# The Tangible DC Collateral Engine

*Phygitization, titrisation and the monetisation of staked bullion on a distributed ledger*

Datachain Foundation SAS*

Working Paper, July 2026

**Abstract**

Staked precious metal is the archetype of pristine collateral. It is a corporeal fungible movable, continuously quoted in deep markets, free of issuer and credit risk, and prudentially favoured to the point that staked bullion matched by bullion liabilities has historically attracted a zero risk weight. It is also, and decisively, an asset without an income stream: its value is a price, not a yield. That single fact disposes of the conventional tokenisation template, since discounted-cash-flow securitisation presupposes a receivable to discount and bullion offers none. The admissible instrument set is instead the one secured lending has used for two centuries, namely Lombard credit, repurchase and collateral transformation, each of which monetises the collateral value of an asset while leaving title undisturbed.

This paper applies that instrument set to a pool of staked 999 fine gold and silver Tangible DC units registered on the Datachain Rope, and routes it through the protocol's existing titrisation chain. A precondition is identified and named: *phygitization*, the operation that constitutes an asset's machine-verifiable source of truth rather than representing an existing one. A dedicated securitisation compartment is then constituted and ring-fenced under Luxembourg law, its backing collateral being the pooled metal and its securitised object being the future-flow receivable arising from the collateral services the pool renders. The compartment issues transfer-restricted tranches ranked senior and mezzanine over a retained equity residual sized to satisfy the five per cent material net economic interest required by Article 6 of Regulation (EU) 2017/2402. Each unit retains its deed, pledged and not conveyed, so that no true-sale analysis attaches to the metal itself.

Three consequences are developed. First, the quality of the evidentiary chain is a determinant of the haircut, and therefore of advance per ounce, rather than a compliance amenity. Second, because the structurer is an onboarded participant of the same ledger, asset-level diligence on origin, authenticity, title and value is discharged from the record, and eligibility becomes a computable predicate rather than a prose schedule reconciled by hand. Third, since every distribution originates in a fee or an interest payment for a service rendered, the yield is non-inflationary in the strict sense and its passage through the revenue channel raises the revenue-backed floor of the associated token. The paper closes with a risk framework, the regulatory perimeter, and a statement of what the design does not resolve.

*Datachain Foundation SAS, RCS Paris 909 676 157, 16 rue Washington, 75008 Paris. Contact: contact@datachain.one. This paper is a technical and financial-architecture study. It does not constitute an offer of securities, a solicitation, or investment, legal or tax advice. Figures are illustrative and are used to explain mechanisms rather than to project returns. Nothing herein is a legal opinion; the regulatory perimeter must be settled by counsel in each jurisdiction and for each investor class.

**Keywords:** phygitization; collateral finance; Lombard credit; securitisation compartment; future-flow receivable; risk retention; proof-of-reserve; tokenised title.

**JEL classification (suggested):** G23; G32; K22; O33.

---

**Scope note.** The asset undergoing structuration, titrisation, tokenisation and subsequent monetisation is, throughout this paper, the pool of staked 999 fine gold and silver Tangible DC units registered on the Datachain Rope (Chain ID 271828). Two other Datachain undertakings, a blue-carbon concession and an agricultural programme, are cited *exclusively as reference structures*: the former supplies the compartment-and-tranche template, the latter a working-capital analogue. Neither is the subject of the transaction described here, and where the pool transacts with such compartments it does so as a provider of credit enhancement and not as their originator.

---

## Contents

# PART I

CHARACTERISATION OF THE SUBJECT ASSET

## 1 The Tangible DC pool: constitution and evidentiary chain

Each Tangible DC unit is a coin of 999 fine gold or silver bearing a sealed, registered tracker, and is represented on the Datachain Rope by two distinct contracts. The evidentiary chain matters more than the metal content. A quantity of gold that cannot be proven to exist, to be staked, and to be unencumbered is not collateral; it is an assertion. The certificate engine produces each of the four elements a secured lender requires, and it is worth setting them out against their legal function rather than their technical description.

**Table 1.** The evidentiary chain and its legal function

| Element | Evidentiary artefact | Legal function |
|---|---|---|
| Existence and identity | Notarised record anchored by hash commitment on the Rope, tied to unit serial and fine weight | Establishes the *res* and its quantum |
| Allocation | Custody Safe-Keeping Receipt with the hash of its instrument committed on-chain | Distinguishes staked metal from an unstaked claim |
| Physical binding | Sealed tracker registered on the platform and bound to the deed | Links the digital record to the specific physical unit |
| Title and encumbrance | Deed token, plus a transfer-restricted regulated title with verified on-chain identity | Permits the lien to be recorded and disposition to be blocked |

### 1.1 Two contracts, two functions

The *deed* is unique and non-fractionable. It constitutes the on-chain evidence of title to a specific unit, remains vested in the holder, and is charged as security rather than transferred. The *regulated title* is fungible and monetisable. It carries the economic entitlement and enforces eligibility in the protocol itself through the claim-topics registry, the compliance module and the identity registry, with the consequence that a transfer to a non-whitelisted address does not fail in settlement or in reconciliation but fails at the protocol layer and never occurs.

### 1.2 Admission criteria

Admission to the pool is a legal act and not an accounting entry. A unit enters only when existence, allocation, custody and unencumbered title are simultaneously provable, and it leaves the admitted set automatically when any one of those attestations lapses. The conditions are conjunctive:

- fineness of 999 attested at assay, with fine weight recorded to the precision of the certificate;
- custody with an insured, audited depositary and a current Safe-Keeping Receipt;

- tracker attestation current as at the marking date;
- deed free of prior charge, verified against the lien register before admission;
- holder identity verified, with sanctions and source-of-funds screening completed.

## 2 Legal characterisation: *res*, allocation and pledge

Three characterisations govern the structure. Each is chosen to keep the metal outside the issuing vehicle and to keep the transaction outside the doctrines that would otherwise recharacterise it.

### 2.1 The unit is a corporeal fungible movable

Bullion is a thing, not a claim. It carries no issuer, no counterparty and no covenant, and therefore no credit risk in the ordinary sense. What it does carry is the full apparatus of the law of things: possession matters, allocation matters, and the maxim *nemo dat quod non habet* governs every disposition. This is why the evidentiary chain of Section 1 is constitutive rather than merely convenient.

### 2.2 Allocation converts a claim into ownership

The distinction between staked and unstaked metal is the distinction between owning a thing and ranking as an unsecured creditor of the party holding it. Unstaked metal is a balance-sheet claim that abates in the depositary's insolvency. Staked metal, identified and segregated, is the depositor's property and is recoverable *in specie*. The Safe-Keeping Receipt, with its hash committed on-chain, is the instrument evidencing that status and is the reason the pool can assert a proprietary rather than a personal position.

### 2.3 The deed is pledged, not conveyed

The pool records a lien over the deed and the linked title. Beneficial ownership and self-custody remain with the holder; the vehicle acquires a security interest and an enforcement right, not the *res*. Two consequences follow. First, there is no disposal of the metal and therefore no realisation event for the holder. Second, because the metal never enters the compartment, no true-sale opinion is required in respect of it, and the recharacterisation risk that attends the sale of a chattel into a securitisation vehicle does not arise. What is transferred to the compartment is the receivable, which is an incorporeal right and is assignable in the ordinary way.

Enforcement mechanics follow the characterisation. On default the pool exercises the lien, and the transfer guard that blocked disposition while the position was live becomes the instrument of realisation. Because the collateral is a liquid, continuously quoted commodity, recovery is high and loss given default is correspondingly low, which is the empirical fact underlying the calibration of Section 18.

