



WHITEPAPER · 6 OCTOBER 2026

# From Product Passports to Smart Products

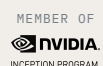
How leading brands turn DPP compliance into full-lifecycle product intelligence.



BUILT ON PRIOR WORK

Developed from SPIN's system architecture first shaped through the EU Horizon 2020 TRICK programme and extended through SPIN's contribution to CEN CWA 18291:2025.

SUPPORTED BY



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# The Product-Centric Era Has Begun

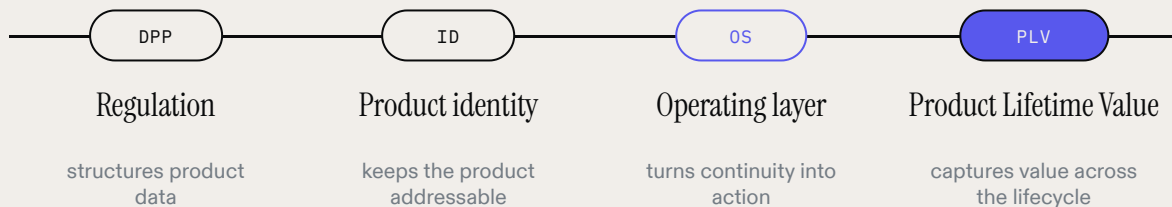
From Customer Lifetime Value to Product Lifetime Value.

The wider textile and fashion ecosystem, an estimated US\$5 trillion opportunity<sup>[1]</sup>, is entering a new infrastructure cycle. From fibres and fabrics to apparel, footwear and sportswear sold into the EU, Digital Product Passport requirements will be introduced progressively over the coming years, requiring structured product information to remain accessible across the value chain and product lifecycle. The broader policy objective is to support a more circular economy by making product information usable for durability, repair, reuse and recycling. Brands are already investing in product data, product identification, data carriers and supplier readiness. The question is no longer whether brands will invest, but what they will build with that investment.

For two decades, brands have optimised around the customer through Customer Lifetime Value. Most physical products are still monetised once, then largely disappear from the brand's operating view, even as value continues through ownership, repair, authentication, resale and reuse.

SPIN anticipated this shift, and its product-centric thesis builds on work developed before DPP implementation began. In 2020, the Circular Retail framework described the product, rather than the transaction, as a persistent unit of value. Europe's DPP regulation and standards now bring the foundations for product-level continuity into the compliance architecture at industry scale. Together, these developments mark the emergence of the Product-Centric Era. CLV remains essential; Product Lifetime Value adds a second economic lens around the product itself. SPIN's live enterprise deployment at an LVMH maison, presented in this report, demonstrates product operability in practice.

## THE OPPORTUNITY • FROM PRODUCT PASSPORTS TO PRODUCT VALUE



Preserve continuity, and the product moves from a static record to an operable asset.

## WHY NOW • VALUE + BRAND DEFENCE

The upside is Product Lifetime Value. The urgency is **authoritative product truth**: knowing what was made, where it moved and what is legitimate.

The same infrastructure that makes products operable also strengthens brand defence. As generative AI makes counterfeit content faster and cheaper to produce at scale, brands need governed product state and lifecycle evidence to distinguish legitimate products and claims from what sits outside the known network.

### AI-ACCELERATED COUNTERFEITING

Generative AI makes counterfeit listings, imagery and narratives faster, cheaper and easier to scale.



### GOVERNED SMART PRODUCT NETWORK

Governed product state and lifecycle evidence establish authoritative product truth, making what sits outside the legitimate network visible.

For brands, CRM made **WHO** visible. Smart Products make **WHAT** visible.

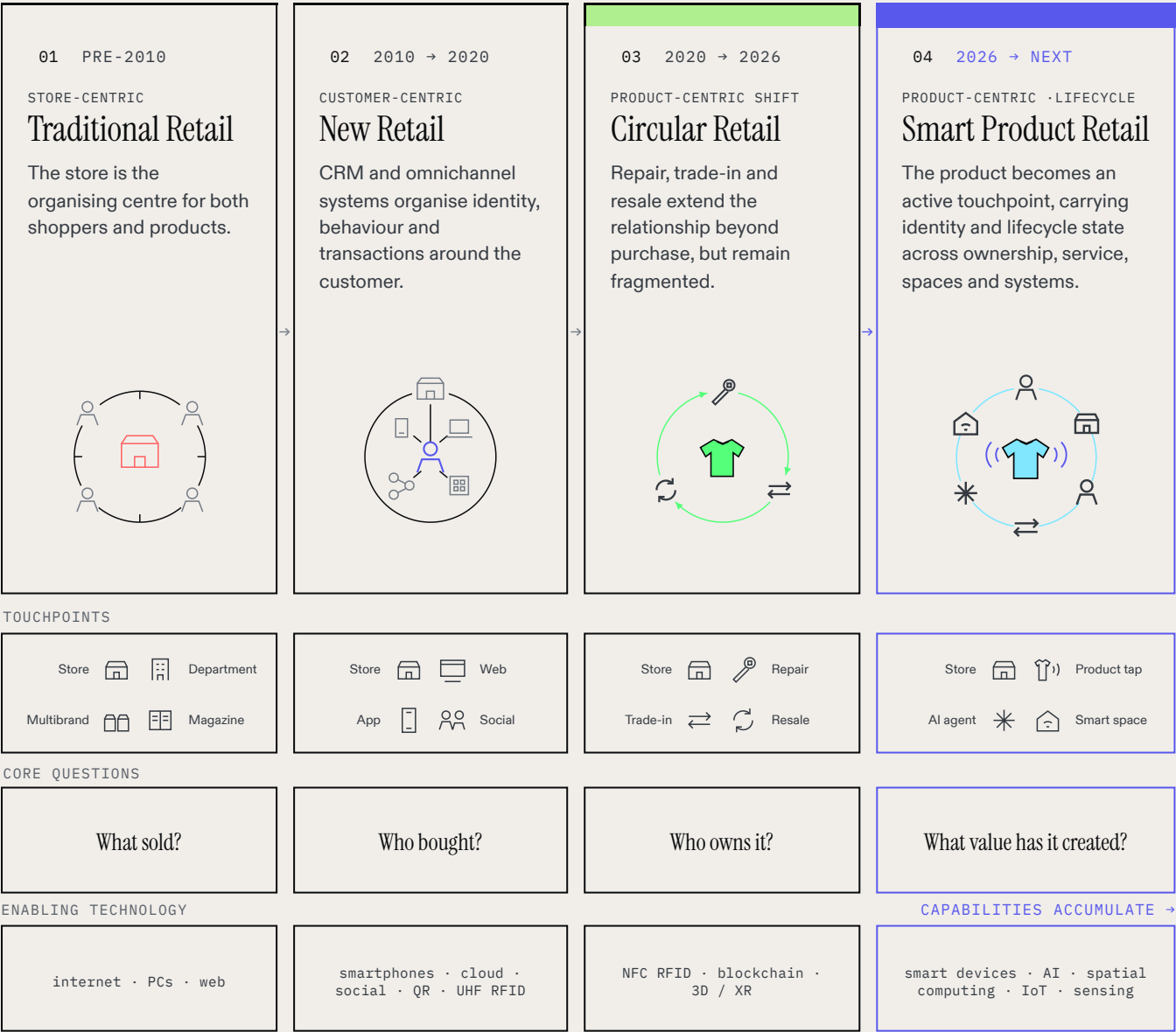
That WHAT becomes strategic when the same physical product remains identifiable and operable across its lifecycle. This continuity is the foundation for Product Lifetime Value and, ultimately, Physical AI.

EXECUTIVE FRAMEWORK · HOW RETAIL'S OPERATING MODEL EVOLVES

# From Traditional Retail to Smart Product Retail

Regulation sets the compliance baseline, and the same DPP investment can establish the identity and lifecycle continuity needed to turn physical products into operable Smart Products. SPIN defines the Product-Centric Era as the next shift in retail's evolution: after store-centric and customer-centric models, the physical product becomes an operable unit of intelligence and value alongside the customer, across its lifecycle.

● CUSTOMER-CENTRIC ERA — ● THE PRODUCT-CENTRIC ERA operability · intelligence · lifecycle value ·



Framework lineage · SPIN R&D evolution. 2016 Circular consumption model → 2020 Circular Fashion Report / Circular Retail → 2021–2024 EU Horizon 2020 TRICK → 2025 CEN CWA 18291:2025 → 2026 Smart Product Retail. Fig. 01 – Retail Evolution · Traditional / New Retail adapted from Bain & Company (2018), via Circular Fashion Report 2020 [1].

Customer relationships remain vital, but increasingly continue through the product as it remains operable across its lifecycle. This creates a persistent point for services, experiences and value creation, enabling Product Lifetime Value today, the governed context for Physical AI tomorrow.

TECHNICAL LINEAGE

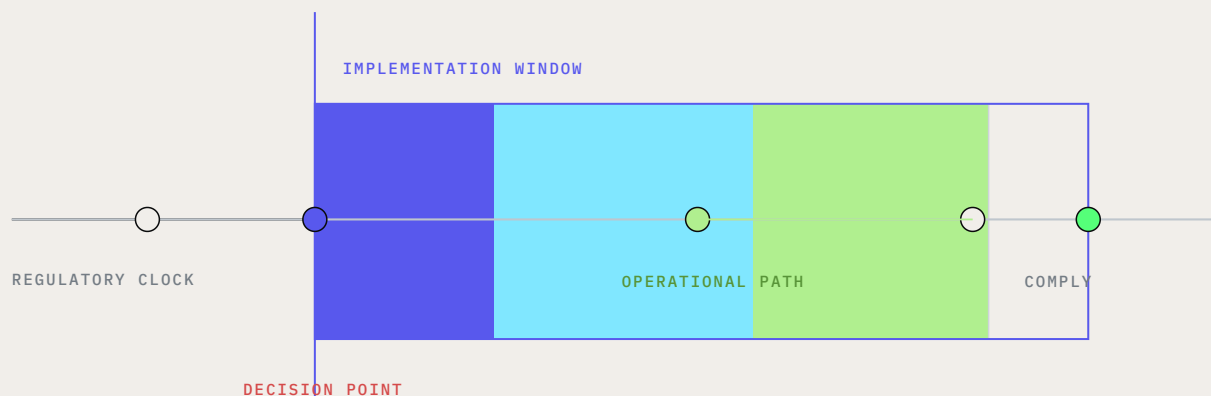
EU HORIZON 2020 TRICK · CEN CWA 18291:2025

This paper builds on CEN CWA 18291:2025, TRICK — Guidelines on data collection from Textile supply chains for the Digital Product Passport. Developed through the EU Horizon 2020 TRICK project, to which SPIN contributed, this work provides part of the technical lineage for the Product Foundation and Smart Product Operating System described in this paper.

Appendix A documents the technical lineage; Research & Industry References list public sources.

# The DPP opportunity most brands are missing

Compliance is the baseline. The strategic choice is what the infrastructure can support beyond it.



INDUSTRY VOICE • LUXURY

*“The DPP is not just a compliance instrument. It can turn the product into a verified bridge between the maison and its community — opening new services and value beyond the first sale.”*

Stefano Rosso • Chairman, Aura Blockchain Consortium / CEO, Marni (OTB Group)

IMPLEMENTATION WINDOW

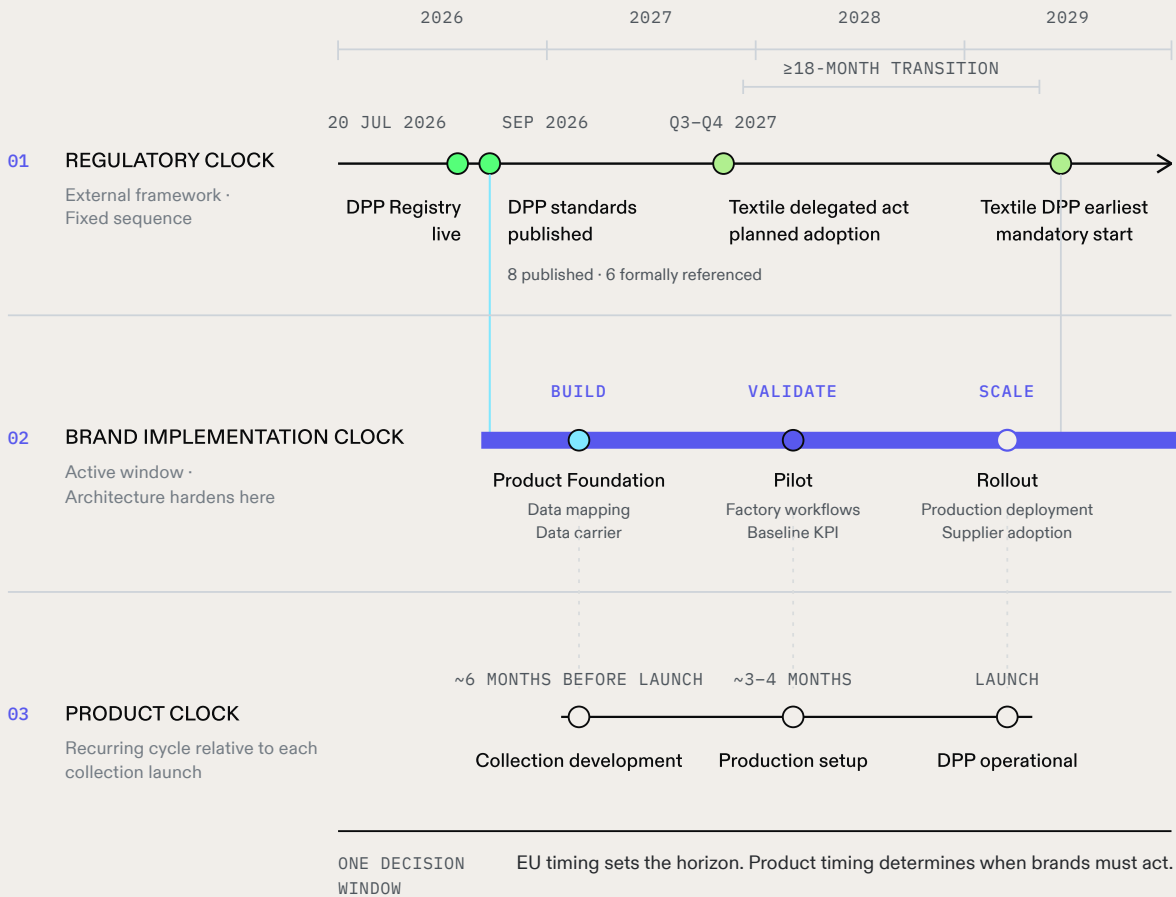
# The compliance deadline is not the first decision point.

The Ecodesign for Sustainable Products Regulation (ESPR) entered into force in 2024, establishing the framework through which Digital Product Passport requirements are being introduced product by product. As of September 2026, the DPP Registry is operational and all eight horizontal DPP standards have been published; six have been formally referenced by the European Commission, while formal reference of the remaining two is pending. For textiles, adoption of the product-specific delegated act is currently planned for Q3–Q4 2027, followed by a transition period of at least 18 months before mandatory application.

