assumptions. [S04] [S08] [S42] Each forum operates on a defined horizon, reads from the same authoritative record, escalates exceptions along explicit decision rights, and tracks every agreed intervention in a persistent action log until its operating effect is verified. [S22] [S43] [S44]

Without a fixed review architecture, a greenfield garment factory falls into two opposite failure modes. In the first mode, supervisors spend their shifts firefighting bundle shortages, thread breaks and rework loops through informal conversations that leave no institutional trace, while senior management reviews monthly summaries that arrive too late to save affected orders. [S02] [S1103] In the second mode, the plant proliferates meetings where every tier debates the same raw numbers from competing spreadsheets, turning line leaders into report compilers rather than floor coaches while still failing to resolve who owns a capacity conflict. [S22] [S1102] GFT avoids both traps by treating the review calendar as an engineered control system. Just as ISO 22400 requires every key performance indicator (KPI) to specify its formula, unit and time behaviour, GFT requires every review forum to specify its input indicators, decision boundary, escalation threshold and verification rule before production begins. [S01] [S44]

The architecture of this cadence is summarised in **Exhibit 50**, p. 168, which maps the factory's review forums across two analytical dimensions: the planning horizon under review and the scope of resource-reallocation authority held by the chair. Intra-shift visual checks and daily line huddles sit in the short-horizon, local-authority quadrant, where the supervisor can rebalance stations, deploy a utility operator or request immediate mechanic attendance. [S04] Cross-line coordination and weekly plant reviews occupy the intermediate zone, where operations, quality, maintenance and human-resources leaders reallocate shared technicians, authorise root-cause investigations and adjust training schedules. [S08] [S14] Monthly S&OP and quarterly governance audits sit in the upper-right zone, where executive leadership reconciles product-family order books, material procurement windows, shift structures and method or capital changes. [S42] [S44]

EXHIBIT 50 / ORDINAL HORIZON AND AUTHORITY INDEX (0 TO 10)

Each cadence has a distinct horizon and authority



DERIVED [S04] [S08] [S42] [S44] Derived: maps GFT review forums across planning horizon (horizontal axis, from intra-shift hours to multi-month family horizon) and resource-reallocation authority (vertical axis, from station rebalance to commercial promise revision), combining daily supervisory balancing (S04), systematic OEE review (S08), monthly product-family S&OP (S42) and S&OP maturity categories (S44). Coordinates are illustrative ordinal positions on a 0 to 10 scale.

Exhibit 50, p. 168 clarifies why a single meeting cannot govern a factory. If a daily shift huddle attempts to renegotiate customer delivery dates, it paralyses the line; if a monthly executive committee attempts to diagnose why a single overlock station lost twenty illustrative minutes on a Tuesday morning, it drowns in operational noise while leaving next quarter's fabric and skill bottlenecks unaddressed. [S07] [S42] The lower-right quadrant represents a structural anti-pattern: forums that review multi-week forecasts without holding the authority to adjust capacity, materials or commercial commitments generate commentary rather than control. [S44] What **Exhibit 50**, p. 168 cannot establish on its own is whether a plant's supervisors and managers have acquired the practical coaching skills required to exercise their assigned authority; that behavioural readiness must be developed through structured workplace practice and verified through routine meeting audits. [S13] [S14] [S44]

11.1

The daily huddle protects the current shift

The daily shift huddle is the foundational operating routine on the garment floor because it connects yesterday's verified record to today's immediate station allocation. Garment-sector improvement programmes documented by the International Labour Organization (ILO), such as the Sustaining Competitive and Responsible Enterprises (SCORE) methodology in Ethiopia, begin with a baseline assessment to identify operational gaps and then measure change systematically through KPIs. [S05] A baseline assessment, however, only produces sustained factory improvement when frontline teams review those KPIs at the start of every working day and translate observed gaps into concrete shift adjustments. [S05] [S1101] In a NIST Manufacturing

Extension Partnership (MEP) case study of a lean daily management system, aligning employees from the shop floor to senior leadership relied on deploying policy score-cards, visual controls, regular huddle-board meetings and daily floor walks to build personal ownership of performance data. [S1101] GFT adapts this discipline to a greenfield sewing, cutting and finishing operation, where high operator density and frequent style transitions make single-shift drift expensive.

11.2 THE HUDDLE AGENDA FOLLOWS A STRICT SEQUENCE AND TIME BOUNDARY

To protect production time, GFT designs the line-level huddle as a standing meeting held directly in front of the physical or digital line board at shift start, bounded to an illustrative duration of 10 to 12 minutes. A huddle that exceeds 15 illustrative minutes either is attempting engineering root-cause analysis that belongs offline, or is suffering from unprepared source records that force participants to argue over what happened on the prior shift. [S22] [S1102] The line supervisor chairs the meeting with the line's quality inspector, assigned maintenance liaison, bundle handler and operator representatives. Because the authoritative record from Chapter 10 closes and validates the prior shift's logs before handover, the supervisor arrives with reconciled figures rather than unverified tally marks. [S01]

The agenda proceeds through five mandatory checks in fixed order:

1. **People, attendance and safety check (illustrative 2 minutes):** The supervisor confirms operator attendance against the planned station roster, notes any ergonomic, needle-safety or machine-guard exceptions from the prior shift, and checks working-time limits so that absent stations are not covered through unapproved overtime. [S18]
2. **Prior-shift first-pass good output and flow check (illustrative 2 minutes):** The team compares prior-shift first-pass good pieces and standard minutes earned against the ramp-adjusted shift target, checking work-in-progress (WIP) bundle age at the bottleneck operation so that raw piece counts do not conceal a starved finishing section. [S03] [S10]
3. **Quality-at-source defect check (illustrative 2 minutes):** The inline and end-of-line quality record is reviewed by top defect code and originating operation, distinguishing first-pass completions from reworked garments and verifying that quarantined bundles have a disposition owner. [S02] [S10]
4. **Cause-coded downtime and constraint check (illustrative 2 minutes):** Rather than quoting an aggregate availability percentage, the supervisor reviews the specific downtime causes recorded on the line, such as mechanic waiting time, needle or looper failure, cut-panel shading mismatch or trim shortage. [S07] [S1102]
5. **Current-shift line balance and owned actions (illustrative 2 to 4 minutes):** The supervisor states the station adjustments for the shift ahead, confirms at most three line-owned actions with named owners and intraday check times, and flags any constraint exceeding line authority for immediate escalation to the daily cross-line support check. [S04] [S22]

11.3 DAILY LINE BALANCING IS THE CORE SUPERVISORY DECISION

In apparel manufacturing, the daily huddle is the forum that executes daily line balancing. ILO evaluation of the Factory Improvement Toolset across Asian garment factories emphasises that line balancing is performed systematically by line supervisors both before production through planning and daily during production. [S04] Pre-production balancing uses the operation breakdown and standard minute values (SMVs), which represent the time value for a task based on the average output rate that qualified workers naturally achieve without over-exertion when adhering to the specified method. [S03] On a real shift, however, two operators may be absent, a new style cohort may be in its second week of ramp-up where the process remains imperfectly understood, or a specific seam may be generating stitch-density defects that slow the station below its normative SMV. [S03] [S11]

During the huddle and the opening hour of the shift, the supervisor uses the skill matrix and the prior shift's operation-level output record to rebalance work across stations. [S04] Within line authority, the supervisor can split a bottleneck operation across two qualified operators, assign a multi-skilled floater to cover an absent station, adjust bundle release pacing to prevent WIP accumulation ahead of a slower learner, or request a workstation guide attachment from the line mechanic. [S04] [S14] What the supervisor must not do is alter the approved construction method without industrial-engineering sign-off, waive an inline quality inspection standard to clear a queue, or compel operators to work unrecorded hours to mask a balancing deficit. [S03] [S18] [S45]

11.4 SUPERVISORY CAPABILITY DETERMINES WHETHER HUDDLES SOLVE PROBLEMS

A fixed huddle agenda fails if supervisors treat variance review as public blame. A randomised impact evaluation by the International Finance Corporation (IFC) in the Cambodian garment industry found that supervisory skills training improved workers' perceptions of relationships with their supervisors and led to moderate improvements in overall firm productivity. [S13] Similarly, a 2025 IFC and ILO Better Work assessment of the Gender Equality and Returns (GEAR) programme in Bangladesh documented that effective supervisor development combined classroom sessions with six to eight weeks of structured line shadowing under an experienced supervisor. [S14]

GFT therefore integrates supervisory coaching directly into the daily cadence. During the first months of a greenfield factory, the production manager or an industrial engineer shadows a rotating sample of daily line huddles each week, observing whether the supervisor invites operator input on station constraints, separates controllable method adherence from external material or machine failures, and assigns clear follow-up checks. [S14] [S1101] A shop-floor production planning and lean manufacturing case study published in *Gestão & Produção* in 2025 illustrates why operator and team-leader dialogue is essential: to identify the true reasons behind assembly-line stoppages, engineers combined written operator records on Overall Equipment Effectiveness (OEE) sheets with daily conversations with assembly-line team leaders. [S1102] In GFT's design, the daily huddle is the structured point where written station logs and frontline operational context meet.

11.5

Visual control shows exceptions and ownership

Between daily huddles, the garment floor is governed through visual control. ILO guidance on lean manufacturing techniques for the ready-made garments industry states that the best approach to performance measurement is to balance metrics across financial, behavioural and core-process categories while using a mix of in-process and end-of-process indicators. [S02] On a sewing line, an end-of-shift summary is an end-of-process indicator: it tells management whether the shift succeeded after the labour hours have already been spent. Hour-by-hour visual control boards provide the in-process signal that lets a supervisor detect and correct a flow interruption within the hour it occurs. [S02] [S1102]

11.6 THE HOUR-BY-HOUR BOARD SEPARATES OUTPUT, QUALITY AND INTERRUPTION CAUSES

Many factories install whiteboards or screens that display only a target piece count and an actual piece count, marking the cell in red whenever actual falls below target. That design violates three measurement principles established earlier in this paper. First, a raw piece count that includes defective or reworked garments overstates saleable throughput and hides the capacity consumed by repair loops; in a NIST MEP manufacturing case, improving first-pass yield from 10 percent to 90 percent was directly associated with cutting total processing time from 11.8 hours to 3.4 hours. [S10] Second, an uncontextualised shortfall does not distinguish whether the line slowed because of a machine breakdown, a missing trim batch or a method learning curve, which is the exact diagnostic failure identified in real-time OEE research when downtime events are merged into a single category. [S07] Third, a red numeral without an assigned responder and escalation status violates the basic rule of visual management, which is to make both the abnormality and the required response visible at a glance. [S22] [S1102]

GFT specifies a six-block line board architecture, illustrated in **Exhibit 51**, p. 172 using an illustrative eight-hour shift scenario for a 40-operator sewing line producing a woven workwear trouser at an approved SMV of 24.0 standard minutes per piece. Under a ramp-adjusted target efficiency of 65 percent during cohort week four, the illustrative shift target is 520 first-pass good pieces, or 65 pieces per hour across eight productive hours. [S03] [S11]

EXHIBIT 51 / ILLUSTRATIVE SHIFT-BOARD CONTROL BLOCKS

The line board pairs results with causes and responses

260 vs 242 pcs **1. Cumulative target vs actual** Hour 4 completed pieces against ramp-adjusted pace (65 pcs/hr at 24.0 SMV)	**228 good pcs (94.2%)** **2. First-pass good output** 14 units routed to rework loop; only first-pass good counts toward pace	**38 pcs at Op 09** **3. Bottleneck WIP buffer** Waistband attach queue exceeds 25-piece upper buffer limit; upstream paced
22 min (DT-M04) **4. Cause-coded interruption** Feed-dog timing fault on twin-needle station 14; not merged into generic loss	**39 / 40 present** **5. People & skill coverage** 1 absent at Op 09 covered by certified Grade B utility operator (ID U-07)	**Tier 2 Mech / 11:30** **6. Active escalation & owner** Owner: Line Mechanic M-03; spare feed-dog fitment due 11:30; verify Hour 5

ILLUSTRATIVE [S02] [S04] [S07] Illustrative: GFT hour-by-hour line-board layout for one 8-hour sewing shift (40 operators, 24.0 SMV woven trouser, ramp cohort week 4 at 65 percent target efficiency). Values are illustrative design entries showing how balanced in-process and end-of-process measures (S02), daily line balancing (S04) and unmerged downtime causes (S07) appear with an explicit owner and response window. Not an observed GFT factory result.

As **Exhibit 51**, p. 172 shows, a supervisor or manager standing at the board at the end of Hour 4 sees that first-pass good output is 32 illustrative pieces behind the cumulative target of 260 pieces because 14 units required rework, that 22 station-minutes were lost to a specific twin-needle feed-dog fault (DT-M04), that WIP has reached 38 illustrative pieces ahead of Operation 09, and that a certified utility operator has been assigned while the line mechanic has an owned corrective action due at 11:30 with verification scheduled at Hour 5. [S02] [S04] [S07] What **Exhibit 51**, p. 172 cannot guarantee by itself is the accuracy of the underlying defect grading or downtime timestamps; those inputs depend on the measurement-system checks and source-capture rules defined in Chapters 4, 6 and 10. [S40]

11.7 VISUAL SIGNALS TRIGGER BOUNDED RESPONSE PROTOCOLS

In GFT's visual control design, an abnormality on the line board or station andon is coupled to a two-stage response rule: containment within the current hour, and escalation if the threshold is breached. In the *Gestão & Produção* lean visual-management study, physical magnets and colour-coded squares on the shop-floor board alerted workers and team leaders immediately when a batch required action or when a scheduling or capacity conflict required a designated decision-maker to intervene. [S1102] GFT applies the same principle to sewing and cutting flow:

- **Green state (within normal operating band):** Hourly first-pass good output sits within the ramp cohort's expected control band, station WIP buffers sit within their bundle limits, and no station has an unaddressed stop exceeding an illustrative 5 minutes. The supervisor maintains standard floor patrols and method checks. [S04] [S09]
- **Amber state (line-containable variance):** Hourly first-pass good output falls more than an illustrative 10 percent below target, two or more identical defects appear at a single operation within 30 illustrative minutes, or a machine stop reaches 10 illustrative minutes. The supervisor, inline quality inspector and line mechanic converge at the station within 5 illustrative minutes, record the cause code on the board, and implement immediate containment such as tension recalibration, bundle pacing or utility-operator support. [S04] [S07]
- **Red state (escalation required):** A machine or material interruption exceeds 20 illustrative minutes without resolution, the same defect code recurs after initial containment, or a cut-panel or trim shortage threatens to starve the line within the next hour. The board status moves to red, and ownership transfers automatically to the designated Tier 2 support function under the plant's escalation rules. [S22] [S1102]

> **GFT NOTE**
>
> In a greenfield garment factory starting with clean manual capture, never maintain a separate manual board and a separate office spreadsheet. The physical hour-by-hour board at the end of the line should hold the structured paper shift sheet that is keyed or scanned once into the authoritative record at shift close, or, once local tablets are introduced, the screen should render the authoritative shift record directly. [S01] [S22] Requiring a supervisor to write hourly figures on a whiteboard, copy them into a notebook, and re-type them after the shift creates transcription error and steals time from line balancing and operator coaching. [S04] [S14]

11.8

The weekly review closes recurring problems

Daily huddles and hour-by-hour boards keep the current shift moving, but they are deliberately bounded to short-term containment and intra-line rebalancing. When a sewing line experiences four needle-bar or looper failures in a single week, when shade variation in dyed pocket fabric causes repeated cutting holds, or when two lines compete for the same three multi-skilled collar-attach operators, a 10-minute shift huddle cannot solve the underlying systemic constraint. Literature reviewing OEE implementations across manufacturing industries notes a widespread lack of

improvement frameworks with systematic steps specifically developed to turn OEE loss measurement into sustained improvement. [S08] Monitoring an aggregate efficiency score without a structured weekly problem-solving forum leaves recurring losses embedded in the process. [S07] [S08]

11.9 THE WEEKLY PLANT REVIEW SHIFTS FROM EVENT CONTAINMENT TO PATTERN REMOVAL

GFT establishes a weekly operational review, chaired by the plant manager or operations manager and attended by line supervisors, industrial engineering, quality assurance, maintenance, cutting/stores and human resources. Held for an illustrative 60 minutes on a fixed weekday morning, the weekly review does not re-read daily shift logs line by line. Instead, it examines seven-day and four-week rolling aggregations drawn from the authoritative record across all six KPI families: production, quality, delivery, cost, people and sustainability. [S02] [S08]

The weekly review performs four analytical tasks that cannot be done inside a single shift:

1. **Pareto decomposition of recurring downtime and rework losses:** Because the daily record preserves event-level downtime causes and operation-level defect codes rather than merging them, the weekly review ranks the top three loss contributors by standard minutes lost across the plant. [S06] [S07] If waiting for cut panels or mechanic response time accounts for the largest share of lost availability across multiple lines, the plant manager assigns a cross-functional corrective action to cutting scheduling or preventive maintenance rather than pressuring line supervisors. [S07] [S08]
2. **Cross-line skill and staffing allocation:** The team reviews the plant-wide skill matrix, training drill completion, absence rates and ramp cohort progress. [S11] [S12] If a line preparing for a complex style changeover next week lacks certified coverage on two critical operations, industrial engineering and human resources schedule targeted capacity-development drills and temporary cross-line transfers before the style enters the line. [S03] [S04]
3. **Working-time, overtime and incentive guardrail check:** Better Work research across garment factories demonstrates that excessive overtime leads to poorer worker health, reduced efficiency, higher accident rates, worker dissatisfaction and high turnover. [S18] In Cameroon, where the labour framework sets a standard 40-hour week, a 48-hour maximum and overtime compensation at 1.2 times the base rate, and where the statutory minimum wage (SMIG) rose to XAF 43,969 a month from 23 February 2024, the weekly review checks that no line relies on chronic overtime or punitive target pressure to meet weekly volume. [R14] [R16] [S18]
4. **Action-log ageing and verification audit:** Every open item from prior weekly reviews is inspected against its due date and expected operating mechanism. An action is closed only if the subsequent week's governed data confirm that the targeted loss or defect pattern actually declined without degrading a guardrail indicator. [S41] [S43]

11.10 THE WEEKLY FORUM SELECTS STRUCTURED IMPROVEMENT CANDIDATES

Not every recurring problem discovered in the weekly review has a known solution. When the weekly Pareto reveals a persistent loss whose cause is uncertain or contested, such as a high seam-puckering rate on a lightweight shirting fabric across two shifts or an unexplained rise in compressed-air energy intensity per thousand standard minutes, the weekly review does not guess a countermeasure in the meeting room. Instead, it charters a formal Plan-Do-Check-Act (PDCA) or A3 investigation, assigns an engineering or quality owner, defines the baseline population, and schedules the investigation for review at defined milestones. [S05] [S41] Chapter 12 specifies the diagnostic and verification mechanics of that improvement loop in full; the weekly management cadence provides the governance forum that commissions those investigations, allocates technician hours to them, and holds their owners accountable for follow-through. [S08] [S41]

11.11

Monthly S&OP reconciles families rather than individual tickets

While daily and weekly routines govern execution against the current schedule, a factory can still fail commercially and operationally if its order book is disconnected from its true floor capability. In a NIST MEP manufacturing case study, high finished-goods inventory, longer-than-desired lead times, decreased capacity and difficulty sustaining lean initiatives resulted directly in lower on-time deliveries, higher overtime costs and an excessive number of expedited orders. [S1103] In garment manufacturing, chronic expediting usually begins weeks before cutting, when commercial teams accept delivery dates based on theoretical machine counts while operations teams struggle with ramp-up learning curves, fabric arrival delays and unmeasured rework. [S10] [S11] [S42]

11.12 PRODUCT-FAMILY AGGREGATION LINKS COMMERCIAL PROMISES TO FLOOR REALITY

Sales and operations planning (S&OP) is the monthly discipline that prevents that disconnect. Academic research on S&OP implementation emphasises that S&OP is performed at least once a month and is reviewed by management at an aggregate product-family level, integrating customer-focused commercial plans with operations at the tactical level of the production planning hierarchy. [S42] Reviewing individual production tickets in a monthly executive meeting overwhelms leadership with thousands of stock-keeping units (SKUs); conversely, reviewing only a single plant-wide piece total conceals the fact that a basic T-shirt taking 7.0 illustrative standard minutes and a tailored jacket taking 45.0 illustrative standard minutes impose completely different work content and skill demands on the sewing floor. [S03] [S42]

GFT structures monthly S&OP around product families defined by shared sewing routing, machine types and SMV bands (for example: basic knit tops, woven school and corporate uniforms, and heavy cotton workwear trousers). Each month follows a structured four-step reconciliation sequence over a rolling three-to-twelve-month horizon:

1. **Data and demonstrated-capability cut-off (business days 1 to 3, illustrative):** The data steward freezes the prior month's authoritative records for first-pass good output, OEE components (availability, performance, quality), ramp-cohort learning trajectories, order-level on-time-in-full (OTIF) delivery, effective labour cost per good garment and resource intensity. [S01] [S06] [S22]
2. **Demand and commercial review (business days 4 to 6, illustrative):** Commercial leadership presents committed orders, provisional customer reservations and style-mix changes by product family, converting all volumes into required standard minutes using industrial engineering's versioned SMV library (or provisional ramp SMVs clearly flagged with uncertainty bounds). [S03] [S42]
3. **Supply, capacity and material review (business days 7 to 10, illustrative):** Operations, industrial engineering, procurement and human resources calculate demonstrated available capacity in standard minutes for each product family, factoring in scheduled working days, operator headcount, skill-matrix certification constraints, ramp-up discount curves, fabric and trim lead times, and planned maintenance. [S04] [S11] [S14]
4. **Executive S&OP reconciliation meeting (business day 12, illustrative, 90 minutes):** Chaired by the general manager or plant director with commercial, operations, finance, human-resources and sustainability leads, the executive forum reviews every capacity, material or working-time gap and makes binding trade-off decisions. [S42] [S44]

11.13 INDUSTRIAL CONTEXT IS SEPARATED FROM FACTORY DEMAND COMMITMENTS

In Cameroon, the strategic importance of disciplined monthly S&OP is reinforced by the broader industrial context recorded in the shared evidence register. Sector sources indicate that roughly 95 percent of Cameroon's cotton fibre is exported raw while about 5 percent is processed locally, against a national industrialisation target of 50 percent local processing by 2030 under the National Development Strategy (SND30). [R06] [R07] At the same time, historical reporting on existing domestic capacity highlights the cost of weak operational utilisation: a July 2023 report on CICAM cited capacity utilisation of 33.7 percent at Garoua, 48.9 percent at CICAM 1 and 10.83 percent at CICAM 2, with underutilisation costing about CFAF 2 billion in 2020. [R12]

GFT treats these inherited sector figures strictly as external industrial context, never as an automatic demand forecast or guaranteed utilisation level for a greenfield plant. [R06] [R12] A national policy target of 50 percent local processing does not place a single confirmed purchase order on a sewing line, and historic underutilisation at another enterprise demonstrates why a factory must align its commercial order book, fabric supply and line capability month by month. [R07] [R12] [S42] Monthly S&OP is the governance forum where a greenfield plant ensures that its commercial promises

match its demonstrated floor capability, while companion papers in this library examine statistical demand forecasting (wp04) and raw-material and finished-goods inventory buffering (wp12) in detail. [S42]

MONTHLY PRODUCT-FAMILY CAPACITY RECONCILIATION

To prevent monthly S&OP from relying on nameplate machine counts, GFT reconciles required demand against demonstrated deliverable capacity in standard minutes for each product family and planning month. [S03] [S42] First, required family work content W sums ordered good quantity multiplied by the approved style Standard Minute Value across all orders due in the month. [S03] Second, gross attended operator minutes A multiply planned sewing operators by scheduled working days, standard shift minutes (for example, 480 illustrative minutes for an 8-hour shift under the 40-hour to 48-hour legal framework), and one minus the baseline unplanned absence share. [R16] [S18] Third, demonstrated deliverable capacity C deducts planned non-production time (daily huddles, preventive maintenance, operator skill drills) and multiplies by the family's demonstrated availability, ramp-adjusted performance and first-pass quality factors from the governed baseline (`C = A x (1 - p) x availability x performance x quality`). [S06] [S11] Whenever required work W exceeds deliverable capacity C, the executive S&OP forum must close the deficit before confirming customer dates by re-phasing delivery dates with customer agreement, reallocating qualified lines from another family, or authorising bounded overtime within the 48-hour legal weekly ceiling and fatigue guardrails. [R16] [S18] [S42]

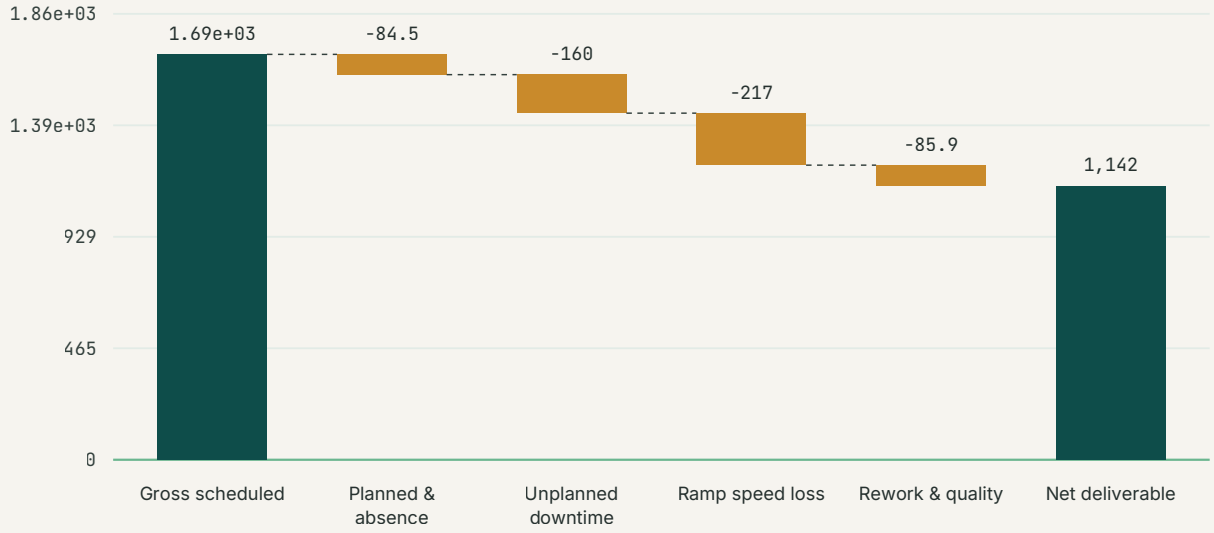
WORKED EXAMPLE: RECONCILING A FOUR-LINE WORKWEAR FAMILY IN MONTH 6

Consider an illustrative monthly S&OP reconciliation for a greenfield factory's woven workwear family in Month 6 of operations. All figures in this worked example are assumed to demonstrate the calculation method and are not observed GFT factory results or forecasts. Commercial demand for next month requests `55,000` good trousers at an approved SMV of `24.0` standard minutes per garment, requiring `1,320.0 thousand` standard minutes. [S03] [S42] Four assigned sewing lines of `40` operators each (`160` operators) over `22` working days at `480` minutes per shift provide `1,689.6 thousand` gross scheduled operator-minutes. [R16] Deducting `5.0 percent` (`84.5 thousand` illustrative minutes) for planned huddles, skill drills and baseline absence leaves `1,605.1 thousand` available minutes. [S04] [S12] Applying Month 5 governed loss rates deducts `10.0 percent` of available time for unplanned downtime (`160.5 thousand` illustrative minutes, leaving `1,444.6 thousand` running minutes), `15.0 percent` of running time for ramp speed loss across two cohort-week-6 lines (`216.7 thousand` illustrative minutes, leaving `1,227.9 thousand` gross earned minutes), and `7.0 percent` for rework and recuts at a `93.0 percent` first-pass yield (`85.9 thousand` illustrative minutes). [S06] [S10] [S11] Net deliverable capacity is `1,689.6 - 84.5 - 160.5 - 216.7 - 85.9 = 1,142.0 thousand` standard minutes (`47,583` illustrative first-pass good garments), exposing a deficit of `178.0 thousand` standard minutes (`7,417` garments) that a naive `85 percent` nameplate assumption (`1,436.2 thousand` minutes) would have hidden. [S42] [S1103] To close the gap objectively, commercial leadership agrees with the customer to phase `5,000` garments (`120.0 thousand` minutes) into the first week of the following month, maintenance and cutting commit to a pre-staging action plan projected to recover `30.0 thousand` minutes, and operations authorises `4` hours per week of pre-scheduled overtime at the statutory `1.2x` rate on the two mature lines for two weeks to supply the remaining `28.0 thousand` standard minutes. [R16] [S42]

The arithmetic from this worked example is visualised in **Exhibit 52**, p. 178, which reconciles gross scheduled operator time to net deliverable standard minutes across the five loss deductions.