## 3 Economic characterisation: why bullion resists discounted-cash-flow treatment

A discounted-cash-flow valuation requires a stream to discount. The value of a cash-flow asset is

$$V \;=\; \int_0^{\infty} e^{-\rho t}\,\mathbb{E}[C(t)]\,dt, \tag{1}$$

and the entire apparatus of cash-flow securitisation, including tranching by expected loss, presupposes that $C(t)$ is non-degenerate. For bullion $C(t) \equiv 0$. The asset yields no coupon, no rent and no production. On the contrary it consumes resources through vaulting, insurance and audit, so that its net carry is negative before any financing use is made of it.

**Table 2.** Two asset types and their admissible techniques

| **Cash-flow asset** | **Bullion** |
|---|---|
| Value derives from $\mathbb{E}[C(t)]$ and its covariance with the pricing kernel | Value is a price, quoted continuously; no flow exists to discount |
| Securitisable by assignment of the receivable and tranching by expected loss | Negative net carry: vaulting, insurance and audit are recurring costs |
| Risk dominated by execution, counterparty and realisation of forecasts | No issuer, no covenant, no credit event; risk is price risk and custody risk |
| Valuation model-dependent and sensitive to the discount rate | Valuation observable rather than modelled, which is its principal virtue as collateral |
| Appropriate technique: true-sale securitisation of the flow | Appropriate technique: secured lending against the *res* |

The proposition that follows is simple and is the thesis of the paper. If an asset has no cash flow, then any yield attributed to it must originate in a service rendered by mobilising it, and not in the asset itself. Collateral finance is precisely the set of techniques that manufacture such a service; the revenue is real, contractual, and earned without disposing of the *res*. Three classical techniques are available, and each has an instantiation in what follows: Lombard credit, treated in Section 18; repurchase and collateral transformation, treated in Section 19; and credit enhancement, treated in Section 17. Each converts an idle stock into a flow of fees. The stock is unchanged in quantity and in ownership. What is created is a receivable, and it is that receivable, not the metal, which is capable of titrisation.

## 4 The protocol chain and the securitised object

The structure is not novel machinery. It is the protocol's existing chain applied to a new underlying. Value passes from the physical unit to the holder's distribution through five links, each with a determinate actor and output.

### 4.1 The securitised object, stated precisely

The object of the titrisation is neither the unit nor the deed. It is the *future-flow receivable*: the contractual right to the collateral-service revenue the pool will earn, comprising Lombard interest, collateral rental fees, guarantee and enhancement fees, liquidity-facility commitment and drawdown commissions, and market-making revenue. That receivable is an incorporeal right, assignable to the compartment in the ordinary way. The metal stands behind it as backing

**Table 3.** The five links of the titrisation chain

| Link | Actor | Function and output |
|---|---|---|
| 1. Digitisation | Platform and certificate engine | Physical unit to verified digital twin; assay, custody, insurance, tracker binding. Output: deed token |
| 2. Structuration, titrisation, tokenisation | Structurer and securitisation undertaking | Constitution of the compartment; assignment of the receivable; tranching; compliance embedded at compartment level. Output: transfer-restricted tranches |
| 3. Distribution | Exchange, automated market maker, structurer network | Listing, liquidity provision, wallet access, qualified-investor placement. Output: distributed parts |
| 4. Monetisation | Banks, funds and financiers | Programmes published against the compartment: collateralisation, guarantees, yield funds, private placement, trade finance, re-tranching. Output: revenue-generating instruments |
| 5. Yield | Holders, asset managers, family offices | Staking of units or parts onto a published, insured programme; contractual periodic distribution by smart contract. Output: distribution to holders |

collateral and the deed is pledged, not sold. This is the pivot on which the entire structure turns, and it is what permits the transaction to be a securitisation in law while remaining secured lending in economic substance.

The distinction is not merely formal. It avoids a disposal of the metal, and with it the recharacterisation and true-sale analysis that attends the conveyance of a chattel into a vehicle. It leaves price exposure with the holder, which is what the holder wants and what makes the programme subscribable. It gives the compartment an income-producing asset capable of supporting tranches ranked by expected loss, which bullion alone could never support. And it confines the vehicle's insolvency estate to receivables and cash, which simplifies the ring-fencing analysis of Section 13.

# PART II

## PHYGITIZATION AND THE SOVEREIGN SUPPLY CHAIN

## 5 Phygitization: the concept and its analytical content

The term *phygitization* was coined by the present author in the formative period of this ecosystem, some three to four years before the date of this paper. It names the operation upon which everything that follows depends, and it is not a stylistic variant of tokenisation. The two are distinct operations with distinct inputs, and conflating them is the most common category error in the tokenised-asset literature.

**Table 4.** Three operations commonly confused

| Operation | Input | Output | Presupposition |
|---|---|---|---|
| Dematerialisation | A paper instrument | A digital record of the same instrument | That a documentary instrument already exists |
| Tokenisation | An existing record of title or claim | A transferable token referencing that record | That an authoritative source of truth already exists |
| Phygitization | A physical object with no documentary origin | The source of truth itself, machine-verifiable and anchored | Nothing prior: it constitutes the record |

### 5.1 The distinction stated formally

Let $\tau$ denote tokenisation and $\varphi$ phygitization, and let $\Omega$ be a physical object, $R$ a record of title or claim, and $T$ a transferable token. Then

$$\tau : R \longrightarrow T \quad \text{requires } R, \qquad \varphi : \Omega \longrightarrow R \quad \text{constructs } R \text{ from } \Omega. \tag{2}$$

Where an asset's record $R$ is absent, $\tau$ is undefined until $\varphi$ has been performed. It follows that tokenising an uninstrumented physical asset is not a weaker instance of the same operation; it is the tokenisation of an assertion. The token is well formed and the claim it references is not, and no quantity of ledger integrity repairs that defect.

The point may be put more bluntly. Incumbent financial infrastructure is digitising paper. Phygitization addresses the assets that were never paper to begin with.

### 5.2 Two canonical instances

The first is instrumented land: sensors on a forest parcel yielding a continuous environmental record, cited here as a reference instance only. The second is instrumented metal: an on-metal tag in a 999 fine unit yielding an interrogable provenance record, which is the subject of this paper. Both share the decisive property that before instrumentation no record existed capable of supporting a security interest, and after it one does. The layer carrying the operation is the Rope, the Real-World Object to Protocol Engine.

### 5.3 Why the concept is dispositive rather than descriptive

A pledge requires an identifiable *res*, and identification is the output of $\varphi$. Phygitization is therefore the precondition of admissibility and not a feature of the product. It is also the component of the haircut that instrumentation compresses, which makes it a determinant of advance per ounce rather than a marketing attribute. Finally it distinguishes this pool from a metal-backed token: such tokens tokenise a custodial claim whose record already existed as a warehouse receipt, whereas here the unit is phygitized and the resulting record is then tokenised.[1]

[1] A terminological note. Public-facing material presently frames this convergence as *hybridisation*. If phygitization is to stand as the term of art, the public record should be aligned.

## 6 On-metal provenance instrumentation

Each unit carries a passive near-field tag laminated as a flexible printed-circuit inlay and sealed to the unit. The engineering constraint is the substrate itself: a conductive body detunes an antenna and induces eddy-current loss, so the inlay is an on-metal design incorporating a ferrite isolation layer rather than a general-purpose label. The device is an NFC Forum Type 2 tag operating at 13.56 MHz over the ISO/IEC 14443 Type A interface.