Legislation sets the obligation, but the hardest architecture choices are made earlier, during product development, data-carrier selection, supplier setup and factory execution. The regulatory calendar sets the outer deadline; each brand’s product clock is determined by its own collection-development and launch cycle.

## Three clocks. One implementation window.

REGULATION · BRAND ARCHITECTURE · PRODUCT CYCLE



WHY THIS MATTERS NOW

## Hard-to-retrofit infrastructure choices are made before production.

Regulatory data fields can continue to mature as category-specific rules are finalised; item-level identity, data-carrier integration and physical attachment are much harder to retrofit once a product enters production.

Illustrative planning view based on current EU ESPR / DPP timing. Product clock is recurring and brand-specific; category timing remains subject to delegated acts.

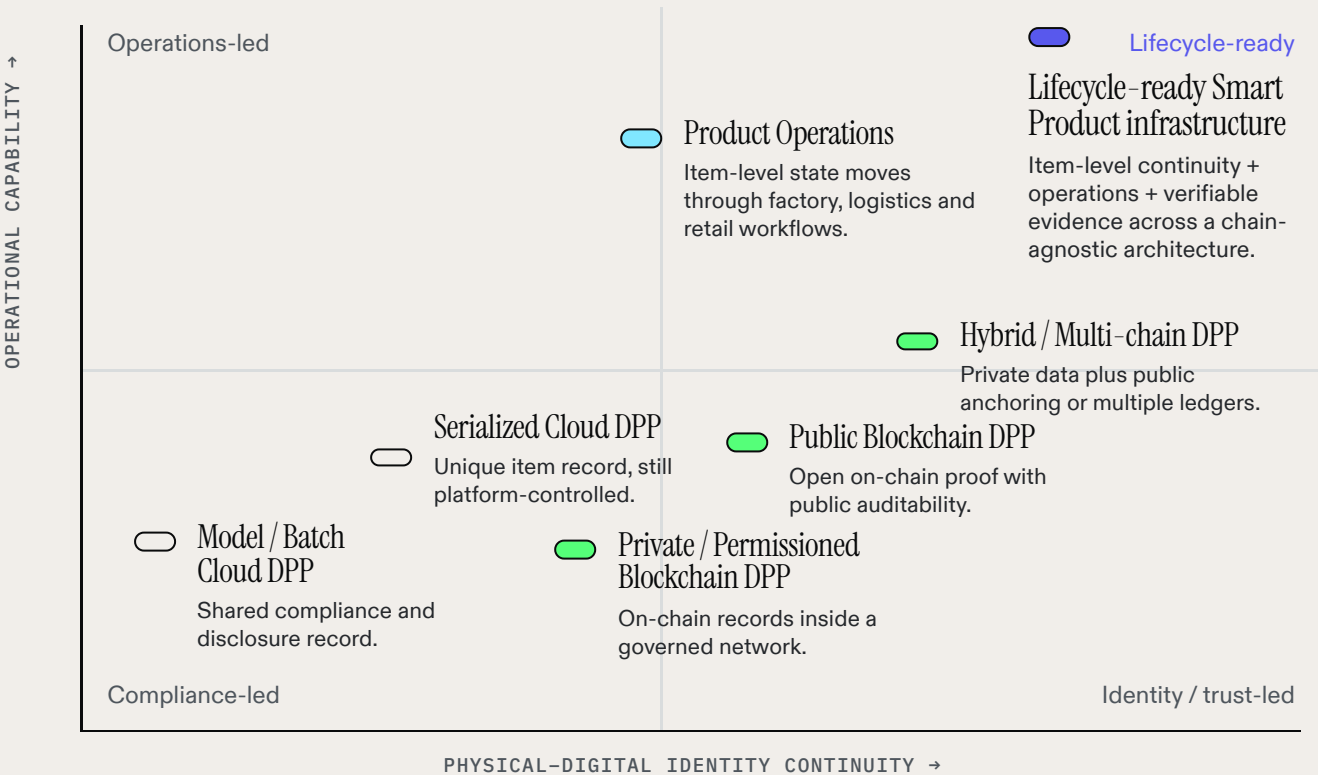
DPP MATURITY · STRATEGIC CHOICE

# DPP is the baseline. Maturity begins when product continuity can support real operations.

Different DPP implementations create different outcomes: some support regulatory disclosure; others preserve item-level identity, operational state and verifiable trust across the lifecycle. ESPR is designed to strengthen circularity through durability, repair, reuse and recycling. The maturity question is not which technology is “best,” but whether the architecture can carry the same physical product through lifecycle events.

## The DPP Maturity Map

Public anchoring does not by itself establish lifecycle maturity; maturity depends on continuity, governance and operational capability.



ARCHITECTURE & TRUST

| ARCHITECTURE             | TRUST TYPE                                           | WHAT IT MEANS                                                                            |
|--------------------------|------------------------------------------------------|------------------------------------------------------------------------------------------|
| Cloud record             | CLOUD · MODEL / BATCH<br>CLOUD · ITEM-LEVEL          | Platform-hosted; verifiability depends on service architecture.                          |
| Permissioned on-chain    | PERMISSIONED ON-CHAIN                                | Cryptographic integrity inside a governed network.                                       |
| Public / hybrid on-chain | PUBLIC ON-CHAIN<br>HYBRID TRUST ARCHITECTURE         | Publicly auditable proof or public anchoring.                                            |
| Lifecycle-ready          | OPERATIONAL CONTINUITY<br>CHAIN-AGNOSTIC CONVERGENCE | Chain-agnostic convergence of item-level continuity, operations and verifiable evidence. |

ESPR / DPP circularity context [2]; Aura / Deloitte [3] for cloud / blockchain architecture and DPP-enabled lifecycle services. Permissioned, public, hybrid and lifecycle-maturity categories are a SPIN analytical framework informed by broader market architectures.

WHAT COMPLIANCE REQUIRES · WHAT ARCHITECTURE MUST DECIDE

The passport provides the regulatory information layer. The architecture beneath it determines what the product can support beyond compliance.

The maturity map shows how far a brand can take the same DPP investment. The compliance baseline is anchored in Regulation (EU) 2024/1781 (ESPR), then shaped by the EU DPP Registry, horizontal technical standards and product-specific delegated acts. Together, these layers define what each category must implement; they do not determine the wider operating architecture built around the same product.

That distinction creates the strategic choice. The same compliance programme can stop at a Digital Product Passport, or establish the Product Foundation for Smart Product Operations spanning authentication, services, ownership, resale, product-enabled experiences and future machine-readable workflows.

|                                                      |                                                                        |                                                                                                                   |                                                                                                      |
|------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| 01                                                   | 02                                                                     | 03                                                                                                                | 04                                                                                                   |
| <b>ESPR · EU regulatory framework</b>                | <b>EU DPP Registry</b>                                                 | <b>European DPP technical standards</b>                                                                           | <b>EU product-specific delegated acts</b>                                                            |
| Defines the legal framework and product obligations. | Registers required product identifiers for regulatory and customs use. | Define interoperable rules for identifiers, data carriers, access and data exchange.                              | Set category-specific requirements for DPP data, data carriers, granularity, timing and application. |
| European Union · Regulation (EU) 2024/1781           | European Commission                                                    | CEN · European Committee for Standardization<br>CENELEC · European Committee for Electrotechnical Standardization | European Commission · under ESPR                                                                     |

A similar boundary appears in CEN CWA 18291:2025: it guides textile supply-chain data collection for the DPP, but not how that data is uploaded to DPP services or how the DPP itself is represented. The agreement builds on EU Horizon 2020 TRICK work to which SPIN contributed. PwC’s Erika Andreetta argues that compliance alone creates no differentiation; Alberto Uncini Manganelli, former Global Senior Vice President at adidas, makes the same commercial point: serious investment follows when a business case is layered on top.

|                                                                                                                                        |                                                                                                                                                                            |
|----------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| COMPLIANCE OUTCOME                                                                                                                     | ARCHITECTURE OUTCOME                                                                                                                                                       |
| <b>Digital Product Passport</b>                                                                                                        | <b>Smart Product infrastructure</b>                                                                                                                                        |
| Provides required product information and regulatory access, but does not by itself create lifecycle continuity or product operations. | Lifecycle-grade physical–digital binding, item-level continuity, governed events and interoperability can support operations, ownership, service, resale and intelligence. |

|                        |                                                                                                                                                                                                                                                  |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| WHY THE WINDOW MATTERS | Use the lead time to establish lifecycle-grade infrastructure before production. Item-level identity, data-carrier integration, trust architecture and operational workflows are easier to design in from the start than to retrofit afterwards. |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

KEY TAKEAWAY

The opportunity is not to build a more elaborate passport. It is to avoid locking compliance into an architecture that cannot later support product operations, service, ownership or intelligence.

Source framework: EU ESPR / DPP architecture [2]; CEN CWA 18291:2025 [4]; interviews with Erika Andreetta, PwC, and Alberto Uncini Manganelli, former Global Senior Vice President at adidas.

# The cost of product blindness

Before sale, it leaks operational value. After sale, it gives away lifetime value.

## The product keeps moving. The brand’s visibility does not.

If compliance defines the baseline, the next question is economic: what happens when the product keeps moving but the brand loses continuity? The economic problem is not that brands lack more dashboards. It is that product identity and lifecycle context rarely stay connected to the same physical item as it moves across systems, spaces, owners and services.

*“Today a product’s relationship with the brand effectively ends at checkout — everything after is inferred, not known.”*

Alberto Uncini Manganelli · former Global Senior Vice President, adidas

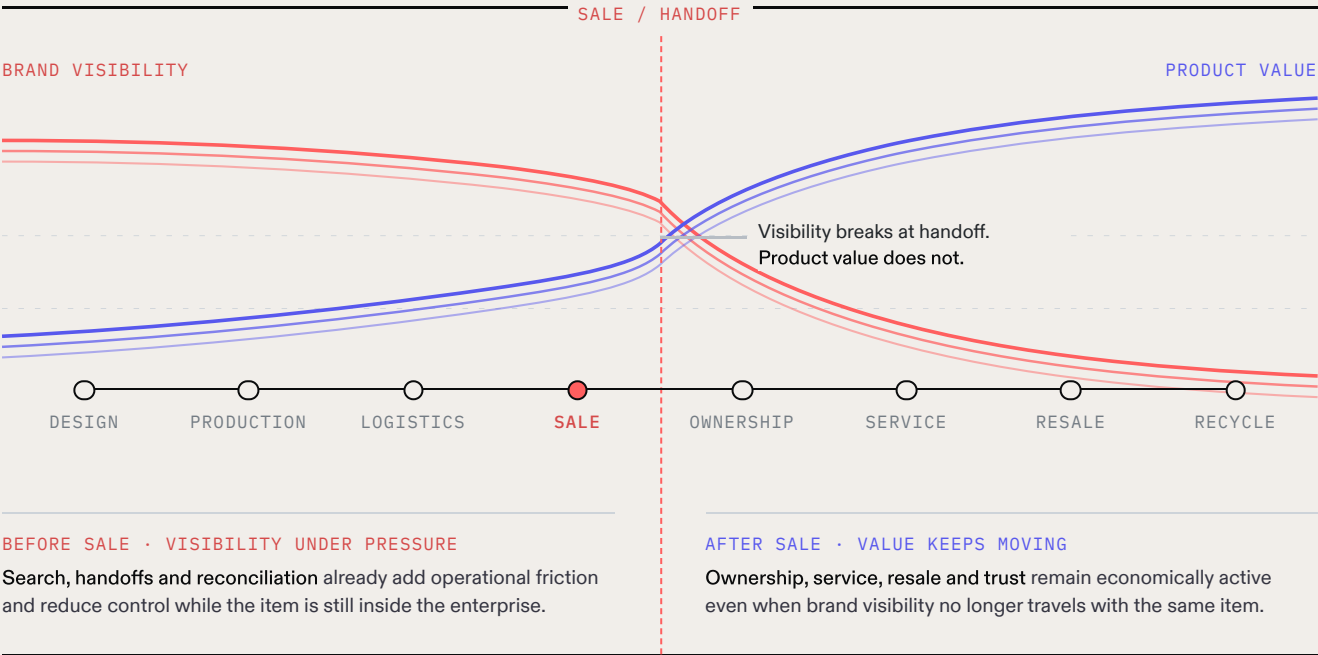
On’s Cyclon programme exposed the same gap operationally. The commercial front end could run through core systems, while returned products, condition, wear and location still had to be reconciled manually — making it difficult even to know when enough returned volume had accumulated to justify consolidated recycling. The problem was not that data did not exist somewhere in the enterprise; it was that continuity around the same physical item had broken.

## Product blindness costs the brand differently before and after sale.

| COMPARISON DIMENSION         | Before sale                                                                                                                                                      | After sale                                                                                                                                                             |
|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| WHAT THE BRAND NEEDS TO KNOW | <b>Where is this item?</b><br>Who has it, what state is it in, and does the record match physical reality?                                                       | <b>Is this still the same item?</b><br>Who owns it now, what has happened to it, and can the brand still recognise it as legitimate?                                   |
| WHAT BLINDNESS CREATES       | <b>Operational friction</b><br>Search · handoff uncertainty · manual reconciliation.                                                                             | <b>Lifecycle fragmentation</b><br>Lost ownership continuity · service without memory · invisible resale.                                                               |
| WHAT IS AT STAKE             | <b>Efficiency and control</b><br>Time, labour and accuracy are lost before the customer ever sees the product.                                                   | <b>Trust and lifecycle revenues</b><br>Service, resale, authentication and future relationships continue to create value, but are harder to capture.                   |
| WHERE CONTINUITY BREAKS      | <b>The product’s real-world state and lifecycle context diverge from the brand’s records.</b><br>Physical reality and enterprise records stop matching reliably. | <b>Item identity and lifecycle history become disconnected.</b><br>The product keeps moving through ownership, service and resale without a governed lifecycle record. |

DIAGNOSTIC VIEW · WHERE DOES YOUR BRAND STOP SEEING THE PRODUCT?

# The Product Visibility Cliff



BEFORE SALE  
OPERATIONAL  
EVIDENCE

**INVENTORY MISMATCH**

54%

of audited fashion/apparel SKUs had physical stock that did not match system records.

ECR Retail Loss [5]

**ITEM-LEVEL ACCURACY**

63% → 95%

Inventory accuracy cited by Deloitte when item-level tagging is implemented properly.

Deloitte Retail Planning, 2025 [6]

AFTER SALE  
LIFECYCLE VALUE  
STILL IN PLAY

**RESALE MARKET**

\$210–220B

Secondhand fashion & luxury commerce, 2025 estimate; projected to reach up to \$360B by 2030.

BCG × Vestiaire Collective, 2025 [7]

**COUNTERFEIT TRADE**

\$467B

Estimated global trade in counterfeit and pirated goods.