EXHIBIT 52 / THOUSAND STANDARD MINUTES PER MONTH

Monthly S&OP reconciles nameplate time to deliverable family capacity



ILLUSTRATIVE [S03] [S06] [S11] [S42] Illustrative: worked arithmetic bridge for a four-line garment family (160 operators, 22 days, 480 minutes per shift = 1,689.6 thousand gross minutes), deducting planned huddles/drills/absence (-84.5), unplanned downtime (-160.5), ramp speed loss (-216.7) and rework loss (-85.9) to reach 1,142.0 thousand net deliverable standard minutes (47,583 garments at 24.0 SMV) against a 1,320.0 thousand standard-minute demand request. Demonstrates monthly S&OP reconciliation (S42) using SMV (S03), OEE components (S06) and ramp constraints (S11). Not an observed GFT factory result.

Exhibit 52, p. 178 makes the commercial and operational conversation objective. Instead of Sales accusing Operations of holding back capacity or Operations accusing Sales of selling impossible lead times, both functions inspect the same four deduction bars and decide which constraint can be moved within the planning window. [S42] [S44] What **Exhibit 52**, p. 178 cannot establish is whether raw fabric and trims will arrive on time for the 47,583 illustrative garments in the net deliverable plan; material readiness must be checked in parallel against supplier confirmation timestamps and warehouse inspection logs before a cutting order is released. [S42]

11.14

Escalation follows decision rights, not hierarchy for its own sake

A multi-tier review cadence works only when participants know which problems belong at their tier and when a problem must move upward. The United States Federal Data Strategy's *Data Governance Playbook* defines data governance as setting and enforcing priorities for managing and using data as a strategic asset, which requires explicit decision rights and accountable roles rather than informal consensus. [S22] At the same time, public-sector performance-management guidance from the United States Office of Personnel Management stresses that performance elements and

standards must be measurable, understandable, verifiable, equitable and achievable. [S45] Holding a sewing supervisor accountable for a missed daily output target when the cutting room delivered mis-numbered bundles or the main air compressor failed violates the achievability and equity standard. [S45]

11.15 DECISION RIGHTS MATCH THE BOUNDARY OF CONTROL

In the *Gestão & Produção* lean shop-floor case study, designing the visual management system required explicitly defining not only what visuals would be implemented, but also *who decides what to produce when there are scheduling or capacity conflicts.* [S1102] GFT formalises that principle across all four tiers of the factory management cadence in **Exhibit 53**, p. 179. Each forum is defined by its frequency, chair, governed inputs, permitted decisions, mandatory escalation triggers and verification rule.

EXHIBIT 53 / GOVERNANCE CHARTER SPECIFICATION

Every review forum has a fixed charter, input contract and decision boundary

Forum & tier	Cadence & duration	Chair & core roles	Governed inputs	Permitted decisions	Escalation & verification rule
Tier 1: Line shift huddle & hourly board	Daily shift start (10 to 12 min illustrative) + hourly check	Line supervisor; inline QC, line mechanic, bundle handler, operators	Prior-shift good output, FPY, station WIP, cause-coded stops, attendance	Rebalance stations, assign utility operator, adjust bundle pace, call mechanic	Escalate stops over 20 min or repeated defects to Tier 2; verify at next hourly check
Tier 2: Cross-line daily support check	Daily mid-morning (15 min illustrative)	Production manager; line supervisors, maintenance lead, QC lead, cutting lead	Active red/amber line escalations, cut-panel buffer, critical machine stops	Reallocate shared mechanics or floaters across lines, re-sequence cutting lots	Escalate systemic losses or over 1 shift delay to Tier 3; verify at next day Tier 2
Tier 3: Weekly plant loss & quality review	Weekly fixed day (60 min illustrative)	Plant director or operations manager; IE, QC, maintenance, HR, stores leads	7-day OEE components, defect Pareto, rework hours, skill matrix, overtime, energy/water	Charter A3/PDCA investigations, revise PM schedule, approve skill drills, close actions	Escalate family capacity deficits above 5% to Monthly S&OP; verify effect over 2 weeks
Tier 4: Monthly product-family S&OP	Monthly business day 12 (90 min illustrative)	General manager; commercial, operations, finance, HR, sustainability leads	Demonstrated family standard-minute capacity, OTIF, cost/good piece, 3 to 12 mo demand	Commit family order book, phase deliveries, approve shift/hiring plan and KPI targets	Escalate capital or policy changes to board; verify forecast vs actual at next S&OP

DERIVED [S04] [S05] [S08] [S22] [S42] [S43] [S44] Derived: combines daily supervisory line balancing (S04), baseline and KPI gap measurement (S05), systematic OEE improvement follow-up (S08), enforced governance decision rights (S22), monthly product-family S&OP (S42), post-completion benefit monitoring (S43) and S&OP maturity dimensions (S44) into a four-tier cadence charter. Meeting durations and numeric escalation triggers are illustrative GFT operating design parameters.

Exhibit 53, p. 179 eliminates ambiguity about where a decision lives. A line supervisor at Tier 1 has full authority to move a certified utility operator to Operation 09 or hold a defective bundle for inline repair, but cannot promise a customer a revised shipment

date or authorise cross-line overtime. [S04] [S45] Conversely, the general manager at Tier 4 commits the product-family order book and staffing plan, but does not override a quality inspector's defect classification on the sewing floor. [S22] [S42] Note that the numeric time thresholds in **Exhibit 53**, p. 179 (such as 10 to 12 minutes for a huddle or 20 minutes for a stop escalation) are illustrative GFT operating design parameters rather than universal constants; a plant must calibrate them to its physical layout and product mix.

11.16 ESCALATION INCLUDES A BOTTOM-UP CHALLENGE ROUTE FOR FLAWED STANDARDS

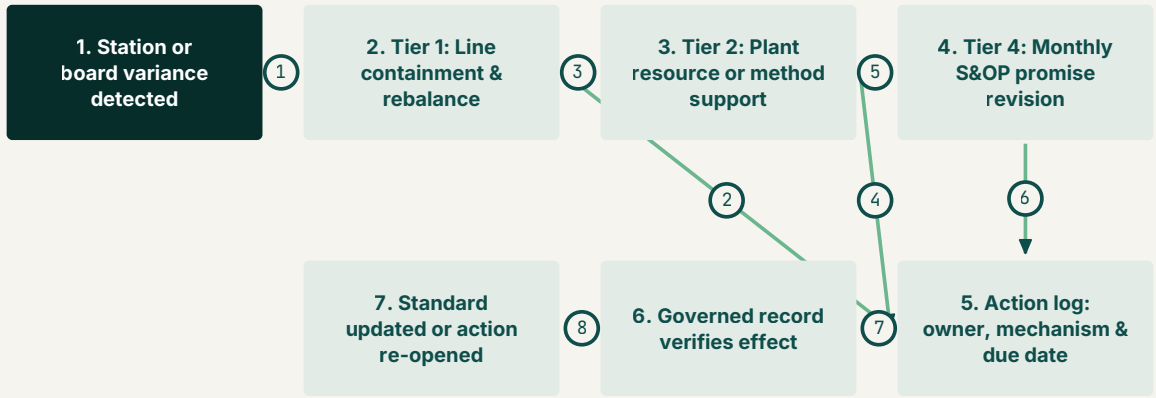
Escalation is not solely a mechanism for reporting shop-floor failures upward; it is equally a mechanism for frontline teams to challenge flawed assumptions imposed from above. A 2025 review of Balanced Scorecard implementation in *Encyclopedia* notes a fundamental criticism of rational, top-down strategy execution: it frequently fails to align with decentralised or adaptive organisational realities. [S46] In a greenfield garment factory, top-down distortion occurs whenever an initial SMV calculation omits a fabric-handling difficulty, whenever a marker-efficiency target forces cutting operators to include selvage flaws, or whenever an aggressive ramp target pressures operators into unsafe speed. [S03] [S17] [S46]

To prevent top-down distortion, GFT embeds a formal **standard-challenge trigger** into the escalation path. If a qualified operator following the specified method cannot achieve the provisional standard time, or if an inline inspector finds that a construction specification causes needle-hole damage on a specific fabric batch, the line supervisor logs a *Method or Standard Exception* at Tier 1 and escalates it to Industrial Engineering and Quality Assurance at Tier 2 and Tier 3. [S03] [S45] While that exception is under engineering review, the affected variance is coded to `Method/Standard Under Review` rather than operator performance loss, protecting workers from inequitable evaluation and ensuring that the data dictionary reflects physical reality. [S22] [S45]

The complete path from an observed variance at the station to a verified decision across the operational and commercial tiers is depicted in **Exhibit 54**, p. 181.

EXHIBIT 54 /

Escalation ends in a verified decision



1. Within line authority
2. Contained on shift
3. Stop over 20 min / cross-line
4. Resource or IE fix assigned
5. Family capacity deficit
6. Order or shift plan revised
7. Observation window elapsed
8. KPI & guardrails confirmed

ILLUSTRATIVE [S22] [S43] [S45] Illustrative: GFT variance-to-owner escalation sequence from station abnormality to Tier 1 line containment, Tier 2 plant resource support and Tier 3/4 commercial re-planning, with every branch converging on the persistent action log and mandatory post-action effect verification as required by data-governance decision rights (S22), equitable standards (S45) and post-completion benefit monitoring (S43).

As **Exhibit 54**, p. 181 illustrates, no escalation branch terminates merely because a manager has been informed or an instruction has been issued. Whether an exception is contained at Tier 1 through a station rebalance, resolved at Tier 2 by replacing a worn feed dog and updating the preventive maintenance checklist, or reconciled at Tier 4 by re-phasing a customer delivery schedule, the decision is written into the governed action log (Node 5), waits for the defined observation window to elapse, and is tested against the authoritative KPI record (Node 6) before closure (Node 7). [S22] [S43] A process flow diagram like **Exhibit 54**, p. 181 is an architectural design contract rather than empirical proof of compliance; whether the plant actually follows these edges without bypassing the verification step must be audited through the action log itself.

11.17

The action log is the memory between meetings

The most common failure in factory performance management is **meeting amnesia**: a problem is discussed earnestly in Tuesday's review, an informal verbal instruction is given, and by the following Tuesday either the instruction has been forgotten under

the pressure of new urgent orders, or the task was performed mechanically without checking whether the problem actually disappeared. [S08] [S41] The UK Department for Transport's *Benefits Management and Evaluation Framework* highlights a governance principle that applies directly to operational improvement: a management framework must ensure that expected benefits are actively owned, managed and monitored beyond the point of project or task completion. [S43] Similarly, Lean Enterprise Institute guidance on testing A3 problem solving stresses that reading an A3 backwards from follow-up to countermeasure, root cause and target condition allows owners and leaders to confirm a logical, fact-based thinking process. [S41]

11.18 EVERY RECORDED ACTION REQUIRES SEVEN MANDATORY FIELDS

To serve as the factory's institutional memory between daily, weekly and monthly forums, GFT treats the **Action Log** as a governed entity inside the system of record defined in Chapter 10. [S22] An item cannot be entered into the action log as a vague aspiration such as *"improve sewing quality on Line 2"* or *"reduce mechanic downtime"*. Every entry must populate seven structured fields:

1. **Action ID and originating forum:** Unique identifier (for example, `ACT-2026-0142`), date opened, and the forum tier (`Tier 1`, `Tier 2`, `Tier 3` or `Tier 4`) that commissioned it. [S22]
2. **Linked KPI, baseline value and source boundary:** The specific metric contract, line or family boundary, and dated baseline observation that triggered the action (for example, *"Line 2 Operation 09 waistband-attach defect rate at 6.4 percent illustrative across 1,250 inspected pieces in Week 14"*). [S01] [S05]
3. **Observed cause or tested hypothesis:** The specific downtime cause code, defect mechanism or capacity gap addressed, distinguishing confirmed physical faults from hypotheses under test. [S07] [S41]
4. **Specific intervention and single accountable owner:** One named role (never a committee or two shared departments) responsible for executing the change, together with the exact physical or procedural modification required. [S22] [S45]
5. **Expected causal mechanism and target movement:** A falsifiable statement of *how* the intervention will move the metric and by what approximate range, plus the guardrail metric that must not degrade (for example, *"Installing a folder guide and conducting a 30-minute operator drill should reduce Op 09 seam-margin defects below 2.0 percent illustrative without reducing hourly output below 60 pieces"*). [S02] [S41]
6. **Implementation due date and verification date:** Two separate dates: the date by which the physical change is installed on the line, and the later date (after a defined sample of shifts or bundles has run) on which its operating effect will be evaluated. [S43]
7. **Verification outcome and disposition:** Populated only from the authoritative KPI record on or after the verification date, recording `Verified & Standardised`, `Partially Effective (Follow-up Chartered)`, or `Ineffective (Re-opened for Root-Cause Diagnosis)`. [S41] [S43]

> **TASK COMPLETION IS NOT ACTION CLOSURE**
>
> A persistent governance failure in manufacturing review systems is allowing action owners to mark an item closed on the day a mechanic replaces a part, an engineer issues a revised work instruction, or a supervisor holds a briefing. [S08] [S43] In GFT's cadence rules, executing the task moves the action status only from `Open` to `Implemented: Awaiting Verification`. The action remains on the weekly review dashboard until the verification window closes and the governed operational record demonstrates that the target KPI moved in the expected direction while guardrail indicators remained intact. [S02] [S43] If a mechanic replaces a looper on Tuesday (`Implemented`), but the Thursday and Friday shift logs still show 18 illustrative minutes per shift of thread-break downtime on the same machine, the action automatically reverts to `Re-opened: Hypothesis Refuted` at the next review. Only verified operational improvement closes an action. [S41] [S43]

11.19

Meeting quality itself needs review

Because meetings consume supervisory and engineering hours, the management cadence must evaluate its own effectiveness with the same rigour it applies to sewing lines. In their evaluation model for sales and operations planning maturity published in *Production*, Grimson and Pyke's five-stage evolutionary framework is analysed across five distinct categories: **meetings and collaboration**, **organisational structure**, **measures of performance**, **information technology** and **integrated planning**. [S44] That research underscores two critical findings for a greenfield factory. First, maturity is multi-dimensional: a company can have advanced information-technology tools while remaining in a low-maturity zone on processes, meetings and collaboration. [S44] Second, gaining maturity is not automatically achieved by how many times a process cycle has been repeated on the calendar; it depends on deliberate effort and the willingness of participants to make the cross-functional process work. [S44]

11.20 FIVE DIAGNOSTIC INDICATORS MEASURE CADENCE HEALTH

To prevent daily huddles, weekly loss reviews and monthly S&OP from decaying into hollow rituals, GFT audits the cadence itself once a month (and comprehensively at the quarterly governance review) using five operational indicators derived directly from the action log and meeting attendance records: [S22] [S44]

- **Pre-meeting data readiness rate:** The percentage of scheduled reviews where the authoritative shift, weekly or monthly KPI pack passed completeness and validation checks before the meeting started. [S22] If participants spend the first twenty minutes of a weekly review debating whether Line 3's downtime log is missing Thursday's second shift, the data spine from Chapter 10 has failed its timeliness check.
- **Decision-to-discussion ratio and duration adherence:** The proportion of agenda items that conclude with a recorded, owned entry in the action log (or an explicit `No Action Required: Within Control Band` disposition) within the scheduled meeting duration. [S44] [S1102] A 10-minute huddle that runs for 28 illustrative minutes is a symptom of poor visual control preparation.

- **Escalation latency:** The elapsed time between the moment a threshold breach is recorded on a station or line board and the moment the responsible Tier 2, Tier 3 or Tier 4 owner logs an active containment or re-planning response. [S07] [S1102]
- **Action-log overdue and verification-pass rates:** Two paired percentages: the share of open actions past their implementation due date, and the share of implemented actions that pass their empirical verification check on the first attempt. [S41] [S43] A high implementation rate paired with a low verification-pass rate indicates that teams are guessing superficial countermeasures rather than diagnosing root causes, signalling a need for the structured A3 and SPC discipline covered in Chapter 12. [S41]
- **Problem recurrence rate within 30 days:** The proportion of `Verified & Closed` actions whose specific defect code or downtime cause re-emerges above threshold on the same line within an illustrative 30-day window, indicating that standardisation or preventive maintenance failed to hold. [S08] [S43]

> **GFT NOTE**
>
> Audit the cadence before buying a real-time executive dashboard. When a factory's weekly review suffers from unowned actions, missing root-cause codes or unresolved sales-versus-operations conflicts, installing wall-mounted digital screens or predictive analytics software only displays the dysfunction at higher resolution. [S27] [S44] In GFT's maturity gates (developed in Chapter 13) and the companion `maturity` and `kpi-cascade` interactive tools, a plant must demonstrate at least two consecutive months of disciplined daily huddles, weekly Pareto closure and monthly product-family S&OP reconciliation using its governed baseline records before approving capital expenditure for automated shop-floor analytics. [S28] [S44]

11.21 THE CADENCE PREPARES THE FLOOR FOR STRUCTURED IMPROVEMENT AND MATURITY GATES

By installing a fixed daily, weekly and monthly cadence from the first quarter of operation, a greenfield garment factory closes the loop between the data spine of Chapter 10 and the physical sewing line. Every measure in the six-family scorecard has a home: hourly and shift flow indicators live on the line board and in the daily huddle, multi-line loss patterns and working-time guardrails live in the weekly plant review, and aggregate demand-to-capacity trade-offs live in monthly product-family S&OP. [S02] [S04] [S42] Crucially, when the weekly review or the action-log audit reveals that a recurring defect or availability loss does not yield to routine supervisory contain-

ment, the cadence does not leave the floor to guess. It hands a clearly bounded, dated problem statement to the factory's formal corrective-action and standardisation loop, which is the subject of Chapter 12. [S05] [S41]

A measure without a calendar is only an observation; a calendar with decision rights and verification turns observation into control.

CHAPTER SOURCE NOTES

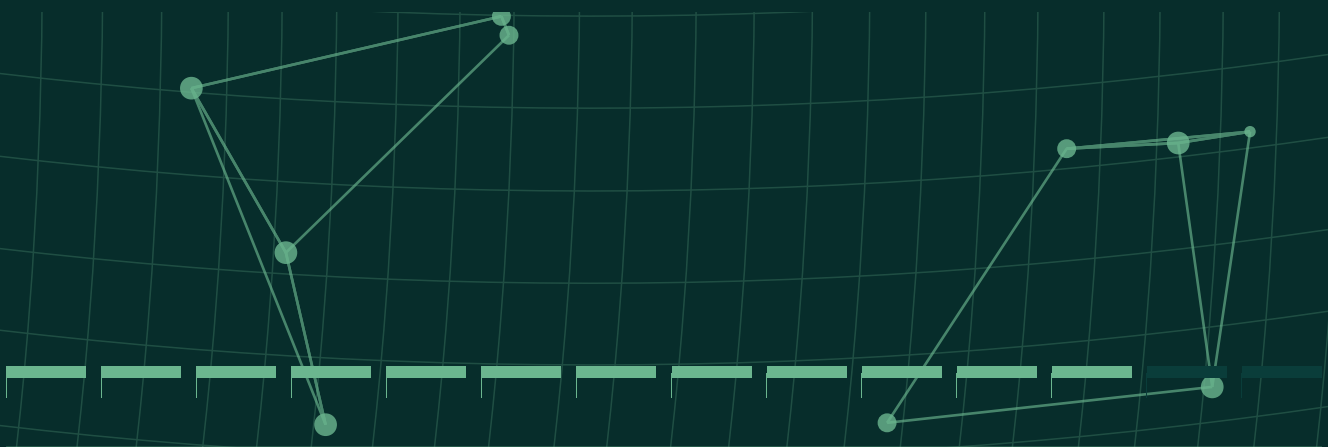
S02 International Labour Organization. 2017-01-01.
S22 United States Federal Data Strategy. 2020-01-01.
S04 International Labour Organization. 2023-01-01.
S08 International Journal of Productivity and Quality Management, Inderscience. 2020-05-11.
S42 Production, SciELO. 2017-01-01.
S43 UK Department for Transport. 2025-01-01.
S44 Production, SciELO. 2017-11-27.
S1103 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2023-10-17.
S1102 Gestão & Produção, SciELO. 2025-04-14.
S01 International Organization for Standardization. 2014-01-01.
S14 IFC and ILO, Better Work. 2025-01-01.
S07 Scientific Reports, Springer Nature. 2025-01-01.
S13 International Finance Corporation. 2009-01-01.
S05 International Labour Organization. 2022-06-01.
S1101 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2026-05-02.
S18 ILO and IFC, Better Work. 2011-01-01.
S03 International Labour Organization. 2023-01-01.
S10 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04.
S11 International Journal of Production Economics, Elsevier. 2001-01-01.
S45 United States Office of Personnel Management. 2019-11-04.
S40 NIST/SEMATECH. 2003-01-01.
S09 NIST/SEMATECH. 2003-01-01.
S06 Diamond Congress, Creative Construction Conference. 2023-01-01.
S12 Applied Sciences, MDPI. 2021-11-23.
R14 WageIndicator. Publication date unrecorded; inherited source-text check.
R16 WageIndicator. Publication date unrecorded; inherited source-text check.
S41 Lean Enterprise Institute. 2022-08-10.
R06 Cameroon Trade Hub. Publication date unrecorded; inherited source-text check.
R07 Ecofin Agency. Publication date unrecorded; inherited source-text check.
R12 Business in Cameroon. Publication date unrecorded; inherited source-text check.
S46 Encyclopedia, MDPI. 2025-03-19.
S17 ILO and IFC, Better Work. 2018-12-20.
S27 Google for Developers. 2025-08-25.
S28 Google Cloud. 2024-08-28.

12

PART III: TURN RECORDS INTO DECISIONS / FROM SIGNAL TO STANDARD

Improvement closes only when the cause and result are verified

A corrective-action system should distinguish abnormal variation, test causes, verify effects and update standard work rather than count completed actions.



CHAPTER 12
DECISION TEST

A corrective-action system should distinguish abnormal variation, test causes, verify effects and update standard work rather than count completed actions.

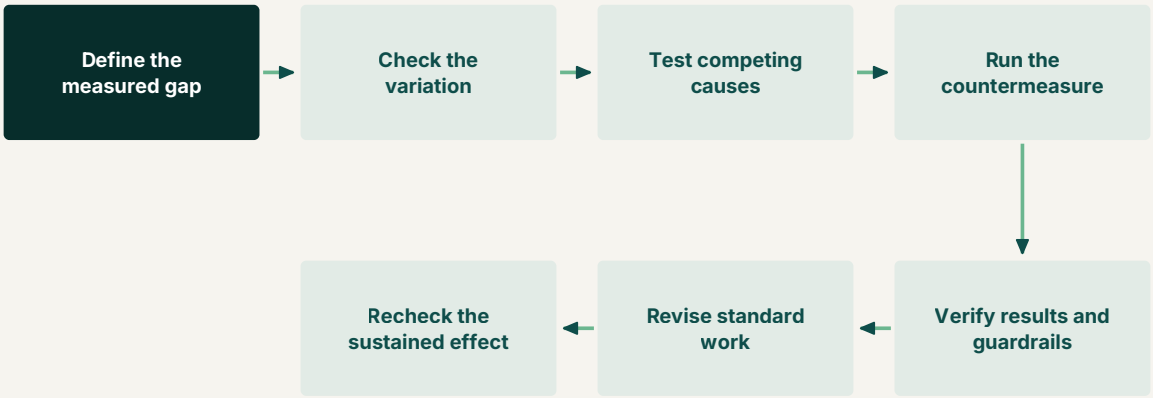
An operational improvement closes only when two propositions survive empirical inspection: first, that discriminating evidence supports the selected root cause against competing explanations, and second, that a comparable production population demonstrates the expected gain without degrading a safety, quality, delivery or working-time guardrail. [S02] [S41] [S43] Completing an action item, holding a briefing, replacing a sewing attachment or issuing a revised form is an administrative output, not a verified operating result. [S08] [S43] In GFT's performance-management architecture for a greenfield cut, make, trim and finishing plant, corrective action forms a closed engineering loop linking a measured baseline gap through variation checks, competing causal hypotheses, controlled trials and post-completion benefit audits to released standard work. [S05] [S09] [S41] [S43] Where any link in that chain remains untested, the item stays open in the governance register regardless of whether a scheduled completion date has passed. [S22] [S43]

This distinction between activity completion and verified effect determines whether the management cadence in Chapter 11 compounds learning or recycles tasks. Reviews of Overall Equipment Effectiveness (OEE) implementations highlight a lack of systematic frameworks that translate loss measurement into sustained improvement steps. [S08] In garment factories, that gap often appears as action-log theatre: huddles and reviews generate task lists, supervisors mark tasks complete once a mechanic adjusts a machine or a trainer speaks to an operator, and the same defects or delays return weeks later. [S04] [S08] [S41] In Cameroon, where as of the 31 January 2024 programme cut-off about 95 percent of cotton fibre is exported raw against about 5 percent processed locally, and where policy targets 50 percent local processing by 2030, a new plant cannot waste engineering capacity on unverified fixes. [R06] [R07] Ramp-up research shows that a new process starts poorly understood, with low yields and rates while teams learn the work. [S11] Treating unverified adjustments as closed improvements corrupts institutional memory and pollutes the dataset needed before predictive models are considered at later maturity gates. [S11] [S27]

Exhibit 55, p. 188 defines the seven-stage verification sequence embedded in the factory's system of record. Rather than moving linearly from a report to a closed ticket, the loop places gates after variation analysis, hypothesis testing, countermeasure execution and standardisation. [S05] [S09] [S41] [S43] When a trial fails to move the primary indicator or breaches a guardrail, the workflow routes the team back to competing causal evidence. [S41] [S1206]

EXHIBIT 55 /

The improvement loop ends at a revised standard



DERIVED [S05] [S09] [S41] [S43] Derived GFT workflow sequence. S05 supports baseline gap identification and KPI change measurement, S09 supports statistical comparison with prior process behaviour, S41 supports inspectable A3 logic and reverse follow-up, and S43 supports benefit monitoring beyond intervention completion. No factory operating effect is asserted.