**Table 5.** Device capabilities and their evidentiary use

| Capability | Specification | Evidentiary use |
|---|---|---|
| Factory identifier | Seven-byte unique identifier, programmed at manufacture, not rewritable | Immutable device identity independent of user memory |
| Originality signature | Elliptic-curve signature over the identifier, verifiable against the manufacturer public key | The anti-cloning primitive: a copied identifier carries no valid signature |
| User memory | 888 bytes of read-write memory | Sufficient for a commitment hash, a serial reference and a version byte |
| Access protection | 32-bit password with acknowledgement word and a configurable protected region | Prevents unauthorised rewriting of the committed payload |
| Read counter | Monotonic on-chip counter | Yields replay and interrogation evidence; a counter that regresses is *prima facie* tampering |

### 6.1 A correction of the record

Earlier material described the instrumentation as combining near-field communication with satellite positioning. That description is withdrawn and should not be relied upon. A passive tag is unpowered, possesses no radio beyond the inductive near-field interface, and has a practical read range of centimetres. It cannot sense or report position. Location, where recorded, is an attribute of the attested reader and its operator, never a measurement made by the unit.

### 6.2 What the tag proves, and what it does not

A valid interrogation establishes the presence of an authentic tag at the moment of reading, the authenticity of the device by verification of the originality signature, the integrity of the committed payload against its on-chain hash, and the interrogation history through the monotonic counter. It does not establish that the tag remains affixed to the original unit, which requires tamper-evident sealing; nor fineness and mass, which require assay and weighing on intake; nor continuous location or custody between reads; nor the absence of substitution during an unobserved interval. The tag is therefore corroborative evidence within a chain and not a self-sufficient warranty of title, which is why admission requires the conjunctive test of Section 1.

## 7 Sovereign identity across the chain

Every actor that touches a unit holds a self-sovereign identity: keys under the subject's own control, claims issued by recognised issuers, and disclosure at the subject's election. The identity is not an account maintained on the subject's behalf by a registry operator; it is a credential the subject bears. Applied across the chain, this converts a documentary custody trail into a cryptographic one in which every handoff is attributable, time-stamped and non-repudiable.

**Table 6.** Participants and the attestations they contribute

| Participant | Function in the chain | Attestation contributed |
|---|---|---|
| Refiner and assayer | Fineness and mass attestation | Assay claim bound to unit serial |
| Inlay manufacturer | Tag supply and pairing to the unit | Pairing attestation under dual control |
| Freight and customs agents | Movement and clearance | Handoff signature with jurisdiction claim |
| Depositary | Vault intake and allocation | Safe-Keeping Receipt, hash committed |
| Holder | Ownership and staking | Deed control, identity and sanctions claims |
| Financier | Publication of a monetisation programme | Licence and business-verification claims |

Identity is not merely recorded; it is operative. The claim-topics registry, the identity registry and the compliance module together determine whether a transfer of a regulated instrument may execute. Eligibility therefore ceases to be a covenant policed after the fact and becomes a precondition of the transaction.

### 7.1 Data minimisation and the erasure problem

Personal data never enters the ledger. What is committed is a hash, a claim topic, an issuer identity and a timestamp; the underlying document remains with the subject. Selective disclosure follows: a financier requires the proposition that a counterparty is verified and sanctions-clear, not the counterparty's identity documents. Erasure under Article 17 of the General Data Protection Regulation is satisfied by tombstoning, which severs resolvability of the off-chain referent and records the severance, rather than by attempting to mutate an immutable record. The distinction matters: the right in question is a right to have data rendered unusable, and destroying resolvability achieves that without impairing ledger integrity.

## 8 Anchoring: strings, knots and derived sets

The Rope departs from the shared-block model. Rather than committing unrelated subjects to a common block, each subject holds an ordered cryptographic thread, and each attestation is committed as a knot upon that string. At the date of this paper the network carries in excess of two million transactions and some six hundred and thirty thousand anchor strings.

A unit's provenance string runs through ten knots: assay, mint, pairing, seal, deed issue, title issue, transit, vault intake, receipt, and admission. Each knot is a signed attestation by an

**Table 7.** The three-layer data model

| Layer | Content | Property |
|---|---|---|
| On-chain | Commitment hash, claim topic, issuer identity, timestamp, counter value, tombstone flag | Immutable, publicly verifiable, free of personal data |
| Subject-held | Assay certificate, Safe-Keeping Receipt, images, identity documents | Held under the subject's key; resolvable only on presentation |
| Derived | Admission set, aggregate proof-of-reserve, lien register | Computed by traversal of the relevant strings, not by reconciliation of ledgers |

identified actor, committed at the moment of the event, and the string is queryable as a single object.

### 8.1 Why this is the operative fact for collateral

A secured lender asks four questions: does the asset exist, is it staked to my borrower, is it unencumbered, and who has handled it. Under a documentary regime each question initiates a request cycle measured in days and answered by copies. Under this model each is answered by traversal of a string, and the answer carries its own proof. The lender's diligence cost falls from a per-transaction fixed cost to a marginal query cost, and the frequency of verification ceases to be constrained by its expense.

The link to the collateral parameters is formal rather than rhetorical. Continuous attestation reduces the residual uncertainty the haircut exists to absorb. Since one component of the haircut compensates for price risk over the realisation horizon and a separate component compensates for provenance and title uncertainty, improving the latter permits a thinner total haircut at unchanged confidence. A better evidentiary chain is therefore a direct determinant of borrowing capacity per ounce.[2]

## 9 Manufacturing and logistics as attested state transitions

The production and distribution pipeline is reconstructed as a finite sequence of state transitions, each of which must be signed by an identified actor before the next may occur. Custody assurance thereby migrates from a periodic audit model, in which confidence decays between inspections, to a continuous attestation model in which the record is complete by construction.

### 9.1 The pairing ceremony is the critical control

Pairing is the moment at which the physical unit and its digital representation are first bound, and it is consequently the point at which a substitution attack is cheapest and most durable. It requires dual control, witness or recorded attestation, and commitment contemporaneous with

[2] A claim requiring attribution. The reduction in audit effort relative to legacy infrastructure, stated elsewhere in the range of seventy to ninety per cent, is the issuer's own estimate and is presented as a target rather than an independently measured result. It should be substantiated by controlled comparison before being relied upon in an offering document.

**Table 8.** The production and distribution pipeline

| Stage | Attesting actor | Committed output |
|---|---|---|
| Refining and assay | Refiner, assayer | Fineness and mass certified; certificate hash committed |
| Minting | Mint | Unit serial struck and bound to the assay claim |
| Pairing | Inlay manufacturer, dual control | Tag identifier bound to unit serial and prospective deed; committed contemporaneously |
| Sealing | Mint or manufacturer | Tamper-evident seal applied |
| Tokenisation | Distributed ledger | Deed minted; regulated title issued to the verified holder |
| Transit and clearance | Forwarder, customs broker | Handoff signatures with jurisdiction claims |
| Vault intake | Depositary | Re-assay or weight verification; allocation recorded; receipt issued and hashed |
| Admission | Pool contract | Conjunctive test applied; unit enters the admitted set |

the act rather than in a subsequent batch. A weakness here propagates silently through every later attestation, because each subsequent knot certifies the tag and not the metal.

### 9.2 Economic effects

In order of materiality to this transaction: provenance and title uncertainty is reduced, permitting a thinner haircut at unchanged confidence and therefore a greater advance per ounce; a continuous attributable record is a better underwriting submission than a periodic inspection report and reduces the reconciliation labour that an audit fee prices; device authentication and sealed pairing move residual counterfeit risk from the metal to the ceremony, where it can be controlled procedurally; the chain of signed handoffs is the evidence that responsible-sourcing frameworks require, produced as a by-product of operations rather than as a separate exercise; and each participant reads the same record, so reconciliation between forwarder, broker, depositary and issuer ceases to be a distinct process.