OECD / EUIPO, 2025 [8]

**REPAIR ADOPTION**

68.3%

of luxury companies in Deloitte's 2026 executive study offer repair or refurbishment services.

Deloitte · Global Powers of Luxury 2026 [9]

EVIDENCE  
BOUNDARY

**Direct:** location · movement · authentication · item history · ownership · service · resale **Adjacent:** reverse logistics · circular routing · returns condition, where item identity materially improves execution **Not claimed:** demand forecasting · overproduction · size planning · generic returns reduction as direct Smart Product ROI.

**No artificial total.** The left side shows operational evidence; the right side shows market scale and service adoption. These different measures are intentionally not added together.

DPP compliance establishes the information baseline, but the Product Visibility Cliff shows what that baseline does not solve on its own: the brand can still lose continuity with the physical item as it moves beyond the point of sale and across systems, owners and services. To carry operations, services and value across the lifecycle, identity, state and lifecycle events must remain connected to the same physical product — the lifecycle-grade foundation of a Smart Product.

**KEY TAKEAWAY**

Product blindness destroys value twice. Before sale, it creates operational friction. After sale, value continues moving while the brand loses visibility.

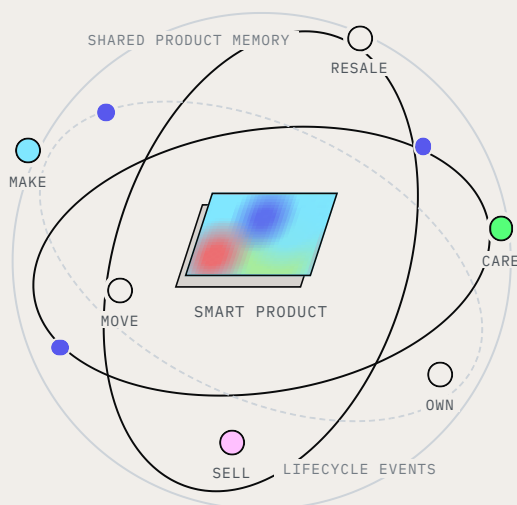
# Beyond the passport: what makes a product smart

The difference between a label that reports and an asset that performs.

## A passport records. A Smart Product performs.

A DPP can make product information accessible across the lifecycle, but information alone does not preserve continuity with the physical item. As Chapter 02 showed, the Product Visibility Cliff appears when the brand can no longer connect identity, state and lifecycle events to the same product as it moves across systems, owners and services. Closing that gap requires lifecycle-grade continuity: SPIN defines a Smart Product as a physical product with lifecycle-grade physical-digital binding, operated by a Smart Product Operating System. In practice, the same item remains identifiable, its history and current state stay connected, important claims can be verified, and governed actions can be triggered from that context over time.

## Four capabilities turn lifecycle continuity into an operable Smart Product.



### SMART PRODUCT OPERATING MODEL

The same product can be bound, recorded, verified and acted on across its lifecycle.

#### 01 Item-Level Continuity

Lifecycle-grade physical-digital binding establishes the product identity; the Smart Product Operating System keeps that identity and lifecycle context continuous across systems, spaces, owners and services.

#### 02 Governed Lifecycle Record

Its history and current state stay connected through a governed record of lifecycle events maintained against the same item identity.

#### 03 Verifiable Trust

Important product claims and lifecycle events can be verified through secure physical identity, governed data inputs and independently auditable integrity records.

#### 04 Programmable Action

Governed product context can determine what happens next, allowing services, automated workflows and AI systems to respond to and act on the product's current identity and lifecycle state.

OPERATING  
CONDITION

BOUND



RECORDED



VERIFIED



ACTED ON

The Smart Product Operating System provides the governed infrastructure AI needs to identify, understand and act on the physical product.

Identity, lifecycle state and trust remain connected to the same physical item over time.

# Traceability changes granularity across the product lifecycle.

A lifecycle-grade product architecture does not replace batch traceability with item identity; it connects them at the right level of granularity. Raw materials and production records are often managed in batches or sub-batches; once a finished product becomes a distinct commercial object, traceability can shift to the individual item. At end of life, those items can be aggregated back into shared material streams.

TRACEABILITY GRANULARITY · PROCESS TIERS

|                                                                                                                                                           |                                                                                                                                                                                  |                                                                                                                                                                                                                                       |                                                                                                                                                                                             |                                                                                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <div>T4 · RAW MATERIALS</div> <div>BATCH</div> <div>Material origin</div> <div>Fibres, yarns, fabrics and components begin as shared material lots.</div> | <div>T3-T2 · PRODUCTION</div> <div>BATCH / SUB-BATCH</div> <div>Transformation</div> <div>Materials are split, combined, processed and assembled across production stages.</div> | <div>T1 · FINISHED PRODUCT</div> <div>SKU + ITEM</div> <div>One physical product</div> <div>The finished product gains a commercial SKU and an item-level identity.</div> <div>BARCODE · QR · NFC RFID<br/>UHF RFID · DUAL RFID</div> | <div>USE · OWN · CARE · RESALE</div> <div>ITEM</div> <div>Lifecycle trace</div> <div>Movement, ownership, authentication, service, repair and resale attach to this specific product.</div> | <div>END OF LIFE · RECYCLING</div> <div>ITEM → BATCH</div> <div>Material stream</div> <div>Products are collected, sorted and transformed back into shared material batches.</div> |
| BATCH                                                                                                                                                     | BATCH / SUB-BATCH                                                                                                                                                                | ITEM                                                                                                                                                                                                                                  | ITEM                                                                                                                                                                                        | BATCH                                                                                                                                                                              |

CONTINUITY REQUIREMENT

A Smart Product preserves continuity as traceability shifts from material batches to one physical item — and eventually back into shared material streams.

SHARED TRUST LAYER

Continuity alone is not enough; the evidence carried across those hand-offs also has to be trustworthy. Signed records, shared proofs or blockchain anchoring can protect record integrity, preserve provenance evidence and make hand-offs independently verifiable across organisations. They strengthen the chain of evidence, but they do not make inaccurate source data true.

*“If you register a product on-chain but your supply-chain data upstream is incomplete or unverified, you are essentially notarising a story, not a fact.”*

Stefano Rosso · Chairman, Aura Blockchain Consortium / CEO, Marni (OTB Group)

Erika Andreetta, Partner at PwC Italy and EMEA Fashion & Luxury Leader, describes the shift as moving beyond tag technology toward “a live, evolving product identity” on which authentication, resale, repair, insurance and recycling services can operate.

FROM LIFECYCLE CONTINUITY TO CONSUMER INTERACTION

~3B

NFC-ENABLED  
SMARTPHONES · 2022

The reader is already in the customer’s pocket.

By 2022, NFC Forum described NFC as a standard feature on approximately three billion smartphones in use. For Smart Products, that means consumer interaction does not require a dedicated reader: the phone itself can become the physical-product interface.

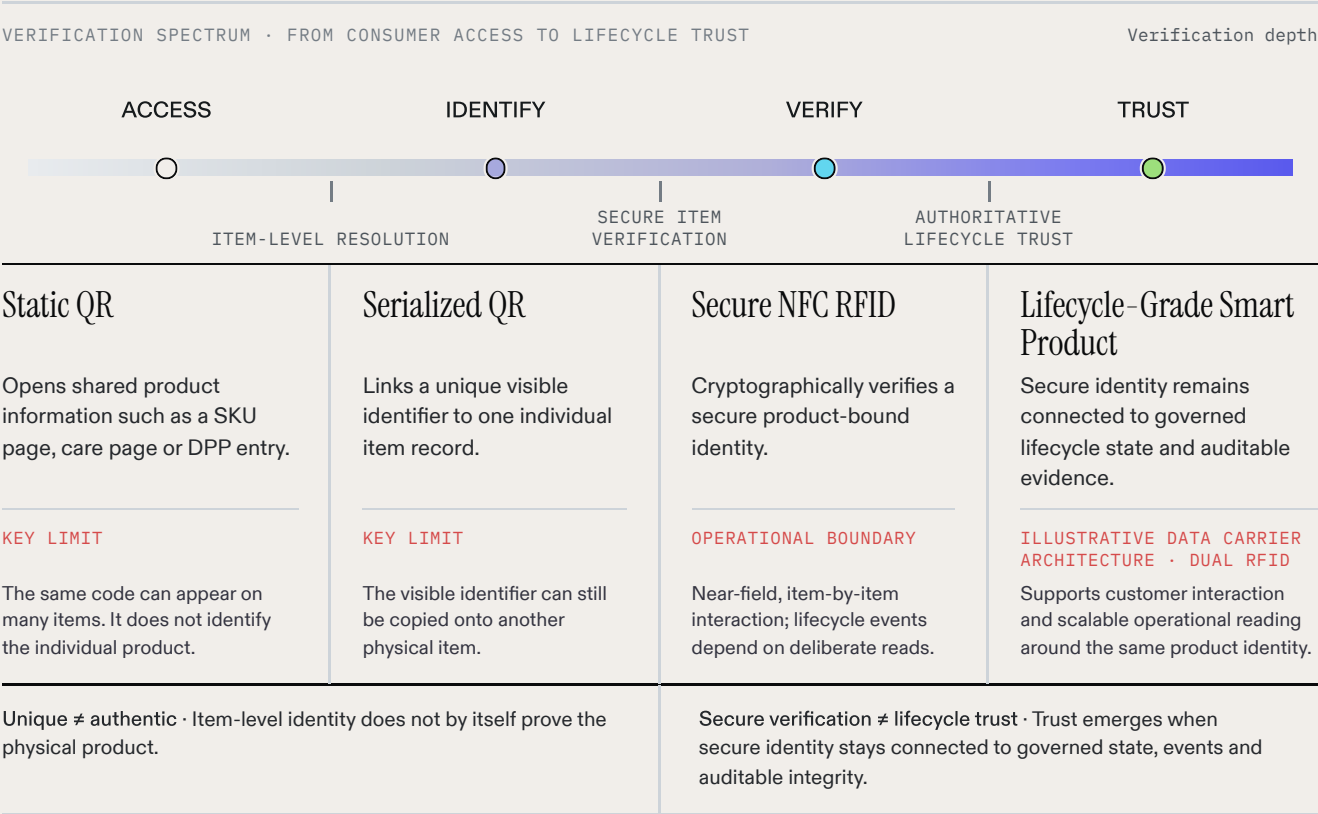
In the same 2022 ABI Research study, more than one-third of respondents had already used NFC to interact with consumer products such as clothing, alcohol or luxury items.<sup>[10]</sup>

# AI is raising the bar for product authentication.

Being readable by a phone is not the same as being securely authenticated. AI-accelerated counterfeiting is increasing the need for authoritative product truth — and sharpening the distinction between consumer access, secure item verification and authoritative lifecycle trust.

Brand protection is becoming more proactive. Amazon reports that proactive AI controls block more than 99% of suspected infringing listings before brands need to report them; in 2025, its early-warning system blocked an infringement attack on a viral product eight days before the brand shared its IP. <sup>[11]</sup>

Brands also need an authoritative reference for the physical product itself. Issued product identities, verified movements and governed lifecycle events create a known product network against which anomalous products, events and claims can be evaluated. The Smart Product Operating System preserves that governed product context across the lifecycle, giving automated detection and enforcement systems a trusted reference for what is known to be legitimate.



Authoritative lifecycle trust does not come from a stronger tag. It comes from secure physical identity remaining connected to governed lifecycle state, events and auditable integrity. Operational sensing can strengthen that lifecycle evidence by supplying trusted observations of product presence, movement and context.

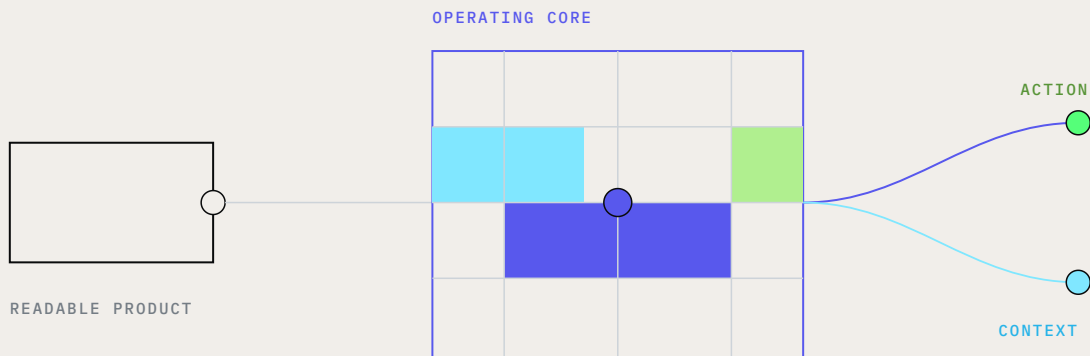
KEY TAKEAWAY

A Smart Product is a physical product with lifecycle-grade physical–digital binding, operated by a Smart Product Operating System. Lifecycle-grade binding makes the product persistent; the Smart Product Operating System makes it operable.