Exhibit 55, p. 188 establishes that standardisation follows result verification, and final closure follows a sustained-effect audit across later shifts. [S41] [S43] What **Exhibit 55**, p. 188 cannot establish by itself is whether the data entering the first node are accurate, whether the sample size can detect the shift, or whether supervisors possess the coaching skill to maintain the revised method; those requirements are enforced through the measurement, statistical and training controls below. [S14] [S24] [S40]

12.1

Problem selection begins with a measurable gap

The first decision in a corrective-action system is not which diagram to draw, but which gap merits scarce engineering, maintenance and supervisory time. [S05] [S22] In the International Labour Organization's (ILO) Sustaining Competitive and Responsible Enterprises (SCORE) programme in Ethiopia's garment sector, improvement begins at step zero with a baseline assessment to identify gaps and opportunities, and tracks change through Key Performance Indicators (KPIs). [S05] GFT applies this baseline-first rule at the boundary where loss occurs. [S01] [S05] A valid charter specifies the line, station or operation code, style or family, method revision, window and metric contract from Chapter 4, retaining both numerator and denominator behind every rate. [S01] [S03] [S1203]

12.2 OPERATIONAL PROBLEM STATEMENTS BIND THE LOSS TO A RECORDED BOUNDARY

An actionable problem statement describes an observable deficit in a governed record rather than a wish for better performance or a premature guess at the cure. [S01] [S41] Stating that first-pass yield at end-of-line inspection on a woven-shirt

cohort fell below its threshold across five shifts, with most nonconformities coded to collar-topstitch puckering at a named operation, gives the team a clear starting point. [S06] [S10] [S1203] Stating that quality is poor or that operators need retraining fails to locate the loss boundary and embeds an untested assumption inside the definition. [S41]

To serve as a baseline, the historical record must represent a defined population rather than a single shift tile. [S05] [S09] It retains the source rows, inclusion rules, boundary and data-quality qualifications behind the indicator. [S23] [S24] During ramp-up, when the process is poorly understood and yields move as operators learn, the cohort stays narrow enough to avoid pooling early learning shifts with stabilised work. [S11] During steady runs, a multi-week window gives a stronger estimate of variation. [S09] [S1207] Before approval, the data steward confirms that an apparent drop was not created by a routing change, modified bundle count or revised defect rule. [S22] [S25] [S40]

12.3 MULTI-FAMILY TRIAGE PREVENTS DATA CONVENIENCE FROM SETTING THE AGENDA

A greenfield plant generates more variances than its engineers can investigate at once. Left to informal choice, teams pick whichever metrics are easiest to chart rather than the losses constraining factory survival. [S02] [S22] Garment lean guidance calls for balancing financial, behavioural and core-process metrics while combining in-process and end-of-process indicators. [S02] GFT translates that balance into a triage filter across its six KPI families:

1. **Production and flow impact:** How many first-pass good garments or standard minutes are lost per shift, and does the loss sit at the bottleneck governing line throughput? [S03] [S06] [S10]
2. **Quality and rework burden:** How many rework minutes or scrapped panels does the fault generate, noting that NIST Manufacturing Extension Partnership case evidence links first-pass yield gains from 10 percent to 90 percent with processing-time reductions from 11.8 hours to 3.4 hours? [S10]
3. **Delivery exposure:** Does the variance threaten on-time-in-full (OTIF) promises or inflate work-in-progress (WIP) age across product families in monthly Sales and Operations Planning (S&OP)? [S42]
4. **People and working-time risk:** Does the condition expose workers to strain, needle injury, inequitable penalties or excessive overtime, which Better Work research links to poorer health, reduced efficiency, accidents and turnover? [S17] [S18] [S45]
5. **Resource intensity:** Does the fault raise electricity, steam, water or fabric waste per good garment within the site boundary? [S30] [S36]

Before authorising a project, the weekly chair asks four questions. [S08] [S22] Is the gap material to a strategic outcome or an immediate safety duty? [S02] [S18] Is the baseline population bounded, complete and free of measurement distortion? [S24] [S40] Does an accountable role hold authority to change the candidate method, machine, material or staffing condition? [S22] Can the primary indicator and its guardrails be observed within a reviewable window? [S02] [S43] If any answer is no, the first task is repairing the definition or measurement contract. [S24] [S40]

GFT NOTE

GFT refuses to open a corrective-action charter on a red dashboard tile alone. [S02] [S08] Every charter records seven elements: quantified gap, process boundary, dated baseline population, suspected mechanism, accountable owner, primary verification KPI and guardrails. [S01] [S05] [S43] Urgent containment, such as quarantining a fabric lot or adding temporary 100 percent inspection, is logged separately with an expiry date so sorting never masquerades as a verified cure. [S41] [S1202]

12.4

Common and special causes require different responses

Once a measurable gap is confirmed, the team must characterise the variation behind it before intervening on the line. [S09] [S1201] NIST's statistical process control (SPC) guidance states that process control compares what is happening today with what happened previously, using historical data to establish stable process behaviour. [S09] Separating chance (common-cause) variation built into the system from assignable (special-cause) variation triggered by a specific disturbance prevents two costly mistakes: tampering with a stable station after routine random movement, or treating a sudden machine or material fault as if it required a plant-wide retraining campaign. [S09] [S1201]

12.5 CONTROL LIMITS, CUSTOMER SPECIFICATIONS AND MANAGEMENT TARGETS SERVE DISTINCT DECISIONS

A frequent error in factory reporting is plotting a customer tolerance or management target on a chart and treating every shift below that line as an assignable event. [S09] [S1207] Three boundaries must stay separate:

- **Control limits** (upper control limit, UCL, and lower control limit, LCL) are calculated from historical mean and variability so nearly all observations fall within the limits while the process remains in control under chance causes. [S1201]
- **Specification limits** state customer or engineering tolerances for garments or lots; NIST defines process capability as comparing an in-control process against specification limits via indices such as C_p and C_{pk}, requiring an in-control process and a sample size of about 50 independent values. [S1207]
- **Management targets** state planning milestones; public-sector standards require targets to be measurable, understandable, verifiable, equitable and achievable. [S45]

Keeping these boundaries distinct guides action. [S09] [S1207] When a shift's defect rate or cycle time breaches a control limit, NIST guidance states that the process is probably out of control and warrants investigation to eliminate the assignable cause. [S1201] Typical special causes include a damaged rotary hook, a wrong needle size fitted after a break, an air-pressure drop at a fusing press, or an unshaded fabric roll. [S07] [S1202] Out-of-Control Action Plans (OCAPs) detail the diagnostic flowchart and containment procedure followed when a signal occurs. [S1202] Removing a special cause restores the prior baseline; it does not improve that baseline beyond its earlier capability. [S09] [S1201]

Conversely, a line can stay inside control limits while first-pass yield sits below target or seam variation exceeds specification. [S1201] [S1207] There, no single hour or operator is an outlier; the loss is a common-cause property of work allocation, folder design, lighting, skill drills or material presentation. [S03] [S04] [S12] Demanding explanations for routine noise inside control limits is tampering. Improving a stable but incapable process requires a system change tested through a controlled trial. [S09] [S1207]

12.6 ATTRIBUTE CHARTS AND SUPPLEMENTARY RUN RULES REQUIRE SAMPLE-SIZE AND FALSE-ALARM DISCIPLINE

Because garment logs track the fraction of nonconforming garments across bundles or shifts, teams use attribute proportion charts (p-charts). [S1203] NIST defines the proportion nonconforming as the ratio of nonconforming items (D) to total items (n), modelled under a binomial distribution with mean p and variance $p(1-p)/n$ when units are independent and the process is stable. [S1203] Two rules follow. First, because limit width depends on $\sqrt{p(1-p)/n}$, comparing shifts with different denominators (n) without adjusting limits creates false flags on small shifts. [S1203] Second, when rework loops violate independence or ramp-up learning shifts p daily, classic 3-sigma binomial limits serve only as approximate guides. [S11] [S1203]

Engineers must also manage false alarms when choosing signalling rules. [S1201] [S1205] Under a normal distribution, 3-sigma limits correspond to a one-sided probability of 0.00135, or 0.0027 in both directions, giving low risk of chasing nonexistent assignable causes. [S1201] NIST notes that a chart is in control only when all points lie within the limits and form a random pattern, since systematic runs (such as 25 of 30 points above the centre line) indicate a shift even inside the limits. [S1201] However, NIST warns that while 3-sigma limits produce a false alarm once every 371 points on average, adding Western Electric Company (WECO) run rules increases false alarms to about once every 91.75 points on average. [S1205] Across dozens of station metrics, false alarms every 91.75 points would swamp engineers. [S1205] GFT reserves supplementary run rules for bottleneck or safety measures and preserves old limits beside any recalculated baseline. [S09] [S1205]

12.7

A3 makes the reasoning inspectable

When a gap requires structured problem solving rather than routine OCAP containment, GFT uses the A3 format as an evidence contract. [S41] [S1202] Its value lies in making every inference between the observed loss and the revised standard open to challenge. [S41] The Lean Enterprise Institute recommends reading an A3 in reverse, starting from follow-up and standardisation and moving backwards through countermeasures, root causes, target condition and current condition, so owners and leaders confirm a logical, fact-based process. [S41]

12.8 REVERSE READING TESTS WHETHER EACH LINK EARNS THE NEXT

Reading backwards defeats the habit of pasting a pre-selected solution onto a thin problem statement. [S41] When reviewing a draft A3 in reverse, six questions must be answered from governed records:

1. **From follow-up back to standardisation:** Does the ongoing check monitor the exact method and parameter standardised, on a fixed cadence with an owner, rather than assuming a briefing holds forever? [S41] [S43]
2. **From standardisation back to verified result:** Were the operation breakdown, skill matrix and metric contract updated only after the trial proved a gain in a comparable population without guardrail loss? [S03] [S12] [S43]
3. **From verified result back to execution:** Does the log prove the countermeasure was installed as specified, and does the gain's timing match its physical mechanism rather than a shift in style mix, volume or staffing? [S41] [S43] [S1208]
4. **From countermeasure back to root-cause evidence:** Does the countermeasure alter a factor that survived discriminating tests against rival material, machine, method, measurement, staffing and environmental hypotheses? [S24] [S40] [S41]
5. **From root-cause evidence back to target and variation:** Did the diagnosis match the variation structure (special versus common cause) and the target mechanism? [S09] [S41] [S1201]
6. **From target back to current condition:** Is the target expressed in the same counting event, boundary, unit and denominator as the baseline statement? [S01] [S05] [S41]

Exhibit 56, p. 193 turns this reverse check into the six-link closure register in the plant's action spine. [S05] [S09] [S24] [S40] [S41] [S43]

EXHIBIT 56 /

Each improvement link has its own evidence and closure test

A3 link	Required source record	Reverse verification test	Gate owner
1. Current condition	Dated baseline cohort, boundary and denominator rows	Is the gap reproducible and free of coding breaks?	Data steward
2. Variation and target	Control chart or run sequence with target mechanism	Does the study match special or common cause behaviour?	Quality or IE lead
3. Root-cause proof	Hypothesis matrix, gauge check and discriminating test	Did evidence eliminate rival explanations?	Investigation owner
4. Countermeasure trial	Pilot release log, affected stations and guardrail list	Was the physical or rule change executed as designed?	Line or maintenance lead
5. Effect verification	Before, after and comparison bridge with audit adjustments	Did net benefit hold without a guardrail deterioration?	Plant review chair
6. Standard and sustain	Method revision, skill sign-off and 30-day sustain check	Can the next shift repeat the gain without extra support?	Operations manager

DERIVED [S05] [S09] [S24] [S40] [S41] [S43] Derived GFT governance register combining baseline gap measurement (S05), historical SPC comparison (S09), data-quality fitness (S24), measurement-system error analysis (S40), reverse A3 logic verification (S41) and post-completion benefits monitoring (S43). Contains governance criteria only, not factory operating results.

Exhibit 56, p. 193 stops an investigation from jumping from link 1 to link 6 when a supervisor says operators were told to be careful. [S41] Each row requires a recorded artefact and a gate owner before advancing. [S22] [S41] What **Exhibit 56**, p. 193 cannot do is generate hypotheses or observe the floor; a team can still fill a table with weak claims unless leadership checks the underlying evidence at the weekly review. [S08] [S41]

12.9 RETAINING FALSIFIED HYPOTHESES PROTECTS INSTITUTIONAL MEMORY

Scientific problem solving in a greenfield plant requires keeping negative results. [S11] [S41] When an A3 team tests whether needle heating causes thread breakage on heavy twill, measures needle temperature across speeds, and finds breakage unchanged while cone-unwinding tension explains the fault, both the falsified heating test and the confirmed tension test remain in the record. [S23] [S41] Deleting rejected hypotheses to make the A3 look tidy destroys half its learning value and forces later teams to repeat dead-end trials. [S11] [S25] [S41]

12.10

Root causes compete until evidence discriminates

Where discipline is weak, root-cause analysis becomes an opinion poll: one voice blames operator care, the mechanic blames fabric, and the supervisor blames cutting. [S07] [S41] GFT replaces anecdote with competing hypotheses across six families: material, method, machine, measurement, staffing and environment. [S03] [S24] [S40] None is accepted until an observable prediction discriminates between it and its rivals. [S41] [S1208]

12.11 DATA FITNESS AND GAUGE ERROR MUST BE TESTED BEFORE ALTERING THE PHYSICAL LINE

Before changing a machine, sequence or training plan, the team tests whether the apparent problem is an artefact of measurement or recording. [S24] [S40] [S1204] NIST's characterisation guidance states that a measurement process is a production process in which measurements are the output, quantified by bias, short-term precision, day-to-day variability and uncertainty. [S1204] NIST's Gauge R&R guidance outlines how to characterise repeatability and reproducibility errors in production instruments. [S40] Alongside this, the UK Government Data Quality Framework defines six core dimensions (completeness, validity, consistency, timeliness, uniqueness and accuracy) for structured records. [S23] [S24]

On a garment floor, measurement error comes from digital logs and human grading:

- **Record completeness and identity joins:** An apparent drop in efficiency or yield can stem from missing scans at handover, duplicate rework tickets, or an updated style SMV applied to half a batch. [S01] [S23] [S24] The data steward checks the six quality dimensions before physical troubleshooting begins. [S24]
- **Inspector repeatability and reproducibility:** Visual grading is vulnerable to drift. Programme evidence notes that manual defect inspection achieves 60 to 70 percent accuracy, missing 20 to 30 percent of defects. [R29] If day and afternoon inspectors interpret a puckering sample differently, the defect log shifts even when sewing quality is unchanged. [R29] [S40]

Whenever a signal depends on visual grading, manual counts or meter reads, GFT requires a measurement check inside link 3 of the A3. [S40] [S41] Two or three inspectors independently classify an illustrative blind set of 20 to 30 garments twice against the reference sample to verify repeatability and agreement. [S40] [S1204] If grading disagreement explains the shift, the countermeasure is calibrating the inspection standard and lighting, not altering the station. [S40] [S1204]

12.12 DISCRIMINATING PREDICTIONS AND BLOCKED TRIALS SEPARATE CONFOUNDED FACTORS

Once data and grading stability are confirmed, physical and organisational hypotheses compete through discriminating predictions. [S41] [S1208] Because OEE and summary defect logs merge events, high-level KPIs rarely isolate a specific mechanism alone. [S07] Engineers stratify the event log and run short tests where rival hypotheses predict opposite outcomes. [S07] [S1208]

On the floor, fabric lots, machines and operators often change together, confounding observation. [S11] [S1208] NIST's Design of Experiments (DOE) glossary defines blocking as scheduling treatment combinations so effects from known changes in materials, operators or machines are concentrated in the blocking variable, isolating nuisance effects. [S1208] Blocked trials on a sewing line are fast: two qualified operators sew bundles from Lot A and Lot B on one calibrated machine, or one lot runs across two feed-dog settings while holding operator and method constant. [S03] [S1208]

Exhibit 57, p. 195 shows how a team scores five competing hypotheses against four evidence checks during an illustrative collar-puckering investigation. [S07] [S24] [S40] [S1208]

EXHIBIT 57 / ILLUSTRATIVE EVIDENCE CONSISTENCY SCORE (0 TO 5 SCALE)

Competing root causes are scored against discriminating evidence tests

	Data log check	Gauge agreement	Lot stratification	Blocked line test
H1: Inspector grading drift	3	1	0	0
H2: Missing shift scan rows	0	3	0	0
H3: Presser-foot pressure high	4	4	2	2
H4: High-shrinkage interlining lot	4	4	5	5
H5: Operator handling sequence	3	4	1	1

Cell scale: 0 to 5

ILLUSTRATIVE [S07] [S24] [S40] [S1208] Illustrative diagnostic scoring matrix for a seam-puckering investigation. Scale runs from 0 (contradicted by evidence) to 5 (fully consistent with discriminating test). S07 supports event-level disaggregation, S24 supports data-record checks, S40 supports gauge/observer repeatability studies, and S1208 supports blocked comparison across materials, machines and operators. Scores are illustrative method examples, not GFT factory measurements.

In **Exhibit 57**, p. 195, an illustrative score of 0 means the check contradicts the hypothesis, while 5 means it survives a discriminating test. [S41] [S1208] The log check (0 for H2) and blind inspector check (1 for H1) rule out recording and grading errors. [S24] [S40] Lot stratification shows the spike concentrated in one interlining lot (5 for H4), and a blocked trial across presser-foot settings confirms that the interlining lot drives the fault while foot pressure acts only as a secondary amplifier (5 for H4, 2 for H3). [S07] [S1208] What **Exhibit 57**, p. 195 cannot prove alone is sample adequacy; the record must attach the actual bundle counts and test logs. [S1203] [S1207]

12.13

Countermeasures need an operational owner

A verified cause improves performance only when an accountable role changes the condition producing the loss. [S08] [S22] The OEE review's call for systematic improvement steps after measurement is an ownership requirement: action lists stall when tasks sit with committees or supervisors who lack authority to alter engineering or purchasing rules. [S08] [S22]

12.14 DECISION RIGHTS ALIGN THE COUNTERMEASURE WITH FUNCTIONAL AUTHORITY

Grounded in data-governance principles enforcing decision rights and accountable roles, GFT assigns countermeasure ownership by authority over the mechanism changed: [S22]

- **Method, tooling and work content:** Industrial engineering owns changes to sequences, guides or time allowances, because SMV assumes qualified workers following a specified method. [S03]
- **Station allocation and balancing:** The line supervisor owns station rebalancing and floater deployment during production. [S04]
- **Machine parameters and maintenance:** The maintenance lead owns feed timing, tension calibration, air pressure and lubrication under OCAP rules. [S08] [S1202]
- **Material specification and containment:** Technical quality and material planning jointly own fabric relaxation, fusing rules and roll acceptance. [S02] [S42]
- **Skill drills and coaching:** Training and operations leads own operator drills and supervisor shadowing, reflecting evidence that drills maintain sewing skills and supervisor training requires six to eight weeks of line shadowing. [S12] [S13] [S14]

METHOD

GFT countermeasure charter and pilot containment protocol

Before releasing a non-trivial countermeasure to a line, the owner records a five-part trial specification:

1. **Causal mechanism:** State the physical or rule change (input X), the work event altered (mechanism M), and the primary KPI expected to move (output Y), using the metric contract formula and unit. [S01] [S41]
2. **Pilot boundary and blocking:** Define the pilot line, station, style cohort, window and sample size, plus the comparison line or blocked window controlling for volume or mix drift. [S09] [S1207] [S1208]
3. **Implementation check:** Specify how day-one execution of the attachment, setting or method is verified on the station before counting output. [S03] [S41]
4. **Cross-family guardrails:** List indicators in adjacent families (first-pass yield, WIP age, overtime or energy intensity) that must not degrade, with an abort rule for safety or quality breaches. [S02] [S18] [S1206]
5. **Verification review date:** Fix the weekly or monthly forum date to audit the before-and-after population and comparison bridge. [S42] [S43]

12.15 MULTI-CHARACTERISTIC GUARDRAILS BLOCK LOSS TRANSFER TO WORKERS OR DOWNSTREAM STATIONS

NIST's process-improvement guidance notes that a process seldom has just one desirable output characteristic; several interrelated characteristics exist such that improving one can degrade another, such as rate versus consistency. [S1206] On a garment line, raising speed at one station can increase defects, flood downstream stations, break needles or encourage skipping ergonomic steps. [S02] [S10] [S18]

Apparel compensation and working-time evidence shows why behavioural and health guardrails are essential. [S16] [S17] [S18] While higher base pay led workers in one apparel study to focus on reducing defects and tardiness, Better Work research found partial piece-rate pay associated with poorer emotional and physical health than hourly pay, and showed that excessive overtime leads to poorer health, reduced efficiency, accidents and turnover. [S16] [S17] [S18] GFT prohibits counting any countermeasure as a verified improvement if its gain came from extending hours beyond the legal and programme guardrail (such as Cameroon's 40-hour standard week, 48-hour maximum and 1.2 overtime rate in the inherited register), increasing strain or hiding rework. [R16] [S10] [S18]

12.16

Verification tests effect and unintended consequences

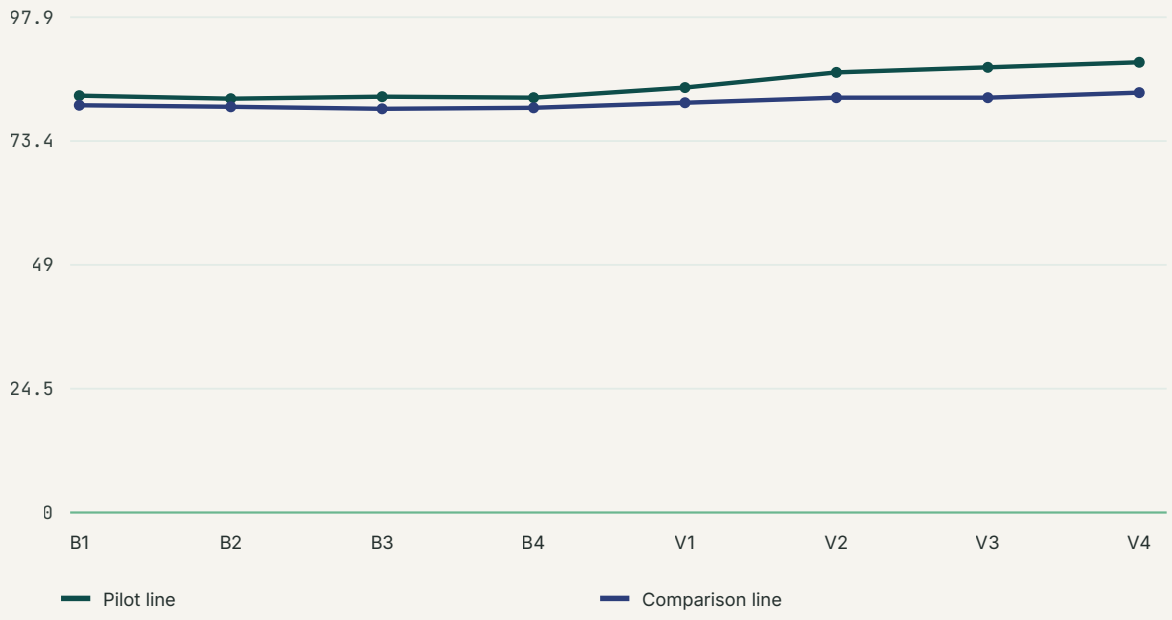
Once a trial finishes its window, the action log moves from implementation to verification. [S41] [S43] The UK Department for Transport's Benefits Management and Evaluation Framework requires benefits to be managed and monitored beyond project completion and separates baseline tracking from evaluating attribution. [S43] GFT applies this rule on the floor: installing a guide or rebalancing a line is completion, whereas proving net improvement in first-pass yield or output is benefit realisation. [S08] [S43]

12.17 DIFFERENCE-IN-DIFFERENCES AND BLOCKED COMPARISONS ISOLATE SHARED TREND DRIFT

During ramp-up, a simple before-and-after comparison on one line is easily confounded by operator learning curves or changing style complexity. [S03] [S11] [S43] To separate the countermeasure's effect from shared plant trends, GFT pairs the pilot line's before-and-after record with a matched comparison line or blocked cohort running the same style family over the same calendar intervals. [S09] [S43] [S1208] **Exhibit 58**, p. 198 shows an illustrative eight-interval sequence across four baseline windows (B1 to B4) and four verification windows (V1 to V4). [S09] [S43]

EXHIBIT 58 / ILLUSTRATIVE PERCENT FIRST-PASS GOOD

A before-and-after claim needs comparable populations



ILLUSTRATIVE [S09] [S43] Illustrative verification model across four baseline windows (B1 to B4) and four post-countermeasure windows (V1 to V4). Pilot line values are 82.4, 81.8, 82.2, 82.0, 84.0, 87.0, 88.0 and 89.0 percent. Comparison line values are 80.5, 80.2, 79.8, 80.0, 81.0, 82.0, 82.0 and 83.0 percent. S09 supports comparison against historical process behaviour and S43 supports post-completion benefit monitoring and attribution analysis. Values are illustrative and do not represent a GFT factory result.

In **Exhibit 58**, p. 198, both lines run parallel during B1 to B4 near 82.0 percent and 80.0 percent. [S09] After the intervention between B4 and V1, the illustrative pilot rises from 82.0 percent to 89.0 percent (a 7.0-point gross move), while the untreated comparison line rises from 80.0 percent to 83.0 percent (a 3.0-point move from shared learning). [S11] [S43] Deducting the 3.0-point shared trend leaves an illustrative 4.0-point difference-in-differences contrast before audit corrections. [S43] What **Exhibit 58**, p. 198 cannot prove alone is identical style or grading discipline across V1 to V4; analysts must still check the inspection and routing logs. [S24] [S40]

WORKED EXAMPLE: SEPARATE MOVEMENT FROM VERIFIED BENEFIT

Consider an illustrative line testing a fusing and collar countermeasure. In baseline window B4, the pilot inspects 10,000 shirts and logs 1,800 needing rework (82.0 percent first-pass yield). In verification window V4, it inspects 10,000 shirts and logs 1,100 needing rework (89.0 percent first-pass yield). Over the same windows, an illustrative matched comparison line moves from 2,000 reworked shirts per 10,000 (80.0 percent) to 1,700 per 10,000 (83.0 percent). Each collar rework loop consumes an illustrative 6.0 standard minutes. All values are illustrative method inputs, not GFT operating results.

