



TSG LAB AG — USE CASE 5

Luxury Goods NFT Authentication Platform

End-to-End Digital Identity and Lifecycle Management for High-Value Physical Products

NFT

AUTHENTICATION

ERC-6551

DIGITAL PASSPORT

EU COMPLIANCE

01 Executive Summary

TSG Lab AG's Luxury Goods NFT Authentication Platform provides a comprehensive, brand-agnostic solution for digitizing the identity, provenance, and lifecycle of any high-value physical product. Every authenticated item receives a unique NFT — its permanent digital twin — linked through tamper-proof NFC chips, QR codes, or embedded RFID tags.

The global luxury goods market exceeded USD 360 billion in 2024, yet faces a counterfeiting epidemic exceeding USD 500 billion annually. Beyond authentication, the platform manages the product's entire lifecycle through smart contracts: ownership registration and transfer, warranty activation, repair logging, insurance integration, secondary market resale with escrow and royalty enforcement, and end-of-life recycling certification. The vision is a world where every luxury product carries an unforgeable digital passport that enhances its value, protects its owner, and creates new revenue opportunities for brands at every lifecycle stage.

02 Business Challenge

- ▶ **USD 500B+ Counterfeiting Industry:** Luxury goods are among the most counterfeited product categories globally, with fakes reaching consumers through online marketplaces, grey market channels, and even seemingly legitimate outlets.
- ▶ **Authentication Scalability:** Manual authentication by brand experts does not scale to the volume of secondary market transactions, increasingly peer-to-peer and cross-border.
- ▶ **Secondary Market Value Leakage:** Brands capture zero revenue from the thriving secondary market, which often exceeds primary market volume for iconic products.
- ▶ **Customer Relationship Discontinuity:** After the initial sale, brands lose visibility into their product and customer — no service reminders, no resale data, no re-engagement opportunities.
- ▶ **EU Sustainability Mandates:** EU Digital Product Passport and Ecodesign Regulations will require verifiable product lifecycle data, challenging legacy systems.
- ▶ **Cross-Category Complexity:** Luxury conglomerates manage diverse product categories (leather goods, watches, jewelry, fashion) with distinct authentication and lifecycle requirements.

03 Technical Solution

Physical-Digital Linking Layer

A multi-modal tagging system supports diverse product categories: **NFC Chips (NTAG 424 DNA)** embedded in leather goods, watch straps, jewelry clasps, and shoe soles with dynamic authentication preventing cloning; **Ultra-Miniature RFID** woven into fabrics or garment labels; **Encrypted QR Codes** laser-engraved for items where chip embedding is impractical; and **Gemstone Spectral Fingerprints** for jewelry items via spectroscopic material-level signatures.

Smart Contract Lifecycle Suite

ProductRegistry.sol — Multi-brand, multi-category product registration with role-based minting authority.

OwnershipProtocol.sol — Gasless ownership transfer via meta-transactions with escrow for peer-to-peer sales.

WarrantyEngine.sol — Category-configurable warranty logic (2-year bags, 5-year watches, lifetime jewelry) with authorized repairer verification.

ServiceJournal.sol — Immutable maintenance and repair log for cleaning, conditioning, hardware repair, and stone re-setting by authorized providers.

RoyaltyProtocol.sol — ERC-2981-compliant royalty enforcement on every secondary market transaction.

CircularityTracker.sol — End-of-life management including refurbishment certification, donation tracking, and material recycling attestation.

Brand & Consumer Portals

A **Brand Dashboard** provides real-time product tracking, secondary market analytics, anti-counterfeiting alerts, and EU DPP compliance reporting. A **Consumer App** delivers tap-to-verify, digital wardrobe management, service booking, and resale listing. An integrated **Marketplace** features verified-only listings with escrow transactions and condition-based pricing intelligence.

04 Implementation Approach

Phase	Activities	Duration
Phase 1: Platform Foundation	Multi-tenant architecture, modular smart contract framework, NFC/RFID hardware selection, IPFS infrastructure	8–10 weeks
Phase 2: Brand Onboarding	Self-service brand portal, product category templates, metadata schema configurator, minting governance	6–8 weeks
Phase 3: Smart Contract Suite	Full lifecycle contracts, formal verification, category-specific logic modules, third-party security audit	10–12 weeks
Phase 4: Physical Tag Integration	NFC kits for multiple product categories, RFID fabric tag development, QR authentication server	8–10 weeks

Phase 5: Consumer Experience	Mobile app (iOS/Android), brand-customizable verification flows, digital wardrobe UX, marketplace	8–10 weeks
Phase 6: Pilot & Expansion	Pilot with 2–3 luxury brands, 5,000+ product tokenizations, consumer feedback, broad market launch	8–12 weeks

05 Technology Stack

Layer	Technologies
Physical Tags	NXP NTAG 424 DNA, Impinj Monza R6-P (RFID), Confidex Steelwave Micro, custom fabric RFID labels
Blockchain	Ethereum Mainnet, Polygon PoS, Arbitrum (L2), Solana (high-volume minting)
Token Standards	ERC-721 (product NFTs), ERC-1155 (collections), ERC-2981 (royalties), ERC-5192 (soulbound), ERC-6551 (token-bound accounts)
Smart Contracts	Solidity 0.8.x, Diamond Proxy Pattern (EIP-2535) for modular upgradeability, Chainlink oracles
Storage	IPFS, Filecoin, Arweave, Cloudflare R2 (CDN acceleration)
Identity & Access	W3C DIDs, Verifiable Credentials, Ethereum Attestation Service, Web3Auth, ERC-4337
Consumer App	React Native, NFC Manager SDK, ARKit/ARCore (AR try-on), Three.js, WalletConnect v2
Brand Dashboard	Next.js, D3.js analytics, GraphQL, The Graph, PostgreSQL, Elasticsearch