INDUSTRY VOICE · GLOBAL SPORTS

*“The hardest part isn’t the tag technology anymore. It’s integration into ERP, PLM and supply-chain systems that were never designed to carry product-level identity.”*

Alberto Uncini Manganeli · former Global Senior Vice President, adidas



## Smart Products require an operating system, not just a tag

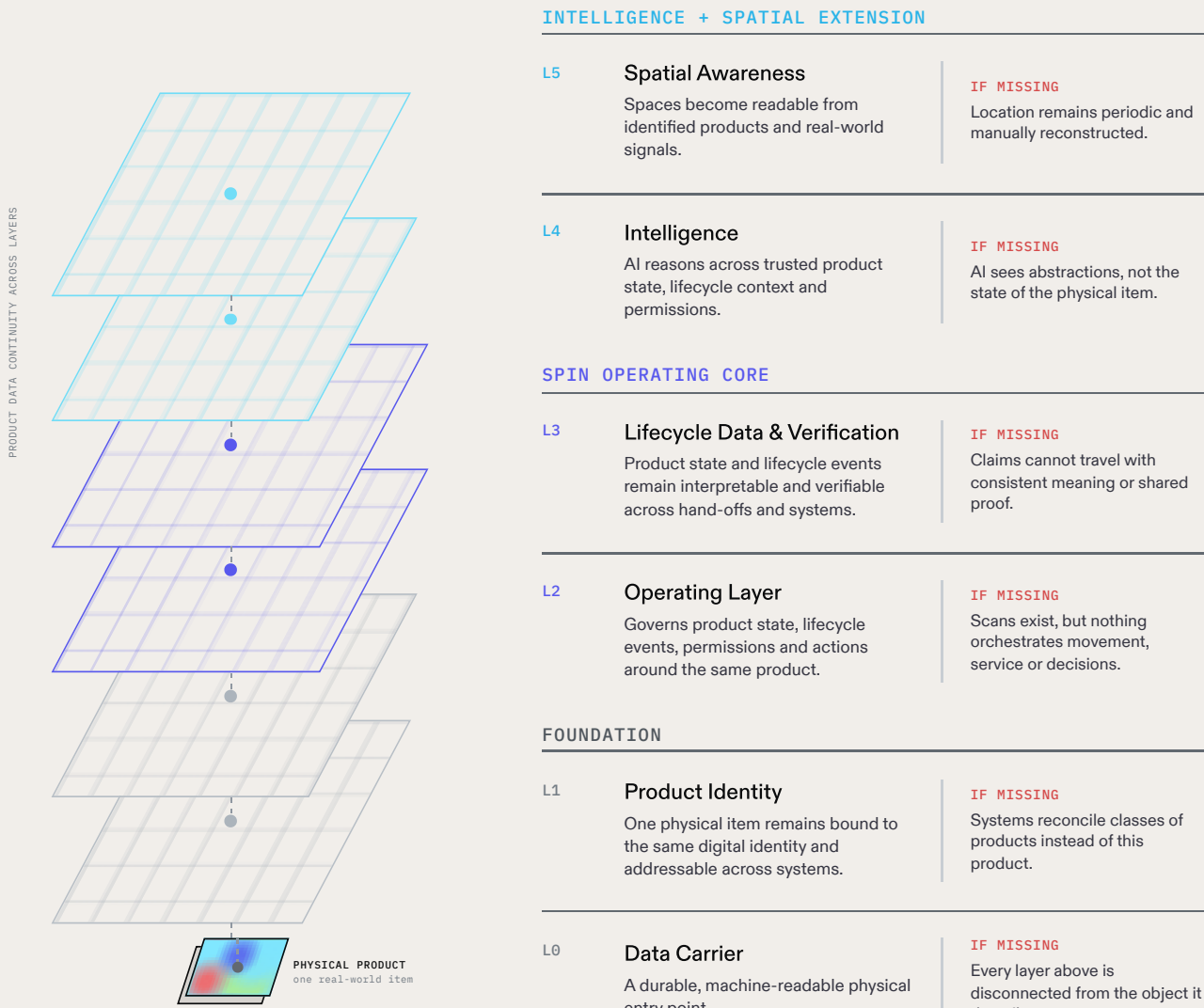
What “Operating System” actually means for a physical product.

SMART PRODUCT ARCHITECTURE · FROM READABLE OBJECT TO INTELLIGENT ACTION

# An operating system turns a readable product into an operable one.

Lifecycle-grade physical–digital binding makes the product persistent. The next architectural question is what makes that persistent product operable.

SPIN defines a Smart Product Operating System as an operating layer for orchestration and control that governs product state, lifecycle events, permissions and actions across connected systems, services and lifecycle workflows. It does not replace ERP, PLM, MES, CRM or other specialist systems; those systems remain authoritative within their domains. Its role is to keep the same physical product operable across them over time. Persistent identity provides the anchor for continuity; the operating system preserves it across systems and lifecycle workflows. Operability requires more: a governed way to know what is true now, what has happened, who is allowed to act and what can happen next.



READABLE

→

IDENTIFIABLE

→

OPERABLE

→

INTELLIGENT

ARCHITECTURE PRINCIPLE

The architecture is cumulative.  
Every layer above the foundation depends on continuity with the same physical item.

FOUNDATION · DATA CARRIER + PRODUCT IDENTITY

# The data carrier is where the Smart Product architecture meets the physical object.

At the DPP baseline, the data carrier provides the physical access point to required product information. Lifecycle-grade infrastructure asks a broader question: can that same connection remain useful as the product moves through operations, ownership, service and reuse? A durable data carrier keeps the physical item connected to its digital identity. Data carrier choice sets the physical ceiling for interaction, operational scale, sensing, security and durability; it does not govern product state or lifecycle action.

*“NFC becomes what I call the last mile of the DPP – it connects the physical product directly to its digital passport, ownership history, authentication records, and resale ecosystem.”*

Terry Chiang · CEO, Securitag Assembly Group (SAG)

TERMINOLOGY

RFID is a technology family.

NFC RFID supports deliberate near-field item interaction; UHF RFID supports scalable operational reading; DUAL RFID combines NFC RFID and UHF RFID around the same product identity. See Appendix C.

DATA-CARRIER CEILING · CAPABILITY FIT, NOT A VENDOR SCORECARD

# The data carrier sets the physical ceiling

Different data carriers support different combinations of interaction, operational scale, sensing, security and lifecycle durability.

| CAPABILITY                          | STATIC QR | SERIALIZED / SIGNED QR | SECURE NFC RFID | UHF RFID | LIFECYCLE-GRADE DUAL RFID <sup>1</sup> |
|-------------------------------------|-----------|------------------------|-----------------|----------|----------------------------------------|
| Consumer & regulatory access        | ●         | ●                      | ●               | ○        | ●                                      |
| Item-level physical-digital binding | –         | ●                      | ●               | ●        | ●                                      |
| Secure item verification            | –         | ◐                      | ●               | ◐        | ●                                      |
| Bulk operational readability        | –         | ○                      | ○               | ●        | ●                                      |
| Lifecycle durability                | ◐         | ◐                      | ◐               | ◐        | ●                                      |
| Spatial & automated sensing         | –         | ○                      | ○               | ●        | ●                                      |

● Strong / native fit   ◐ Implementation-dependent   ○ Limited / indirect   – Not designed for this job

HOW TO READ THIS

<sup>1</sup> Defined configuration: NFC-based secure verification and UHF operational reading share one item-level identity, with physical-digital binding and durability validated for the intended product lifecycle.

ARCHITECTURE BOUNDARY

A lifecycle-grade data carrier is necessary, not sufficient.

The data carrier determines what can be reliably read, sensed or verified from the physical item. The Smart Product Operating System determines how product context and actions are governed and orchestrated across systems.

# DUAL RFID connects customer interaction and operational reading to one product identity.

NFC RFID and UHF RFID solve different jobs around the same physical product. NFC RFID supports deliberate item interaction for ownership, secure verification, service and post-sale engagement; UHF RFID supports one-to-many operational reading across factory, logistics, inventory and movement workflows. DUAL RFID combines both read modes around the same product identity, allowing one item to move between customer and operational environments without changing identity.

For lifecycle-grade use, read capability is only part of the requirement. The physical implementation must also remain durable, securely bound to the product and appropriate to the conditions it will encounter across its intended life — including, where relevant, secure chip capabilities and resistance to heat, wash, abrasion or other environmental stress.

## OPERATING CORE · ORCHESTRATED PRODUCT STATE AND ACTION

# A Smart Product Operating System orchestrates product actions through four core controls.

| STATE                                                                                  | EVENTS                                                                                        | PERMISSIONS                                                             | ACTIONS                                                                                     |
|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| What is true now?                                                                      | What happened, when and by whom?                                                              | Who can read, change or act?                                            | What can happen next?                                                                       |
| Location, ownership, condition and service state remain current against the same item. | Make → move → sell → own → care → resale become machine-readable events around the same item. | Access and authority are governed by lifecycle stage, role and context. | Systems, services, spaces and AI can trigger workflows against the product's current state. |

## THE OPERATING GRAMMAR

STATE · EVENTS · PERMISSIONS · ACTIONS form the operating grammar used to orchestrate product actions across connected systems and lifecycle workflows. Selected lifecycle events can also carry independently timestamped integrity proofs, making shared evidence auditable without transferring operational authority to the verification layer.

# The operating core turns product continuity into governed product operations.

## THREE TESTS OF LIFECYCLE CONTINUITY

|                               | DOES THE PRODUCT REMAIN ADDRESSABLE THROUGH ALL THREE? | CONTINUITY |
|-------------------------------|--------------------------------------------------------|------------|
| After sale                    | <div><div></div><div></div></div>                      | ✓          |
| Outside systems you control   | <div><div></div><div></div></div>                      | ✓          |
| After your own system changes | <div><div></div><div></div></div>                      | ✓          |

**Stress test:** if the product becomes unresolvable when a webpage, firewall, vendor contract or database changes, continuity exists only inside that system — not with the product.

OPERATING CORE · LIFECYCLE DATA + VERIFICATION

## One product lifecycle. A hybrid architecture of trust.

The operating system does not need to move every product record onto one database or blockchain. Operational state can remain in the enterprise systems responsible for it, while selected proofs remain independently verifiable across organisations and over time.

### GOVERNANCE PRINCIPLES

#### Keep operational authority where the work happens.

Product, manufacturing, logistics, service and ownership records remain governed by the authorised enterprise systems and participants that create them.

#### Make selected lifecycle evidence independently verifiable.

Important events and claims can be signed, timestamped or anchored through interoperable trust infrastructure without transferring operational authority to any single vendor or blockchain.

The result is chain-agnostic: operational authority stays with the systems responsible for the work, while shared evidence remains independently verifiable. The verification principles are documented in Appendix D.

*“Enterprise systems manage operational data, data carriers connect the physical product to the digital record, standards define meaning, and blockchain provides the integrity layer for shared verification.”*

Andreas Pletscher · COO, Cardano Foundation

INTELLIGENCE + SPATIAL EXTENSION · TOWARD PHYSICAL AI

## Intelligence and spatial context extend product operability toward Physical AI.

Intelligence turns governed product context into decisions and automation, while spatial context adds location and environmental signals around the same product. Together, these layers make the same physical item legible to AI in real-world context, allowing AI to reason across product identity, lifecycle state, events, evidence and permissions. The Smart Product Operating System governs when and how that context can inform or trigger product action. Chapter 09 develops this progression in the AI Readiness Ladder.

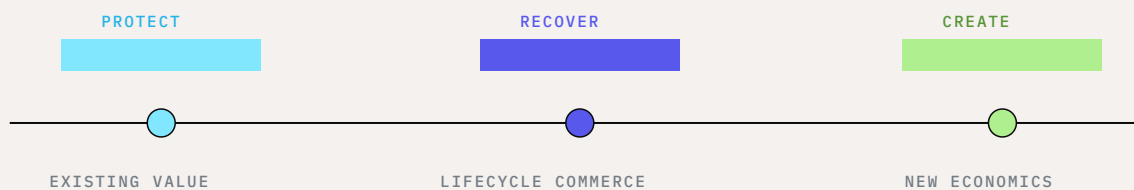
Once the product becomes operable across its lifecycle, architecture becomes economics: what value can the brand protect, recover and create?

### KEY TAKEAWAY

A Smart Product Operating System is the orchestration and control layer, not a label. It governs state, lifecycle events, permissions and actions while orchestrating how the same product is acted on across systems and services — creating the governed context that intelligence and spatial capabilities can use.

# From Customer Lifetime Value to Product Lifetime Value

Protect existing value. Recover lifecycle commerce.  
Create new product economics.



---

INDUSTRY VOICE • PREMIUM PERFORMANCE SPORTS

*“Anchoring the consumer relationship to the physical product creates deeper engagement — and ultimately translates into commercial growth.”*

Tobias Breme • Global Head of Emerging Sports, On

# Customer Lifetime Value follows the customer. Product Lifetime Value follows the product across its life.

Once the product becomes operable across its lifecycle, its economics change.

Brands have spent decades optimising Customer Lifetime Value (CLV). SPIN defines Product Lifetime Value (PLV) as the commercial and operational value that can be protected, recovered or created around the same physical product across transactions, services, experiences, owners and end-of-life pathways.

|                      | CUSTOMER-CENTRIC ECONOMICS<br>CLV                                                                         | PRODUCT-CENTRIC ECONOMICS<br>PLV                                                                                                                        |
|----------------------|-----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| ECONOMIC UNIT        | <b>Customer</b><br>The customer is the primary unit around which value is measured.                       | <b>Product</b><br>A specific physical item becomes an economic unit that can remain identifiable and economically actionable over time.                 |
| RELATIONSHIP TRACKED | <b>Brand ↔ customer</b><br>The relationship develops through acquisition, purchase and retention.         | <b>Brand ↔ product ↔ owners over time</b><br>The same item can remain economically relevant across services, owners and future users.                   |
| VALUE EVENTS         | <b>Customer transactions and engagement</b><br>Purchase, repeat purchase, retention and related activity. | <b>Product-linked lifecycle events</b><br>First sale, care & repair, resale, refurbishment, upcycling, take-back and recycling.                         |
| GROWTH LOGIC         | <b>Acquire · Convert · Retain</b><br>Increase value by expanding and deepening the customer relationship. | <b>Protect · Recover · Create</b><br>Increase PLV by preserving value, recapturing value already in motion, or enabling new value around the same item. |
| MEASURE              | <b>Customer Lifetime Value</b><br>Economic value of the customer relationship over time.                  | <b>Product Lifetime Value</b><br>Economic value that can be preserved, recovered or created around the same product across its life.                    |

|                                                    |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                            |
|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| HOW PLV EXPANDS<br><br>Three recurring value modes | <b>Protect</b><br><br>Preserve existing product value by reducing loss, fraud and avoidable operating costs.<br><br>Locate products · Track movements · Reconcile inventory · Verify authenticity | <b>Recover</b><br><br>Recapture value from existing resale and service activity outside the brand, and recover residual value from products and materials.<br><br>Enable resale · Provide care & repair · Refurbish & upcycle · Take back & recycle | <b>Create</b><br><br>Enable additional revenue through new product-enabled business models, services and experiences.<br><br>Offer other product-enabled services · Enable membership & experiences · Activate insurance & extended warranty · Offer rental & subscription |
|                                                    |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                            |

Protect, Recover and Create are not sequential steps. The same activity can support different value modes, depending on how value is preserved, recaptured or newly generated.

# One product can participate in more than one economic event.

PLV extends beyond the first sale because the same product can participate in multiple value events over time. One physical item can generate multiple transactions and paid service events across its life. Lifetime Product GMV captures the cumulative commercial value of those transactions and paid services around the same product.

DEFINITION

## Lifetime Product GMV

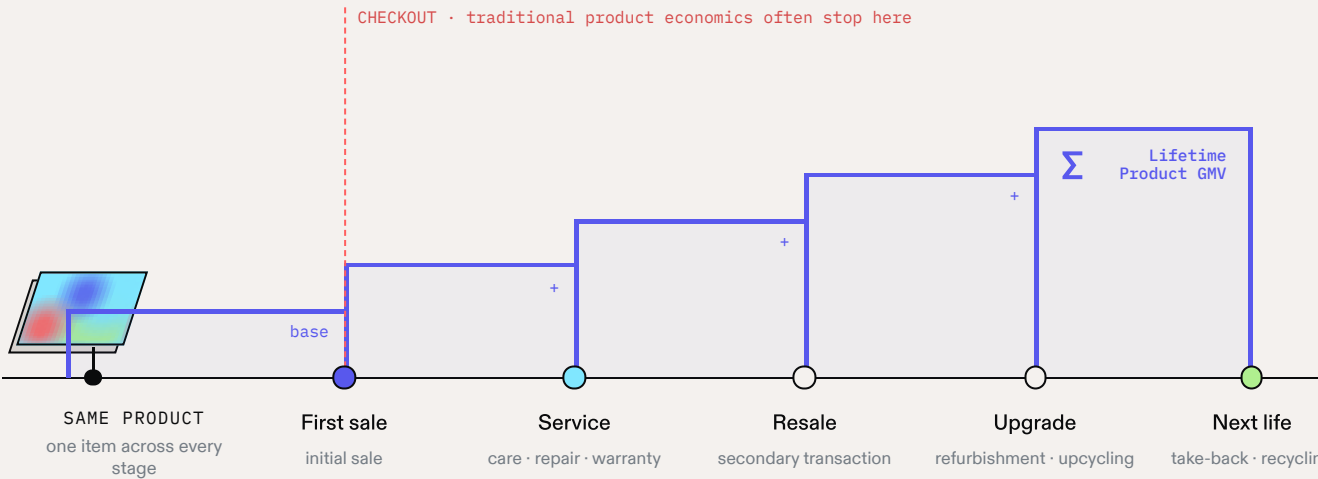
The cumulative merchandise and service value generated around the same physical product over time.