The review analyst reconciles gross movement to net verified benefit in three steps:

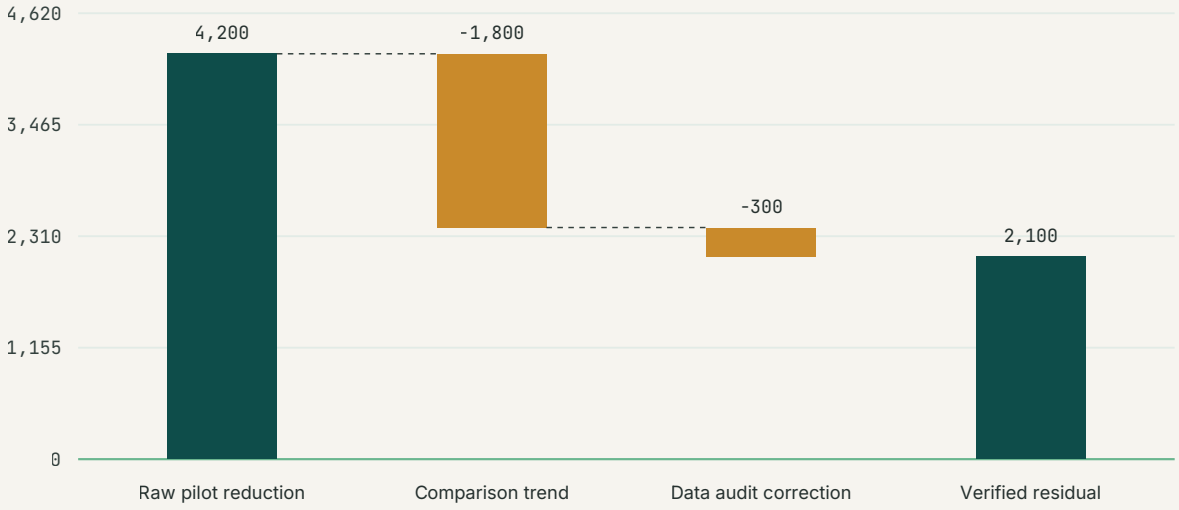
1. **Gross pilot reduction:** In this illustrative calculation, reworked units fell by $1,800 - 1,100 = 700$ pieces, saving $700 \times 6.0 = 4,200$ gross rework minutes. [S10] [S43]
2. **Comparison trend deduction:** The untreated illustrative comparison line fell by $2,000 - 1,700 = 300$ rework pieces, or $300 \times 6.0 = 1,800$ illustrative minutes from shared learning, leaving $4,200 - 1,800 = 2,400$ minutes. [S11] [S43]
3. **Data audit correction:** Reconciling inline tallies against finishing receipts uncovers 50 illustrative repaired shirts on the pilot line in V4 omitted at shift change, deducting $50 \times 6.0 = 300$ illustrative minutes. [S24] [S43]

The conservative illustrative verified residual is $4,200 - 1,800 - 300 = 2,100$ avoided rework minutes per 10,000 shirts (350 net pieces, or 3.5 percentage points). [S43]

Exhibit 59, p. 200 displays this reconciliation as a waterfall bridge so leadership sees both raw movement and attribution deductions. [S24] [S43]

EXHIBIT 59 / ILLUSTRATIVE REWORK MINUTES PER 10,000 PIECES

Verified benefit reconciles gross movement to operating effect



ILLUSTRATIVE [S43] Illustrative reconciliation bridge from the worked example. Opening gross reduction on the pilot line is 700 pieces x 6 minutes = 4,200 minutes. Deducting comparison-line learning movement (300 pieces x 6 minutes = -1,800 minutes) and omitted rework tickets found in the data audit (50 pieces x 6 minutes = -300 minutes) yields an adjusted net operating benefit of 2,100 minutes. S43 supports benefit monitoring and attribution discipline beyond project completion, not these illustrative numbers.

Exhibit 59, p. 200 prevents claiming 4,200 saved minutes when half occurred on untreated lines and part came from unlogged tickets. [S24] [S43] What **Exhibit 59**, p. 200 cannot establish alone is whether 2,100 freed minutes reduced cash payroll or increased sales; that requires the cost rules below. [S03] [S42]

12.18 PHYSICAL MINUTE SAVINGS MUST NOT BE BOOKED AS AUTOMATIC CASH REDUCTIONS

Verification separates physical capacity release from cash savings. [S02] [S43] Saving an illustrative 2,100 rework minutes (35 standard hours) does not automatically cut the monthly wage bill if operators are paid on fixed monthly contracts (such as above Cameroon's SMIG of XAF 43,969 a month from 23 February 2024 in the inherited register). [R14] [S03] Real economic benefit takes three verifiable forms:

- **Avoided overtime premium:** Eliminating end-of-shift rework queues cuts paid overtime hours (at 1.2 times normal pay in the inherited register) while protecting working-time guardrails. [R16] [S18]
- **Converted good output:** Reassigning freed rework time to a constrained assembly operation with available cut work produces additional first-pass good garments in the monthly S&OP plan. [S03] [S04] [S42]
- **Reduced material scrap:** Avoiding panel recuts lowers fabric consumption per good garment within the site boundary. [S10] [S36]

Controllers therefore record saved minutes as a physical flow gain first, booking financial savings only when payroll, overtime or fabric ledgers confirm an expenditure drop or shipped-volume rise. [S02] [S42] [S43]

12.19

Standardisation preserves the gain

A verified countermeasure becomes a lasting factory asset only when the next shift can repeat it without the project team standing beside the line. [S41] [S43] Standardisation locks a verified change into master data, station layout, operator skill and routine control. [S03] [S21] [S41]

12.20 RELEASED STANDARD WORK SYNCHRONISES OPERATION BREAKDOWNS, SKILL MATRICES AND METRIC CONTRACTS

Because SMV is defined around a specified method performed by qualified workers, any method change requires a coordinated release across four registers: [S03] [S21] [S25]

1. **Operation breakdown revision:** Industrial engineering issues a versioned method sheet detailing sequence, guide attachment, speed, stitch density, needle size and self-check, with an effective date so historical rows stay linked to the prior version. [S03] [S21] [S25]
2. **Station configuration lock:** Maintenance updates the setup card, removes obsolete attachments from the floor, and marks calibrated pressure or tension ranges on the machine. [S02] [S1202]
3. **Demonstrated skill reassessment:** Because sewing drills maintain operator skills and supervisor training requires line shadowing, a morning briefing is insufficient. [S12] [S14] Supervisors observe each operator executing the revised sequence at target quality, log competence in the skill matrix, and record ergonomic feedback. [S12] [S14] [S45]
4. **Metric contract migration:** Where the new standard shifts the process mean or variance, the data steward closes the old baseline epoch and calculates new control limits once a sufficient post-change sample (such as about 50 independent observations for capability estimation) accumulates, retaining earlier limits for audit. [S09] [S22] [S1207]

12.21 CONTROL PLANS AND SUSTAINED-EFFECT AUDITS GATE FINAL CLOSURE

The final A3 link connects the standard to the daily and weekly cadence in Chapter 11. [S41] [S44] Each revised standard carries an updated control plan and OCAP specifying the leading parameter checked at shift start, the lagging KPI on the line board, the owner and the containment trigger. [S02] [S1202]

Following benefits-management rules requiring monitoring beyond completion, GFT places newly standardised actions into a 30-day sustain window. [S41] [S43] Only when the weekly review confirms at the end of that window that the method remains in use, the net gain holds without special support, and no guardrail has degraded is

the item marked closed and verified. [S18] [S41] [S43] Failed trials are archived with their boundary conditions rather than erased, turning every investigation into reusable evidence for the maturity gates in Chapter 13. [S11] [S27] [S41]

No action is complete until its cause is tested, its result is verified and its method is taught.

CHAPTER SOURCE NOTES

S02 International Labour Organization. 2017.

S41 Lean Enterprise Institute. 2022-08-10.

S43 UK Department for Transport. 2025.

S08 International Journal of Productivity and Quality Management, Inderscience. 2020-05-11.

S05 International Labour Organization. 2022-06-01.

S09 NIST/SEMATECH. 2003.

S22 United States Federal Data Strategy. 2020.

S04 International Labour Organization. 2023.

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

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

S11 International Journal of Production Economics, Elsevier. 2001.

S27 Google for Developers. 2025-08-25.

S1206 NIST/SEMATECH. 2003.

S14 IFC and ILO, Better Work. 2025.

S24 UK Government Data Quality Hub. 2020-12-03.

S40 NIST/SEMATECH. 2003.

S01 International Organization for Standardization. 2014.

S03 International Labour Organization. 2023.

S1203 NIST/SEMATECH. 2003.

S06 Diamond Congress, Creative Construction Conference. 2023.

S10 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04.

S23 ISO/IEC. 2008.

S1207 NIST/SEMATECH. 2003.

S25 W3C. 2017-01-31.

S42 Production, SciELO. 2017.

S17 ILO and IFC, Better Work. 2018-12-20.

S18 ILO and IFC, Better Work. 2011.

S45 United States Office of Personnel Management. 2019-11-04.

S30 GHG Protocol, WRI and WBCSD. 2004.

S36 UNIDO and UNEP. 2015.

S1202 NIST/SEMATECH. 2003.

S1201 NIST/SEMATECH. 2003.

S07 Scientific Reports, Springer Nature. 2025.

S12 Applied Sciences, MDPI. 2021-11-23.

S1205 NIST/SEMATECH. 2003.

S1208 NIST/SEMATECH. 2003.

S1204 NIST/SEMATECH. 2003.

R29 MDPI; industry inspection literature. Publication date unrecorded; inherited source-text check.

S13 International Finance Corporation. 2009.

S16 PLOS ONE. 2020-02-05.

R16 WageIndicator. Publication date unrecorded; inherited source-text check.

R14 WageIndicator. Publication date unrecorded; inherited source-text check.

S21 National Institute of Standards and Technology. 2016.

S44 Production, SciELO. 2017-11-27.

GREEN FUTURE TECH
LIMITED / HONG KONG SAR

13

Maturity gates stop digital ambition outrunning discipline

The factory should earn each digital step through reliable records, active management and verified improvement rather than buy a platform to compensate for their absence.

CHAPTER 13
DECISION TEST

The factory should earn each digital step through reliable records, active management and verified improvement rather than buy a platform to compensate for their absence.

A greenfield garment factory should advance its digital architecture through explicit maturity gates rather than calendar milestones or procurement schedules. In GFT's operating design, a plant deploys automated analytics, manufacturing execution platforms, and machine-learning models only after proving three preconditions: clean source capture, active management routines, and verified corrective actions. [S22] [S27] [S44] Buying a complex platform before a line reconciles daily piece counts, classifies downtime accurately, or closes a root-cause investigation does not accelerate maturity. Instead, premature automation encodes unverified assumptions into software, hides measurement error behind screens, and diverts engineering attention from the floor. Governing progression through four evidence-based stages, from controlled manual capture to active cadence, verified improvement, and a data-driven floor, protects capital and ensures that every digital tool rests on an auditable foundation. [S27] [S43] [S44]

The temptation to skip foundational discipline is strong in contemporary apparel manufacturing. Executive surveys report that 75 percent of fashion leaders prioritise artificial intelligence at scale, encouraged by sector estimates showing inventory costs falling by 35 to 40 percent, forecast errors declining by 20 to 50 percent, and lost sales dropping by up to 65 percent. [R27] Those projections, estimating US$150 to 275 billion in sector operating-profit potential over three to five years, describe mature supply chains holding years of transaction history. [R27] They are not a forecast for a new cut, make, trim, and finishing plant. In Cameroon, where as of the 31 January 2024 programme cut-off about 95 percent of cotton fibre is exported raw against about 5 percent processed locally, and where policy targets 50 percent local processing by 2030, a greenfield plant starts without an inherited database. [R06] [R07] Ramp-up research shows that a new process begins poorly understood, with low yields and production rates while teams learn the work. [S11]

13.1

Maturity spans behaviour as well as technology

Operational maturity is a joint property of human routines, organisational accountability, and technical infrastructure, not a count of software licences. When management evaluates readiness solely by inspecting information-technology assets, a factory can look advanced because it displays office charts while supervisors still dispute bundle counts on paper. Research on sales and operations planning maturity by Grimson and Pyke avoids this distortion by evaluating five evolutionary stages across five categories: meetings and collaboration, organisational structure, measures of performance, information technology, and integrated planning. [S44] A factory that installs five-stage planning software while running one-stage reactive meetings remains functionally immature because it cannot turn outputs into physical adjustments. [S44]

GFT adapts this five-domain structure to govern a greenfield factory across its first eighteen months, an illustrative horizon detailed in the closing roadmap. [S44] GFT binds all five domains to four sequential gates: Gate One (clean manual capture), Gate Two (active management cadence), Gate Three (verified improvement loop), and Gate Four (data-driven floor). Each gate requires proof across every domain before capital

or engineering time is released for the next layer. [S22] [S43] [S44] Production, the warp of the factory, and measurement, the weft, remain under equal tension as the plant scales.

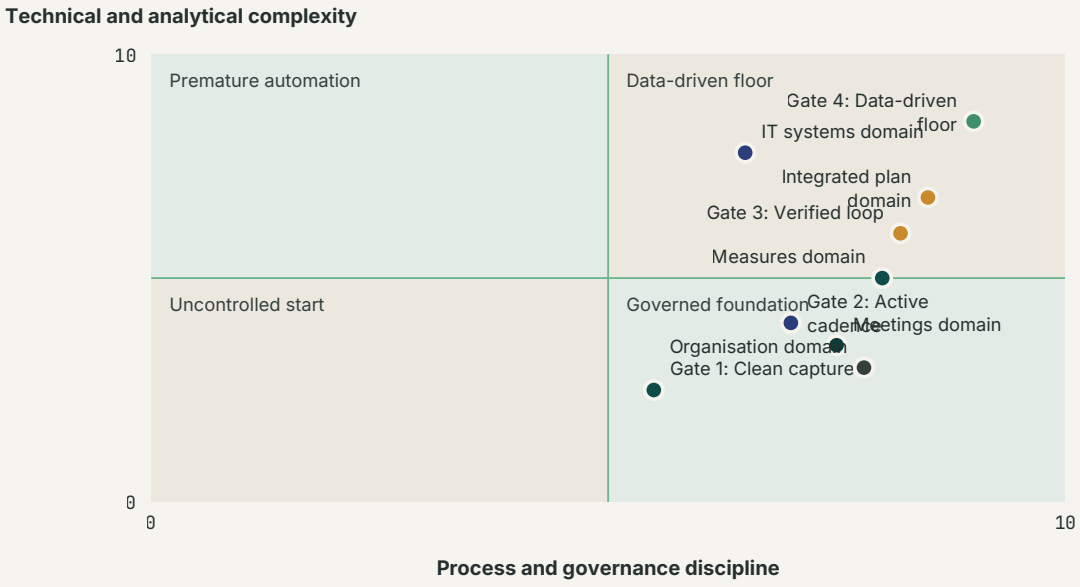
13.2 ASYMMETRICAL ADVANCEMENT CREATES FRAGILE AUTOMATION

When a plant upgrades information technology faster than performance measures or meeting discipline, three faults appear. First, unvalidated source inputs travel faster through automated pipelines than through manual review, turning local recording mistakes into plant-wide scheduling errors. [S23] [S24] Second, supervisors disengage from reviews when digital tools present composite indices or opaque recommendations that conflict with workstation constraints. [S07] [S46] Third, commercial and finance teams treat software outputs as authoritative forecasts even when standard minute values or first-pass yield denominators remain provisional during style ramp-up. [S01] [S11]

To make this interdependence inspectable, **Exhibit 60**, p. 206 maps the five maturity domains from the sales and operations planning literature alongside GFT's four gates across process and governance discipline on the horizontal axis, and technical and analytical complexity on the vertical axis. [S22] [S27] [S44]

EXHIBIT 60 / DERIVED MATURITY INDEX (0 TO 10 SCALE)

Five domains must advance together



DERIVED [S44] [S22] [S27] Derived maturity mapping combining the five evaluation categories of Grimson and Pyke in S44 with data-governance rules from S22 and machine-learning readiness guidance from S27. Coordinates are derived structural positions on an illustrative 0 to 10 ordinal scale, not empirical factory measurements.

The derived positions in **Exhibit 60**, p. 206 explain why GFT sequences governance ahead of technical complexity. [S22] [S27] [S44] The upper-left quadrant represents premature automation, where a factory invests in complex software while governance discipline stays below the midpoint. GFT's path moves first into the lower-right governed foundation quadrant during Gate One and Gate Two, establishing meeting discipline, role accountability, and metric definitions before crossing into the upper-right

data-driven quadrant at Gate Three and Gate Four. [S27] [S44] While **Exhibit 60**, p. 206 clarifies structural order across domains, it cannot establish the exact calendar duration any specific factory will require to move between gates.

13.3 GATE AUDITS REQUIRE CROSS-FUNCTIONAL SIGN-OFF

No single department holds unilateral authority to declare a gate passed. Data governance guidance defines governance as setting and enforcing priorities for managing and using data as a strategic asset, requiring explicit decision rights and accountable roles. [S22] GFT assigns gate review authority jointly to the plant director, the quality and industrial-engineering leads, the human-resources lead, and the data steward. If the information-technology lead shows that a dashboard ingests sewing counts every five minutes, an illustrative polling interval, but the quality lead shows that inspectors disagree on defect grading in 25 percent of repeat checks during an illustrative gauge study, the gate stays closed. [S24] [S40] Performance standards must be measurable, understandable, verifiable, equitable, and achievable across all teams before the system scales. [S45]

13.4

Clean manual capture is the first digital asset

A controlled manual or lightweight digital log is not an awkward stopgap; it is the factory's first genuine digital asset. Garment-floor studies show that front-line data in multi-variety, small-batch apparel lines can be captured through radio-frequency identification (RFID) systems and sewing-machine power monitors. [S19] [S20] Yet raw event streams become useful for control charts or work-time extraction only when linked to defined operations, tasks, and batches. [S19] [S20] Without an unambiguous counting boundary, an RFID scan merely records that a bundle tag passed an antenna; it does not prove that the operation met first-pass quality rules or followed the specified method. [S01] [S03] [S10]

GFT treats Gate One as a test of semantic and procedural control rather than hardware spend. During the first months of production, a structured workbook or form-entry tool is acceptable provided it enforces the data-quality model in ISO/IEC 25012 and the six core data-quality dimensions defined by the UK Government Data Quality Framework: completeness, validity, consistency, timeliness, uniqueness, and accuracy. [S23] [S24] When a clerk or supervisor logs shift output, downtime minutes, defect codes, and meter reads in a governed table that checks every identifier against master data, the factory is building a machine-readable repository. [S21] [S25]

13.5 CONTROLLED WORKBOOKS MUST OBEY DATABASE DISCIPLINE

For a manual or lightweight capture tool to qualify as a Gate One asset, it must follow five rules:

1. **Shared vocabularies and identifiers:** Every row references controlled identifiers for order, style, method revision, operation, line, shift, defect code, downtime cause, and utility meter, following W3C and NIST smart-manufacturing interoperability standards. [S21] [S25]

2. **Explicit formulas and units:** Every calculated key performance indicator (KPI) implements the formula, unit, and time behaviour in the factory's ISO 22400 metric contract, separating raw observations from derived ratios. [S01]
3. **Validation at entry and roll-up:** The template applies range and cross-field rules aligned with ISO/IEC 25012 and the six DAMA UK quality dimensions. [S23] [S24] First-pass good pieces, reworked pieces, and rejected pieces must sum to total pieces inspected, and run time plus downtime cannot exceed attended shift minutes. [S06] [S10]
4. **Timestamps and audit trails:** Records separate event time from entry time, and any post-shift edit retains the original value, author, and reason code. [S22] [S24]
5. **Measurement-system verification:** Before manual counts, defect gradings, or meter reads are accepted as Gate One evidence, the plant runs repeatability and reproducibility checks based on Gauge R&R principles so observer disagreement is bounded. [S09] [S40]

> **GFT NOTE**
>
> GFT recommends keeping the Gate One capture schema identical to the table structure of a future manufacturing execution system. Using the same primary keys, effective-date columns, and lookup lists in day-one workbooks avoids data-cleansing projects later. When the plant migrates to a database or edge service, historical rows import directly. [S21] [S25]

13.6 SENSOR OVERLAYS VALIDATE RATHER THAN RESCUE WEAK DEFINITIONS

Once manual capture runs reliably, targeted sensing can cut clerical effort or sharpen time resolution. Attaching a power monitor to bottleneck sewing machines lets engineers extract stitching and idle times automatically, while bundle-level RFID readers log work-in-progress movements across cutting, sewing, and finishing. [S19] [S20] In GFT's gate sequence, sensors are tested against the manual baseline rather than deployed alone. If a power trace reports 380 running minutes on a shift while the downtime log implies 420 running minutes, an illustrative 40-minute gap, that discrepancy triggers a check of threshold calibration and logging timeliness. [S20] [S40] Because the metric contract exists, the sensor strengthens the system of record. [S01] [S22]

13.7

Active management is a separate gate

Clean data sitting in an unreviewed table creates storage cost, not control. Gate Two requires the factory to prove that its teams use captured records on a fixed cadence to make decisions, allocate resources, and close gaps. In the sales and operations planning maturity model, meetings and collaboration form a core domain alongside organisational structure and performance measures. [S44] Moving from reactive fire-fighting to coordinated management depends on whether teams meet with shared facts, test assumptions, and leave with owned actions. [S42] [S44]

Active management spans three nested horizons that must work before predictive software is considered. Daily, line supervisors hold shift-start huddles using balanced in-process and end-of-process measures to review prior-shift good output, first-pass yield, downtime causes, and operator skill coverage, rebalancing stations during the shift as flow changes. [S02] [S04] [S05] Weekly, operations, quality, and maintenance leaders review recurring losses and cross-line constraints, applying a systematic improvement method rather than reading composite overall equipment effectiveness (OEE) scores alone. [S06] [S07] [S08] Monthly, senior leadership conducts sales and operations planning at the product-family level, reconciling delivery promises with demonstrated line capability, material supply, and workforce ramp curves. [S11] [S42]

13.8 DASHBOARDS DO NOT SUBSTITUTE FOR CLOSED-LOOP EXECUTION

Confusing visual reporting with active management is a common digitalisation failure. A sponsor may install wall screens showing colour-coded hourly targets, yet find months later that the same sewing machines fail repeatedly for the same thread-break or feed-dog faults. OEE literature warns that measuring availability, performance, and quality without a systematic improvement framework fails to produce lasting gains, while merged downtime categories obscure specific losses. [S07] [S08] Balanced-scorecard research likewise notes that a rigid top-down cascade can fail in adaptive settings when supervisors cannot challenge flawed standards or escalate bottlenecks. [S46]

Gate Two audits behavioural execution across four operating trails:

- **Forum adherence:** Daily huddles, weekly loss reviews, and monthly product-family S&OP meetings run on schedule with role owners present and records validated beforehand. [S24] [S42] [S44]
- **Decision latency:** When an in-process measure crosses an escalation limit, such as a drop in operation first-pass yield or a spike in waiting downtime, elapsed time between logging and assignment stays within the agreed window. [S02] [S10]
- **Fact-based root-cause logic:** Repeated variances trigger structured problem solving. Leaders read A3 sheets in reverse, from follow-up and countermeasures back to cause evidence and problem definition, confirming fact-based analysis. [S41]
- **Verified benefit closure:** Actions close only when post-implementation monitoring confirms that the target metric moved as expected in a comparable cohort and that guardrail metrics held steady. [S05] [S43]

Until a factory clears Gate Two with a low backlog of overdue actions and a verified trail of resolved constraints, adding predictive algorithms is wasteful. Teams that do not act on a logged machine fault today will not act more reliably on a probabilistic alert tomorrow. [S08] [S27]

13.9

History-dependent models wait for usable history

Machine-learning engineering guidance states a primary rule: if machine learning is not required for a product or decision, do not use it until data exists. [S27] In a green-field garment factory, almost every core decision during the first year, including line balancing, bundle release, defect containment, preventive maintenance scheduling, and submeter reconciliation, can be handled through deterministic arithmetic, statistical process control, and structured review. [S04] [S09] [S27] History-dependent models need representative, accurately labelled training distributions. During early ramp-up, the process shifts week by week as operators build skill, engineers refine methods, and fabric batches vary. [S03] [S11] Training a predictive model on unstable ramp-up logs yields brittle weights that fail once the line nears steady state.

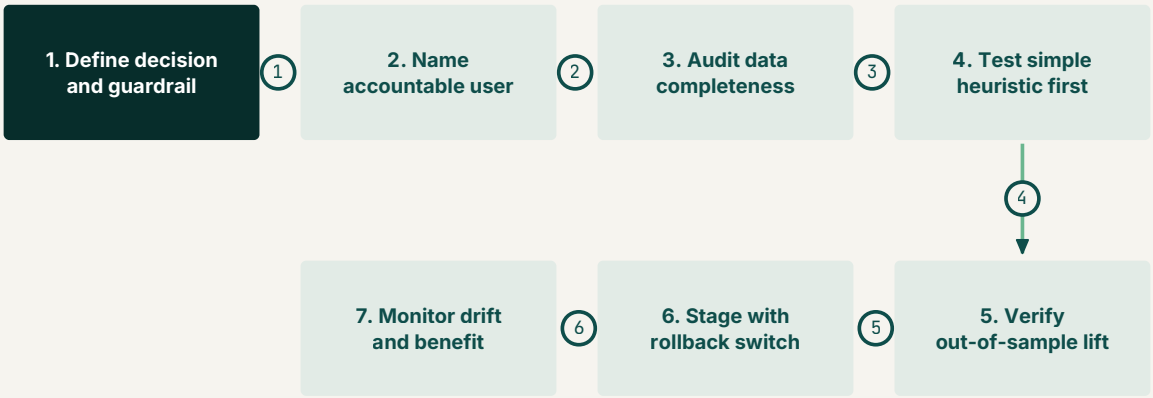
GFT enforces Gate Three and Gate Four use-case qualification so model count never becomes a vanity target. Even when market reports project rapid growth in specialised artificial-intelligence segments, such as the fabric-defect-detection AI market estimated at US$523.4 million in 2024 and projected to reach US$6,522.1 million by 2033 at 33.8 percent compound annual growth, a factory must separate pre-trained optical sensing from plant-specific historical forecasting. [R28] Inspection studies report that manual fabric inspection is 60 to 70 percent accurate, missing 20 to 30 percent of defects, whereas line-scan computer vision running at up to 60 metres a minute can exceed 90 percent accuracy across more than 40 defect types. [R29] Yet even a pre-trained camera needs local calibration against the plant's weaves, dye shades, defect taxonomy, and human adjudication logs before its outputs govern acceptance. [R29] [S25] [S40]

13.10 EVERY CANDIDATE MODEL MUST CLEAR SEVEN EVIDENCE GATES

Before any machine-learning or analytical use case receives budget, GFT subjects the proposal to a seven-step gate sequence combining machine-learning rules, gradual MLOps controls, and the trustworthiness functions (govern, map, measure, manage) of the NIST AI Risk Management Framework. [S27] [S28] [S1301] **Exhibit 61**, p. 211 shows this qualification flow.

EXHIBIT 61 / SEQUENTIAL QUALIFICATION GATES

A use case passes evidence gates before build



1. Actionable lever
2. Cadence assigned
3. Contract met
4. Gap remains
5. Beats heuristic
6. Live shadow test

ILLUSTRATIVE [S27] [S28] [S1301] Illustrative GFT decision sequence for qualifying candidate analytical and machine-learning use cases. Design logic synthesises the data-first rule in S27, phased MLOps automation in S28, and lifecycle trustworthiness evaluation in S1301.

As shown in **Exhibit 61**, p. 211, the sequence filters out weak proposals early. [S27] [S28] [S1301] At Step 1 and Step 2, the proposer identifies the decision the model will change, the guardrail metrics, and the role owner who will act on the output within a daily, weekly, or monthly forum. [S02] [S22] [S44] At Step 3, the data steward audits whether historical records meet completeness, validity, consistency, uniqueness, and measurement-error thresholds across comparable cohorts. [S24] [S40] Step 4 requires building and testing a transparent heuristic or statistical baseline first, such as a rolling cohort average, a standard minute bottleneck check, or a control chart. [S03] [S09] [S27] Only when Step 5 proves meaningful lift over that heuristic on held-out chronological cohorts does the model advance to staged shadow deployment (Step 6) and drift and benefit monitoring (Step 7). [S28] [S43] [S1301] Because **Exhibit 61**, p. 211 is an illustrative workflow, it defines procedural checkpoints, not a guarantee of financial return without local testing.