## 10 Origination and the certificate engine

The storefront is the origination channel for the asset class described here, and it is treated as part of the structure rather than as a commercial appendage. Origination quality determines collateral quality: the point at which a holder is identified, a deed is minted and a title is issued is the point at which the evidentiary chain either begins properly or begins defectively.

The build comprises an internationalised storefront covering the purchase and onboarding flow in eight languages; a twenty-nine section implementation specification fixing the onboarding, identity and issuance sequence so that origination is uniform; an addendum extending the path to digital product forms alongside physical units and to multi-stakeholder logistics; and a pre-order certificate engine rendering a three-dimensional certificate with hash notarisation and embedded royalty support, which creates a recorded and transferable claim at the moment of order and

before physical delivery.

### 10.1 The continuity that matters legally

The pre-order certificate is locked by a transfer guard so that it cannot be disposed of while the underlying order is open. That guard is the same primitive the pool later employs to give effect to its lien over a staked unit. The mechanism by which a holder's disposition is restrained is therefore identical at origination and at pledge, has been exercised in production, and does not require a novel enforcement theory when the unit is subsequently charged as collateral.

In the terms of Section 8, the storefront writes the first knots of a unit's string: the holder's identity claims, the order commitment, the certificate notarisation and, on delivery, the deed and title issuance. A unit originated outside this path is not thereby excluded from the pool, but it must satisfy the same conjunctive admission test retrospectively, which is materially more expensive and occasionally impossible. The commercial recommendation follows from the legal analysis: origination should be funnelled through the instrumented path.[3]

## PART III

TITRISATION AND TOKENISATION

## 11 The structurer as participant: asset-level diligence from the record

In a conventional securitisation the arranger stands outside the asset. Its first and most expensive task is to assemble a data room: origin documents, assay certificates, custody receipts, valuation reports, title and encumbrance searches, chain-of-custody affidavits, each obtained by request from a party with no interest in the arranger's timetable. That assembly, and its subsequent reconciliation, is the bulk of the cost and substantially the whole of the delay.

Here the arranger is not outside. The structurer occupying the second link is an onboarded participant of the same ledger on which the asset's history is written, and reads the unit's string directly. The information required to perform diligence on the asset, and on the counterparty presenting it, is already resident and already attributed. The structuring act therefore begins where it conventionally ends.

### 11.1 From verified record to financial instrument

The consequence is not merely faster diligence. It changes the nature of the eligibility schedule. Conventionally, eligible collateral is defined in prose in the transaction documents, tested by a servicer, and reported periodically, with reconciliation breaks as the normal condition. Here the schedule is expressible as a predicate evaluated over the strings, so that the definition of the portfolio and the portfolio itself are the same object. Writing $\mathbf{1}\{\cdot\}$ for the indicator of an attested

[3] An open point for counsel. The pre-order certificate is a claim to future delivery and may, depending on jurisdiction and on how it is marketed, be characterised as something other than a simple sale contract. Its treatment should be settled before the digital product forms are distributed at scale.

**Table 9.** The five structuring predicates and where each is answered

| Predicate | Question | Resident evidence | Residual work |
|---|---|---|---|
| Origin | Whence the metal, and is the sourcing chain compliant | Signed handoffs from refiner, assayer, forwarder and broker, bearing jurisdiction claims | Issuer independence; sampled testing against the sourcing framework |
| Authenticity | Is this the unit it purports to be | Originality signature, pairing attestation under dual control, seal record | Physical inspection on a sampled basis |
| Title and encumbrance | Who owns it, and is it already charged | Deed control, lien register, transfer-guard state | No off-ledger charge in the holder's jurisdiction |
| Value | What is it worth, and how volatile | Fine weight from the assay claim; spot from the oracle set; net asset value marked continuously | Independent price validation; volatility estimation |
| Counterparty | Is the presenting holder eligible | Claim topics, identity, sanctions and business-verification claims | Enhanced diligence where risk-rated |

condition,

$$E(i,t) \;=\; \mathbf{1}\{\text{assay valid}\}\cdot\mathbf{1}\{\text{receipt current}\}\cdot\mathbf{1}\{\text{tracker attested}\} \\ \cdot\;\mathbf{1}\{\text{deed unencumbered}\}\cdot\mathbf{1}\{\text{holder eligible}\}, \quad (3)$$

and the admitted set together with the issuance constraint are

$$\mathscr{A}(t) \;=\; \big\{\, i : E(i,t)=1 \,\big\}, \qquad \text{issuance capacity} \;\le\; f\big(C(t)\big), \quad (4)$$

$$\text{where} \quad C(t) \;=\; \sum_{i\in\mathscr{A}(t)} (1-h_{m(i)})\, w_i\, S_{m(i)}(t). \quad (5)$$

Exclusion on lapse is automatic and requires no servicer action, and the compartment's issuance capacity is computed rather than asserted.

## 12 Informational asymmetry, disclosure duties and the limits of integration

Securitisation exists in part to price an informational asymmetry. The originator knows the quality of the collateral better than the investor; the investor, unable to distinguish, prices for the average and demands a premium; and the originator's retention of a first-loss interest functions as a costly signal that the pool is not adversely selected. The economics are those of a market for lemons, and the spread contains a component attributable to opacity rather than to risk.

Where arranger and investor read the same attested record, that asymmetry is reduced at source rather than compensated for. The prediction is specific and testable: the opacity component of the senior spread should compress, and reliance on retention as a signalling device should fall, although retention remains a legal obligation under Article 6 irrespective of how transparent the pool is.

**Table 10.** Correspondence with the disclosure regime

| Source | Obligation | Effect of integration |
|---|---|---|
| Art. 5, Reg. (EU) 2017/2402 | Institutional investors must conduct due diligence before assuming a position and monitor it thereafter | Monitoring becomes continuous rather than periodic |
| Art. 7, Reg. (EU) 2017/2402 | Originator, sponsor and issuing vehicle must make asset-level information and investor reports available | The ledger is a natural substrate: data already per-unit, timestamped and attributed |
| Rating methodologies | Asset-by-asset data with verifiable provenance | Supplied natively; the reconciliation step is largely displaced |
| STS designation | Conditions for the simple, transparent and standardised label | Not claimed in this paper; any such claim requires separate analysis |

### 12.1 The limits, stated without qualification

*Integrity is not veracity.* The ledger establishes that an assertion was made, by whom and when. It does not establish that the assertion was true. An erroneous assay, faithfully committed, becomes an immutable error.

*Circularity of trust.* If the issuers of critical claims are onboarded by, or affiliated with, the ecosystem operator, independent verification degenerates into self-certification. For assay, custody, valuation and audit the claim issuer must be independent of both issuer and arranger, affiliate-issued claims should be inadmissible for those predicates, and independence should itself be an attested attribute of the issuer's identity.

*Access is a permission, not a property.* Under a sovereign-identity design with data minimisation, the arranger sees what it is authorised to see. Durable read access for the life of the instrument must be secured contractually at onboarding and must not be capable of unilateral withdrawal in a manner that impairs the compartment.

*Erasure against record retention.* Tombstoning must be constrained so that it severs personal-data referents only. It must not be capable of severing a unit's provenance string, which the transaction requires to survive for the life of the notes. The boundary between erasable personal data and retained asset attestation should be fixed in the data model and opined upon.

*Evidential recognition.* Whether a court will admit a signed on-chain attestation, and with what weight, is jurisdictional. Electronic signature and timestamp frameworks assist within the European Union but do not dispose of the question elsewhere.