It is not a revenue metric and does not imply brand capture. It is one measurable commercial layer of PLV, which also includes operational value.

SAME PRODUCT · VALUE ACCUMULATING ACROSS LIFECYCLE EVENTS

## Cumulative transaction value across the same product

ONE MEASURABLE LAYER OF PLV



PLV VALUE MODE

BASE VALUE

CREATE · PROTECT

RECOVER

PROTECT · CREATE

RECOVER

Only transactions and paid services contribute to Lifetime Product GMV. Lifecycle activities can also protect or recover value without generating a transaction.

WHAT THIS MEASURES

## Lifetime Product GMV = first-sale GMV + subsequent GMV around the same product

This makes the commercial layer measurable while keeping PLV broader than transaction value. Protected operational value — such as loss avoided, visibility retained, service continuity or work reduced — can sit inside PLV without ever appearing as GMV.

SPIN framework · illustrative lifecycle economics

WHAT MAKES THIS MEASURABLE

## Lifetime Product GMV becomes measurable only when the same physical item remains identifiable across transactions and service events.

That continuity keeps the product's lifecycle history retrievable, while new events remain tied to the same product identity and governed product context over time.

# The post-sale economy already exists. The evidence takes different forms.

ESPR is designed to support greater product circularity across the lifecycle, while DPP requirements are introduced progressively by product group and can include information for repair, reuse, refurbishment, recycling and end-of-life handling.<sup>[2]</sup> For brands already making that compliance investment, the opportunity is to carry identity and continuity further across the lifecycle so post-sale activity around the same physical product remains visible and economically addressable. The evidence takes different forms: resale is the clearest market pool to model; care and service are better evidenced through observed enterprise revenue and adoption; circularity is best treated as a structural endpoint rather than a revenue pool.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <div>RESALE · MARKET SCALE</div> <div>\$210–220B</div> <div>Secondhand fashion &amp; luxury commerce · 2025 estimate</div> <div>This is evidence that a large product economy already exists after first sale. It is not a single-brand TAM.</div> <div>PLV MODE</div> <div>Recover</div> <div>Enable resale to recapture value from transactions already taking place beyond the first sale.</div> <div>BGX × Vestiaire Collective · 2025 [7]</div> | <div>CARE &amp; REPAIR · ENTERPRISE REVENUE</div> <div>€500M+</div> <div>LVMH repair + refill revenue in 2025</div> <div>More than 10M repairs, refills and product take-backs were also reported. Deloitte separately finds 68.3% of luxury companies offer repair or refurbishment.</div> <div>POTENTIAL PLV MODES</div> <div>Protect · Recover · Create</div> <div>Provide care &amp; repair to preserve product value, recapture external service activity or introduce additional paid services.</div> <div>LVMH LIFE 360 / URD 2025 [12] · Deloitte Global Powers of Luxury 2026 [9]</div> | <div>CIRCULARITY · STRUCTURAL ENDPOINT</div> <div>&lt;1%</div> <div>Clothing material recycled back into new clothing</div> <div>Product identity does not solve recycling alone, but circular systems still need composition, history and routing evidence to act on products at end of life.</div> <div>PLV MODE</div> <div>Recover</div> <div>Take back &amp; recycle to recover residual product and material value.</div> <div>Ellen MacArthur Foundation · A New Textiles Economy [13]</div> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                     |                                                                                                                                                                                                                                                                                                                                                       |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EVIDENCE DISCIPLINE | Resale is modelled as a market pool; care is supported by named-enterprise revenue and industry adoption; circularity is used as structural context. These categories are intentionally not added into a single “PLV market size.” Together, they show something more important: economic activity continues around the product after the first sale. |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                    |                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BRAND RELEVANCE · FROM MARKET SIZE TO PRODUCT BASE | <div>The market evidence shows that value already moves through resale, care &amp; repair and other post-sale channels.</div> <div>A brand’s PLV opportunity depends on the lifecycle activities it can participate in around its product base, and the commercial and operational value it can capture from those activities.</div> |
|----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                              |                                                                                                                                                                                                                                       |
|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BRAND PLV OPPORTUNITY · ILLUSTRATIVE DRIVERS | <div>Brand PLV opportunity is shaped by four drivers:</div> <div>IDENTIFIABLE + OPERABLE PRODUCTS × LIFECYCLE ACTIVITIES × BRAND PARTICIPATION × COMMERCIAL + OPERATIONAL VALUE PER ACTIVITY</div> <div>≈ Brand PLV opportunity</div> |
|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

# The same infrastructure creates value differently by sector.

Once lifecycle-grade infrastructure keeps the same product identifiable and operable over time, the economic opportunity differs by sector. The Protect · Recover · Create framework remains constant; what changes is where continuity prevents value leakage, brings existing lifecycle activity back into the brand relationship, or enables new services and experiences.

| SECTOR               | Protect                                                                       | Recover                                                           | Create                                                                                                          |
|----------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Luxury & Fashion     | Locate products · Track movements · Reconcile inventory · Verify authenticity | Enable resale · Provide care & repair · Refurbish & upcycle       | Offer other product-enabled services · Enable membership & experiences · Activate insurance & extended warranty |
| Sport & Performance  | Locate products · Track movements · Reconcile inventory · Verify authenticity | Enable resale · Provide care & repair · Take back & upcycle       | Enable membership & experiences · Offer other product-enabled services · Offer rental & subscription            |
| Hospitality & Spaces | Locate products · Track movements · Reconcile inventory                       | Enable resale · Refurbish & upcycle · Take back & recycle         | Enable membership & experiences · Offer other product-enabled services · Offer rental & subscription            |
| Textile & B2B        | Locate products · Track movements · Reconcile inventory                       | Provide care & repair · Refurbish & upcycle · Take back & recycle | Offer other product-enabled services<br>Workwear / linen rental & maintenance where applicable.                 |

SPIN framework · sector applications

## INDUSTRY VIEWS

### Luxury & Fashion

Stefano Rosso · Chairman, Aura Blockchain Consortium · CEO, Marni (OTB Group)

Sees the physical product becoming more than an authentication point — a continuing medium between the maison and its community after sale.

### Sport & Performance

Alberto Uncini Manganelli · former Global Senior Vice President, adidas

Identifies authentication and resale as the strongest near-term commercial case, followed by warranty automation and product-enabled services.

### Sport & Performance

Tobias Breme · Global Head of Emerging Sports, On

Points to operations as the fastest source of measurable value — through supply-chain traceability, production-scrap visibility and sourcing information — while seeing equally significant potential in customer and community applications.

### Garment Manufacturing

Alex Chou · CEO, Makalot

Argues that product intelligence has to begin at origin: manufacturing knowledge must be structured for downstream use rather than reconstructed later.

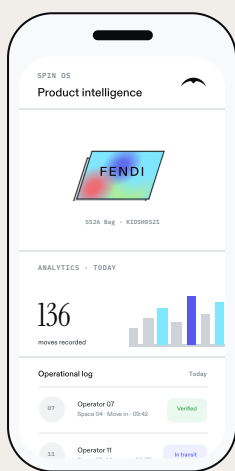
## KEY TAKEAWAY

Customer Lifetime Value measures the relationship with a person. Product Lifetime Value measures the value that can be protected, recovered or created around the same physical product across transactions, owners and services. The opportunity differs by sector; the foundation remains the same. Start with one use case that makes that value measurable in real operations.

# Smart Products in motion: enterprise deployment

How an LVMH maison turns product visibility into operational intelligence.

Realising Product Lifetime Value starts with keeping products visible and actionable in real operations. At FENDI, SPIN deployed its Smart Products Operating System (SPIN OS) across live enterprise operations to improve visibility and control of high-value products. The deployment demonstrates **Protect** in practice: preserving product value by reducing lost-product risk and manual work. The same operating foundation can support future **Recover** and **Create** opportunities across care, resale and other product-enabled services.



Illustrative interface  
· demonstration data

100%

Product-tracking  
accuracy across the  
deployed operation

FENDI deployment ·  
SPIN OS

Hours →  
Seconds

Reduction in product-  
location time

FENDI deployment ·  
SPIN OS

100%

Identified manual  
workflow discrepancies  
resolved

FENDI deployment ·  
SPIN OS

Results refer to the defined deployment perimeter. Underlying operational data and measurement details remain confidential.

## CHALLENGE

High-value products moved across multiple locations and internal or external teams without consistent real-time item-level visibility, creating time- and labour-intensive search, handoff and reconciliation work.

## DEPLOYMENT

SPIN deployed its Smart Products Operating System (SPIN OS) to turn FENDI's high-value products into operable Smart Products within the live operational workflow. The deployment uses SPIN's proprietary P2 Washable UltraThin Smart Tag, a DUAL RFID (NFC RFID + UHF RFID) data carrier developed with Securitag Assembly Group (SAG). The system created a shared, real-time view of product status across locations while reducing the manual effort required to locate, verify, hand off and reconcile items. The next phase will build on this foundation with Smart Spaces powered by SPIN OS, extending product-location and movement tracking across the defined operational perimeter.

## WHAT IT PROVES

Smart Product operations turn product visibility into measurable operational performance. By making high-value products visible and actionable across real workflows, brands can reduce lost-product risk and manual work, improve locating and handling efficiency, close operational blind spots and protect value otherwise lost through inefficiency.

### KEY TAKEAWAY

The result is not simply better visibility. It is lower operational friction, faster product handling and greater control over value that would otherwise leak through product blindness.

# The Smart Product Playbook

Product Foundation → Product Operations → Product Intelligence.

Use DPP implementation to establish the foundation for Smart Products. Build identity, lifecycle-grade binding and interoperability from the outset, then extend the same infrastructure into operational workflows and new sources of product value.

## Implementation Map

SPIN FRAMEWORK · ILLUSTRATIVE PROGRESSION

|                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <div>01</div> <div>FOUNDATION</div> <div>Product Foundation</div> <div>Establish the authoritative product reference through product identity, lifecycle-grade physical-digital binding and interoperability. The binding depends on a data carrier designed for the product's intended lifecycle.</div> <div>CAPABILITY FOCUS</div> <div>product identity · lifecycle-grade physical-digital binding · interoperability</div> | <div>02</div> <div>OPERATIONS</div> <div>Product Operations</div> <div>Use the Smart Product Operating System to preserve lifecycle continuity and orchestrate state, events, permissions and actions across real workflows.</div> <div>CAPABILITY FOCUS</div> <div>lifecycle state · workflow orchestration · permissions &amp; actions</div> | <div>03</div> <div>INTELLIGENCE</div> <div>Product Intelligence</div> <div>Extend governed product context into decisions, automation, spatial awareness and new economics.</div> <div>CAPABILITY FOCUS</div> <div>decision support · predictive insight · spatial awareness</div> |
| Foundation establishes the authoritative product reference · Operations preserves continuity and orchestrates action · Intelligence compounds what the product can do.                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                | ONE ARCHITECTURE<br>CAPABILITIES COMPOUND                                                                                                                                                                                                                                          |

## Choose where to prove value first.

FOUR EXECUTIVE ENTRY POINTS · ONE BUILD PATH

|                  | Growth & control<br>CEO / GM                                    | Economics<br>CFO / BUSINESS LEAD                             | Operations<br>COO / SUPPLY CHAIN                                      | Technology<br>CIO / CDO / PRODUCT                            |
|------------------|-----------------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------|
| WHAT IS AT STAKE | Brand control & trust                                           | Margin leakage & untapped revenue                            | Operational friction & blind spots                                    | Fragmentation & reuse                                        |
| FIRST QUESTION   | Where do product authenticity disputes put brand trust at risk? | Which use case delivers enough net value to justify scaling? | Which workflow loses the most time locating and reconciling products? | What can the next use case reuse to reduce integration work? |
| MEASURE FIRST    | Authenticity dispute rate (%) · resolution time (days)          | Net pilot benefit (€) · estimated payback period (months)    | Location time (seconds/item) · reconciliation time (seconds/batch)    | Integration time (weeks) · integration cost (€)              |

**Start narrow.** One product, capsule collection or operational perimeter where the pain is measurable.

**Architect wide.** The next use case inherits identity and integration instead of rebuilding them.

KEY TAKEAWAY

Use measurable operational and economic results to guide expansion. Reuse the Product Foundation and extend through the same Smart Product Operating System, preserving lifecycle continuity as new workflows and partners are added.

# The ecosystem it takes to make a product intelligent

Lifecycle intelligence only works when it can operate across systems.

Smart Product lifecycles extend beyond any one system. The Smart Product Playbook begins with one measurable deployment, but scaling requires coordination across the wider ecosystem. Production, commerce and post-sale services are managed by different systems and partners; product identity and lifecycle context must remain continuous as the product moves between them.

## ECOSYSTEM ARCHITECTURE

One Smart Product Operating System orchestrates product action across systems, services and programmes.

### HARDWARE, SUPPLY CHAIN & SYSTEMS

#### Data carrier & hardware

NFC RFID · UHF RFID  
encoding · readers · sensors

#### Supply chain

product suppliers · product  
manufacturers  
logistics partners

#### Enterprise systems & platforms

PLM · ERP · MES · CRM  
commerce & DPP platforms

### LIFECYCLE ORCHESTRATION



### SERVICES, TRUST & INTELLIGENCE

#### Service providers & platforms

care & repair · resale  
rental · insurance · warranty  
take-back · upcycling · recycling

#### Trust & verification

blockchain &  
verification networks

#### Intelligence

AI agents · spatial systems

Connections represent governed exchange and orchestration, with each system retaining authority over its own records.

## WHAT THIS ARCHITECTURE PROTECTS

### 01 · PRESERVE EXISTING SYSTEMS

Extend product operations without replacing existing systems.

PLM, ERP, MES, CRM, logistics and commerce systems remain authoritative in their domains, allowing brands to extend product operations while retaining their existing systems and integrations.

### 02 · PRESERVE LIFECYCLE CONTINUITY

Maintain lifecycle continuity as systems and partners change.

The Smart Product Operating System keeps the same product identifiable and its lifecycle context continuous as applications, verification networks and service providers change.

### 03 · EXTEND WITHOUT REBUILDING

Extend the same product context into new workflows and services.