GATE READINESS AND HEURISTIC-COMPARISON CHECK

GFT applies a three-part check before approving history-dependent model development:

1. **Cohort data-completeness ratio (`C_data`):** Over the lookback window of `N_shifts` scheduled shifts, count the shifts `N_valid` with complete records passing ISO/IEC 25012 validity rules and Gauge R&R bounds. [S23] [S24] [S40] Compute `C_data = N_valid / N_shifts`, which must meet the governed threshold (such as an illustrative minimum of 0.95).
2. **Cadence action-closure ratio (`C_act`):** In the target forum over the preceding window, divide actions closed with verified effect (`A_verified`) by total actions due (`A_due`), giving `C_act = A_verified / A_due`. [S43] [S44] If the forum does not routinely close actions on deterministic signals, predictive signals wait.
3. **Net operational lift over heuristic (`V_net`):** Let `L_heuristic` be measured loss under a simple rule, and `L_model` be loss under the candidate model on out-of-time cohorts, minus ongoing engineering and compute cost `K_ops`. [S27] [S28] Approval requires `V_net = (L_heuristic - L_model) - K_ops > 0`, with no harm to worker health or quality guardrails. [S17] [S18]

WORKED EXAMPLE: QUALIFYING A SEWING-LINE BOTTLENECK PREDICTOR AGAINST A SIMPLE HEURISTIC

Consider an illustrative greenfield garment factory at Month 10 of ramp-up running 6 sewing lines on 2 shifts per day across a 25-working-day month (300 line-shifts per month). A vendor proposes a machine-learning model to predict intraday station bottlenecks and recommend operator moves every two hours, at an illustrative cost of XAF 18,000,000 a year (XAF 1,500,000 per month). These figures are illustrative assumptions constructed to demonstrate the gate method, not observations from a GFT factory.

Step 1: Audit data completeness (`C_data`). The data steward inspects the prior 3 months (900 illustrative line-shifts). Shift-end good output is 99 percent complete, but hourly station counts are complete on only 738 line-shifts because two lines recently switched styles and used provisional operation breakdowns. The completeness ratio is `738 / 900 = 0.82` (82 percent), below the plant's illustrative 95 percent threshold. [S03] [S24]

Step 2: Test the simple deterministic heuristic. Industrial engineering introduces a Gate Two rule based on ILO line-balancing practice: before each shift and at mid-shift break, the supervisor checks station buffers against the Standard Minute Value (SMV) and moves a cross-trained operator from the skill matrix whenever a queue exceeds 45 standard minutes of work. [S03] [S04] [S12] Over an illustrative 4-week trial across the 4 clean lines (200 line-shifts), waiting downtime drops from an illustrative 28 minutes to 14 minutes per line-shift, recovering 2,800 line-minutes per month at zero software cost.

Step 3: Evaluate residual lift (`V_net`). An offline back-test on the 4 clean lines estimates that the algorithm might trim waiting downtime by a further 3 minutes per line-shift (to 11 minutes), saving 600 line-minutes per month. At an illustrative labour and overhead recovery value of XAF 1,800 per line-minute, gross monthly value is XAF 1,080,000. Subtracting the illustrative monthly software cost of XAF 1,500,000 gives a net effect of `1,080,000 - 1,500,000 = -420,000 XAF`.

Decision outcome: The proposal fails both the completeness gate (82 percent against 95 percent) and the net-value gate (-XAF 420,000 per month against the SMV rule). The plant keeps the supervisor rule, brings all 6 lines above 95 percent completeness during months 11 and 12, and defers predictive balancing until style complexity and line count justify it. [S04] [S27]

13.11

MLOps can grow in stages

When a candidate use case clears every qualification gate, such as an optical fabric-defect classifier or a family-level demand model once multi-season history exists, the factory needs controls to keep the model reliable in production. [R27] [R29] Machine-learning operations (MLOps) should not start with a heavy orchestration platform. Cloud guidance notes that teams can implement MLOps practices gradually to improve automation of model development and production. [S28] For a site with a small technical team, starting with automated continuous-retraining pipelines adds fragility and can let a model retrain on corrupted sensor bursts or unlabelled style changes. [S24] [S28]

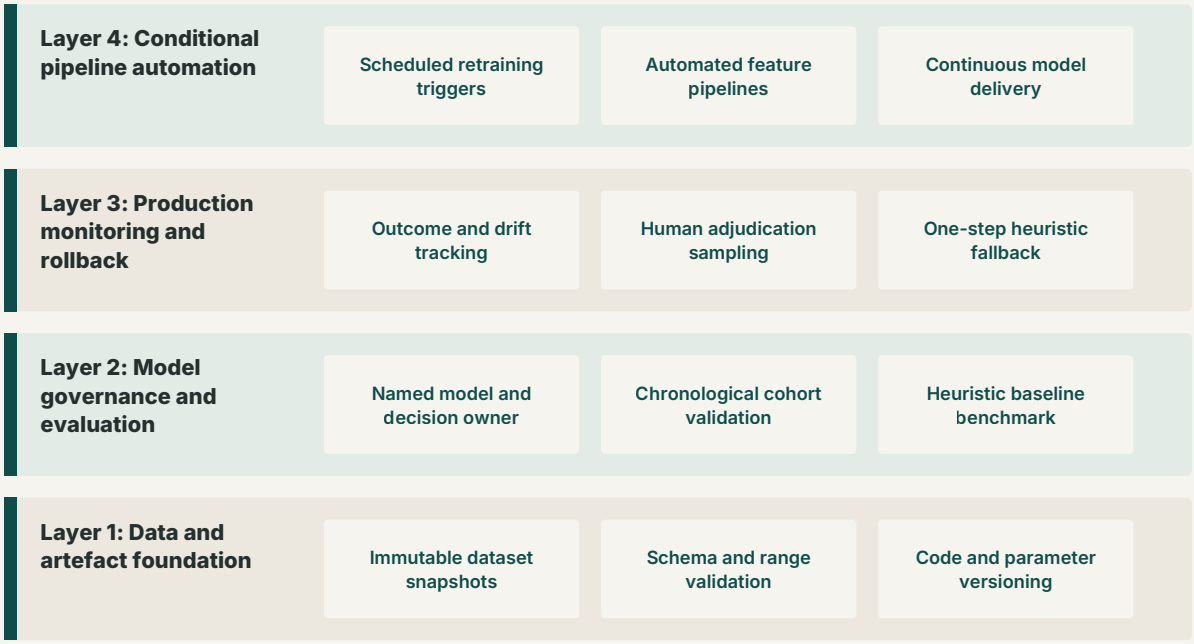
GFT sequences MLOps maturity through staged controls aligned with the NIST AI Risk Management Framework functions of governing accountability, mapping context, measuring performance and drift, and managing incidents through fallback routines. [S28] [S1301] Initially, the plant uses script-backed manual MLOps controls focused on reproducibility and safety. Automated retraining and feature pipelines follow only when model count and retraining frequency make manual triggers a constraint. [S28]

13.12 FOUR CONTROL LAYERS PROTECT PRODUCTION FROM MODEL DECAY

To separate mandatory day-one governance from optional later automation, **Exhibit 62**, p. 214 arranges MLOps responsibilities into a four-layer architecture. [S23] [S28] [S1301] The bottom three layers are compulsory before any model influences a factory decision; the top layer is conditional on scale.

EXHIBIT 62 / STAGED CONTROL LAYERS

Initial MLOps controls precede pipeline automation



DERIVED [S28] [S23] [S1301] Derived four-layer control architecture combining gradual MLOps implementation principles from S28, structured data-quality requirements from S23, and AI risk-management evaluation functions from S1301. Layers 1 to 3 are mandatory at first model deployment; Layer 4 is conditional on portfolio scale.

Reading **Exhibit 62**, p. 214 from bottom to top shows how engineering controls prevent silent model decay: [S23] [S28] [S1301]

- **Layer 1 (Data and artefact foundation):** Training and test datasets are stored as immutable, timestamped snapshots tied to active metric definitions and master-data versions. [S01] [S21] [S25] Incoming features pass ISO/IEC 25012 schema, completeness, and range checks before inference, so a disconnected power sensor or missing batch code is flagged as a fault rather than passed as zero. [S20] [S23]

- **Layer 2 (Model governance and evaluation):** Every model has a named operational owner alongside its technical steward, satisfying data-governance and AI accountability rules. [S22] [S1301] Evaluation uses chronological splits across styles and shifts rather than random shuffles, ensuring accuracy claims reflect forward prediction and beat the heuristic benchmark. [S27] [S1301]
- **Layer 3 (Production monitoring and rollback):** Live predictions are logged beside physical outcomes and human adjudication samples, such as inspectors re-grading a share of camera-flagged fabric rolls. [R29] [S40] If input distributions shift or verified accuracy drops below the acceptance band, supervisors execute a one-step rollback to the heuristic or manual protocol without stopping the line. [S28] [S1301]
- **Layer 4 (Conditional pipeline automation):** Automated feature stores, continuous integration, and scheduled retraining jobs are added only after the plant runs multiple validated models whose manual retraining cycle consumes substantial engineering time. [S28]

While **Exhibit 62**, p. 214 defines the hierarchy of MLOps controls, it cannot specify the exact retraining interval for a given factory model, which depends on empirical drift across seasonal fabric and style changes.

13.13

Architecture must respect the site's constraints

A digital architecture that assumes unbroken high-bandwidth internet links, unlimited cloud budgets, and resident vendor engineers will fail under the conditions of a greenfield site. Operational technology (OT) security and reliability guidance from NIST emphasises that industrial systems face distinct performance, reliability, and safety requirements compared with office systems. [S1302] On a garment floor, bundle ticket printing, cutting-table marker release, in-line quality logging, and utility sub-meter accumulation cannot halt because an external telecom link lags or a cloud service enters maintenance.

To match architecture to site constraints, GFT applies the distributed computing principles of the NIST Fog Computing Conceptual Model. [S26] Fog and edge computing place applications, management, and analytics inside the local network using a distributed model, shortening the path between capture and processing. [S26] Running local validation, buffering, and time-critical inference on site-resident nodes keeps shift operations running during wide-area outages, while synchronising summaries to central storage when connectivity returns. [S26] [S1302]

13.14 BUILD-AGAINST-BUY DECISIONS REQUIRE OFFLINE, PORTABILITY, AND EXIT TESTS

When sponsors decide whether to build an internal tool, configure open-source software, or buy a commercial suite, procurement reviews too often focus on vendor demonstrations. Public-sector technology guidance notes that choosing technology shapes a team's ability to operate and iterate its service, and advises using open standards to manage interfaces between components so later changes remain prac-

tical. [S1303] Similarly, NIST smart-manufacturing standards research stresses that exchanging and using product, production, and business data across disparate systems depends on information standards. [S21]

GFT applies four engineering tests to every build-against-buy choice:

1. **Offline survivability:** Can the shop-floor interface capture events, validate schemas, display shift boards, and run local inference across an illustrative 72-hour internet outage using local nodes and persistent queues? [S26] [S1302]
2. **Open-standard interoperability:** Does the system expose documented application programming interfaces (APIs) and bulk exports in open formats (CSV, JSON, or Parquet) mapped to ISO 22400 and W3C vocabulary identifiers, without extraction fees? [S01] [S25] [S1303]
3. **Local maintainability:** Can the plant's engineers and data stewards add a style, update a standard minute value, or configure a defect code without paying the vendor for custom consulting? [S03] [S22] [S1303]
4. **Reversible vendor exit:** If the vendor raises licence fees, retires the product, or misses service levels, can the factory extract its full event log, master-data tables, and audit trails and switch tools within one monthly S&OP cycle? [S21] [S22] [S1303]

Exhibit 63, p. 216 applies these criteria across four functional subsystems of a greenfield garment factory.

EXHIBIT 63 / ARCHITECTURAL EVALUATION MATRIX

Build-against-buy includes exit and offline tests

Subsystem	Gate 1 to 2 mode	Gate 3 to 4 mode	Offline requirement	Exit and portability test
Source capture and line boards	Governed workbook or local web form	Modular edge capture with RFID or power inputs	Full shift operation on local LAN with buffered sync	Daily automated export of raw events in open schema
Shop-floor MES and routing	Master-data tables plus paper bundle travellers	Configurable MES module bound to metric contracts	Local execution of work orders and bundle tracking	Complete routing and WIP history exportable without vendor scripts
Fabric and garment vision	Standardised manual grading and Gauge R&R checks	Edge camera inference writing to shared defect taxonomy	Local on-device inference at line speed without cloud lag	Retained image samples and labels stored in plant repository
Demand and S&OP analytics	Deterministic capacity and SMV reconciliation sheets	Statistical or ML forecast benchmarked on heuristic	Monthly batch run executable on local workstation	Model weights, features and SQL logic owned by plant

ILLUSTRATIVE [S21] [S22] [S26] [S1303] Illustrative GFT option assessment for four factory subsystems, applying smart-manufacturing interoperability standards from S21, data-governance ownership rules from S22, local fog-computing resilience from S26, and open-standards interface guidance from S1303.

The progression across columns in **Exhibit 63**, p. 216 shows why architecture should grow with maturity rather than begin at maximum vendor lock-in. [S21] [S26] [S1303] For source capture and shop-floor execution, Gate One and Gate Two rely on governed tables and local forms that cost little and let the factory refine operation codes and downtime taxonomies through shift experience. [S07] [S25] At Gate Three and Gate Four, the plant can extend modular local services or license a commercial MES module, knowing which schemas and offline functions the vendor must support. [S21] [S26] For computer vision, where line-scan inspection runs at up to 60 metres a minute, inference executes on local edge hardware beside the frame because wide-area network latency cannot match moving fabric, while labelled images stay in the plant's repository so future models are not tied to one vendor. [R29] [S26] [S1303] Because **Exhibit 63**, p. 216 is an illustrative comparison, it is not procurement, legal, or contract advice; sponsors must assess local telecom reliability, power quality, and internal engineering skills before signing contracts.

13.15

Governance persists through platform migration

The final maturity rule protects the factory when it upgrades its software stack: moving from a Gate One workbook to a Gate Three database or a Gate Four manufacturing execution system is a storage transition, not a reset of operational meaning. In poorly governed projects, a vendor arrives with pre-built KPI definitions that quietly change how availability, first-pass yield, standard minutes, or water consumption are calculated. If the new platform counts repaired garments as first-pass output, merges waiting time into breakdown time, or drops the distinction between water withdrawal and water consumption, the factory loses its historical baseline. [S06] [S07] [S10] [S34] Management can no longer tell whether a post-migration rise in efficiency reflects physical improvement on the lines or a silent shift in software arithmetic. [S05] [S43]

GFT prevents this loss of institutional memory by treating the data governance framework, ISO 22400 metric contracts, and W3C-aligned master-data vocabularies as the constitution of the factory's performance system. [S01] [S22] [S25] Any incoming software platform, whether built in-house or licensed, must conform to the factory's existing definitions rather than overwrite them.

13.16 MIGRATION ACCEPTANCE REQUIRES PARALLEL HISTORICAL RECONCILIATION

Before an upgraded database, MES, or analytics service becomes the system of record, the data steward and business owners run a four-step migration protocol:

1. **Contract inheritance check:** Every KPI tile, query, and API endpoint in the new platform is checked against the metric contract register so formulas, numerators, denominators, units, rounding, and time boundaries match. [S01] [S22]
2. **Master-data preservation:** Identifiers for styles, operations, lines, shifts, defect codes, downtime causes, and meters migrate with effective dates intact, keeping prior cohorts queryable. [S21] [S25]

3. **Back-calculated parallel run:** The plant loads three months of Gate One and Gate Two events into the new platform and runs two parallel weeks of live shifts through both paths. Calculated KPIs across all six families must reconcile within rounding tolerances across every shift and family. [S02] [S23] [S24]
4. **Versioned definition migration:** If a review refines a metric formula during the upgrade, the revised definition receives a new version identifier, both formulas are computed across a bridge period, and charts annotate the boundary so benefits monitoring stays valid. [S22] [S43]

> **PREMATURE PLATFORM CUTOVER DESTROYS BASELINE CONTINUITY**
>
> The highest-risk moment in a factory's eighteen-month progression is retiring the validated manual or lightweight log on the day a new platform goes live, before parallel reconciliation is complete. If configuration bugs, scanner misreads, or interface confusion corrupt two weeks of shift records during ramp-up, the plant creates a permanent gap in its statistical process control and S&OP series. [S09] [S42] GFT resolves this risk by requiring a two-week dual-recording window: the legacy sheet retires only when the data steward and supervisors sign off that the new system reproduces shift totals with zero unexplained variance and passes all six data-quality checks. [S23] [S24]

13.17 MATURITY GATES PREPARE THE EIGHTEEN-MONTH ROADMAP

Binding technical ambition to behavioural and evidentiary proof turns digital strategy from a speculative purchase into an engineering discipline. A greenfield garment factory does not need artificial intelligence on its first shift; it needs clear counting rules, honest downtime and defect logs, and supervisors who use daily evidence to balance lines and support workers. [S01] [S04] [S27] Once that warp and weft are tight, each subsequent layer, from edge buffering and machine sensing to statistical forecasting and computer vision, fits into a governed structure that proves whether the technology improved cost per good garment, delivery reliability, or resource intensity. [S19] [S20] [S26] [S43] The next chapter translates these four gates into an eighteen-month roadmap of deliverables, benefit registers, and board scorecards. This guidance is an engineering framework and does not constitute investment, legal, or tax advice.

Digital tools amplify the discipline a factory already practises; maturity gates ensure there is discipline to amplify before the software arrives.

CHAPTER SOURCE NOTES

S22 United States Federal Data Strategy. 2020.

S27 Google for Developers. 2025-08-25.

S44 Production, SciELO. 2017-11-27.

S43 UK Department for Transport. 2025.

R27 McKinsey, The State of Fashion 2025. Publication date unrecorded; inherited source-text check.

R06 Cameroon Trade Hub. Publication date unrecorded; inherited source-text check.
R07 Ecofin Agency. Publication date unrecorded; inherited source-text check.
S11 International Journal of Production Economics, Elsevier. 2001.
S23 ISO/IEC. 2008.
S24 UK Government Data Quality Hub. 2020-12-03.
S07 Scientific Reports, Springer Nature. 2025.
S46 Encyclopedia, MDPI. 2025-03-19.
S01 International Organization for Standardization. 2014.
S40 NIST/SEMATECH. 2003.
S45 United States Office of Personnel Management. 2019-11-04.
S19 The International Journal of Advanced Manufacturing Technology, Springer Nature. 2019-09-03.
S20 Applied Sciences, MDPI. 2020-04-29.
S03 International Labour Organization. 2023.
S10 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04.
S21 National Institute of Standards and Technology. 2016.
S25 W3C. 2017-01-31.
S06 Diamond Congress, Creative Construction Conference. 2023.
S09 NIST/SEMATECH. 2003.
S42 Production, SciELO. 2017.
S02 International Labour Organization. 2017.
S04 International Labour Organization. 2023.
S05 International Labour Organization. 2022-06-01.
S08 International Journal of Productivity and Quality Management, Inderscience. 2020-05-11.
S41 Lean Enterprise Institute. 2022-08-10.
R28 DataIntelo. Publication date unrecorded; inherited source-text check.
R29 MDPI; industry inspection literature. Publication date unrecorded; inherited source-text check.
S28 Google Cloud. 2024-08-28.
S1301 National Institute of Standards and Technology. 2023-01-26.
S17 ILO and IFC, Better Work. 2018-12-20.
S18 ILO and IFC, Better Work. 2011.
S12 Applied Sciences, MDPI. 2021-11-23.
S1302 National Institute of Standards and Technology. 2023-09-28.
S26 National Institute of Standards and Technology. 2018-03-14.
S1303 UK Government Digital Service. 2024-10-15.
S34 Global Reporting Initiative. 2018.

14

PART IV: SCALE WITH CONTROL / RECOMMENDATIONS AND ROADMAP

The first eighteen months install a system that can prove value

GFT recommends four gated stages: clean capture, active cadence, verified improvement and a data-driven floor, with value measured in the same system throughout.

CHAPTER 14
DECISION TEST

GFT recommends four gated stages: clean capture, active cadence, verified improvement and a data-driven floor, with value measured in the same system throughout.

The first eighteen months of a greenfield garment factory should install a governed performance-management system across four gated stages: clean capture in months one to three, an active management cadence in months four to eight, a verified improvement loop in months nine to twelve, and connected digital applications in months thirteen to eighteen, where the month boundaries define an illustrative planning design rather than a fixed calendar promise. [S01] [S05] [S27] [S43] [S44] Rather than treating performance management as a retrospective reporting layer added after production stabilises, GFT engineers the measurement contract into the physical operation before the first bundle of fabric is cut. [S01] [S1401] Every stage produces an auditable operational asset that serves as the entry condition for the next stage: unambiguous metric definitions enable validated shift logs, validated logs feed daily and monthly decision forums, decision forums direct root-cause countermeasures, and verified historical records provide the training foundation for selective sensing and machine learning. [S23] [S27] [S41] [S42] By measuring both factory output and system health inside the same governed architecture from the first shift, sponsors and plant leaders build a facility that can prove the causes of its own performance. [S02] [S43]

This disciplined sequence is vital when a new cut, make, trim, and finishing plant operates inside an industrialising raw-material economy. As of the 31 January 2024 programme evidence cut-off, about 95 percent of Cameroon's cotton fibre is exported raw while about 5 percent is processed locally, against a national industrialisation target of 50 percent local processing by 2030. [R06] [R07] Those sector figures define the strategic importance of competent domestic manufacturing, but they do not guarantee commercial margins or steady-state throughput for any individual factory. [R06] [R07] Empirical ramp-up research shows that a newly launched production process is initially poorly understood, causing low yields and low production rates to occur together while operators, technicians, and supervisors learn the work. [S11] If a greenfield plant attempts to copy the software stack of a mature global apparel chain on day one, or chases headline volume targets without tracking rework, downtime causes, and working-time guardrails, it destroys the evidence needed to stabilise the floor. [S07] [S10] [S18] The eighteen-month roadmap resolves that tension by matching management complexity to demonstrated operational readiness.

14.1

Approve the operating contract before the first shift

A performance-management system begins before commissioning, when factory sponsors and operational leaders approve the metric contracts, master-data vocabularies, role accountabilities, and baseline rules as mandatory pre-shift deliverables. [S01] [S22] [S45] Public-sector digital delivery guidance states the governing rule plainly: teams should work out their measurements as they build the service, not afterwards, and establish a baseline against which subsequent changes are judged. [S1401] Waiting until month three of live sewing to debate whether first-pass yield excludes repaired garments or whether machine availability excludes material waiting time guarantees that the first quarter of ramp-up history will be irreconcilable. [S06] [S07] [S10]

GFT therefore places a formal pre-shift approval gate ahead of month one. Before production starts, the plant director, industrial-engineering lead, quality lead, human-resources lead, sustainability lead, and data steward sign off on the foundational operating charter across all six programme families: production, quality, delivery, cost, people, and sustainability. [S02] [S22] In keeping with garment-sector lean guidance, this charter balances financial, behavioural, and core-process metrics while pairing in-process leading indicators with end-of-process lagging outcomes. [S02] Every approved key performance indicator (KPI) is documented using the structure of ISO 22400-2, stating its exact formula, constituent elements, unit of measure, time behaviour, counting boundary, and rounding convention. [S01] Simultaneously, every performance standard attached to those metrics is tested against public-administration performance criteria to verify that expectations are measurable, understandable, verifiable, equitable, and achievable under ramp-up conditions. [S45]

14.2 PRE-SHIFT DELIVERABLES LOCK IN IDENTITY, OWNERSHIP AND WORKER SAFEGUARDS

To prevent ambiguity during initial line commissioning, the pre-shift charter establishes four operational artefacts before the first shift clock starts:

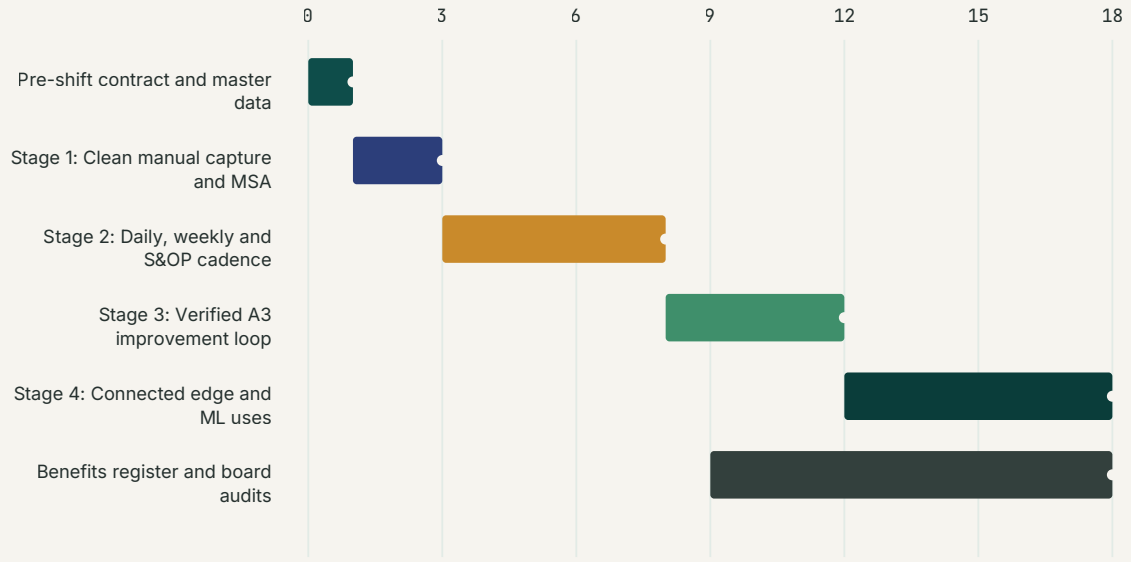
1. **The six-family KPI dictionary and source-event map:** Each headline measure is bound to its physical event on the cutting, sewing, finishing, or utility floor. Good output is tied to first-pass acceptance at a named inspection boundary; overall equipment effectiveness (OEE) is decomposed into availability, performance rate, and quality; standard minute values (SMVs) are linked to a documented method and qualified operator cohort; and energy, water, and waste indicators are assigned explicit boundaries and production denominators. [S01] [S03] [S06] [S10] [S30] [S33]
2. **The master-data and vocabulary register:** Following smart-manufacturing interoperability standards and W3C data best practices, the plant defines controlled identifier tables for styles, method revisions, operations, lines, workstations, shifts, defect codes, downtime causes, and utility meters. [S21] [S25] Every identifier carries an effective start date and an accountable steward so codes are never silently overwritten when a garment routing changes. [S22] [S25]
3. **The role accountability matrix:** Data governance requires setting and enforcing priorities for managing data as a strategic asset through explicit decision rights. [S22] The charter names one business owner, one data steward, and one review chair for every metric family, ensuring that no indicator enters the factory without an owner authorised to act on its signal. [S22] [S44]
4. **The labour and target safeguard protocol:** Because early ramp-up standards are provisional, the pre-shift contract codifies statutory and behavioural protections for the workforce. [S11] [S45] In a Cameroon operating context, the protocol embeds the statutory 40-hour standard working week, the 48-hour maximum week, the 1.2 times overtime pay multiplier, and the statutory minimum wage (SMIG) baseline, which rose by 5 percent from XAF 41,875 a month in 2023 to XAF 43,969 a month from 23 February 2024 (about US$76, with the CFA franc pegged to the euro at 655.957). [R14] [R16] [R32] The protocol also prohibits uncalibrated partial piece-rate schemes that empirical Better Work research associates with

poorer emotional and physical worker health, and enforces overtime monitoring to avoid the fatigue, accidents, and turnover linked to excessive working hours. [S17] [S18]

To show how the pre-shift charter initiates the wider eighteen-month sequence, **Exhibit 64**, p. 223 presents GFT's illustrative programme roadmap across the four gated stages and the parallel benefit verification stream. [S05] [S27] [S42] [S43] [S44]

EXHIBIT 64 / PLANNING MONTHS (0 TO 18)

Four gated stages sequence the eighteen-month rollout



ILLUSTRATIVE [S01] [S05] [S24] [S41] [S42] [S43] [S44] [S27] Illustrative GFT programme roadmap sequencing pre-shift contract approval (month 0 to 1), Stage 1 clean capture (months 1 to 3), Stage 2 active cadence (months 3 to 8, covering months four to eight of full operation), Stage 3 verified improvement (months 8 to 12, covering months nine to twelve), Stage 4 connected digital uses (months 12 to 18, covering months thirteen to eighteen), and ongoing benefit verification (months 9 to 18). Timing is a planning design, not a guaranteed schedule.