## 13 The compartment: ring-fencing and insolvency remoteness

The programme is constituted as a dedicated compartment of a Luxembourg securitisation undertaking under the law of 22 March 2004 on securitisation as amended on 25 February 2022. Equivalently it may be constituted as a compartment of the platform's own special purpose vehicle under the standard programme template, the two being interchangeable for present purposes.

Statutory segregation allocates assets and liabilities to a compartment constituting a separate estate, so that investors in one compartment have recourse only to that compartment's assets and creditors of another have none. Limited recourse and non-petition covenants confine obligations to realised assets and restrain insolvency petitions, rendering the vehicle bankruptcy-remote in the sense rating methodologies require. Because a new compartment is constituted within an existing undertaking rather than by incorporating a new company, time to market is compressed materially and fixed structuring cost falls. Compliance attaches at compartment level, so that financial institutions inherit the perimeter rather than rebuilding diligence.

**Table 11.** Structure of the estate

| **Inside the compartment** | **Outside the compartment** |
|---|---|
| The assigned future-flow receivable | The metal, which remains with the depositary |
| Cash and stablecoin balances, including the liquid buffer | The deed, which remains vested in the holder |
| The reserve and insurance fund | Beneficial ownership and price exposure |
| Security interests over pledged deeds, held for enforcement | The holder's self-custody |
| Contractual rights under each published programme | |

The design intention is that an insolvency anywhere in the structure leaves the metal untouched and recoverable *in specie* by its owner, while investors' recourse is confined to a segregated estate of receivables and cash. Custody and pledge should be documented under a single governing law to avoid a conflicts analysis at the moment of enforcement.

## 14 Staking, lien and perfection of the security interest

Staking is the act by which a holder brings a unit within the pool's security. It is deliberately constructed as the grant of a charge rather than a deposit of property, and the on-chain mechanics are the means of perfection. The holder deposits the title and links the deed to the pool contract, which records a lien; no ownership passes. The lien is recorded on the ledger and is publicly verifiable, and registration on an immutable record supplies the notice function that a filing or possession would serve in a conventional secured transaction. The transfer guard prevents disposition while the unit backs a live position, so the holder cannot defeat the charge by transfer. On breach of the liquidation threshold the pool may exercise the lien, settlement being made first in cash from the liquid buffer, with physical realisation through the depositary as a throttled last resort.

### 14.1 The sense in which this is non-custodial

No counterparty acquires the power to dispose of the holder's unit for its own account. The pool holds an enforcement right exercisable only on defined and published conditions, and those conditions are executed by code rather than by discretion. That is a materially stronger position than a custodial deposit, in which the depositor holds a personal claim against an intermediary

and ranks with its creditors.

### 14.2 Points requiring documentary treatment

The governing law of the pledge and of the custody arrangement should be identical, and the depositary should acknowledge the charge. Priority as between the pool's lien and any depositary lien for unpaid fees must be settled expressly, with the pool ranking first. The enforcement waterfall must be drafted so that cash settlement is the primary remedy and physical realisation is subordinate and rate-limited. Set-off and netting provisions should address the holder who is simultaneously a borrower and a junior participant. Finally, the holder's redemption right must be expressly subordinated to any live lien and subject to a notice period for physical settlement.

## 15 Net asset value, marking and proof-of-reserve

Collateral value is established by two independent verifications, price and existence, and a position is only as good as the weaker of the two. Writing $\mathscr{A}(t)$ for the admitted set, $w_i$ for fine weight in troy ounces and $S_m(t)$ for the spot price of metal $m$,

$$\mathrm{NAV}_B(t) \;=\; \sum_{i\in\mathscr{A}(t)} w_i\, S_{m(i)}(t), \qquad C(t) \;=\; \sum_{i\in\mathscr{A}(t)} \big(1-h_{m(i)}\big) w_i\, S_{m(i)}(t), \tag{6}$$

where $C(t)$ is the haircut value on which advances are sized. Admission is conditional and revocable: a unit whose custody or tracker attestation has lapsed is excluded from $\mathscr{A}(t)$, and therefore from net asset value, until re-verified.

Price verification uses gold and silver oracle feeds on the ledger with deviation and staleness checks against a secondary source, a fallback oracle on primary failure, and circuit-breakers that freeze new borrowing on anomalous prints. Existence and allocation verification uses the notarised per-unit record, the Safe-Keeping Receipt with committed hash, and the tracker binding attested as current, with an aggregate proof-of-reserve published showing unit count, serials, custody attestations and total insured fine weight, and an independent audit of the depositary on a stated cycle. The two failure modes are independent, and the controls must therefore be independent: a price feed without proof of existence values metal that may not be there, and an attestation without a price feed cannot support a liquidation test.

Part accounting follows. With $\pi(t)$ the price of one part,

$$\pi(t) \;=\; \frac{\mathrm{NAV}_B(t) + \text{accrued net income} - \text{liabilities}}{\text{parts outstanding}}. \tag{7}$$

Mechanically each part behaves as a tokenised vault share wrapped in transfer restrictions. Legally it is a security issued from a Luxembourg compartment, and the vault analogy should not be permitted to obscure that.

## 16 Double tokenisation, subordination and the waterfall

The compartment issues several tranche classes, each a distinct transfer-restricted token, ranked by priority of payment. The economics of tranching are unchanged from conventional structured

finance: subordination redistributes expected loss, and the senior coupon falls as the cushion beneath it thickens.

**Table 12.** Tranche classes

| Class | Rank | Economic content |
|---|---|---|
| Senior | 1 | First claim on income and on principal. Capped distribution. Subscribed by holders seeking metal exposure with a modest and predictable carry |
| Mezzanine | 2 | Ranks behind senior; absorbs loss above the equity layer. Higher and more variable distribution reflecting its position in the loss sequence |
| Equity residual | 3 | Retained by the originator and not tokenised. Absorbs first loss and takes the residual. Sized to at least five per cent of the material net economic interest as required by Article 6 of Regulation (EU) 2017/2402 |

The distribution waterfall runs in strict order: priority structure costs, administration fees, custody premiums and insurance; accrual to the reserve and insurance fund until its target size is attained; the senior coupon; the mezzanine coupon; principal repayment, senior then mezzanine; the token buy-and-make allocation, adding to protocol-owned liquidity; and the residual to retained equity.

Two observations follow. Subordination is what makes the pool a credible provider of first loss to third parties, since a vehicle with no junior layer cannot write a guarantee whereas one with a funded equity and mezzanine can. And retention of the equity by the originator is not merely a regulatory obligation: it aligns the originator with the senior classes and is the principal answer to the adverse-selection objection of Section 12.

# PART IV

MONETISATION

## 17 The monetisation catalogue applied to bullion

The fourth link is the point at which a financier publishes a programme against the compartment. The catalogue is fixed by the platform; what follows is its instantiation for staked metal. Collateralisation is the principal route and the others are complements, not substitutes.

Conditions precedent are common to every programme: insurance in place with a stated minimum coverage ratio to net asset value and on-chain attestation; legal compliance verified at compartment level so that the financier inherits rather than reconstructs the perimeter; platform minimums met as to size, tenor and collateral quality; and holder participation by staking, with distribution effected contractually through the smart contract rather than at the discretion of a manager.