New workflows and product-enabled services build on the same identity, physical–digital binding and integrations, extending the initial investment across the product lifecycle.

# Clear boundaries make the ecosystem easier to govern.

Effective ecosystem governance requires clear responsibility for product records and actions, with the brand defining permissions and service policy and each participant retaining authority within its own domain.

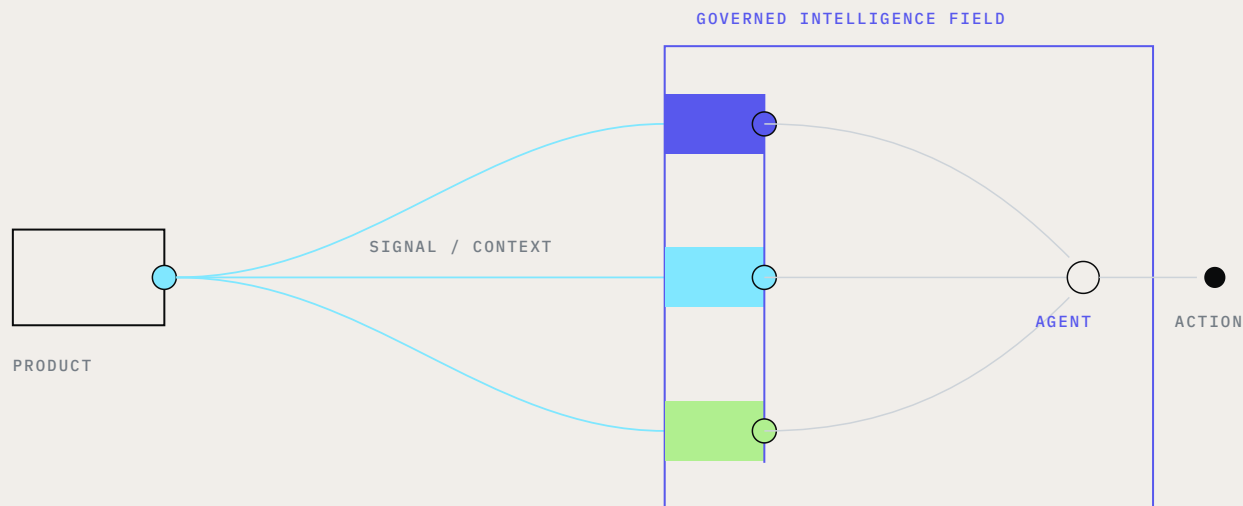
GOVERNANCE BOUNDARIES

| DOMAIN                         | PARTICIPANTS & SYSTEMS                                                                                                            | RESPONSIBILITY & BOUNDARY                                                                                                                                                            |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DATA CARRIER & HARDWARE        | data carrier manufacturers · reader & sensor providers                                                                            | Provide data carriers designed for the product's intended lifecycle to support physical–digital binding; supply hardware for encoding, reading and sensing.                          |
| SUPPLY CHAIN                   | product suppliers · product manufacturers<br>logistics partners                                                                   | Bind product identity at source and provide origin, production, quality and logistics evidence, with each participant responsible for the records it issues.                         |
| ENTERPRISE SYSTEMS & PLATFORMS | PLM · ERP · MES · CRM<br>logistics systems · commerce & DPP platforms                                                             | Retain authority over domain master data and transactions while the OS references these records and coordinates permitted updates.                                                   |
| SERVICE PROVIDERS & PLATFORMS  | Providers & platforms for care & repair, resale, rental & subscription, insurance & warranty, take-back, upcycling and recycling. | Execute service workflows and retain their source records while returning service status and lifecycle events against the same product identity.                                     |
| LIFECYCLE ORCHESTRATION        | Smart Product Operating System                                                                                                    | Preserve lifecycle continuity while orchestrating permitted actions across systems, services and workflows within their respective authority boundaries.                             |
| TRUST & VERIFICATION           | blockchain & verification networks                                                                                                | Verify record integrity and source provenance where supported, without treating integrity proofs as evidence that the original claim was true or transferring operational authority. |
| INTELLIGENCE                   | AI agents · spatial systems                                                                                                       | Use product context to reason, recommend and act within explicit permissions, while keeping AI outputs distinguishable from source evidence.                                         |

|                        |                                                                                                                                                                                                                                                                        |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ARCHITECTURE PRINCIPLE | Interoperability preserves choice without flattening brand sovereignty. As Stefano Rosso frames the boundary, protocols and verification should travel across systems; the experience, relationship logic and brand expression should remain controlled by the maison. |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

KEY TAKEAWAY

The Smart Product Operating System preserves continuity while specialist systems retain domain authority. AI can then use the product’s records and evidence to support decisions and act within explicit permissions.



09

# Physical AI is the next horizon

AI cannot act on products it cannot identify, trust or understand.

INDUSTRY SIGNAL · NVIDIA STATE OF AI IN RETAIL & CPG 2026 [18]

*“AI agents are increasing the speed and efficiency of operations, while physical AI systems are helping streamline and automate warehouse and supply chain operations.”*

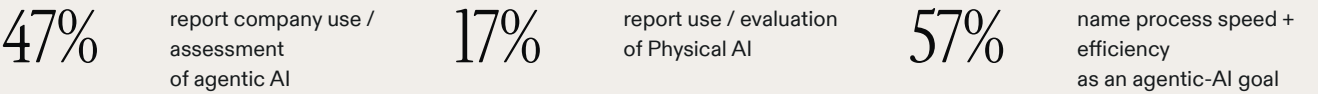
# Physical AI is the next horizon

AI cannot act on products it cannot identify, trust or understand.

Most physical products are still offline to AI. Their images and descriptions may be online, but that does not make the physical item identifiable and operable across its lifecycle.

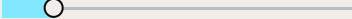
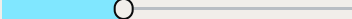
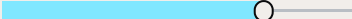
The ecosystem architecture gives AI access to governed product context without displacing the authority of the systems and partners that contribute to it. AI agents can use that context to support lifecycle decisions and permitted actions. Physical AI brings perception, reasoning and action into the physical world. Smart Products provide the identity, lifecycle evidence and permissions needed to govern those interactions.

INDUSTRY SIGNAL · SURVEY OF RETAIL & CPG PROFESSIONALS · NVIDIA STATE OF AI IN RETAIL & CPG 2026 [18]



SPIN FRAMEWORK · PRODUCT-LEVEL AI READINESS

## The AI Readiness Ladder

|    |                                                                                                                                                                                                 |                                                                                      |                          |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------|
| 01 | <p>Which product is this?</p> <p>Lifecycle-grade physical–digital binding establishes which physical item the agent is referencing.</p>                                                         |  | IDENTITY                 |
| 02 | <p>What happened to it?</p> <p>The lifecycle record preserves events and their sources, giving the agent a structured history it can read and reason across.</p>                                |  | LIFECYCLE EVENTS         |
| 03 | <p>Where is it / in what context?</p> <p>Current observations give the agent context about the product's condition, location and physical surroundings.</p>                                     |  | PHYSICAL / SPATIAL STATE |
| 04 | <p>Can I trust what I know?</p> <p>The agent assesses product claims against traceable evidence and the authoritative product reference. This is the role of authoritative lifecycle trust.</p> |  | EVIDENCE / VERIFICATION  |
| 05 | <p>Am I allowed to act?</p> <p>Explicit permissions define which actions the agent may request or execute.</p>                                                                                  |  | PERMISSIONS / GOVERNANCE |

Together, these five checks determine whether product context is ready for governed action. The evidence, physical observations and permission controls required depend on the workflow.

*“As AI agents become part of product lifecycle management, the quality of the records they act on becomes critical. Decentralized infrastructure can give AI agents a stronger trust foundation — a way to check whether a product identity is authentic, authorized, and unaltered.”*

Andreas Pletscher · COO, Cardano Foundation

## Product infrastructure makes AI action governable.

The Smart Product Operating System keeps product state, history and permissions connected while coordinating permitted actions across workflows. Agents can use that context to recommend or initiate actions, while the responsible systems and service providers retain authority over their records. This allows brands to extend automation without losing the evidence and accountability established across the product lifecycle.

## What agents can do with readable and operable products.

### CUSTOMER RELATIONSHIP AGENT

Using a confirmed ownership transfer and the new owner's permissions, a customer relationship agent can initiate the appropriate brand relationship and offer relevant product-enabled services.

### SERVICE AGENT

A service agent can use product identity, condition and service history to recommend care or repair, coordinate an authorised service workflow and retrieve the provider's completion record.

### CIRCULARITY AGENT

A circularity agent can assess returned products using composition, condition and lifecycle evidence, then recommend resale, repair, upcycling or recycling through the appropriate service providers.

### SMART SPACE AGENT

A Smart Space agent can combine product reads and sensor observations with the product's current state and lifecycle history to detect unexpected movements or states and trigger an alert or permitted workflow. With the customer's permission and a confirmed association between the product and their account, it can also support personalised in-store services.

Industry context · On's Tobias Breme notes that without item-level material history, brands cannot reliably automate circularity decisions.

### KEY TAKEAWAY

Smart Products give AI agents the identity, evidence and permissions required for lifecycle decisions and permitted actions. Combined with physical sensing and appropriate execution systems, this infrastructure also supports Physical AI across operational and commercial spaces.

# Build Smart Products from where you are

How to build forward from the systems, data carriers and product data you already have.

The decisions brands make during DPP implementation will shape more than compliance. They determine whether product identity, data carriers and integrations can later support operations and services across the lifecycle. Use that investment to build operable Smart Products and realise Product Lifetime Value through Protect, Recover and Create. The implementation window is now, while these choices are still being designed into products and workflows. Start with one measurable business outcome and expand as the evidence supports it.

## FOUR STARTING POINTS

|                                                                                 |                                                            |                                                                                           |                                                                                                                             |
|---------------------------------------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| 01                                                                              | 02                                                         | 03                                                                                        | 04                                                                                                                          |
| <b>Starting from zero</b>                                                       | <b>Already have DPP</b>                                    | <b>Already use QR or RFID</b>                                                             | <b>Already building AI</b>                                                                                                  |
| Start with one measurable product problem.                                      | Check whether your DPP can support real workflows.         | Check item-level identity and continuity.                                                 | Give your AI the product context it needs.                                                                                  |
| Define one product or collection, one operating perimeter and one baseline KPI. | Follow one item through operations, service and ownership. | Can you identify the individual item and follow it across locations and lifecycle events? | Can it identify the item, understand its history and current state, check the evidence and act within explicit permissions? |

DIFFERENT STARTING POINTS • ONE EXECUTION METHOD

|                                                                                                                                        |                                                                                                                            |                                                                                                                                |                                                                                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| 01                                                                                                                                     | 02                                                                                                                         | 03                                                                                                                             | 04                                                                                                                               |
| <b>Diagnose</b>                                                                                                                        | <b>Pilot</b>                                                                                                               | <b>Prove</b>                                                                                                                   | <b>Expand</b>                                                                                                                    |
| Define the business question, assign an owner and establish a baseline. Identify where product visibility, trust or continuity breaks. | Establish the Product Foundation required for one real workflow and operate it through the Smart Product Operating System. | Compare the result with the baseline: location time, inventory discrepancy rate, service turnaround time or net pilot benefit. | Reuse the same product identity, physical-digital binding, lifecycle history and integrations through the same operating system. |
| OUTPUT                                                                                                                                 | OUTPUT                                                                                                                     | OUTPUT                                                                                                                         | OUTPUT                                                                                                                           |
| One use case • one owner • one baseline KPI                                                                                            | One live product perimeter                                                                                                 | One measured operational or economic result                                                                                    | One reusable product capability                                                                                                  |

Where could your products keep creating value—and what would it take to make that operational? Let's identify the first use case together.

[Start a conversation now.](#)

### KEY TAKEAWAY

The next step is to choose one product or workflow, assign a business owner and agree a measurable outcome. Reuse what already works, prove the result, then expand through the same Smart Product Operating System. That is how Product Lifetime Value becomes operational today while the same foundation prepares for Physical AI.

# CEN CWA 18291:2025

A practical six-step reference for structuring textile supply-chain data toward Digital Product Passport readiness, developed from EU Horizon 2020 TRICK outcomes with contributions from SPIN and other CEN Workshop participants.

WHAT IT IS

## TRICK — Guidelines on data collection from Textile supply chains for the Digital Product Passport

CWA 18291:2025 is a CEN Workshop Agreement developed from outcomes of the EU Horizon 2020 TRICK programme and contributions from related European initiatives. It gives textile brands and supply-chain partners a practical method for structuring traceability, sustainability evidence and collaborative data processes toward DPP readiness while product-specific requirements continue to mature. <sup>[4]</sup>

It is a CEN-published standardisation deliverable rather than EU legislation or a formal European Standard. Its role is practical and preparatory: brands and supply-chain partners can use it now to organise evidence, traceability boundaries and data structures that will need to connect with the horizontal DPP standards and future product-specific requirements.

Official document: [CWA 18291:2025 \(CEN-CENELEC\)](#)

WHY IT MATTERS NOW

For brands, the practical value lies in the six-step method below, which provides a ready-to-use sequence for defining objectives, mapping the actual supply chain and evidence, setting traceability boundaries, organising collaborative data exchange and structuring the data model that supports DPP statements. Brands can begin this work while product-specific requirements continue to mature.

CEN CWA 18291:2025 · SIX-STEP GUIDELINE

|                                                                                                                                                                                                                             |                                                                                                                                                                                                                      |                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>01</b></p> <p><b>Identify objectives, legal value of data &amp; supply-chain strategy</b></p> <p>Define the purpose of data gathering, the legal value of evidence and the strategy for supply-chain involvement.</p> | <p><b>02</b></p> <p><b>Describe the actual supply chain with actors &amp; roles</b></p> <p>Map the current supply chain, actors, roles, physical assets, information exchanges and potential data barriers.</p>      | <p><b>03</b></p> <p><b>Set up the traceability system</b></p> <p>Define traceable assets, identifiers, boundaries, events, evidence, verification criteria and the required traceability functions.</p>                             |
| <p><b>04</b></p> <p><b>Sustainability data gathering</b></p> <p>Structure the collection of environmental, social and circularity data and the evidence supporting it.</p>                                                  | <p><b>05</b></p> <p><b>Reference collaborative processes for data gathering</b></p> <p>Define how data moves across organisations, including quality, confidentiality, interoperability and disclosure policies.</p> | <p><b>06</b></p> <p><b>Data model for traceability &amp; sustainability data gathering</b></p> <p>Structure the common data model so traceability and sustainability information can support DPP statements and downstream use.</p> |

Step titles follow CWA 18291:2025 clauses 4.3 and 5. Descriptions are condensed from the CWA. SPIN applies the six-step method within the Product Foundation stage of the Smart Product Playbook.

SPIN SMART PRODUCT PLAYBOOK · PRODUCT FOUNDATION

Use the six steps as the data-mapping starting point for Product Foundation: establish what must be known, where the evidence comes from and how it should be structured before moving into Product Operations. The method can begin before category-specific DPP implementation is final.