The numeric planning window in **Exhibit 64**, p. 223 illustrates how each stage builds on the previous stage rather than launching all workstreams in month one. [S27] [S44] Pre-shift preparation occupies the initial commissioning window from point 0 to point 1 on the illustrative month scale, ensuring that Stage 1 capture begins immediately when the first sewing line starts. Subsequent stages advance only when their entry gate criteria are verified, and the benefits register runs continuously from month 9 through month 18 to satisfy post-implementation monitoring requirements. [S43] Because **Exhibit 64**, p. 223 is an illustrative planning design, it cannot predict local construction delays, customs clearance times, or recruitment pace; if a factory requires an illustrative five months instead of three to pass measurement-error checks, the calendar shifts while the gate order remains fixed.

14.3

Months one to three establish clean capture

During the illustrative window of months one to three, the factory's priority in performance management is establishing clean, complete, and reconciled source capture at the point of work. [S05] [S23] [S24] Garment productivity programmes such as the International Labour Organization (ILO) SCORE methodology begin at step zero with a structured baseline assessment to identify operational gaps and measure subsequent change through KPIs. [S05] In a greenfield plant, months one to three construct that step-zero baseline across the initial production cohorts. Rather than deploying complex analytics, the operations and engineering teams launch controlled manual or lightweight local-form logs for line output, downtime, first-pass quality, attendance, skill demonstrations, and utility meters. [S12] [S23] [S39]

Every capture sheet introduced in this stage is engineered as a structured dataset governed by ISO/IEC 25012 and checked against the six core data-quality dimensions defined by DAMA UK and the UK Government Data Quality Framework: completeness, validity, consistency, timeliness, uniqueness, and accuracy. [S23] [S24] Following agile alpha-phase practice, where teams test solutions to discovery problems on a bounded scope before full build, the data steward and industrial engineers test the recording forms on the first commissioned sewing line, remove ambiguous fields, and verify that line clerks and supervisors can complete entries within shift boundaries. [S1402]

14.4 CORE LOGS ENFORCE RECONCILIATION AND MEASUREMENT-SYSTEM CHECKS

To pass Gate One at the end of month three, the factory must demonstrate that its core operational logs satisfy five verification checks across the floor:

- **Shift piece and time reconciliation:** At each sewing and finishing line, pieces started, pieces completed, first-pass good pieces, reworked pieces, and rejected pieces must reconcile at shift close. [S06] [S10] Simultaneously, scheduled shift minutes must reconcile to attended minutes, running minutes, and cause-coded downtime minutes so merged downtime categories never obscure specific equipment, material, or waiting losses. [S06] [S07]
- **Provisional work-content tagging:** Industrial engineers record operation breakdowns and assign provisional SMVs based on the specified method and qualified-worker definition, flagging learning cohorts explicitly so early ramp speeds are never confused with steady-state capability. [S03] [S11]
- **Repeatability and reproducibility of human grading:** Because manual defect inspection in apparel literature is often only 60 to 70 percent accurate and misses 20 to 30 percent of defects, the quality lead conducts structured Gauge R&R studies on end-of-line and cutting inspectors during month two. [R29] [S40] Using reference garment samples with known faults, the plant measures repeatability within each inspector and reproducibility across inspectors, retraining staff until classification agreement meets the gate threshold. [S40]

- **Demonstrated skill and working-time logs:** Human-resources and line leaders record operator competence by specific sewing operation and method revision, scheduling capacity-development drills to prevent skill degradation while logging daily attendance, lateness, and overtime hours against statutory limits. [R16] [S12] [S18]
- **Utility and waste boundary logging:** Facilities engineers establish a meter register for main electricity incomers, compressors, boilers, and water lines, recording absolute readings alongside production denominators in accordance with ISO 50001, IEA metering guidance, and GRI standards for energy, water consumption versus withdrawal, and waste destinations. [S29] [S33] [S34] [S35] [S39]

> **GFT NOTE**
>
> GFT recommends freezing the capture schema during months one to three to the minimum fields required for daily reconciliation and the six-family baseline. When department heads request extra columns for secondary analytics during month two, the data steward defers those additions to a post-Gate-One backlog. Keeping the initial log narrow ensures that 100 percent of active lines achieve timely, cross-checked shift closure in an illustrative twelve-week window before any new reporting burden is introduced. [S22] [S24]

14.5

Months four to eight make the cadence routine

Once Gate One confirms that source records are complete and measurement error is bounded, the illustrative window of months four to eight installs the management cadence that turns passive logs into owned operational decisions. [S42] [S44] A factory improves when each management tier reviews its assigned signals on a fixed schedule, diagnoses constraints within its authority, and escalates structural bottlenecks with intact evidence. [S08] [S22] Research on sales and operations planning (S&OP) maturity emphasises that evolutionary progress requires advancing meetings and collaboration, organisational structure, and integrated planning alongside performance measures and information technology. [S44]

During this second stage, GFT requires every review forum in the plant to read from the single authoritative record established in Stage 1. [S22] [S24] Private supervisor notebooks, unverified slide decks, and parallel finance spreadsheets are barred from management meetings. When the daily line huddle, the weekly plant problem-solving meeting, and the monthly S&OP review all query the same validated shift tables, discussions move immediately from arguing over whose piece count is correct to deciding how to remove the constraint on the floor. [S21] [S22] [S42]

14.6 THREE LINKED FORUMS CONNECT STATION BALANCING TO PRODUCT-FAMILY PLANNING

Stage 2 operationalises three distinct management loops, each with its own horizon, chair, and decision rights: [S04] [S42] [S44]

1. **The daily shift huddle and live line rebalance:** Garment-sector improvement reports establish that line balancing is performed systematically by line supervisors both before production through planning and daily during production. [S04]

At the start of each shift, the supervisor leads a short huddle at the visual line board to review prior-shift good output, first-pass yield, cause-coded downtime, attendance, and work-in-progress (WIP) age. [S02] [S07] [S10] During the shift, supervisors use hourly progress checks and the demonstrated skill matrix to reallocate operators before queues starve downstream stations. [S04] [S12] Because supervisory capability is a primary production control, months four to eight pair these daily routines with structured supervisor development: following Better Work evidence where trainees completed classroom modules and shadowed a supervisor on a production line for six to eight weeks, GFT coaches line leaders on live huddles, fair communication, and escalation discipline. [S13] [S14]

2. **The weekly cross-line constraint and action review:** Every week, the plant director chairs a cross-functional review with production, quality, maintenance, industrial engineering, human resources, and sustainability leads. The weekly forum examines recurring downtime causes across lines, Pareto rankings of defect mechanisms, overtime concentration, skill-coverage gaps, and resource-intensity anomalies. [S07] [S08] [S18] [S36] Crucially, the weekly meeting audits the plant action log: no item closes merely because a task was performed; an action remains open until subsequent shift records confirm that the targeted loss actually declined. [S08] [S43]

3. **The monthly product-family S&OP reconciliation:** In accordance with industrial S&OP practice, management conducts a formal review at least once a month at an aggregate product-family level. [S42] Commercial, planning, procurement, finance, and operations leaders reconcile customer orders and delivery promises against demonstrated line capability, material lead times, and operator skill availability. [S03] [S21] [S42] Instead of scheduling orders against theoretical nameplate capacity, the monthly S&OP uses the ramp-adjusted good-output curves and first-pass yield ranges observed in the governed record, protecting on-time-in-full (OTIF) delivery reliability. [S11] [S42]

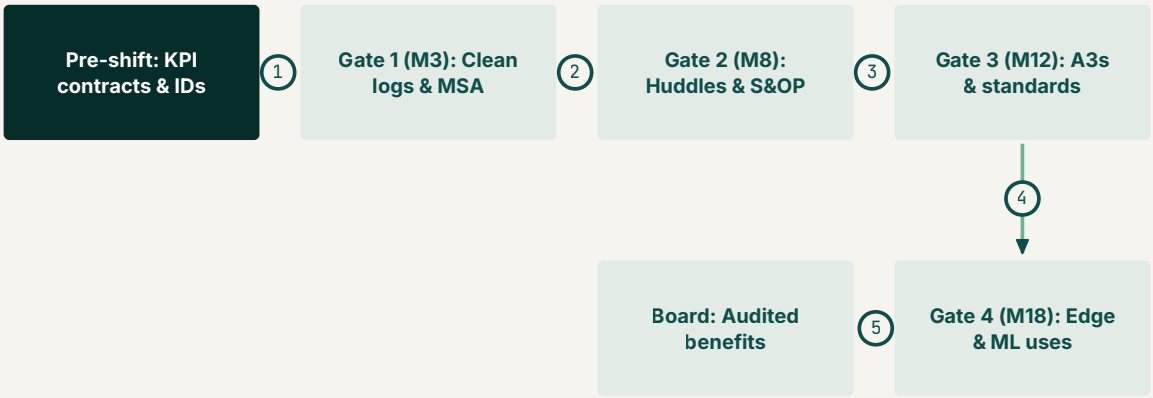
14.7 BOTTOM-UP CHALLENGE PROTECTS FAIRNESS AND ADAPTIVE LEARNING

A critical test during months four to eight is ensuring that the KPI cascade does not harden into an arbitrary top-down command structure. Scholarship on the balanced scorecard notes that a purely rational, top-down execution model can fail in decentralised or adaptive environments where front-line conditions evolve rapidly. [S46] In a greenfield garment factory, fabric batches vary, sewing methods undergo refinement, and provisional SMVs occasionally misstate the work content of a complex seam. [S03] [S11] GFT therefore builds a formal bottom-up challenge route into the Stage 2 cadence: if a line supervisor or operator team demonstrates through clean shift logs that a missed target resulted from ungraded fabric defects, compressor pressure drops, or an unachievable provisional standard, the weekly review reclassifies the variance as an engineering or supply action rather than a line failure. [S16] [S45] [S46] This rule preserves the equity and verifiability of performance standards and aligns compensation with behaviours that workers actually control, notably defect reduction and attendance. [S16] [S45]

To illustrate how Stage 1 and Stage 2 deliverables feed the later stages of the roadmap, **Exhibit 65**, p. 227 maps the derived handoff chain across the eighteen-month system. [S01] [S05] [S24] [S27] [S41] [S42] [S43] [S1401]

EXHIBIT 65 /

Each roadmap stage hands an audited asset to the next gate



1. Enables clean capture
2. Feeds trusted cadence
3. Selects priority gaps
4. Supplies clean history
5. Proves residual value

DERIVED [S01] [S05] [S24] [S41] [S42] [S43] [S27] [S1401] Derived GFT stage-gate handoff sequence combining pre-shift measurement design (S01, S1401), baseline and data-quality control (S05, S24), monthly S&OP cadence (S42), A3 problem solving and post-completion benefit monitoring (S41, S43), and data-gated machine learning (S27).

The dependency chain in **Exhibit 65**, p. 227 explains why GFT treats calendar shortcuts as an operational hazard. [S27] [S44] Gate 2's monthly S&OP and daily huddles cannot function if Gate 1 has not eliminated competing piece counts and uncalibrated defect grading. [S24] [S40] [S42] Equally, Gate 3's structured improvement projects rely on Gate 2's reviews to select problems based on strategic consequence, and Gate 4's predictive models depend on Gate 3 having stabilised standard work and labelled historical exceptions. [S27] [S41] While **Exhibit 65**, p. 227 establishes the logical order of deliverables, it does not imply that earlier stages stop once passed; capture validation, daily huddles, and A3 problem solving continue permanently as the spine of the plant.

14.8

Months nine to twelve prove the improvement loop

By month nine on the illustrative roadmap, the factory possesses six months of reconciled shift history and a stable rhythm of daily, weekly, and monthly reviews. Months nine to twelve use that foundation to prove the closed-loop improvement system, moving the plant from reactive containment to verified root-cause elimination and standard-work revision. [S08] [S09] [S41] [S43] Factories often stall here because they confuse activity with improvement, logging corrective actions while line OEE, rework hours, and energy per piece remain unchanged. [S08] Stage 3 closes that

loophole by requiring teams to complete end-to-end improvement cycles governed by statistical variation checks, reverse-tested A3 logic, guardrail verification, and formal benefits tracking. [S09] [S41] [S43]

14.9 STATISTICAL VARIATION CHECKS AND REVERSE-READ A3S GOVERN DIAGNOSIS

During months nine to twelve, improvement teams apply a four-part engineering sequence to the priority gaps selected by the weekly and monthly reviews: [S09] [S41] [S43]

1. **Separate common-cause noise from special-cause signals:** Before altering a sewing method or maintenance schedule, engineers apply statistical process control (SPC) principles by comparing current line behaviour against the historical baseline established in Stages 1 and 2. [S09] Where cohort stability and sample size support control charts, the team checks whether a defect spike or throughput drop crossed statistical control limits (indicating an assignable special cause such as a defective thread batch) or remained within routine common-cause variation (requiring systemic redesign of work allocation, tooling, or operator drills). [S09] [S12] Control limits remain separate from customer specifications and management targets so teams never tamper with a stable process in response to routine noise. [S09]
2. **Test A3 reasoning in reverse:** Every major corrective project is documented on a single-page A3 charter linking the baseline gap, process boundary, competing root-cause hypotheses, countermeasure, verification window, and standard-work update. [S05] [S41] Following Lean Enterprise Institute guidance, the plant director and engineering lead audit each A3 by reading it backwards from the proposed standardisation step to the initial problem statement, confirming that every causal link is backed by source-record evidence. [S41]
3. **Verify primary effects alongside cross-family guardrails:** When a countermeasure is deployed on a line, the team monitors a defined post-intervention cohort against the baseline cohort and, where feasible, a matched comparison line. [S05] [S13] [S43] Verification checks both the primary KPI and its paired guardrails: a throughput countermeasure is rejected if first-pass yield falls or overtime rises, and a quality countermeasure is recalibrated if processing time expands disproportionately, respecting the physical link between first-pass yield and lead time documented in NIST manufacturing cases. [S02] [S10] [S18]
4. **Update standard work and prune non-decision metrics:** When verification proves a sustained gain, engineering and quality teams update the official method revision, recalculate the SMV if the method changed, refresh the skill matrix, and log the improvement in the benefits register. [S03] [S12] [S41] [S43] Simultaneously, Stage 3 conducts a metric-hygiene audit at month twelve: any secondary KPI that has not informed a concrete management decision or guardrail check during the preceding two quarters is retired from review boards. [S01] [S22]

GATE THREE VERIFICATION PROTOCOL FOR KPI RETIREMENT AND STANDARD UPDATES

At the month-twelve Gate Three audit, the data steward and business owners inspect every active metric and completed A3 project against three objective rules: [S01] [S41] [S43]

- **Decision trace check:** Each KPI on daily, weekly, and monthly boards must point to at least one logged decision, escalation, or guardrail verification in the Stage 2 and Stage 3 action register. Metrics with zero decision references over six months are archived from operational boards. [S01] [S22]
- **Standard-work synchronisation:** Every closed A3 claiming a process improvement must cite the updated method revision number, the date operators were drilled on the revised method, and the effective date of any revised SMV or inspection standard. [S03] [S12] [S41]
- **Post-completion persistence:** In line with benefits management frameworks, no improvement cycle is counted towards Gate Three passage until its primary metric and guardrails have held their verified improvement across at least four consecutive weeks after project closure. [S43]

14.10

Months thirteen to eighteen connect approved digital uses

Only after the factory passes Gate Three at month twelve, having proven clean source capture, routine management cadence, and verified process improvement, does the illustrative roadmap enter Stage 4 (months thirteen to eighteen) to connect automated sensing, manufacturing execution modules, and machine-learning applications. [S27] [S28] [S44] This timing directly implements machine-learning engineering guidance: if machine learning is not absolutely required for an operation, teams should not use it until they have data, and they should benchmark complex models against simple heuristics first. [S27] By month thirteen, the greenfield plant possesses a year of governed, versioned, and reconciled operational history across styles, lines, operators, machines, and utility meters. [S01] [S21] [S23]

Stage 4 also follows public-sector beta-to-live service principles, where teams take solutions tested in earlier phases, build them for production scale, verify how they integrate with or replace existing workflows, and address technical constraints before live dependence. [S1403] Rather than purchasing a monolithic software suite, GFT introduces digital tools one approved use case at a time, using gradual MLOps automation and distributed edge computing so the floor remains resilient even when external telecommunications fail. [S26] [S28]

14.11 USE CASES MUST PASS DECISION, DATA, BASELINE AND RESILIENCE GATES

During months thirteen to eighteen, candidate digital investments in the garment plant cluster into four operational areas, each governed by entry and acceptance checks: [S19] [S26] [S27] [S28]

1. **Targeted source-capture sensing (RFID and machine power monitoring):** Apparel manufacturing research demonstrates that RFID systems can record front-line worker production data in multi-variety, small-batch lines, and that power-monitoring sensors on sewing machines can extract working times across sewing tasks. [S19] [S20] In Stage 4, GFT deploys RFID bundle readers or power sensors selectively on bottleneck lines where manual ticket scanning creates delays. Because master-data identifiers and ISO 22400 event schemas were fixed before shift one, sensor events write directly into the existing validation pipeline without altering KPI definitions. [S01] [S21] [S25]
2. **Edge-buffered shop-floor execution:** Following the NIST fog-computing conceptual model, which decentralises applications, management, and analytics into the local network, Stage 4 runs shop-floor data collection, line-board rendering, and validation rules on local plant hardware with persistent queues. [S26] If wide-area connectivity drops, sewing lines continue logging events locally over the factory network and synchronise without duplicate records once connectivity returns. [S24] [S26]
3. **Computer-vision augmentation in fabric and garment inspection:** Published textile inspection literature notes that while manual inspection is 60 to 70 percent accurate and misses 20 to 30 percent of defects, computer-vision systems can exceed 90 percent accuracy across more than 40 defect types at line-scan speeds of up to 60 metres a minute. [R29] When fabric volume and defect cost justify piloting an inspection camera in Stage 4, camera detections map into the existing W3C-aligned defect taxonomy and undergo Gauge R&R agreement checks against senior human adjudicators before any automated rejection rule is enabled. [R29] [S25] [S40]
4. **Statistical and machine-learning decision support in S&OP and maintenance:** While global fashion reports cite potential AI-at-scale reductions of 35 to 40 percent in inventory costs and 20 to 50 percent in forecast errors across mature retail networks, a single factory in month fourteen must evaluate forecasting or predictive-maintenance models against its own local heuristic baselines. [R27] [S27] Using gradual MLOps practices, the plant versions its training datasets, tests whether a model outperforms the deterministic capacity rules used in Stage 2 S&OP, assigns an owner to review exceptions, and keeps a rollback to the deterministic calculation. [S27] [S28] [S42]

UNRECONCILED CUTOVER IN MONTHS THIRTEEN TO EIGHTEEN CAN ERASE A YEAR OF BASELINES

When automated RFID readers, smart utility submeters, or MES screens go live during Stage 4, differences in timestamp triggering or rounding can introduce an artificial step-change into OEE availability, piece counts, or energy-intensity ratios. [S01] [S06] [S33] GFT mandates an illustrative minimum ten-shift parallel run for every Stage 4 deployment: automated streams and governed logs run side by side until the data steward certifies that shift totals reconcile within specified measurement-system tolerances and that offline fallback procedures execute cleanly. [S23] [S24] [S26] [S40]

14.12

The benefits register separates movement from attribution

A performance-management system proves its value only if it can distinguish genuine operational improvement from background shifts in product mix, order volume, material batches, or accounting rules. [S05] [S43] The UK Department for Transport's benefits management and evaluation framework establishes the core governance principle: a formal framework ensures that expected benefits are defined upfront, assigned to owners, and managed and monitored beyond project completion. [S43] In a greenfield garment factory, raw KPI trajectories between month one and month eighteen reflect overlapping forces: operators climb learning curves, commercial teams shift from introductory T-shirts to higher-SMV woven shirts, utility baseloads spread across larger volumes, and inspection calibration tightens during Gauge R&R checks. [S03] [S11] [S36] [S40]

GFT prevents false attribution by maintaining a governed benefits register as part of the system of record from Stage 3 onwards. [S22] [S43] Every major intervention, whether an A3 line-balancing redesign, a supervisor coaching cohort, a compressor leak-repair campaign, or a Stage 4 RFID deployment, is entered into the register before implementation with a named benefit owner, a physical mechanism, a dated baseline population, adjustment rules, and cross-family guardrails. [S02] [S41] [S43]

14.13 EVERY CLAIMED GAIN MUST SURVIVE A FOUR-STEP ATTRIBUTION BRIDGE

Before any efficiency, quality, cost, or sustainability gain is reported to the factory board as a verified benefit, the data steward and finance lead reconcile the observed KPI movement through four sequential adjustments: [S01] [S33] [S40] [S43]

1. **Cohort and work-content normalisation:** Piece counts and labour hours are translated into standard work content using approved SMVs for the specific style and method revision, ensuring that a shift from a 12-SMV garment to an 18-SMV garment (illustrative work-content values) is evaluated on standard minutes produced rather than raw piece count alone. [S01] [S03]
2. **Volume and fixed-baseload separation:** For resource-intensity and overhead measures, where ISO 50001, GRI 302, and UNIDO guidance link relative indicators to production output, the register separates efficiency gains caused by higher line utilisation from direct physical reductions in process energy, water consumption, or fabric waste. [S29] [S33] [S35] [S36]

3. **Measurement-rule and calibration adjustment:** If a Gauge R&R study or metric-contract update changed how defects or downtime were recorded between the baseline and follow-up windows, the bridge subtracts the measurement-rule effect using dual-graded bridge samples so calibration changes are never misread as physical quality shifts. [S01] [S22] [S40]
4. **Guardrail and persistence deduction:** Finally, the register checks whether any paired guardrail deteriorated during the evaluation window (such as overtime rising or delivery lateness growing) and verifies whether the net residual gain persisted across post-completion monitoring checks. [S02] [S18] [S43]

To show the structure of this governance ledger, **Exhibit 66**, p. 232 displays an illustrative extract from a GFT benefits register across four greenfield interventions. [S03] [S10] [S14] [S33] [S41] [S43]

EXHIBIT 66 /

The benefits register makes every claim auditable

Intervention and owner	Baseline cohort and mechanism	Observed movement and bridge adjustments	Guardrails verified	Audit status
Collar-attach folder and A3 method update (Quality lead)	Line 2 woven shirt cohort; reduce seam puckering and rework loop	Gross FPY rise adjusted for inspector Gauge R&R recalibration and style mix	Operation cycle time, operator ergonomics and zero overtime increase	Verified sustained at 8 weeks post-A3
Supervisor 6 to 8 week line-shadowing cohort (HR and Production leads)	Lines 1 to 4 shift huddles; faster daily rebalancing and waiting reduction	Waiting-downtime drop adjusted for fabric-delivery delays on matched lines	Worker survey feedback, absence rate and first-pass yield stability	Verified sustained at 12 weeks post-coaching
Quick-changeover presser-foot kit and standard work (IE lead)	Small-batch style transitions; separate internal and external setup steps	Changeover minute reduction adjusted for batch-size variation across orders	First-bundle defect rate after style start and mechanic safety checks	Provisional: awaiting second monthly S&OP cycle
Compressor leak repair and header isolation (Facilities and Sustainability leads)	Plant compressed-air ring; eliminate off-shift leakage and pressure drops	kWh per 1,000 standard minutes adjusted for ambient load and shift volume	Pneumatic folder pressure stability and sewing availability	Verified sustained across 3 monthly meter closes

ILLUSTRATIVE [S43] [S05] [S10] [S14] [S33] [S41] Illustrative benefits-register table applying the post-completion monitoring discipline of S43, baseline KPI tracking from S05, A3 causal verification from S41, first-pass yield and flow linkage from S10, supervisor line shadowing from S14, and energy-intensity normalisation from S33. All entries describe governance structure and illustrative mechanisms, not realised GFT factory results.

Each row in **Exhibit 66**, p. 232 demonstrates how the benefits register prevents inflated performance claims. [S41] [S43] The register binds the intervention to an accountable owner, names the physical mechanism tested, states which confounding variables were stripped out in the attribution bridge, and records the guardrail checks required for sign-off. [S02] [S05] [S43] Notice that the third entry in **Exhibit 66**, p. 232 remains marked provisional until it completes its post-implementation monitoring

window. [S43] Because **Exhibit 66**, p. 232 is an illustrative governance template, it does not report empirical savings from an operating GFT facility; plant teams must populate every column with their own audited shift records.