**Table 13.** Programme types and their instantiation

| Programme | Instantiation for the bullion pool | Role |
|---|---|---|
| Credit lines | Advance against parts or directly against staked units: the distributed Lombard book of Section 18 | Primary |
| Guarantees | Instruments accepted as an on-chain verifiable pledge, attracting reduced haircuts: the collateral rental and enhancement of Section 19 | Primary |
| Private placement | Senior and mezzanine classes placed to private-banking and qualified clients through the structurer network, with listing where appropriate | Complement |
| Trade and inventory finance | Vaulted-metal inventory lines and dealer financing secured on staked stock | Complement |
| Yield funds | The pool acts as enhancement provider to such vehicles rather than as one; metal itself does not carry a sustainability objective | Indirect |
| Re-tranching | Aggregation of collateral-service receivables and refinancing to second-rank institutions | Refinancing |

## 18 Distributed Lombard credit and its calibration

A holder who has staked may draw an advance in stablecoin or in the platform token up to a conservative loan-to-value, retaining the unit, its price exposure and its upside, and paying interest. Capital is supplied by the liquid buffer and by subscribers to the junior class, so that the community occupies the lender's position and takes the lender's spread.

### 18.1 Calibration of the ceiling

The ceiling is not a preference but a solution. Let $\Delta$ be the horizon required to complete an orderly realisation, $\sigma_m$ the volatility of metal $m$ over that horizon, $\lambda_m$ the loan-to-value ceiling and $\theta_m$ the liquidation threshold with $\theta_m > \lambda_m$. The threshold is set so that the probability of collateral value falling below outstanding exposure during $\Delta$ does not exceed a tolerance $\alpha$:

$$\mathbb{P}\left[\frac{S_m(t+\Delta)}{S_m(t)} < \frac{\lambda_m}{\theta_m}\right] \le \alpha, \qquad \text{with} \qquad h_m \approx z_\alpha \, \sigma_m \sqrt{\Delta}. \tag{8}$$

Gold, whose realised volatility is materially lower than silver's, therefore supports a higher ceiling. Illustratively the ordering the formula produces places gold in the region of sixty to seventy per cent and silver in the region of forty-five to fifty-five per cent. These figures illustrate the ordering, not a committed policy.

### 18.2 Credit quality of the exposure

Expected loss is the product

$$\mathrm{EL} = \mathrm{PD} \times \mathrm{LGD} \times \mathrm{EAD}. \tag{9}$$

The distinguishing feature of metal-secured lending is not a low probability of default but an exceptionally low loss given default: the collateral is liquid, continuously quoted and free of issuer risk, so recoveries approach the marked value net of realisation costs. This is the empirical

basis on which Lombard advances against bullion have historically ranked among the safest credit a bank extends.

### 18.3 Enforcement designed to avoid procyclicality

Positions are tested against the oracle mark rather than at periodic revaluation dates. On breach, the buffer settles the position and the borrower is charged; no metal is sold. Physical realisation proceeds by title transfer and a custody sale instruction, rate-limited and pre-arranged with the depositary. Rates are fixed per term or set by a utilisation curve so that scarcity of buffer raises the price of credit. The purpose of the buffer-first design is to prevent a single distressed position from transmitting into the metal market or into the token. An instantaneous on-chain default and a multi-day physical sale are mismatched by construction; the buffer absorbs that mismatch and must be sized to a stress scenario rather than to the average case.

## 19 Collateral rental and collateral transformation

Counterparties frequently require high-grade collateral in order to obtain something else: a market maker requires margin, a trading desk requires a credit line, a vehicle requires enhancement to improve the rating of its senior obligations. The pool can supply that capacity for a fee without conveying any unit. In wholesale markets this is the collateral-transformation trade, and its economics are a fee for the loan of quality rather than of principal.

Re-use of pledged collateral raises collateral velocity and with it systemic linkage. The controls are quantitative and are treated as governed parameters rather than management discretion: a maximum rented fraction of net asset value, per-counterparty limits, live monitoring of over-collateralisation, business-verification diligence on every counterparty, and a contractual prohibition on onward rehypothecation. Caps must be conservative at inception and relaxed only against evidence.

The risk is asymmetric in the pool's favour. The pool is paid a fee *ex ante* and bears a contingent obligation *ex post*, so sizing requires only that expected fee income exceed expected loss, and expected loss is compressed by the same low loss-given-default that governs the Lombard book. The binding constraint is concentration, not credit.

Where the pool writes enhancement, the reference structures cited in this paper illustrate the form it takes: pledging metal alongside a project's own collateral so that a senior loan prices more cheaply; subscribing a first-loss slice or issuing a bullion-reserved note so that a senior tranche obtains a non-correlated cushion; or extending a revolving liquidity line across the interval between expenditure and first revenue. In each case the pool is the enhancement provider and the counterparty remains the originator of its own transaction.

## 20 The bullion pillar beneath the token floor

The platform token carries a four-pillar fundamental reference price with a floor defined as the maximum of its components. The pool contributes in two distinct ways, one indirect and one direct, and does so without disposing of any metal.

The indirect contribution runs through the revenue-backed pillar. With $R_{\text{annual}}$ the platform revenue, $\eta$ the share routed to the revenue channel, $M_{\text{staked}}$ the staked supply and $\text{APY}_{\text{target}}$ the target distribution rate,

$$P_{\text{RBF}} \;=\; \frac{R_{\text{annual}} \cdot \eta}{M_{\text{staked}} \cdot \text{APY}_{\text{target}}}. \tag{10}$$

Net income of the compartment is platform revenue. It enters $R_{\text{annual}}$ and is routed at $\eta = 0.60$, so every fee the pool earns raises $P_{\text{RBF}}$ mechanically and without any discretionary act.

The direct contribution is a mark-to-market reserve pillar. With $\kappa$ the fraction of pool net asset value committed in support of the token and $M_{\text{circ}}$ the circulating supply,

$$P_{\text{BRB}} \;=\; \frac{\kappa \cdot \text{NAV}_B}{M_{\text{circ}}}, \qquad\qquad P_{\text{floor}} \;=\; \max\!\big(P_{\text{RBF}}, P_{\text{GLP}}, P_{\text{BRB}}\big). \tag{11}$$

The parameter $\kappa$ is deliberately small, illustratively of the order of 0.10 to 0.25 and never unity, so that the claim remains over-collateralised and physically deliverable even after a drawdown in the metal price. The quantity is published, verifiable by proof-of-reserve, and moves with the spot price. Asked what stands beneath the floor, the structure can therefore answer with a quantity rather than an argument: a stated weight of insured 999 fine metal, staked, attested and expressed per circulating unit.

A caveat must be stated properly. A floor supported by a pledged fraction of a volatile asset is a floor that moves. $P_{\text{BRB}}$ is not a guarantee and must never be presented as one. Its merit is that it is measurable and deliverable and that $\kappa$ is governed and capped; its limitation is that it declines with the metal price precisely when support is most wanted.

## 21 Yield architecture and quantitative illustration

Revenue arises from Lombard interest paid by borrowers, collateral rental fees, guarantee and enhancement fees, liquidity-facility commitment and drawdown commissions, and market-making revenue on posted liquidity. Writing $u_j$ and $r_j$ for the utilisation and net rate of programme $j$,

$$R_g \;=\; \sum_j u_j \cdot \text{NAV}_B \cdot r_j, \qquad\qquad R_n \;=\; R_g - \text{costs} - \text{reserve accrual}. \tag{12}$$

No term in the expression is a token emission; every term is a payment by an identifiable obligor for a service rendered. That is the precise sense in which the distribution is revenue-backed.