06 Key Features & Capabilities

- Universal Product Coverage** — Single platform for handbags, watches, jewelry, fashion, shoes, accessories, and art — with category-specific metadata schemas.
- Brand-Customizable Experience** — White-label consumer verification flows for each brand to maintain visual identity within the shared platform.
- NFC Tap-to-Verify** — Sub-2-second authentication via smartphone NFC scan — no app installation required (Progressive Web App fallback).

- ✔ **Token-Bound Accounts (ERC-6551)** — Each product NFT acts as its own wallet, holding warranty certificates, service records, digital content, and loyalty tokens.

- ✔ **Condition-Based Pricing Intelligence** — AI model provides condition-aware price estimates for resale, accounting for wear, service history, and market demand.

- ✔ **Digital Product Passport (EU Compliance)** — Platform generates EU DPP-compliant data packages automatically from on-chain records.

- ✔ **Multi-Brand Interoperability** — Consumers manage products from different brands in a single digital wardrobe with unified verification and marketplace access.

- ✔ **Circularity & Sustainability Tracking** — Full lifecycle tracking from creation to end-of-life with carbon footprint accumulation and recycling certification.

07 Business Benefits & ROI

Counterfeiting Deterrence

40–60% reduction in online counterfeit listings within the first year of NFC-enabled product deployment

Secondary Market Revenue

2–5% royalty on every secondary sale creates a significant new revenue stream from previously untapped market activity

Customer Lifetime Value

Persistent digital relationship increases post-sale engagement — 20–30% more service revenue, 15% higher repeat purchases

EU DPP Compliance

Pre-built compliance with EU Digital Product Passport requirements, avoiding potential fines and market access restrictions

Resale Value Enhancement

Authenticated products with verified provenance command 15–25% premium in secondary markets

Sustainability Reporting

Automated lifecycle carbon accounting supports ESG reporting and sustainability marketing initiatives

08 Use Case Scenarios

Handbag Authentication & Resale

A consumer purchases a luxury handbag from an authorized boutique. The NFC chip embedded in the lining is scanned, transferring the NFT to the customer's wallet and activating the 2-year warranty. Three years later, the consumer lists the bag on the platform marketplace — buyers see the complete provenance: original purchase date, one professional cleaning service, zero ownership disputes. The seller achieves 15% above market benchmark, and the brand receives a 3% royalty on the resale.

Jewelry Lifecycle Management

A high-end jeweler tokenizes a 5-piece collection of diamond and emerald pieces. Each piece carries a spectroscopic fingerprint as an unforgeable physical identifier. When a piece is re-set three years later at an authorized atelier, the ServiceJournal records the event on-chain. When eventually sold at auction, the complete provenance — gemstone origin, initial sale, re-setting event — commands a 22% premium over comparable unverified pieces.

EU Digital Product Passport Compliance

A luxury fashion brand preparing for EU Ecodesign Regulation compliance uses the platform's CircularityTracker to log material sourcing, manufacturing carbon footprint, shipping emissions, and end-of-life options for 50,000 garments annually. The platform auto-generates EU DPP-compliant reports, eliminating 3 months of annual compliance work and positioning the brand ahead of regulatory deadlines.

09 Security & Compliance

- **NFC Cloning Prevention:** NTAG 424 DNA with SUN protocol generates a unique authentication signature per tap — cryptographically impossible to clone.
- **Multi-Brand Data Isolation:** Strict tenant isolation in the multi-brand architecture ensures no brand can access another brand's product data.
- **Smart Contract Upgradeability:** Diamond Proxy Pattern (EIP-2535) enables modular upgrades to individual contract facets with timelock governance.

- **KYC/AML Compliance:** High-value transactions trigger Chainalysis AML screening; zero-knowledge proof identity verification for high-value ownership transfers.
- **GDPR Compliance:** Personal ownership data off-chain with encrypted references; anonymized analytics for brand dashboards.
- **EU Regulatory Alignment:** Digital Product Passport, Ecodesign Regulation, and EU Omnibus Directive compliance built into the platform architecture.

10 Future Enhancements

AR Try-On Integration: Augmented reality visualization allowing consumers to virtually try luxury products before purchase through the brand's app.

DeFi Collateralization: Enable NFT-authenticated luxury goods as collateral in DeFi lending protocols, unlocking liquidity without physical asset transfer.

AI Condition Assessment: Computer vision models that analyze product photos to automatically assess condition and update the NFT metadata with condition scores for resale.

Carbon Offset Marketplace: Integration with verified carbon credit markets enabling brands and consumers to offset product lifecycle emissions directly through the platform.

Consumer Loyalty Protocol: Token-based loyalty system where interactions with the platform (service bookings, referrals, community participation) generate brand loyalty tokens redeemable for exclusive experiences.