WORKED EXAMPLE

To see how the benefits register arithmetic reconciles gross movement to verified residual value, consider an illustrative Stage 3 evaluation on a greenfield sewing line producing a standard woven workshirt over a four-week baseline cohort (Cohort A, month eight) and a four-week post-intervention cohort (Cohort B, month eleven) after an A3 collar-assembly method and supervisor line-balancing intervention. [S04] [S41] [S43] All figures in this worked example are explicitly illustrative and constructed solely to demonstrate the reconciliation method: [S01] [S43]

1. **Recorded cohort inputs (illustrative):** [S01] [S10]
2. In Cohort A (baseline), the line attends 40,000 illustrative direct operator-hours across the four-week window, paid at an illustrative blended direct wage and benefit rate of XAF 400 per operator-hour (total direct payroll equals XAF 16,000,000). The line completes 50,000 total shirts at an initial first-pass yield of 80.0 percent, yielding 40,000 first-pass good shirts without rework. The gross baseline effective direct labour cost per first-pass good shirt is XAF 16,000,000 divided by 40,000, which equals XAF 400.00 per good shirt. [S01] [S10]
3. In Cohort B (post-intervention), the line again attends 40,000 illustrative direct operator-hours at the XAF 400 hourly rate (total direct payroll equals XAF 16,000,000). Total shirts completed rise to 55,000 and recorded first-pass yield reaches 90.0 percent, yielding 49,500 first-pass good shirts. The observed gross effective direct labour cost falls to XAF 16,000,000 divided by 49,500, or XAF 323.23 per good shirt, a gross reduction of XAF 76.77 per good shirt (19.2 percent). [S01] [S10]
4. **Attribution bridge adjustments (illustrative):** [S03] [S40]
5. *Style-mix and SMV adjustment:* During Cohort B, scheduling shifted 20 percent of line volume to a simpler pocket variant whose approved SMV was lower, increasing natural throughput by an illustrative 2,000 good shirts without any change in line efficiency. Removing those 2,000 mix-driven shirts leaves 47,500 comparable good shirts, corresponding to an illustrative unit cost of XAF 16,000,000 divided by 47,500, or XAF 336.84 per good shirt. Thus, XAF 336.84 minus XAF 323.23 equals XAF 13.61 per good shirt attributed to style-mix simplification. [S03] [S42]
6. *Measurement-calibration adjustment:* Between Cohort A and Cohort B, a Gauge R&R check corrected an over-rejection bias among two inspectors who had classified minor loose trimming threads as sewing rework. [S40] Dual-grading of an illustrative bridge sample showed that 1.0 percentage point of the apparent 10.0 percentage-point FPY gain (550 shirts in Cohort B) resulted from cleaner inspector adherence to the defect definition. Removing those 550 calibration-adjusted shirts leaves 46,950 comparable first-pass good shirts, corresponding to an illustrative unit cost of XAF 16,000,000 divided by 46,950, or XAF 340.79 per good shirt. Thus, XAF 340.79 minus XAF 336.84 equals XAF 3.95 per good shirt logged as a measurement correction. [S24] [S40]
7. **Verified residual benefit and guardrail check (illustrative):** [S18] [S43]
8. Subtracting the illustrative style-mix effect (XAF 13.61) and calibration effect (XAF 3.95) from the gross reduction (XAF 76.77) leaves an illustrative verified residual benefit of XAF 59.21 per first-pass good shirt (XAF 400.00 minus XAF 340.79 equals XAF 59.21, or a 14.8 percent verified unit-cost reduction). [S01] [S43]

9. Before crediting this illustrative XAF 59.21 per shirt reduction in the benefits register, the data steward verifies that weekly hours remained within the 40-hour standard and 48-hour statutory maximum, overtime did not increase, and customer OTIF held steady across the eight-week post-A3 monitoring window. [R16] [S18] [S43]

14.14

The board measures system health as well as factory output

At the eighteen-month mark, the ultimate test of the performance-management system is how the sponsoring board and executive leadership evaluate the factory. If board reviews examine only aggregate shipment volume and financial unit cost, leadership recreates at the governance level the blindness that OEE decomposition and first-pass yield rules prevented on the sewing floor. [S02] [S06] [S10] A factory can temporarily hit an eighteenth-month output target by deferring maintenance, burning out operators with excessive overtime, shipping reworked seconds as first-quality goods, or letting clerks fabricate missing meter reads. [S07] [S18] [S24] Conversely, a plant that reports honest ramp-up variance alongside high data completeness, rapid action closure, and audited benefit bridges gives its sponsors a trustworthy basis for capital allocation. [S43] [S44]

GFT therefore structures the closing board scorecard around six paired tiles that unite the six operational KPI families with three explicit measures of performance-system health. [S02] [S24] [S43] [S44] This dual view reflects both the ILO recommendation to balance financial, behavioural, and core-process metrics and the S&OP maturity principle that organisational, meeting, and measurement discipline must be evaluated alongside operational results. [S02] [S44]

14.15 PAIRED BOARD INDICATORS UNITE THE SIX FAMILIES WITH GOVERNANCE PROOF

In every quarterly board packet and at the month-eighteen Stage 4 review, plant leadership presents the governed indicators summarised in **Exhibit 67**, p. 236, keeping cohort denominators, range bounds, and benefit-register links open to inspection. [S01] [S02] [S24] [S43] [S44]

EXHIBIT 67 /

The board sees operating results and system health together

OEE & FPY

Production & Quality

Good output, A x P x Q split & first-pass yield (S06, S10).

OTIF & XAF

Delivery & Cost

Monthly S&OP order OTIF & labour cost per good unit (S01, S42).

40 to 48 hrs

People & Sustainability

Skill coverage, hour limits & kWh/L/kg per unit (R16, S33).

6 checks

Health: Data completeness

Shifts passing DAMA & MSA checks on time (S24, S40).

Held %

Health: Action closure

A3 actions verified in follow-up cohorts (S41, S43).

Net XAF

Health: Audited benefit

Residual gain after mix & calibration bridge (S43).

ILLUSTRATIVE [S01] [S02] [S06] [S10] [S24] [S33] [S42] [S43] [S44] Illustrative six-tile board scorecard layout combining GFT's six operating KPI families (production, quality, delivery, cost, people, sustainability) with three system-health indicators (data completeness, verified action closure, audited residual benefit), derived from S01, S02, S06, S10, S24, S33, S42, S43 and S44. Tile values state the governed formula and gate role rather than invented factory performance numbers.

The six tiles in **Exhibit 67**, p. 236 complete the argument of this white paper by showing how the six operating families and the three system-health gates lock together at the highest decision level of the enterprise. [S02] [S43] [S44] The first three tiles group the six operating families into three paired trade-off views (production with quality, delivery with effective unit cost, and people with resource intensity) so no single operational priority can advance by transferring harm to its partner family. [R16] [S02] [S06] [S10] [S33] The second three tiles tell the board whether the operating figures deserve to be believed: if data completeness falls below the gate threshold, or if action closure and audited benefit tiles show that management actions are closing on paper without verified residual effects on the floor, the board directs engineering effort back to capture and cadence discipline before authorising new capital or digital spend. [S24] [S27] [S43] Because **Exhibit 67**, p. 236 defines a structural governance contract without fabricated factory numbers, it serves as an inspectable template that any greenfield sponsor can adopt prior to shift one.

14.16 COMPANION PAPERS AND INTERACTIVE TOOLS EXTEND THE OPERATING SYSTEM

This eighteen-month performance-management roadmap connects directly to the companion white papers and interactive decision tools in the GFT research library. [S01] [S22] [S44] Sponsors examining the macro-industrial context of Cameroon's cotton-to-garment value chain can pair this paper with `wp01`, while engineering teams preparing for Stage 4 digital deployments can consult `wp03` on computer-vision defect inspection, `wp04` on demand forecasting, `wp07` and `wp18` on resilient edge and reference architecture, `wp14` on data governance, and `wp15` on lean flow. [R06] [R29] [S26] [S27] Similarly, human-resources and sustainability leaders can extend the people and resource contracts using `wp06`, `wp09`, `wp12`, and `wp16`. [S13] [S30] Within the interactive toolset, the `kpi-cascade`, `maturity`, `ramp-planner`, `oee-line`, `line-balancing`, `labour-cost`, `footprint`, `supervisor-pipeline`, `edge-architecture`, `build-or-buy`, `use-case-portfolio`, and `unit-economics` tools implement the exact formulas, denominators, and gate criteria defined across these fourteen chapters. [S01] [S44]

Finally, readers and sponsors should note the scope boundary of this work: the recommendations, metric contracts, worked examples, and eighteen-month roadmap presented in this paper constitute operational and industrial-engineering guidance. They do not constitute investment, legal, accounting, or tax advice. Every greenfield garment programme must validate its commercial assumptions, labour contracts, environmental permits, and capital budgets against current local statutes and site-specific engineering studies before committing funds. When sponsors combine that project-specific due diligence with a line-level measurement system installed from the very first shift, they equip the factory to learn rapidly, protect its workforce, and prove the value it creates.

A factory proves its value not by the promises in its business plan, but by the integrity of the record it keeps from its first shift.

CHAPTER SOURCE NOTES

S01 International Organization for Standardization. 2014.

S05 International Labour Organization. 2022-06-01.

S27 Google for Developers. 2025-08-25.

S43 UK Department for Transport. 2025.

S44 Production, SciELO. 2017-11-27.

S1401 UK Government Digital Service. 2017-12-05.

S23 ISO/IEC. 2008.

S41 Lean Enterprise Institute. 2022-08-10.

S42 Production, SciELO. 2017.

S02 International Labour Organization. 2017.

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

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

S11 International Journal of Production Economics, Elsevier. 2001.

S07 Scientific Reports, Springer Nature. 2025.

S10 National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04.

S18 ILO and IFC, Better Work. 2011.

S22 United States Federal Data Strategy. 2020.

S45 United States Office of Personnel Management. 2019-11-04.

S06 Diamond Congress, Creative Construction Conference. 2023.

S03 International Labour Organization. 2023.

S30 GHG Protocol, WRI and WBCSD. 2004.

S33 Global Reporting Initiative. 2016.

S21 National Institute of Standards and Technology. 2016.

S25 W3C. 2017-01-31.

R14 WageIndicator. 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.

S17 ILO and IFC, Better Work. 2018-12-20.

S24 UK Government Data Quality Hub. 2020-12-03.

S12 Applied Sciences, MDPI. 2021-11-23.

S39 International Energy Agency. 2014.

S1402 UK Government Digital Service. 2019-05-08.

R29 MDPI; industry inspection literature. Publication date unrecorded; inherited source-text check.

S40 NIST/SEMATECH. 2003.

S29 International Organization for Standardization. 2018.

S34 Global Reporting Initiative. 2018.

S35 Global Reporting Initiative. 2020.

S08 International Journal of Productivity and Quality Management, Inderscience. 2020-05-11.

S04 International Labour Organization. 2023.

S13 International Finance Corporation. 2009.

S14 IFC and ILO, Better Work. 2025.

S36 UNIDO and UNEP. 2015.

S46 Encyclopedia, MDPI. 2025-03-19.

S16 PLOS ONE. 2020-02-05.

S09 NIST/SEMATECH. 2003.

S28 Google Cloud. 2024-08-28.

S1403 UK Government Digital Service. 2021-02-19.

S26 National Institute of Standards and Technology. 2018-03-14.

S19 The International Journal of Advanced Manufacturing Technology, Springer Nature. 2019-09-03.

S20 Applied Sciences, MDPI. 2020-04-29.

R27 McKinsey, The State of Fashion 2025. Publication date unrecorded; inherited source-text check.

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

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.

R03 Inherited evidence R03 GRADE C

SODECOTON. Publication date unrecorded. sodecoton.cm

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.

R04 Inherited evidence R04 GRADE C

Financial Fortune Media. Publication date unrecorded. financialfortunemedia.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.

R05 Inherited evidence R05 GRADE C

Ecofin Agency. Publication date unrecorded. ecofinagency.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.

R06 Inherited evidence R06 GRADE C

Cameroon Trade Hub. Publication date unrecorded. cameroontradehub.cm

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.

Inherited source-text check; original source not independently re-opened for this edition.

R08 Inherited evidence R08 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.

R09 Inherited evidence R09 GRADE C

Ecofin Agency. Publication date unrecorded. ecofinagency.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.

R10 Inherited evidence R10 GRADE C

Ecofin Agency. Publication date unrecorded. ecofinagency.com

Camtext SA: 12,000 t a year processed; about 12,000 jobs at the Dibamba hub and 3,000 at Garoua; return on investment near 11 years; optimal capacity around 2033.

Inherited source-text check; original source not independently re-opened for this edition.

R11 Inherited evidence R11 GRADE C

Business in Cameroon; MMI News. Publication date unrecorded. businessincameroon.com; mimimefoinfos.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.

R12 Inherited evidence R12 GRADE C

Business in Cameroon. Publication date unrecorded. businessincameroon.com

CICAM capacity utilisation, July 2023 report: Garoua 33.7 percent, CICAM 1 48.9 percent, CICAM 2 10.83 percent; underutilisation cost about CFAF 2 billion in 2020.

Inherited source-text check; original source not independently re-opened for this edition.

R13 Inherited evidence R13 GRADE C

Business in Cameroon; MMI News. Publication date unrecorded. businessincameroon.com; mimimefoinfos.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.

R14 Inherited evidence R14 GRADE C

WageIndicator. Publication date unrecorded. wageindicator.org

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.

Inherited source-text check; original source not independently re-opened for this edition.

R15 Inherited evidence R15 GRADE C

wage.is. Publication date unrecorded. wage.is/cameroon

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.

Inherited source-text check; original source not independently re-opened for this edition.

R17 Inherited evidence R17 GRADE C

just-style. Publication date unrecorded. just-style.com

Cambodia garment-sector minimum wage US$204 a month for 2024 (labour-cost benchmark).

Inherited source-text check; original source not independently re-opened for this edition.

R18 Inherited evidence R18 GRADE B

Congressional Research Service IF10149; AGOA (Wikipedia). Publication date unrecorded. congress.gov; en.wikipedia.org

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.

R23 Inherited evidence R23 GRADE C

MacMap; AfCFTA. Publication date unrecorded. macmap.org

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.

R24 Inherited evidence R24 GRADE C

Mordor Intelligence. Publication date unrecorded. mordorintelligence.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.

R25 Inherited evidence R25 GRADE C

Market.us. Publication date unrecorded. market.us

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.

R26 Inherited evidence R26 GRADE C

Statista. Publication date unrecorded. statista.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.

R27 Inherited evidence R27 GRADE B

McKinsey, The State of Fashion 2025. Publication date unrecorded. mckinsey.com

AI at scale in fashion: inventory cost down 35 to 40 percent; forecast accuracy up 20 to 30 percent; revenue per customer up 15 to 25 percent; forecast errors cut 20 to 50 percent; lost sales down up to 65 percent; 75 percent of executives prioritising; sector operating-profit potential US$150 to 275 billion over three to five years.

Inherited source-text check; original source not independently re-opened for this edition.

R28 Inherited evidence R28 GRADE C

DataIntelo. Publication date unrecorded. dataintelo.com

Fabric-defect-detection AI market US$523.4 million (2024) to US$6,522.1 million (2033) at 33.8 percent a year; Asia-Pacific about 46 percent in 2024.

Inherited source-text check; original source not independently re-opened for this edition.

R29 Inherited evidence R29 GRADE C

MDPI; industry inspection literature. Publication date unrecorded. mdpi.com

Manual defect inspection 60 to 70 percent accurate, missing 20 to 30 percent of defects; computer vision above 90 percent across more than 40 defect types; line-scan inspection up to 60 metres a minute.

Inherited source-text check; original source not independently re-opened for this edition.

R30 Inherited evidence R30 GRADE C

Design Journal (Taylor and Francis). Publication date unrecorded. tandfonline.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.

R31 Inherited evidence R31 GRADE C

arXiv 2509.04705. Publication date unrecorded. arxiv.org/abs/2509.04705

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.

R32 Inherited evidence R32 GRADE C

Wise; XE. Publication date unrecorded. wise.com; xe.com

CFA franc to US dollar reference rates; franc pegged to the euro at 655.957. The GFT study's method note places the franc near 590 to 610 per US dollar across the 2023 study window and near 563 to 577 more recently, and treats currency conversions as estimates.

Inherited source-text check; original source not independently re-opened for this edition.

c01-S01 ISO 22400-2:2014 Automation systems and integration: Key performance indicators for manufacturing operations management, Part 2: Definitions and descriptions GRADE A

International Organization for Standardization. 2014-01. https://www.iso.org/standard/54497.html

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c01-S02 Lean Manufacturing Techniques for Ready Made Garments Industry GRADE A

International Labour Organization. 2017. https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@africa/@ro-abidjan/@sro-cairo/documents/publication/wcms_621950.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c01-S11 Learning and process improvement during production ramp-up GRADE B

International Journal of Production Economics, Elsevier. 2001. https://faculty.wharton.upenn.edu/wp-content/uploads/2012/04/P14.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c01-S19 A method of garment factory workers' performance monitoring using control chart based on RFID system GRADE B

The International Journal of Advanced Manufacturing Technology, Springer Nature. 2019-09-03. https://link.springer.com/article/10.1007/s00170-019-04352-3

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c01-S20 Remote Sensing of Sewing Work Levels Using a Power Monitoring System GRADE B

Applied Sciences, MDPI. 2020-04-29. https://mdpi-res.com/d_attachment/applsci/applsci-10-03104/article_deploy/applsci-10-03104.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c01-S27 Rules of Machine Learning: Best Practices for ML Engineering GRADE C

Google for Developers. 2025-08-25. https://developers.google.com/machine-learning/guides/rules-of-ml

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c01-S30 The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard, Revised Edition GRADE B

GHG Protocol, WRI and WBCSD. 2004. https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S02 Lean Manufacturing Techniques for Ready Made Garments Industry GRADE A

International Labour Organization. 2017-09-18. https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@africa/@ro-abidjan/@sro-cairo/documents/publication/wcms_621950.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S03 Sector systems analysis of textiles and clothing subsector in Ghana GRADE A

International Labour Organization. 2024-01-17. https://researchrepository.ilo.org/view/pdfCoverPage?instCode=41ILO_INST&filePid=13123115820002676&download=true

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S04 Implementation of the Factory Improvement Toolset in the Asian garment sector: Final report GRADE A

International Labour Organization. 2023-03-21. https://www.ilo.org/media/365276/download

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S05 **Advancing productivity, quality improvement and decent work in Ethiopia's garment industry: results so far** GRADE A

International Labour Organization. 2022-06-01. https://www.ilo.org/resource/article/advancing-productivity-quality-improvement-and-decent-work-ethiopias

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S09 **e-Handbook of Statistical Methods: What are Process Control Techniques?** GRADE A

NIST/SEMATECH. 2003-06-01. https://www.itl.nist.gov/div898/handbook/pmc/section1/pmc12.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S10 **First Pass Yield Improvement Creates Dramatic Reduction in Lead Time** GRADE A

National Institute of Standards and Technology, Manufacturing Extension Partnership. 2022-08-04. https://www.nist.gov/mep/successstories/2021/first-pass-yield-improvement-creates-dramatic-reduction-lead-time

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S11 **Learning and process improvement during production ramp-up** GRADE B

International Journal of Production Economics, Elsevier. 2001-10-26. https://faculty.wharton.upenn.edu/wp-content/uploads/2012/04/P14.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S12 **Evaluation of Manual Skill Degradation Due to Automation in Apparel Manufacturing** GRADE B

Applied Sciences, MDPI. 2021-11-23. https://mdpi-res.com/d_attachment/applsci/applsci-11-11098/article_deploy/applsci-11-11098.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S13 **Supervisory Skills Training in the Cambodian Garment Industry: A Randomized Impact Evaluation** GRADE B

International Finance Corporation. 2009-11-01. https://documents1.worldbank.org/curated/en/431711583473548974/pdf/Supervisory-Skills-Training-in-the-Cambodian-Garment-Industry-A-Randomized-Impact-Evaluation.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S14 **Creating Better Jobs for Women and Boosting Productivity in Bangladesh's Garment Factories: An Assessment of the Gender Equality and Returns Program** GRADE B

IFC and ILO, Better Work. 2025-07-16. https://documents1.worldbank.org/curated/en/099719204242622010/pdf/IDU-d36f5c2c-9598-45cb-8df7-342148bfa9ea.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S15 **Worker productivity and soft skills** GRADE B

World Bank. 2017-09-07. https://blogs.worldbank.org/en/impactevaluations/worker-productivity-and-soft-skills

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S18 **Excessive Overtime, Workers and Productivity: Evidence and Implications for Better Work** GRADE B

ILO and IFC, Better Work. 2023-03-28. https://betterwork.org/wp-content/uploads/Discussion-Paper-Series-No-2-Excessive-Overtime-Workers-and-Productivity-Evidence-and-Implications-for-Better-Work.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S40 **e-Handbook of Statistical Methods: Gauge R & R studies** GRADE A

NIST/SEMATECH. 2003-06-01. https://www.itl.nist.gov/div898/handbook/mpc/section4/mpc4.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S45 **Performance Management Cycle** GRADE A

United States Office of Personnel Management. 2019-11-04. https://www.opm.gov/policy-data-oversight/performance-management/performance-management-cycle/

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S0201 **e-Handbook of Statistical Methods: What is Process Capability?** GRADE A

NIST/SEMATECH. 2003-06-01. https://www.itl.nist.gov/div898/handbook/pmc/section1/pmc16.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S0202 **Challenges of Change: An Experiment Promoting Women to Managerial Roles in the Bangladeshi Garment Sector** GRADE B

National Bureau of Economic Research. 2020-08-03. https://www.nber.org/papers/w27606

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S0203 **e-Handbook of Statistical Methods: What are Control Charts?** GRADE A

NIST/SEMATECH. 2003-06-01. https://www.itl.nist.gov/div898/handbook/pmc/section3/pmc31.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c02-S0204 Same source record as c02-S14.

c03-S01 **ISO 22400-2:2014 Automation systems and integration: Key performance indicators (KPIs) for manufacturing operations management, Part 2: Definitions and descriptions** GRADE A

International Organization for Standardization. 2014-01. https://www.iso.org/standard/54497.html

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c03-S02 Same source record as c01-S02.

---

c03-S04 **Implementation of the Factory Improvement Toolset in the Asian garment sector: Final report** GRADE A

International Labour Organization. 2023. https://www.ilo.org/media/365276/download

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c03-S22 **Data Governance Playbook** GRADE A

United States Federal Data Strategy. 2020-07. https://resources.data.gov/assets/documents/fds-data-governance-playbook.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c03-S46 **Balanced Scorecard: History, Implementation, and Impact** GRADE B

Encyclopedia, MDPI. 2025-03-19. https://mdpi-res.com/d_attachment/encyclopedia/encyclopedia-05-00039/article_deploy/encyclopedia-05-00039.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c03-S0301 **Methods and Tools for Performance Assurance of Smart Manufacturing Systems** GRADE A

National Institute of Standards and Technology. 2015-12. https://nvlpubs.nist.gov/nistpubs/ir/2015/NIST.IR.8099.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c04-S01 Same source record as c01-S01.

---

c04-S06 **Comparison of OEE-Based Manufacturing Productivity Metrics** GRADE B

Diamond Congress, Creative Construction Conference. 2023. https://repozitorium.omikk.bme.hu/bitstreams/162797a0-f2a8-4202-b41b-0a77f8695779/download

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c04-S09 **e-Handbook of Statistical Methods: What are Process Control Techniques?** GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section1/pmc12.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c04-S10 Same source record as c02-S10.

c04-S22 **Data Governance Playbook** GRADE A

United States Federal Data Strategy. 2020. https://resources.data.gov/assets/documents/fds-data-governance-playbook.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c04-S23 **ISO/IEC 25012:2008 Software engineering: Software product Quality Requirements and Evaluation: Data quality model** GRADE A

ISO/IEC. 2008. https://www.iso.org/obp/ui/#iso:std:iso-iec:25012:ed-1:v1:en

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c04-S24 **The Government Data Quality Framework** GRADE A

UK Government Data Quality Hub. 2020-12-03. https://www.gov.uk/government/publications/the-government-data-quality-framework/the-government-data-quality-framework

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c04-S25 **Data on the Web Best Practices** GRADE A

W3C. 2017-01-31. https://www.w3.org/TR/dwbp/

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c04-S40 **e-Handbook of Statistical Methods: Gauge R & R studies** GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/mpc/section4/mpc4.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c05-S01 **ISO 22400-2:2014 Automation systems and integration: Key performance indicators for manufacturing operations management, Part 2: Definitions and descriptions** GRADE A

International Organization for Standardization. 2014. https://www.iso.org/standard/54497.html

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c05-S02 Same source record as c01-S02.

---

c05-S03 **Sector systems analysis of textiles and clothing subsector in Ghana** GRADE A

International Labour Organization. 2023. https://researchrepository.ilo.org/view/pdfCoverPage?instCode=41ILO_INST&filePid=13123115820002676&download=true

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c05-S04 Same source record as c03-S04.

c05-S06 Same source record as c04-S06.

c05-S07 Uncovering the Influence of Operational Factors on Manufacturing Efficiency with Real Time Data GRADE B

Scientific Reports, Springer Nature. 2025. https://www.nature.com/articles/s41598-025-22776-8.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c05-S08 Overall equipment effectiveness: a review and development of an integrated improvement framework GRADE B

International Journal of Productivity and Quality Management, Inderscience. 2020-05-11. https://www.inderscience.com/info/inarticle.php?artid=107240

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c05-S10 Same source record as c02-S10.

c05-S11 Same source record as c01-S11.

c05-S19 Same source record as c01-S19.

c05-S20 Remote Sensing of Sewing Work Levels Using a Power Monitoring System GRADE B

Applied Sciences, MDPI. 2020-04-29. https://www.mdpi.com/2076-3417/10/9/3104

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c05-S21 NIST IR 8107: Current Standards Landscape for Smart Manufacturing Systems GRADE A

National Institute of Standards and Technology. 2016. https://nvlpubs.nist.gov/nistpubs/ir/2016/NIST.IR.8107.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c05-S22 Same source record as c04-S22.

c05-S23 Same source record as c04-S23.

c05-S24 Same source record as c04-S24.

c05-S25 Same source record as c04-S25.

c05-S0501 NIST AMS 100-31: Summary Report: Meeting of the ASME Standards Subcommittee on Advanced Monitoring, Diagnostics, and Prognostics for Manufacturing Operations Hosted at NIST GRADE A

US National Institute of Standards and Technology. 2020-03. https://nvlpubs.nist.gov/nistpubs/ams/NIST.AMS.100-31.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c05-S0502 **NISTIR 7911: Assessment of Real-Time Factory Performance through the Application of Multi-Relationship Evaluation Design** GRADE A

US National Institute of Standards and Technology. 2013-04. https://nvlpubs.nist.gov/nistpubs/ir/2013/nist.ir.7911.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c05-S0503 **First Pass Yield: What is it, Formula, and How to Improve** GRADE C

MachineMetrics. 2021-09-22. https://www.machinemetrics.com/blog/first-pass-yield

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c06-S01 **ISO 22400-2:2014 Automation systems and integration: Key performance indicators (KPIs) for manufacturing operations management, Part 2: Definitions and descriptions** GRADE A

International Organization for Standardization. 2014. https://www.iso.org/standard/54497.html

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c06-S02 Same source record as c01-S02.

---

c06-S03 Same source record as c05-S03.

---

c06-S04 Same source record as c03-S04.

---

c06-S05 **Advancing productivity, quality improvement and decent work in Ethiopia's garment industry - results so far.** GRADE A

International Labour Organization. 2022-06-01. https://www.ilo.org/resource/article/advancing-productivity-quality-improvement-and-decent-work-ethiopias

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c06-S06 Same source record as c04-S06.

---

c06-S07 Same source record as c05-S07.

---

c06-S08 Same source record as c05-S08.

---

c06-S09 Same source record as c04-S09.

---

c06-S10 Same source record as c02-S10.

---

c06-S11 Same source record as c01-S11.

---

c06-S12 Same source record as c02-S12.

c06-S16 Factory benefits to paying workers more: The critical role of compensation systems in apparel manufacturing GRADE B

PLOS ONE. 2020-02-05. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7001908/

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c06-S17 Piece rate pay brings mixed results for garment workers, new study shows GRADE B

ILO and IFC, Better Work. 2018-12-20. https://betterwork.org/piece-rate-pay-brings-mixed-results-for-garment-workers-new-study-shows/

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c06-S19 Same source record as c01-S19.

c06-S21 Same source record as c05-S21.

c06-S22 Same source record as c04-S22.

c06-S23 ISO/IEC 25012:2008 Software engineering: Software product Quality Requirements and Evaluation (SQuaRE): Data quality model GRADE A

ISO/IEC. 2008. https://www.iso.org/obp/ui/#iso:std:iso-iec:25012:ed-1:v1:en

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c06-S24 Same source record as c04-S24.

c06-S25 Same source record as c04-S25.

c06-S27 Same source record as c01-S27.

c06-S36 RECP Experiences at INCALSA GRADE A

UNIDO and UNEP. 2015. https://www.unido.org/publications/ot/9653721/pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c06-S40 Same source record as c04-S40.

c06-S41 How to Test Your A3 Thinking GRADE B

Lean Enterprise Institute. 2022-08-10. https://www.lean.org/the-lean-post/articles/test-your-pdca-thinking-by-reading-your-a3-backwards/

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c06-S45 Same source record as c02-S45.

c06-S0601 e-Handbook of Statistical Methods: Counts Control Charts GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section3/pmc331.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c06-S0602 e-Handbook of Statistical Methods: Proportions Control Charts GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section3/pmc332.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c06-S0603 e-Handbook of Statistical Methods: What is Acceptance Sampling? GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section2/pmc21.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c06-S0604 e-Handbook of Statistical Methods: What is Process Control? GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section1/pmc13.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c07-S03 Same source record as c05-S03.

c07-S04 Same source record as c03-S04.

c07-S06 Same source record as c04-S06.

c07-S10 Same source record as c02-S10.

c07-S21 Same source record as c05-S21.

c07-S42 A case method for Sales and Operations Planning: a learning experience from Germany GRADE B

Production, SciELO. 2017. https://www.scielo.br/j/prod/a/XfhQgJkknFjhysGrgCNcPrg/?lang=en

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c08-S01 ISO 22400-2:2014 Automation systems and integration: Key performance indicators (KPIs) for manufacturing operations management, Part 2: Definitions and descriptions GRADE A

International Organization for Standardization. 2014-01-15. https://www.iso.org/standard/54497.html

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c08-S02 Lean Manufacturing Techniques for Ready Made Garments Industry GRADE A

International Labour Organization. 2017-02-26. https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@africa/@ro-abidjan/@sro-cairo/documents/publication/wcms_621950.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c08-S03 Same source record as c02-S03.