Consider, illustratively, a pool of 100,000 euro-equivalent of staked metal, of which forty per cent is lent as Lombard at a six per cent net borrower rate, fifteen per cent is rented as collateral at a two per cent fee, ten per cent supports a guarantee at a five per cent fee, and the balance is held in buffer at a low stablecoin yield. Gross fee and interest income is then of the order of low single-digit thousands per annum before costs. After custody, insurance, accrual to the reserve and the buy-and-make allocation, the junior class might see a mid single-digit net distribution and the senior class a low single-digit one, in each case in addition to continued ownership of the metal. The figures are deliberately conservative and are offered to display the structure of the return rather than its level. Upside is driven by rental and enhancement demand; downside by

defaults coinciding with a drawdown in the metal price, both bounded by over-collateralisation.

Two safety balances are treated as non-negotiable. The liquid buffer is sized to stress and not to the mean, and funds redemptions, advances and cash-settled liquidations without disturbing metal. The reserve and insurance fund absorbs residual credit and operational loss before any loss reaches the senior class.

# PART V

## RISK, COMPLIANCE AND GOVERNANCE

## 22 Risk framework and controls

The structure earns its return by assuming measured and over-collateralised risk. Each exposure is paired with a control, and each control is quantitative or procedural rather than aspirational.

**Table 14.** Exposures and controls

| Exposure | Mechanism of loss | Control |
|---|---|---|
| Metal price | Adverse movement in $S_m$ erodes collateral value | Conservative $\lambda_m$ and $h_m$ calibrated to $\sigma_m\sqrt{\Delta}$; continuous marking; $\theta_m$ above $\lambda_m$; $\kappa$ held small |
| Realisation | Physical settlement is slower than an on-chain default | Cash settlement from the buffer as primary remedy; throttled physical sale; buffer sized to stress |
| Oracle | A mis-mark values collateral incorrectly | Multiple feeds with deviation and staleness tests; fallback oracle; circuit-breakers |
| Custody and counterparty | Depositary failure or default of a rental counterparty | Insured and audited custody with receipt and proof-of-reserve; diligence; hard caps |
| Provenance and substitution | A tag cloned, or detached and re-applied to a substituted unit | Originality signature verified on every read; monotonic counter; dual-control pairing with contemporaneous commitment; tamper-evident sealing; re-assay on intake |
| Attestation staleness | A unit with lapsed attestation continues to be valued | Automatic exclusion from the admitted set; no governance discretion; published re-attestation cadence |
| Rehypothecation | Re-use chains exposures across the system | Maximum rented fraction of net asset value; per-counterparty limits; prohibition on nested pledges |
| Correlation | Enhancement losses coinciding with a metal drawdown | Non-correlated underlyings; first loss sized below expected fee income; exposure capped per vehicle |
| Smart contract | Defect in lien, vault or liquidation logic | Audit and formal review of critical paths; conservative launch caps; standing bug bounty |
| Legal and recharacterisation | Challenge to the pledge, the assignment or segregation | Single governing law for custody and pledge; depositary acknowledgement; express priority; counsel opinion before launch |
| Governance capture | Concentration of voting power | Per-member caps on parts and votes; quorum, comment window and time-lock |

No control removes risk; each bounds it. The senior class is a low-risk position combining

metal ownership with a modest carry. The junior class is a genuine credit investment and can lose money if defaults and a metal drawdown coincide. Any presentation that blurs that distinction is defective.

## 23 Regulatory perimeter and legal wrapper

The instruments described are regulated activities and must sit within the perimeter the ecosystem already occupies. What follows identifies the applicable regimes and the questions counsel must settle; it is not itself a legal opinion.

Classification of the parts and of any bullion-reserved note falls to be determined under Directive 2014/65/EU and Regulation (EU) 2023/1114, and determines disclosure, distribution and venue. Securitisation obligations arise under Regulation (EU) 2017/2402, including retention of at least five per cent material net economic interest under Article 6 and the transparency and due-diligence duties of Articles 7 and 5 respectively; the simple, transparent and standardised label is not claimed. The vehicle and its segregation are governed by the Luxembourg law of 22 March 2004 as amended on 25 February 2022. Lending, guarantee-writing and collateral rental are regulated activities requiring authorisation or an exemption, and the design assumes a licensed arranger. Fund and mandate regimes, including Directive 2011/61/EU and Regulation (EU) 2019/2088, are relevant where a programme is wrapped as a fund. Data protection is addressed by keeping personal data off-chain and committing only hashes, claim topics and timestamps. Conduct obligations require risk disclosure, prohibition on guaranteed-return language, cooling-off where applicable, and suitability by investor class.

The sequencing recommendation is as follows. Settle the classification of the part and of any note before any distribution, and in each target jurisdiction separately. Restrict the initial offering to qualified investors and widen only against advice. Obtain the true-sale and segregation opinions on the assignment of the receivable, and the enforceability opinion on the pledge, from counsel in the governing-law jurisdiction. Put insurance in place as a condition precedent rather than a post-closing covenant.

## 24 Reference structures and market precedents

Nothing proposed here is exotic. It is conventional secured finance executed on a ledger and mutualised across a community of owners. Lombard lending against metal and securities is the private-banking staple this most closely resembles. Repurchase and collateral transformation supply the fee-for-quality economics. Staked metal tokens establish the custody and attestation pattern but do not extend credit against it. Tokenised private-credit protocols supply pooled distributed lending with tranching by loss position. Over-collateralised on-chain lending against real assets supplies the governance of collateral parameters. Tokenised vault standards supply the share-accounting convention that the part follows mechanically though not legally. Proof-of-reserve attestation supplies the verifiability standard. Securitisation tranching and credit wraps supply subordination, waterfall ranking and the pricing of enhancement. These are design analogues; no affiliation or endorsement is implied.

As to the two Datachain reference structures, the blue-carbon concession supplies the template for the compartment and tranche architecture, namely the twin compartments, the senior and mezzanine classes, the retained equity and the single waterfall. The agricultural programme supplies the working-capital analogue, namely a cash-conversion cycle bridged by a revolving facility repaid from on-chain revenue as sales settle. Neither is the subject of this transaction, and the pool's relation to either is that of an enhancement or liquidity provider.

The novelty lies not in any single instrument, each of which is old, but in the combination: pristine physical collateral, mutualised across a distributed body of owners rather than intermediated by one balance sheet; wired simultaneously into a token-liquidity floor and an institutional enhancement pipeline; and verifiable end to end on a single ledger, so that diligence which conventionally consumes weeks is reduced to a query.

## 25 Governance

The pool is owned by its participants, who are the unit holders. Governance operates through the sovereign identity layer, which makes it resistant to identity multiplication, with stake-weighted voting capped per member so that no holder can capture the parameter set. Governed parameters comprise the loan-to-value and haircut tables, the rental cap and per-counterparty concentration limits, the pledgeable fraction $\kappa$, the fee schedule and reserve-fund target, and approval of each enhancement exposure. Procedural safeguards comprise a quorum requirement on sensitive changes, a public comment window before effect, a time-lock between adoption and application, per-member caps on parts and votes, and on-chain publication of all accounting. The governing analogy is the cooperative credit union rather than the fund: members supply the reserve, set the lending rules, bear the risk and retain the spread that an intermediary would otherwise take.

## 26 Implementation sequence

Phase one constitutes the pool and its proof-of-reserve: the vault contract with transfer-restricted parts and vault accounting, lien and transfer-guard integration with the certificate engine, oracle feeds, and aggregate proof-of-reserve published. No borrowing occurs: the objective is to stake, mark and prove. Phase two introduces the distributed Lombard book, with a utilisation-curve rate model, liquidation with buffer-first settlement, and the liquid buffer and reserve fund funded; senior and junior classes go live. Phase three effects token integration, posting protocol-owned liquidity, publishing the reserve-pillar contribution through the oracle, and activating the buy-and-make allocation. Phase four opens collateral rental, with pledge and capacity issuance, counterparty onboarding, caps and monitoring. Phase five wires the compartment into the enhancement template as over-collateralisation, first loss, bullion-reserved note and liquidity facility, beginning with a single pilot exposure. Each phase reuses existing components rather than introducing new infrastructure.