EU HORIZON 2020 · TRICK DEVELOPMENT PROGRAMME

TRICK (2021–2024) was a €9.60M Horizon 2020 Innovation Action with €8.00M in EU contribution, coordinated by Fratelli Piacenza across 35 consortium organisations, including the Italian Customs Agency, ENEA and LABLACO SRL. At the time, lablaco was the corporate name, while SPIN was the technology platform; the company now operates as Smart Products Infrastructure Network, Inc. (SPIN). TRICK developed and validated a blockchain-secured, full-lifecycle DPP architecture across two textile pilots — fashion and technical workwear — spanning supply-chain traceability, circular services and end-of-use workflows. Within the textile pilot, SPIN provided its Smart Products Operating System (SPIN OS) to manage and orchestrate lifecycle traceability data, while its product-facing interface (SPIN Field) served as the DPP interface for product authentication, consumer engagement and end-of-use / take-back workflows. <sup>[14]</sup>

Pilot evidence: TRICK D5.6, §2.1.8.6, pp. 28–31 <sup>[14]</sup>. SPIN OS / SPIN Field are the product names used in this paper; the deliverable uses “Spin Fashion” / “Spin App”.

## APPENDIX B · REGULATORY TIMELINE

# EU ESPR / DPP Regulatory Reference

Current regulatory baseline as of 6 October 2026. Dates remain indicative where the European Commission labels them indicative. Under ESPR, application of a delegated act generally cannot begin earlier than 18 months after entry into force, except in duly justified cases.<sup>[2]</sup>

|              |                                                                                     |                                                                                                                                                                                                                                                                                                            |            |
|--------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 28 Jun 2024  |    | <b>ESPR published</b><br>Regulation (EU) 2024/1781 establishes the framework for product-specific ecodesign requirements and the Digital Product Passport.                                                                                                                                                 | CONFIRMED  |
| Apr 2025     |    | <b>Working Plan 2025–2030 adopted</b><br>Textiles are included among the ESPR priority product groups, defining the sequence for future delegated acts.                                                                                                                                                    | CONFIRMED  |
| 20 Jul 2026  |    | <b>DPP Registry live</b><br>The EU Digital Product Passport Registry is live.                                                                                                                                                                                                                              | CONFIRMED  |
| Jul–Sep 2026 |  | <b>Eight horizontal standards published</b><br>Six of the eight standards are cited in the Official Journal through Commission Implementing Decision (EU) 2026/1736.<br><br>OJ citation pending: EN 18239 and EN 18246, as of 6 October 2026.                                                              | CONFIRMED  |
| 18 Feb 2027  |  | <b>Battery passport mandatory</b><br>The first product-category passport requirement takes effect for specified battery categories under the Batteries Regulation.                                                                                                                                         | CONFIRMED  |
| Q3–Q4 2027   |  | <b>Textile delegated act · planned adoption</b><br>The Commission's general DPP roadmap places adoption of the ESPR Delegated Act for textiles in Q3–Q4 2027; the textile-specific page currently states Q4 2027. Timing remains indicative.                                                               | INDICATIVE |
| 2028–2029    |  | <b>Transition &amp; implementation window</b><br>Brands translate final requirements into product, supplier, data and operational implementation. As a general rule under ESPR, application cannot begin earlier than 18 months after the delegated act enters into force, except in duly justified cases. | INDICATIVE |
| ~2029+       |  | <b>Earliest general-rule application</b><br>Final application timing remains subject to the adopted delegated act, its entry into force and any duly justified exceptions.                                                                                                                                 | INDICATIVE |

 CONFIRMED     INDICATIVE / PLANNED

APPENDIX C · PHYSICAL IDENTITY REFERENCE

# Physical Identity & Data–Carrier Reference

Reference companion to Chapter 04. Use these criteria to assess whether the physical identity layer can support the interaction, read scale, durability, security and interoperability required across the product lifecycle.

PHYSICAL IDENTITY · SIX LIFECYCLE-GRADE CRITERIA

|                                                                   |                                                                      |                                                                    |
|-------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Identify</b><br>One physical item, not only a SKU.             | <b>Persist</b><br>Remain usable through the product's intended life. | <b>Verify</b><br>Separate access to data from proof of the object. |
| <b>Operate</b><br>Read at the speed and scale operations require. | <b>Engage</b><br>Support the human / product interaction point.      | <b>Interoperate</b><br>Remain useful beyond one vendor interface.  |

TERMINOLOGY  
COMPANION

## RFID is a technology family, not a synonym for UHF RFID.

RFID is the broad family of radio-frequency identification technologies. In this paper, NFC RFID refers to near-field RFID used for deliberate item interaction; UHF RFID refers to longer-range RFID used for scalable one-to-many operational reading; and DUAL RFID combines both on the same product architecture. Using “RFID” to mean only UHF is common industry shorthand, but technically imprecise.

| RFID FAMILY / TECHNOLOGY | TYPICAL FREQUENCY              | INTERACTION MODEL                                                                                             | TYPICAL PRODUCT USE                                                                         |
|--------------------------|--------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| LF RFID                  | ~125–134.2 kHz                 | Very short range; slower reads                                                                                | Access, animal ID, specialised industrial identification                                    |
| NFC RFID                 | 13.56 MHz                      | Near-field; deliberate tap / very short-range interaction. NFC is a standards ecosystem within the HF family. | Consumer interaction, secure verification interfaces, service, claim / register, DPP access |
| UHF RFID                 | ~860–960 MHz, region-dependent | Longer range; fast one-to-many / bulk reading                                                                 | Inventory, logistics, movement, presence, factory and retail operations                     |

### Can passive RFID provide continuous location tracking?

Not on its own: passive NFC RFID and UHF RFID tags do not contain GPS or a battery and therefore do not autonomously report a person's or product's location. A compatible reader must interact with the tag, while a network of readers can create time-and-place observations when a tagged object enters configured read zones. This is event-based detection rather than autonomous GPS-style tracking.

### RF exposure and deployment compliance

RFID deployments are subject to applicable radio and human-exposure requirements. For passive tags, exposure considerations primarily concern the powered reader environment; deployment-specific compliance depends on reader power, antenna configuration, distance, duty cycle and jurisdiction.

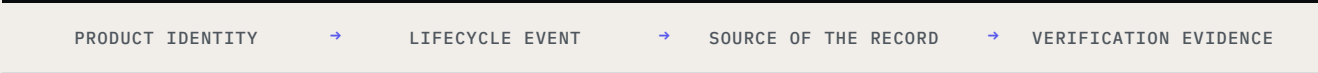
Frequency and range are implementation-dependent. NFC RFID reference: NFC Forum [15]; UHF RFID reference: RAIN Alliance [16]. Human-exposure reference: ICNIRP 2020 RF EMF Guidelines [17].

APPENDIX D · INTEGRITY & VERIFICATION

# Lifecycle Data Integrity & Verification

Lifecycle data should remain operational while verification remains independent. A lifecycle-grade product architecture does not require every piece of enterprise data to be placed on a blockchain or copied into a new central system. Product, manufacturing, logistics, service and customer data may remain within the enterprise systems responsible for governing them.

LIFECYCLE VERIFICATION · EVIDENCE CHAIN



What must remain connected is the relationship between the product identity, the lifecycle event, the source of the record, and the evidence required to verify that record later.

VERIFICATION PRINCIPLES · SOURCE TO INDEPENDENT VALIDATION

|                                                                                                                                                                                         |                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <div>01</div> <div>Source</div> <div>The authorised system or participant that creates an operational fact, such as manufacture, movement, handoff, repair or ownership transfer.</div> | <div>02</div> <div>Structure</div> <div>The event is expressed in a consistent, machine-readable lifecycle format so it remains interpretable across systems and over time.</div>                                          |
| <div>03</div> <div>Integrity</div> <div>A cryptographic proof or equivalent integrity mechanism can demonstrate that the referenced record has not been altered after commitment.</div> | <div>04</div> <div>Verification</div> <div>An authorised party can later verify record integrity and, where supported, its authenticated source without relying on the original application as the sole trust point.</div> |

Verification proves integrity, not truth: it can show that a record was issued or committed by an identified source and has not changed, but it cannot establish that the underlying real-world claim was accurate when created. Data quality, authorisation and evidence must therefore begin where the event is created.

The objective is not “putting the product on blockchain”, but preserving a product history that can survive changes in applications, service providers and trust infrastructure without losing identity or evidentiary continuity.

Detailed protocol schemas, resolver logic, cryptographic implementation and conformance specifications sit outside the scope of this public whitepaper.

Protocol provenance · OPALS · lifecycle verification · SPIN · 2026

APPENDIX E · GLOSSARY

# Glossary

Core terms used throughout the report.

SPIN FRAMEWORK · CANONICAL TERMS · 2026

Definitions reflect how SPIN develops and uses these concepts throughout this report.

| PARADIGM                      | OPERABLE UNIT | OPERATING LAYER                                                | ECONOMIC LENS          | NEXT HORIZON |
|-------------------------------|---------------|----------------------------------------------------------------|------------------------|--------------|
| PRODUCT-CENTRIC ERA           | SMART PRODUCT | SMART PRODUCT OPERATING SYSTEM                                 | PRODUCT LIFETIME VALUE | PHYSICAL AI  |
| SPIN MODEL · RETAIL EVOLUTION |               | SPIN SMART PRODUCT PLAYBOOK                                    |                        |              |
| Smart Product Retail          |               | Product Foundation → Product Operations → Product Intelligence |                        |              |

|                       |                                                                                                                                                                                                                                                                       |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ARCHITECTURE BOUNDARY | The Smart Product Operating System does not replace ERP, PLM, MES, CRM or a master product database. Specialist systems remain authoritative in their domains; the operating layer preserves product continuity and operability across them and across the lifecycle. |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

REFERENCE GLOSSARY · REGULATORY, FRAMEWORK & TECHNICAL TERMS

|                                |                                                                                                                                                                                                                                                                           |                    |                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DPP                            | Digital Product Passport — a digital product-information record required under applicable EU legislation, with specific data and access requirements defined by the relevant product rules.                                                                               | SPIN OS            | SPIN's Smart Products Operating System, used to orchestrate Smart Product actions across connected systems, services and workflows.                                                                                                                                                                                                                                         |
| ESPR                           | Ecodesign for Sustainable Products Regulation (EU 2024/1781) — the framework that introduces DPPs progressively across product categories.                                                                                                                                | AI Agents          | Agents that reason and act on governed product context across permissions, services, spaces and workflows within explicit controls.                                                                                                                                                                                                                                         |
| Product-Centric Era            | SPIN's framing for the shift in which the physical product becomes an operable unit of intelligence and value alongside the customer, across its lifecycle.                                                                                                               | Smart Space        | A physical environment made operationally aware through identified products and real-world sensing, so systems can interpret product presence, movement and context.                                                                                                                                                                                                        |
| Smart Product                  | A physical product with lifecycle-grade physical–digital binding, operated by a Smart Product Operating System.                                                                                                                                                           | Physical AI        | AI systems that perceive, reason about and act in the physical world. In the Smart Product context, product identity, lifecycle state, physical context and permissions make individual products legible and actionable to those systems.                                                                                                                                   |
| Smart Product Retail           | SPIN's product-centric retail model in which the same physical product remains identifiable and operable across systems, spaces, services and owners throughout its lifecycle, allowing customer relationships, services and experiences to continue through the product. | CEN CWA 18291:2025 | TRICK — Guidelines on data collection from Textile supply chains for the Digital Product Passport; a CEN Workshop Agreement providing practical guidance for textile supply-chain traceability and sustainability data gathering toward DPP readiness. It is a CEN-published standardisation deliverable, distinct from EU legislation and from a formal European Standard. |
| Product Lifetime Value (PLV)   | The commercial and operational value that can be protected, recovered or created around the same physical product across transactions, services, experiences, owners and end-of-life pathways.                                                                            | RFID               | Radio-frequency identification — a broad family of technologies that includes LF, HF and UHF systems. NFC RFID and UHF RFID are distinct technologies within this family.                                                                                                                                                                                                   |
| Product Foundation             | The authoritative product reference built through product identity, lifecycle-grade physical–digital binding and interoperability, with a data carrier designed for the product's intended lifecycle.                                                                     | NFC RFID           | Near Field Communication — a 13.56 MHz near-field RFID technology used for deliberate tap-based interaction, including consumer access, service and secure verification interfaces.                                                                                                                                                                                         |
| Product Operations             | The orchestration of product state, lifecycle events, permissions and actions across real workflows through a Smart Product Operating System.                                                                                                                             | UHF RFID           | Ultra-high-frequency passive RFID used for longer-range, one-to-many operational reading such as inventory, logistics and product movement.                                                                                                                                                                                                                                 |
| Product Intelligence           | The application of governed product context to decisions, automation, spatial awareness and new economics.                                                                                                                                                                | DUAL RFID          | A product architecture that combines NFC RFID and UHF RFID on the same item so deliberate human interaction and scalable operational reading can share one product identity.                                                                                                                                                                                                |
| Smart Product Operating System | An operating layer that governs product state, lifecycle events, permissions and actions and orchestrates product action across connected systems, services and workflows.                                                                                                |                    |                                                                                                                                                                                                                                                                                                                                                                             |

## REFERENCES · BIBLIOGRAPHY

# Research & Industry References

Regulatory facts, market evidence, enterprise disclosures, technical references and framework provenance cited in this paper are separated by source type below. Where a report uses data from an earlier measurement year, the data year is noted. URLs were last accessed October 2026. Original interview contributions are identified separately under Acknowledgements & Contributors rather than duplicated in the bibliography.