---

c08-S04 Implementation of the Factory Improvement Toolset in the Asian garment sector: Final report GRADE A

International Labour Organization. 2023-02-14. https://www.ilo.org/media/365276/download

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c08-S05 Same source record as c02-S05.

---

c08-S10 Same source record as c02-S10.

---

c08-S11 Same source record as c02-S11.

---

c08-S12 Same source record as c02-S12.

---

c08-S13 Same source record as c02-S13.

---

c08-S14 Same source record as c02-S14.

---

c08-S15 Same source record as c02-S15.

---

c08-S16 Same source record as c06-S16.

---

c08-S17 Same source record as c06-S17.

---

c08-S18 Same source record as c02-S18.

---

c08-S22 Data Governance Playbook GRADE A

United States Federal Data Strategy. 2020-07-01. https://resources.data.gov/assets/documents/fds-data-governance-playbook.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c08-S40 Same source record as c02-S40.

c08-S45 Same source record as c02-S45.

c08-S46 Same source record as c03-S46.

c08-S0801 Factory benefits to paying workers more: The critical role of compensation systems in apparel manufacturing (Quasi-experimental treatment findings) GRADE B

PLOS ONE. 2020-02-05. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0227510

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c08-S0802 Same source record as c02-S0202.

c08-S0803 Reaching Living Wage for Garment Workers GRADE B

Fair Labor Association. 2021-08-13. https://www.fairlabor.org/resource/reaching-living-wage-for-garment-workers/

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c08-S0804 Improved working conditions in the apparel industry make workers' lives better and businesses stronger GRADE A

International Labour Organization. 2016-09-26. https://www.ilo.org/resource/news/improved-working-conditions-apparel-industry-make-workers%E2%80%99-lives-better-and

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c08-S0805 Improving the garment industry through supervisors GRADE B

ILO and IFC, Better Work. 2016-09-26. https://betterwork.org/improving-the-garment-industry-through-supervisors/

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c09-S29 ISO 50001:2018 Energy management systems: Requirements with guidance for use GRADE A

International Organization for Standardization. 2018. https://www.iso.org/obp/ui/en/#iso:std:iso:50001:ed-2:v1:en

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c09-S30 Same source record as c01-S30.

c09-S31 GHG Protocol Scope 2 Guidance GRADE A

GHG Protocol, WRI and WBCSD. 2015. https://ghgprotocol.org/scope-2-guidance

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c09-S32 **Product Life Cycle Accounting and Reporting Standard** GRADE A

GHG Protocol, WRI and WBCSD. 2011. https://ghgprotocol.org/sites/default/files/ghgp/standards/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c09-S33 **GRI 302: Energy 2016** GRADE A

Global Reporting Initiative. 2016. https://www.globalreporting.org/pdf.ashx?id=12467

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c09-S34 **GRI 303: Water and Effluents 2018** GRADE A

Global Reporting Initiative. 2018. https://www.globalreporting.org/pdf.ashx?id=12488

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c09-S35 **GRI 306: Waste 2020** GRADE A

Global Reporting Initiative. 2020. https://www.globalreporting.org/pdf.ashx?id=12521

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c09-S36 Same source record as c06-S36.

---

c09-S37 **Investigation of the energy consumption and emission for a readymade garment production and assessment of the saving potential** GRADE B

Energy Efficiency, Springer Nature. 2024-12-03. https://link.springer.com/article/10.1007/s12053-024-10281-2

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c09-S38 **Assessing the potential of GHG emissions for the textile sector: A baseline study** GRADE B

Heliyon, Elsevier. 2023-11-17. https://pmc.ncbi.nlm.nih.gov/articles/PMC10700620/

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c09-S39 **Energy Efficiency Indicators: Fundamentals on Statistics** GRADE A

International Energy Agency. 2014. https://www.iea.org/reports/energy-efficiency-indicators-fundamentals-on-statistics

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c10-S01 Same source record as c06-S01.

---

c10-S19 Same source record as c01-S19.

c10-S20 Same source record as c05-S20.

c10-S21 Same source record as c05-S21.

c10-S22 Same source record as c04-S22.

c10-S23 Same source record as c06-S23.

c10-S24 Same source record as c04-S24.

c10-S25 Same source record as c04-S25.

c10-S26 NIST SP 500-325: Fog Computing Conceptual Model GRADE A

National Institute of Standards and Technology. 2018-03-14. https://csrc.nist.gov/pubs/sp/500/325/final

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S01 ISO 22400-2:2014 Automation systems and integration: Key performance indicators (KPIs) for manufacturing operations management, Part 2: Definitions and descriptions GRADE A

International Organization for Standardization. 2014-01-01. https://www.iso.org/standard/54497.html

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S02 Lean Manufacturing Techniques for Ready Made Garments Industry GRADE A

International Labour Organization. 2017-01-01. https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@africa/@ro-abidjan/@sro-cairo/documents/publication/wcms_621950.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S03 Sector systems analysis of textiles and clothing subsector in Ghana GRADE A

International Labour Organization. 2023-01-01. https://researchrepository.ilo.org/view/pdfCoverPage?instCode=41ILO_INST&filePid=13123115820002676&download=true

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S04 Implementation of the Factory Improvement Toolset in the Asian garment sector: Final report GRADE A

International Labour Organization. 2023-01-01. https://www.ilo.org/media/365276/download

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S05 Same source record as c06-S05.

c11-S06 **Comparison of OEE-Based Manufacturing Productivity Metrics** GRADE B

Diamond Congress, Creative Construction Conference. 2023-01-01. https://repozitorium.omikk.bme.hu/bitstreams/162797a0-f2a8-4202-b41b-0a77f8695779/download

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c11-S07 **Uncovering the Influence of Operational Factors on Manufacturing Efficiency with Real Time Data** GRADE B

Scientific Reports, Springer Nature. 2025-01-01. https://www.nature.com/articles/s41598-025-22776-8.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c11-S08 Same source record as c05-S08.

---

c11-S09 **e-Handbook of Statistical Methods: What are Process Control Techniques?** GRADE A

NIST/SEMATECH. 2003-01-01. https://www.itl.nist.gov/div898/handbook/pmc/section1/pmc12.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c11-S10 Same source record as c02-S10.

---

c11-S11 **Learning and process improvement during production ramp-up** GRADE B

International Journal of Production Economics, Elsevier. 2001-01-01. https://faculty.wharton.upenn.edu/wp-content/uploads/2012/04/P14.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c11-S12 Same source record as c02-S12.

---

c11-S13 **Supervisory Skills Training in the Cambodian Garment Industry: A Randomized Impact Evaluation** GRADE B

International Finance Corporation. 2009-01-01. https://documents1.worldbank.org/curated/en/431711583473548974/pdf/Supervisory-Skills-Training-in-the-Cambodian-Garment-Industry-A-Randomized-Impact-Evaluation.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c11-S14 **Creating Better Jobs for Women and Boosting Productivity in Bangladesh's Garment Factories: An Assessment of the Gender Equality and Returns Program** GRADE B

IFC and ILO, Better Work. 2025-01-01. https://documents1.worldbank.org/curated/en/099719204242622010/pdf/IDU-d36f5c2c-9598-45cb-8df7-342148bfa9ea.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

---

c11-S17 Same source record as c06-S17.

c11-S18 Excessive Overtime, Workers and Productivity: Evidence and Implications for Better Work GRADE B

ILO and IFC, Better Work. 2011-01-01. https://betterwork.org/wp-content/uploads/Discussion-Paper-Series-No-2-Excessive-Overtime-Workers-and-Productivity-Evidence-and-Implications-for-Better-Work.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S22 Data Governance Playbook GRADE A

United States Federal Data Strategy. 2020-01-01. https://resources.data.gov/assets/documents/fds-data-governance-playbook.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S27 Same source record as c01-S27.

c11-S28 MLOps: Continuous delivery and automation pipelines in machine learning GRADE B

Google Cloud. 2024-08-28. https://cloud.google.com/architecture/mlops-continuous-delivery-and-automation-pipelines-in-machine-learning

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S40 e-Handbook of Statistical Methods: Gauge R & R studies GRADE A

NIST/SEMATECH. 2003-01-01. https://www.itl.nist.gov/div898/handbook/mpc/section4/mpc4.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S41 Same source record as c06-S41.

c11-S42 A case method for Sales and Operations Planning: a learning experience from Germany GRADE B

Production, SciELO. 2017-01-01. https://www.scielo.br/j/prod/a/XfhQgJkknFjhysGrgCNcPrg/?lang=en

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S43 Local Authority Major Schemes: Benefits Management and Evaluation Framework GRADE A

UK Department for Transport. 2025-01-01. https://assets.publishing.service.gov.uk/media/6863b944b466cce1bb121a96/local-authority-major-schemes-bme-framework.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S44 Proposal of a model for sales and operations planning (S&OP) maturity evaluation GRADE B

Production, SciELO. 2017-11-27. https://www.scielo.br/j/prod/a/8qcRfnznSVpH9MtBL9vxWgr/?lang=en

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S45 Same source record as c02-S45.

c11-S46 Same source record as c03-S46.

c11-S1101 Lean Daily Management System Implementation Improves Workforce Culture GRADE A

National Institute of Standards and Technology, Manufacturing Extension Partnership. 2026-05-02. https://www.nist.gov/mep/successstories/2025/lean-daily-management-system-implementation-improves-workforce-culture

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S1102 Enhancing production planning and control of semi-finished products: a case study combining Business Process Management and Lean Manufacturing GRADE B

Gestão & Produção, SciELO. 2025-04-14. https://www.scielo.br/j/gp/a/GDzxdwrwGyBMmvQwsS5xCtb/?format=html&lang=en

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c11-S1103 Visual Management Tools and Set-Up Reduction Drive Quality and Production Gains GRADE A

National Institute of Standards and Technology, Manufacturing Extension Partnership. 2023-10-17. https://www.nist.gov/mep/successstories/2023/visual-management-tools-and-set-reduction-drive-quality-and-production-gains

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S01 Same source record as c06-S01.

c12-S02 Same source record as c01-S02.

c12-S03 Same source record as c05-S03.

c12-S04 Same source record as c03-S04.

c12-S05 Same source record as c02-S05.

c12-S06 Same source record as c04-S06.

c12-S07 Same source record as c05-S07.

c12-S08 Same source record as c05-S08.

c12-S09 Same source record as c04-S09.

c12-S10 Same source record as c02-S10.

c12-S11 Same source record as c01-S11.

c12-S12 Same source record as c02-S12.

c12-S13 Supervisory Skills Training in the Cambodian Garment Industry: A Randomized Impact Evaluation GRADE A

International Finance Corporation. 2009. https://documents1.worldbank.org/curated/en/431711583473548974/pdf/Supervisory-Skills-Training-in-the-Cambodian-Garment-Industry-A-Randomized-Impact-Evaluation.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S14 Creating Better Jobs for Women and Boosting Productivity in Bangladesh's Garment Factories: An Assessment of the Gender Equality and Returns Program GRADE A

IFC and ILO, Better Work. 2025. https://documents1.worldbank.org/curated/en/099719204242622010/pdf/IDU-d36f5c2c-9598-45cb-8df7-342148bfa9ea.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S16 Same source record as c06-S16.

c12-S17 Same source record as c06-S17.

c12-S18 Excessive Overtime, Workers and Productivity: Evidence and Implications for Better Work GRADE A

ILO and IFC, Better Work. 2011. https://betterwork.org/wp-content/uploads/Discussion-Paper-Series-No-2-Excessive-Overtime-Workers-and-Productivity-Evidence-and-Implications-for-Better-Work.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S21 Same source record as c05-S21.

c12-S22 Same source record as c04-S22.

c12-S23 Same source record as c06-S23.

c12-S24 Same source record as c04-S24.

c12-S25 Same source record as c04-S25.

c12-S27 Same source record as c01-S27.

c12-S30 Same source record as c01-S30.

c12-S36 Same source record as c06-S36.

c12-S40 Same source record as c04-S40.

c12-S41 Same source record as c06-S41.

c12-S42 Same source record as c07-S42.

c12-S43 Local Authority Major Schemes: Benefits Management and Evaluation Framework GRADE A

UK Department for Transport. 2025. https://assets.publishing.service.gov.uk/media/6863b944b466cce1bb121a96/local-authority-major-schemes-bme-framework.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S44 Same source record as c11-S44.

c12-S45 Same source record as c02-S45.

c12-S1201 e-Handbook of Statistical Methods: 6.3.1. What are Control Charts? GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section3/pmc31.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S1202 e-Handbook of Statistical Methods: 6.1.3. What is Process Control? GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section1/pmc13.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S1203 e-Handbook of Statistical Methods: 6.3.3.2. Proportions Control Charts GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section3/pmc332.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S1204 e-Handbook of Statistical Methods: 2.1.1. What are the issues for characterization? GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/mpc/section1/mpc11.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S1205 e-Handbook of Statistical Methods: 6.3.2. What are Variables Control Charts? GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section3/pmc32.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S1206 **e-Handbook of Statistical Methods: 5.1.2. What are the uses of DOE?** GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pri/section1/pri12.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S1207 **e-Handbook of Statistical Methods: 6.1.6. What is Process Capability?** GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section1/pmc16.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c12-S1208 **e-Handbook of Statistical Methods: 5.7. A Glossary of DOE Terminology** GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pri/section7/pri7.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c13-S01 Same source record as c06-S01.

c13-S02 Same source record as c01-S02.

c13-S03 Same source record as c05-S03.

c13-S04 Same source record as c03-S04.

c13-S05 Same source record as c06-S05.

c13-S06 Same source record as c04-S06.

c13-S07 Same source record as c05-S07.

c13-S08 Same source record as c05-S08.

c13-S09 Same source record as c04-S09.

c13-S10 Same source record as c02-S10.

c13-S11 Same source record as c01-S11.

c13-S12 Same source record as c02-S12.

c13-S17 Same source record as c06-S17.

c13-S18 Same source record as c12-S18.

c13-S19 Same source record as c01-S19.

c13-S20 Same source record as c05-S20.

c13-S21 NIST IR 8107: Current Standards for Smart Manufacturing Systems GRADE A

National Institute of Standards and Technology. 2016. https://nvlpubs.nist.gov/nistpubs/ir/2016/NIST.IR.8107.pdf

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c13-S22 Same source record as c04-S22.

c13-S23 Same source record as c06-S23.

c13-S24 Same source record as c04-S24.

c13-S25 Same source record as c04-S25.

c13-S26 Same source record as c10-S26.

c13-S27 Same source record as c01-S27.

c13-S28 Same source record as c11-S28.

c13-S34 Same source record as c09-S34.

c13-S40 e-Handbook of Statistical Methods: Gauge R & R studies GRADE A

NIST/SEMATECH. 2003. https://www.itl.nist.gov/div898/handbook/pmc/section4/mpc4.htm

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c13-S41 Same source record as c06-S41.

c13-S42 Same source record as c07-S42.

c13-S43 Same source record as c12-S43.

c13-S44 Same source record as c11-S44.

c13-S45 Same source record as c02-S45.

c13-S46 Same source record as c03-S46.

c13-S1301 AI Risk Management Framework GRADE A

National Institute of Standards and Technology. 2023-01-26. https://www.nist.gov/itl/ai-risk-management-framework

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c13-S1302 SP 800-82 Rev. 3, Guide to Operational Technology (OT) Security GRADE A

National Institute of Standards and Technology. 2023-09-28. https://csrc.nist.gov/pubs/sp/800/82/r3/final

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c13-S1303 Choosing technology: an introduction GRADE A

UK Government Digital Service. 2024-10-15. https://www.gov.uk/service-manual/technology/choosing-technology-an-introduction

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c14-S01 Same source record as c06-S01.

c14-S02 Same source record as c01-S02.

c14-S03 Same source record as c05-S03.

c14-S04 Same source record as c03-S04.

c14-S05 Same source record as c06-S05.

c14-S06 Same source record as c04-S06.

c14-S07 Same source record as c05-S07.

c14-S08 Same source record as c05-S08.

c14-S09 Same source record as c04-S09.

c14-S10 Same source record as c02-S10.

c14-S11 Same source record as c01-S11.

c14-S12 Same source record as c02-S12.

c14-S13 Same source record as c12-S13.

c14-S14 Same source record as c12-S14.

c14-S16 Same source record as c06-S16.

c14-S17 Same source record as c06-S17.

c14-S18 Same source record as c12-S18.

c14-S19 Same source record as c01-S19.

c14-S20 Same source record as c05-S20.

c14-S21 Same source record as c05-S21.

c14-S22 Same source record as c04-S22.

c14-S23 Same source record as c06-S23.

c14-S24 Same source record as c04-S24.

c14-S25 Same source record as c04-S25.

c14-S26 Same source record as c10-S26.

c14-S27 Same source record as c01-S27.

c14-S28 Same source record as c11-S28.

c14-S29 Same source record as c09-S29.

c14-S30 Same source record as c01-S30.

c14-S33 Same source record as c09-S33.

c14-S34 Same source record as c09-S34.

c14-S35 Same source record as c09-S35.

c14-S36 Same source record as c06-S36.

c14-S39 Same source record as c09-S39.

c14-S40 Same source record as c04-S40.

c14-S41 Same source record as c06-S41.

c14-S42 Same source record as c07-S42.

c14-S43 Same source record as c12-S43.

c14-S44 Same source record as c11-S44.

c14-S45 Same source record as c02-S45.

c14-S46 Same source record as c03-S46.

c14-S1401 How to set performance metrics for your service GRADE A

UK Government Digital Service. 2017-12-05. https://www.gov.uk/service-manual/measuring-success/how-to-set-performance-metrics-for-your-service

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c14-S1402 How the alpha phase works GRADE A

UK Government Digital Service. 2019-05-08. https://www.gov.uk/service-manual/agile-delivery/how-the-alpha-phase-works

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

c14-S1403 How the beta phase works GRADE A

UK Government Digital Service. 2021-02-19. https://www.gov.uk/service-manual/agile-delivery/how-the-beta-phase-works

Opened source record.

Accessed 2026-10-30. Quote retained in the machine-readable source record.

Stable definitions make comparisons useful.

Andon

A visible or audible signal that calls attention to an abnormal condition and triggers a defined response.

Availability

The OEE component representing the share of planned production time during which the process is actually running.

Baseline

A dated and defined reference population against which later performance is compared.

Corrective and preventive action

The controlled investigation, correction, cause removal and verification used to prevent a problem recurring.

Control limit

A statistically derived boundary used to assess process variation, distinct from a customer specification or management target.

Corrective action

An owned intervention intended to remove a detected problem or its underlying cause.

Cost per good garment

The relevant cost divided by garments accepted without rework or rejection under a stated counting rule.

Data governance

The decision rights, accountabilities, policies and controls used to manage data as an organisational asset.

Data owner

The role accountable for the meaning, permitted use and quality requirements of a defined data domain.

Data quality

The fitness of data for its intended use, assessed through dimensions such as completeness, validity, consistency and accuracy.

Data steward

The role responsible for applying definitions, quality checks and issue-resolution procedures to operational data.

Downtime

Time within a defined production window when a resource is not running, classified by a controlled cause taxonomy.

Edge capture

Collection or processing of operational data close to the machine or work event, often with local buffering.

Effective labour cost

Labour cost interpreted against productive capability and good output rather than nominal wage alone.

Energy performance indicator

A measure or ratio used to characterise energy performance against an appropriate activity or output basis.

First-pass yield

The proportion of units completing a process correctly without rework, repair or correction.

Functional unit

The quantified performance or service unit used as the reference for a product-level assessment.

Gauge R&R

A measurement-system study of repeatability and reproducibility, used to assess variation from gauges or observers.

Good garment

A garment meeting the defined acceptance condition at a named process boundary under the applicable counting rule.

Hourly output

Units completed in a stated hour, accompanied by the quality and work-context definitions needed for comparison.

Key performance indicator

A defined measure used to assess an outcome or process and support a named management decision.

KPI cascade

The traceable translation of strategic outcomes into family, plant, line and station measures.

Lead time

Elapsed time between two declared order or production events, with waiting and processing components identified where possible.

Line balancing

The allocation and adjustment of work among operations to improve flow against available capacity and skill.

Manufacturing execution system

A system that manages and records manufacturing operations and their execution close to the production process.

Master data

Controlled reference information about entities such as styles, operations, defects, machines and meters.

Maturity gate

An evidence-based condition that must be met before a factory advances to a more complex operating or digital stage.

On-time in full

The proportion of orders meeting the agreed delivery date and quantity under stated partial-shipment and receipt rules.

Overall equipment effectiveness

A composite production measure formed from availability, performance and quality components.

Performance rate

The OEE component comparing actual production speed with the defined reference rate during running time.

Piece rate

Compensation linked to the number of pieces produced, requiring explicit quality, safety and fairness safeguards.

Plan-Do-Check-Act

An iterative improvement cycle for planning a change, testing it, studying results and acting on what is learned.

Production denominator

The output or activity basis used to normalise a resource, cost or impact measure.

Reference flow

The quantity of product or material required to fulfil the defined unit of analysis.

Rework

Additional work required to correct a unit that did not meet requirements on its first completion.

Right first time

The operating condition in which work meets requirements without correction, commonly expressed through first-pass yield.

Sales and operations planning

The recurring management process that reconciles demand, supply, capacity and financial plans at an agreed aggregate level.

Scope 1

Direct greenhouse-gas emissions from sources owned or controlled by the reporting organisation.

Scope 2

Indirect greenhouse-gas emissions associated with purchased or acquired electricity, steam, heat and cooling.

Scope 3

Other indirect greenhouse-gas emissions occurring in the reporting organisation's value chain.

Standard minute value

The standard work content of a task under a specified method for qualified workers applying ordinary effort.

Standard work

The current approved method, sequence, timing and resources for performing a task consistently.

Statistical process control

The use of statistical methods and historical behaviour to understand variation and identify abnormal process conditions.

System of record

The authoritative source for a defined entity or transaction, including its correction and reconciliation rules.

Takt time

The available production time divided by required customer demand for a defined period and product scope.

Target

A desired performance level with a stated basis, horizon, owner and review rule.

Throughput

The rate at which units or good units complete a defined process boundary over a stated period.

Work in progress

Units that have entered a defined production process but have not yet crossed its completion boundary.

Follow the terms back to their context.

Page references point to occurrences in chapter prose. When a term does not occur in a chapter, its glossary definition is indexed.

Andon 134 173

Availability 60 62 64 77 78 79 80 81 83 84 85 86 92 108 133 138 155 160 169 174 176 177 184 209 217 221 222 226 231

Baseline 18 19 26 27 28 32 33 38 40 43 54 69 70 74 91 99 100 102 125 128 133 148 149 150 168 175 177 182 184 187 188 189 190 191 192 197 199 201 208 211 217 221 222 224 225 228 231 232 234

Control limit 69 99 100 190

Corrective action 65 81 96 172 174 187

Corrective and preventive action 266

Cost per good garment 122 129 176 218

Data governance 61 71 158 178 207 217 222 237

Data owner 266

Data quality 64 83 95 160 194 207 224

Data steward 24 52 61 62 155 158 176 189 194 201 207 211 213 217 218 222 224 225 229 231 235

Downtime 76 79 80 81 82 83 86 87 94 123 131 133 134 135 156 157 169 171 172 174 177 182 183 184 205 207 208 209 213 217 218 221 222 224 226 232

Edge capture 266

Effective labour cost 120 122 123

Energy performance indicator 266

First-pass yield 17 30 31 32 33 36 37 38 41 43 44 62 63 79 82 83 85 87 90 91 92 93 96 98 110 122 124 128 133 161 171 177 188 189 191 196 197 199 206 209 217 221 226 228 234 235

Functional unit 267

Gauge R&R 42 66 100 101 134 194 208 212 224 230 231 232 234

Good garment 25 80 85 98 120 122 133 135 139 144 146 149 189 200

Hourly output 127 182

Key performance indicator 167 208 222

KPI cascade 226

Lead time 114 117 228

Line balancing 37 38 43 47 78 80 81 103 109 125 128 170 173 210 225

Manufacturing execution system 153 208 217

Master data 34 64 66 87 107 153 156 162 167 201 207

Maturity gate 267

On-time in full 267

Overall equipment effectiveness 74 77 84 92 170 187 209 222

Performance rate 78 81 84 86 222

Piece rate 267

Plan-Do-Check-Act 175

Production denominator 25 139 144

Reference flow 138 141 147

Rework 17 30 31 32 36 37 44 49 51 62 63 74 76 82 83 86 87 88 90 91 92 93 96 97 98 101 103 106 107 110 111 114 115 116 117 120 122 123 130 133 155 167 172 174 175 177 189 191 194 197 199 200 221 227 234

Right first time 90

Sales and operations planning 106 112 115 167 175 183 189 205 206 208 209 225

Scope 1 268

Scope 2 147

Scope 3 268

Standard minute value 33 34 76 81 98 106 122 123 133 177 213 216

Standard work 34 98 187 227 228 231

Statistical process control 32 42 70 99 190 210 218 228

System of record 102 158 160 182 187 208 217 231

Takt time 268

Target 17 18 19 30 42 43 44 51 52 53 54 55 56 60 68 69 70 71 74 79 90 91 102 107 110 120 131 133 138 139 144 148 149 150 169 171 172 173 174 176 179 180 182 183 190 191 192 201 209 210 212 221 222 226 235

Throughput 30 49 74 79 81 82 93 94 171 189 221 228 234

Work in progress 57 62 109

A reproducible edition keeps its limits visible.

Production is the warp. Measurement is the weft.

Green Future Tech prepared this white paper from published sources opened during research, each recorded with its URL, publisher, date and a quoted sentence in the evidence register, and from GFT's Cameroon textile programme evidence register (R entries, transcribed from the programme's data annex and flagged where refreshed in 2026). Derived figures show their inputs; illustrative models are labelled with their basis. No figure is presented as audited, and nothing here is legal, tax or investment advice.

Source treatment preserves uncertainty.

Inherited records reproduce the supplied finding and attribution only where cited. Their source-text status is preserved. Original publication dates and exact source URLs are incomplete in that register. These records require independent validation before external reliance. New chapter-local sources carry a publication date, complete URL, publisher, exact supporting quotation and access date.

The exports share a content model.

The PDF and web edition use the same parsed chapter blocks and SVG exhibits. The build records input hashes, artifact hashes, layout measurements and elapsed time. Cross-references, source notes and the term index are generated from identifiers rather than manually typed page numbers.

IMPRINT

Issued by Green Future Tech Limited, Hong Kong SAR.
Engineering the sustainable production of tomorrow.

GFT Research. Edition 2026-10-30. Document wp02. Locally generated proof. No named author, office, certification or client endorsement is implied.

GREEN FUTURE TECH

LIMITED / HONG KONG SAR

The factory that makes the garment should make the evidence.

Engineering the sustainable production of tomorrow.