## 27 Limitations and unresolved questions

The following are stated plainly because a structure of this kind fails through unexamined assumptions rather than through identified risks.

Scale is a precondition and not an aspiration. Vaulting, insurance and audit are recurring fixed costs and compress net distribution, so below a threshold of pooled value the arithmetic does not work; the threshold should be computed before launch rather than discovered after it.

The settlement mismatch is mitigated and not eliminated. An on-chain default is instantaneous and a physical sale is not. The buffer absorbs the difference but does not abolish it, and a sufficiently correlated stress will test that.

The regulatory path is assumed and not established. Classification of the part, of any note, of the lending activity and of collateral rental must be settled per jurisdiction. This paper assumes a viable licensed route without demonstrating one.

Rehypothecation adds linkage even when capped. Collateral velocity is a systemic variable; caps must begin conservative and move only against evidence, and the temptation to relax them will be strongest when demand is highest.

Demand for the enhancement uses is a hypothesis. Appetite for rented collateral and for enhanced tranches is asserted rather than observed. The Lombard book and the floor contribution stand on their own if that demand is slow to appear, and the business case should be built on that basis.

Two single points of failure remain, namely the oracle and the depositary. Both warrant redundancy, independent attestation and a documented failure procedure, and neither is fully addressed by contract alone.

The correlation in the floor pillar is adverse. $P_{\mathrm{BRB}}$ declines with the metal price precisely when support is most wanted. The parameter $\kappa$ is capped for that reason, but the direction of the effect cannot be engineered away.

## 28 Conclusion

Tangible DC has been treated as inventory. Its greater value is as a reserve, and the apparatus required to mobilise a reserve already exists within the protocol. Applied to staked gold and silver, the chain yields a ring-fenced Luxembourg compartment which takes assignment of a future-flow receivable, issues transfer-restricted tranches ranked over a retained equity, publishes monetisation programmes against them, admits holders to a contractual and insured distribution, and refinances into the institutional market so that capital recycles. Along the way it deepens token liquidity, places staked metal beneath the token floor, and enhances the ecosystem's other compartments from inside the same vehicle.

Four contributions may be claimed. The first is to identify the correct object of the securitisation, which is the receivable and not the *res*. The second is to establish phygitization as the precondition of admissibility rather than a feature of the product, since a pledge requires an identifiable thing and identification is what instrumentation supplies. The third is to point the classical

collateral techniques at staked bullion whose record was constituted rather than assumed. The fourth is to mutualise the resulting spread across the body of owners who supply the collateral, rather than surrendering it to a single intermediated balance sheet.

Every unit distributed is a fee or an interest payment made by an identifiable obligor for a service actually rendered. It is not a freshly minted token, and it raises the revenue-backed floor on its way to the participant. That is the whole of the claim, and it is deliberately no larger than that.

## A Notation

| Symbol | Definition |
|---|---|
| $w_i$ | Fine metal weight of unit $i$, in troy ounces, as attested by the certificate engine |
| $S_m(t)$ | Spot price of metal $m \in \{\mathrm{Au}, \mathrm{Ag}\}$ at time $t$, as marked by the oracle set |
| $\mathscr{A}(t)$ | Set of admitted units; a unit with lapsed custody or tracker attestation is excluded |
| $\mathrm{NAV}_B(t)$ | Collateral net asset value, $\sum_{i \in \mathscr{A}(t)} w_i S_{m(i)}(t)$ |
| $C(t)$ | Haircut collateral value on which advances are sized |
| $\lambda_m,\ \theta_m$ | Loan-to-value ceiling and liquidation threshold for metal $m$, with $\theta_m > \lambda_m$ |
| $h_m$ | Haircut applied to metal $m$ |
| $L_i(t)$ | Outstanding Lombard principal plus accrued interest secured on unit $i$ |
| $\mathrm{OC}(t)$ | Over-collateralisation ratio, $\mathrm{NAV}_B(t)$ divided by aggregate secured exposure |
| $\kappa$ | Fraction of pool net asset value pledged in support of the token floor, $\kappa \ll 1$ |
| $\eta$ | Share of platform revenue routed to the revenue channel, taken at 0.60 |
| $u_j,\ r_j$ | Utilisation and net rate of monetisation programme $j$ |
| $\pi(t)$ | Price of one compartment part, equal to net asset value per part |
| $E(i,t)$ | Eligibility predicate for unit $i$ at time $t$ |
| $\sigma_m,\ \Delta,\ z_\alpha$ | Volatility of metal $m$, realisation horizon, and the $\alpha$-quantile of the standard normal |

## B Glossary

**Staked metal**
Specific identified units held for a named beneficiary, recoverable *in specie*, as distinct from an unstaked balance which is a personal claim against the holder.

**Lombard credit**
An advance secured on liquid collateral at a conservative loan-to-value, the borrower retaining title and price exposure.

**Collateral transformation**
Supply of high-grade collateral to a counterparty that lacks it, for a fee, without transfer of beneficial ownership.

**Rehypothecation**
Re-use by a secured party of collateral pledged to it; hard-capped in this design and subject to a prohibition on nesting.

**Credit enhancement**
Interposition of over-collateralisation, first loss, a guarantee or a liquidity line so as to reduce a tranche's expected loss and hence its coupon.

**Future-flow receivable**
The contractual right to revenue not yet accrued; here the collateral-service revenue of the pool, and the object of the titrisation.

**Compartment**
A statutorily segregated estate within a securitisation undertaking, to which investor recourse is confined.

**Risk retention**
The material net economic interest of at least five per cent that the originator must retain under Article 6 of Regulation (EU) 2017/2402.

**Phygitization**
The operation that constitutes an asset's machine-verifiable source of truth, as distinct from tokenisation, which presupposes such a source and represents it.

**Proof-of-reserve**
Cryptographic and custodial attestation that the backing assets exist, are staked and are unencumbered.

**Safe-Keeping Receipt**
The depositary's instrument evidencing allocation of identified metal, with its hash committed on-chain.

**Liquid buffer**
Stablecoin and token balances held to settle redemptions, advances and cash liquidations without disturbing the metal.

## C Evidentiary base

This paper relies on the following internal instruments: the structuring *modus operandi* agreed with the securitisation partner (March 2026), which establishes the five-link chain and identifies the future-flow receivable as the securitised object; the monetisation process document (April 2026), which specifies double tokenisation, the registries, primary issuance and on-chain distribution; the structuration proposition (May 2026), which sets out the two-compartment architecture, the senior and mezzanine classes, the retained equity and waterfall ranking; the institutional programme framework, which enumerates programme asset types including precious metals and the insurance matrix; the token price mechanism specification, version 2.0, which defines the four-pillar reference price and the revenue channel; and the certificate engine documentation, which governs the notarised record, the custody receipt and hash, the tracker binding and proof-of-reserve.

Regulatory instruments cited are Directive 2014/65/EU; Directive 2011/61/EU; Regulation (EU) 2017/2402, in particular Articles 5, 6 and 7; Regulation (EU) 2019/2088; Regulation (EU) 2023/1114; Regulation (EU) 2016/679, in particular Article 17; and the Luxembourg law of 22 March 2004 on securitisation as amended by the law of 25 February 2022. Market precedents named in Section 24 are industry references and do not denote affiliation.