|    |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 01 | Framework / provenance    | lablaco / Circular Fashion Summit, with Vogue Business, PwC Italy and other contributors. <i>Circular Fashion Report 2020 – Year Zero</i> . November 2020. P. 17 estimates a US\$5.3 trillion opportunity across digitised circular fashion, including adjacent segments and unrealised value. P. 12, Figure 7 (see also p. 6) describes a product-centric, ownership-based Circular Retail model, extending the Traditional Retail / New Retail framing cited from Bain & Company (2018). lablaco's history dates its circular-fashion consumption model to 2016 and the report launch to 2020. <a href="#">Report (DocSend)</a> · <a href="#">lablaco history</a> .                                                                                                                                   |
| 02 | Regulatory / primary      | European Commission / EUR-Lex / CEN-CENELEC. <i>Regulation (EU) 2024/1781</i> (ESPR); <i>Working Plan 2025–2030</i> , COM(2025) 187 final; <i>Regulation (EU) 2023/1542</i> , Article 77 (battery passports from 18 February 2027); Commission DPP timeline and textile-apparel guidance; and Decision (EU) 2026/1736. Registry launch: 20 July 2026. Eight horizontal standards are published; six are cited in the Official Journal, with EN 18239 and EN 18246 citation pending as of 6 October 2026. Textile adoption remains indicative: Q3–Q4 2027 on the general roadmap; Q4 2027 on the textile page. <a href="#">ESPR</a> · <a href="#">Working Plan</a> · <a href="#">Batteries, Art. 77</a> · <a href="#">DPP timeline</a> · <a href="#">Textiles</a> · <a href="#">Decision 2026/1736</a> . |
| 03 | Industry / independent    | Deloitte × Aura Blockchain Consortium. <i>Embracing Digital Product Passport as a Regulatory Requirement: Setting a New Standard for Luxury Experiences and Circularity</i> . 2024. Used as industry context for DPP-enabled post-sale touchpoints, ownership continuity and services such as warranty, repair and transfer; not treated as deployment evidence in this paper. <a href="#">Reference</a> .                                                                                                                                                                                                                                                                                                                                                                                              |
| 04 | Standards / primary       | CEN-CENELEC. <i>CWA 18291:2025 – TRICK: Guidelines on data collection from Textile supply chains for the Digital Product Passport</i> . October 2025. A CEN Workshop Agreement initiated within the EU Horizon 2020 TRICK programme, providing practical guidance for textile supply-chain traceability and sustainability data gathering toward DPP readiness. It is a CEN-published standardisation deliverable, distinct from EU legislation and from a formal European Standard. <a href="#">Official PDF</a> .                                                                                                                                                                                                                                                                                     |
| 05 | Operational / independent | ECR Retail Loss. <i>Measuring the Sales Impact of Improving Inventory Records</i> . Published 6 July 2020. Research covering approximately 1M SKUs across about 100 stores. 59.54% of audited SKUs showed inventory-record inaccuracy overall; for fashion/apparel retailers, 54.08% did not match physical stock. <a href="#">Reference</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 06 | Operational / secondary   | Deloitte. <i>Retail Planning</i> . 2025. Deloitte cites industry evidence that item-level tagging, when properly implemented, can increase inventory accuracy from 63% to 95%. This paper treats the figure as secondary evidence cited by Deloitte, not as a SPIN deployment result. <a href="#">Reference PDF</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 07 | Market / independent      | Boston Consulting Group × Vestiaire Collective. <i>Resale's Next Chapter: How Fashion and Luxury Brands Can Win in the Secondhand Market</i> . October 2025. Secondhand fashion & luxury market: ~\$210–220B in 2025, expected to reach \$320–360B by 2030, growing ~10% annually. Survey base: 7,800 Vestiaire Collective community members; results are therefore resale-engaged, not a general-population sample. <a href="#">Report</a> .                                                                                                                                                                                                                                                                                                                                                           |
| 08 | Market / independent      | OECD / EUIPO. <i>Mapping Global Trade in Fakes 2025: Global Trends and Enforcement Challenges</i> . 7 May 2025; data year 2021. Estimated global trade in counterfeit and pirated goods: ~\$467B, or up to 2.3% of global imports. Clothing, footwear and leather goods represented 62% of seizure counts; this is not a value share and is not multiplied by the \$467B estimate in this paper. <a href="#">OECD</a> .                                                                                                                                                                                                                                                                                                                                                                                 |
| 09 | Market / independent      | Deloitte. <i>Global Powers of Luxury 2026</i> . Research involving 420 senior luxury executives across ten countries. 68.3% of companies offer repair or refurbishment services; 53.8% operate certified pre-owned or trade-in programmes; 44.5% partner with resale platforms. <a href="#">Reference</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

# Research & Industry References

|    |                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10 | Technical / adoption evidence | NFC Forum · ABI Research. <i>Worldwide NFC Technology Use Surges Over Last 24 Months / 2022 ABI Usage and Adoption Study</i> . July 2022. NFC Forum reported NFC as a standard feature on approximately three billion smartphones in use; the sponsored nine-country ABI Research study also found that more than one-third of respondents had used NFC for consumer-product interaction, including clothing, alcohol and luxury items. <a href="#">NFC Forum announcement</a> · <a href="#">Study overview</a> .                                                                                                                                                                                                                                                                                                                                            |
| 11 | Industry / platform evidence  | Amazon. <i>Trustworthy Shopping Experience Report 2025</i> . Published 2026. Amazon reports proactive AI-driven controls blocking more than 99% of suspected infringing listings before brands need to find and report them, and describes a 2025 early-warning case in which infringing listings targeting a viral new product were blocked eight days before the brand shared its IP. <a href="#">Reference</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 12 | Enterprise disclosure         | LVMH. <i>LIFE 360 / 2025 Environmental Performance and Universal Registration Document</i> . 2025 results: more than 10M repairs, refills and product take-backs completed; revenue from repair and refill services estimated at more than €500M. <a href="#">LIFE 360</a> · <a href="#">URD 2025</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 13 | Systemic / independent        | Ellen MacArthur Foundation. <i>A New Textiles Economy: Redesigning Fashion's Future</i> . 28 November 2017. Less than 1% of material used to produce clothing is recycled into new clothing. Used here as a structural circularity endpoint, not as Smart Product-addressable market size. <a href="#">Reference</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 14 | Programme / primary           | European Commission · CORDIS. <i>TRICK — Product Data Traceability from Cradle to Cradle by Blockchains Interoperability and Sustainability Service Marketplace</i> . Horizon 2020 Innovation Action, Grant Agreement 958352 (2021–2024); total project cost €9.60M, EU contribution €8.00M; coordinated by Fratelli Piacenza with 34 listed participants plus the coordinator. <a href="#">Project fact sheet</a> . Pilot implementation: TRICK D5.6, <i>Performance evaluation report of TC pilot</i> , §2.1.8.6, pp. 28–31 (public submitted deliverable): SPIN's DPP integration, data transfer and consumer interface. The project's 23 February 2022 partner profile documents SPIN's item-level traceability and circular-service role. <a href="#">D5.6</a> · <a href="#">Deliverable register</a> · <a href="#">Official SPIN partner profile</a> . |
| 15 | Technical reference           | NFC Forum. <i>NFC Technology — Technical Overview</i> . NFC operates at 13.56 MHz and supports very short-range interaction, including battery-less tag use cases. <a href="#">Reference</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 16 | Technical reference           | RAIN Alliance. <i>What is RAIN RFID?</i> Reference overview of RAIN RFID (UHF RFID) operating principles and one-to-many operational use cases. <a href="#">Reference</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 17 | Technical reference           | ICNIRP. <i>Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz)</i> . <i>Health Physics</i> 118(5):483–524, 2020. <a href="#">Reference</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 18 | Industry / survey             | NVIDIA. <i>State of AI in Retail and CPG 2026 / From Warehouse to Wallet</i> . 7 January 2026. NVIDIA's third annual survey of hundreds of retail and CPG professionals reports 47% using or assessing agentic AI, 17% using or evaluating Physical AI, and 57% identifying increased process speed and efficiency as a goal for agentic AI. <a href="#">Reference</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

Research and standards lineage, including the EU Horizon 2020 TRICK programme and CEN CWA 18291:2025, is documented separately in Appendix A rather than presented as a current ecosystem dependency.

ACKNOWLEDGEMENTS & CONTRIBUTORS

# Industry Voices & Supporting Partners

Original interviews and written contributions informed the research and argument of this report. Publicly sourced quotations remain documented under Research & Industry References.

## Industry Voices & Contributors

|                                                                                                                                      |                                                                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
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| <b>Terry Chiang — CEO, Securitag Assembly Group (SAG)</b><br>Interview contribution to this report · 2026                            | <b>Alex Chou — CEO, Makalot</b><br>Interview contribution to this report · 2026                          |
| <b>Alberto Uncini Manganelli — former Global Senior Vice President, adidas</b><br>Interview contribution to this report · 2026       | <b>Andreas Pletscher — COO, Cardano Foundation</b><br>Interview contribution to this report · 2026       |
| <b>Stefano Rosso — Chairman, Aura Blockchain Consortium / CEO, Marni (OTB Group)</b><br>Interview contribution to this report · 2026 |                                                                                                          |

## Supporting Organisations & Ecosystem Partners

SAG, Makalot and the Cardano Foundation support this report, bringing expertise in product identification, global manufacturing and public blockchain infrastructure. Separately, SPIN is a member of NVIDIA Inception; programme membership does not imply NVIDIA’s endorsement of this report.

RFID / NFC / WIRELESS SENSING · GLOBAL PRODUCT IDENTIFICATION

### SAG

Securitag Assembly Group (SAG) is a specialist RFID and wireless-identification manufacturer developing NFC, HF and UHF RFID tags, sensor-enabled applications and customised identification solutions for industrial, logistics, healthcare, automotive and IoT use cases. Founded in 1999, SAG works with major global technology companies including Sony, and is a member of AIM, RAIN RFID and the NFC Forum, as well as an NXP MIFARE Advanced Partner.

GLOBAL APPAREL MANUFACTURING · MAJOR BRAND & RETAIL SUPPLY CHAINS

### Makalot

Makalot is a global apparel manufacturing and innovation group with an international production network across Asia and the Americas. Its publicly listed client roster includes Gap, Old Navy, Athleta, Under Armour, ASICS, Zara, Abercrombie & Fitch, Target and Walmart. Alongside global manufacturing, Makalot operates Portal:M, its digital innovation studio focused on industrialising 3D, AI and XR technologies across apparel development, including digital product creation, manufacturable digital twins and StyTrix, its real-time AI platform connecting design intelligence with production-ready workflows.

PUBLIC BLOCKCHAIN INFRASTRUCTURE · ENTERPRISE & INSTITUTIONAL ADOPTION

### Cardano Foundation

The Cardano Foundation is an independent Swiss-based not-for-profit advancing Cardano as secure public blockchain infrastructure for enterprises, institutions and governments. Its real-world adoption work spans enterprise, financial and public-sector applications, including collaborations with UNDP and Petrobras. The Foundation has also joined the UNDP Blockchain Advisory Group and participates in Mastercard’s Crypto Partner Program, supporting the adoption of trusted, scalable and independently verifiable blockchain infrastructure worldwide.

MEMBER OF NVIDIA INCEPTION

### NVIDIA Inception

NVIDIA Inception is NVIDIA’s global programme supporting AI startups building on its accelerated computing ecosystem. NVIDIA technologies — including GPUs, RTX and Omniverse — together with OpenUSD, provide the compute, simulation and digital-twin infrastructure behind advanced AI and Physical AI development. Across retail and luxury, NVIDIA technologies are used by groups including LVMH and Moët Hennessy for advanced 3D and digital workflows. SPIN is a member of NVIDIA Inception.

ABOUT THIS REPORT

# Authorship & Research Method

Original concepts and strategic frameworks developed by the lead author, supported by SPIN's technology and standards work, industry interviews, source research and a disclosed research methodology.

AUTHORSHIP

LEAD AUTHOR · ORIGINAL  
CONCEPTS & STRATEGIC  
FRAMEWORKS

Eliana Kuo — Co-CEO & Founder, SPIN (Smart Products Infrastructure Network)  
Created the report's original concepts and strategic frameworks; led thesis development, framework design, narrative architecture, interpretation and final editorial direction. Participant in the EU Horizon 2020 TRICK programme and contributor to CEN CWA 18291:2025.

CONTRIBUTOR · TECHNOLOGY &  
STANDARDS

Lor Albrighti — Co-CEO & Founder, SPIN (Smart Products Infrastructure Network)  
Contributed to SPIN's hardware and software development, Smart Product architecture and standards work, and to the report's technology and standards perspective. Participant in the EU Horizon 2020 TRICK programme and contributor to CEN CWA 18291:2025.

RESEARCH METHOD

RESEARCH &  
EDITORIAL PROCESS

1,000+ RESEARCH, EDITORIAL &  
PRODUCTION ITERATIONS

HUMAN-LED · AI-ASSISTED

ROLE OF AI

AI deepened the editorial process; authorship and direction remained with SPIN.

This report was developed through more than 1,000 substantive research, analytical, editorial, visual and production iterations. The process included source verification, argument testing, framework development, writing, structural review, editorial refinement, visual design and production.

OpenAI ChatGPT and Anthropic Claude were used as research and editorial tools to support research synthesis, source auditing, comparative analysis, challenge testing, consistency checks and language refinement. AI-generated output was not treated as an independent source of evidence. Core concepts, strategic frameworks, interpretations, conclusions and final editorial decisions were developed, reviewed and approved by the lead author and SPIN.

RESPONSIBLE AI USE

Intelligence has human, operational and environmental costs, which makes responsible use more important, not less.

AI-assisted research carries a real compute and environmental cost. SPIN used that capacity to deepen research, verification and editorial rigour rather than substitute for human judgment or accelerate disposable content. We ask readers to use, cite and build on this work responsibly, preserving attribution, evidence and context.

ITERATION NOTE · The 1,000+ figure includes substantive human and AI-assisted research, analytical, editorial, visual and production passes; it is not a count of AI prompts or model runs.

RESEARCH APPROACH

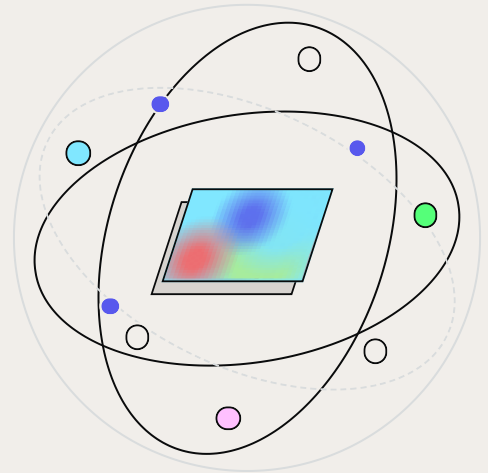
The report combines desk research, regulatory and standards review, industry interviews, enterprise deployment evidence and comparative analysis. Original interview contributors are listed separately under Acknowledgements & Contributors; public research is listed under Research & Industry References.

Contributor participation, partner acknowledgement or inclusion in cited research does not imply endorsement of every argument or conclusion in this report.



DPP is the starting point.

The opportunity is to build beyond compliance with operable Smart Products — unlocking Product Lifetime Value today and creating the foundation for Physical AI tomorrow.



#### ABOUT SPIN

SPIN builds the software and hardware infrastructure that turns physical products into a network of Smart Product nodes for Physical AI — unlocking smarter operations and new lifecycle revenue opportunities for brands.

SPIN combines lifecycle-grade physical-digital binding with SPIN OS, its Smart Products Operating System, to keep the same physical item identifiable, operable and AI-readable across systems, spaces, owners and services. This infrastructure provides a foundation for Digital Product Passport (DPP) compliance while enabling authentication, ownership, care and repair, resale, automation, and product-enabled services and experiences that protect, recover and create Product Lifetime Value.

R&D / STANDARDS LINEAGE · EU HORIZON 2020 TRICK · CEN CWA 18291:2025 CONTRIBUTOR

#### SPIN · A DECADE OF RESEARCH & DEVELOPMENT

2016 → 2026



#### UPGRADE THE INFRASTRUCTURE YOU ALREADY HAVE.

One product · one perimeter · one measurable outcome.

[start@spinfrequency.com](mailto:start@spinfrequency.com) · [spinfrequency.com](https://spinfrequency.com)