NOCTURA

A Compliant Privacy Protocol on Solana
A Next-Generation Wallet and Token Ecosystem Built for Speed, Security, and Institutional Confidence.

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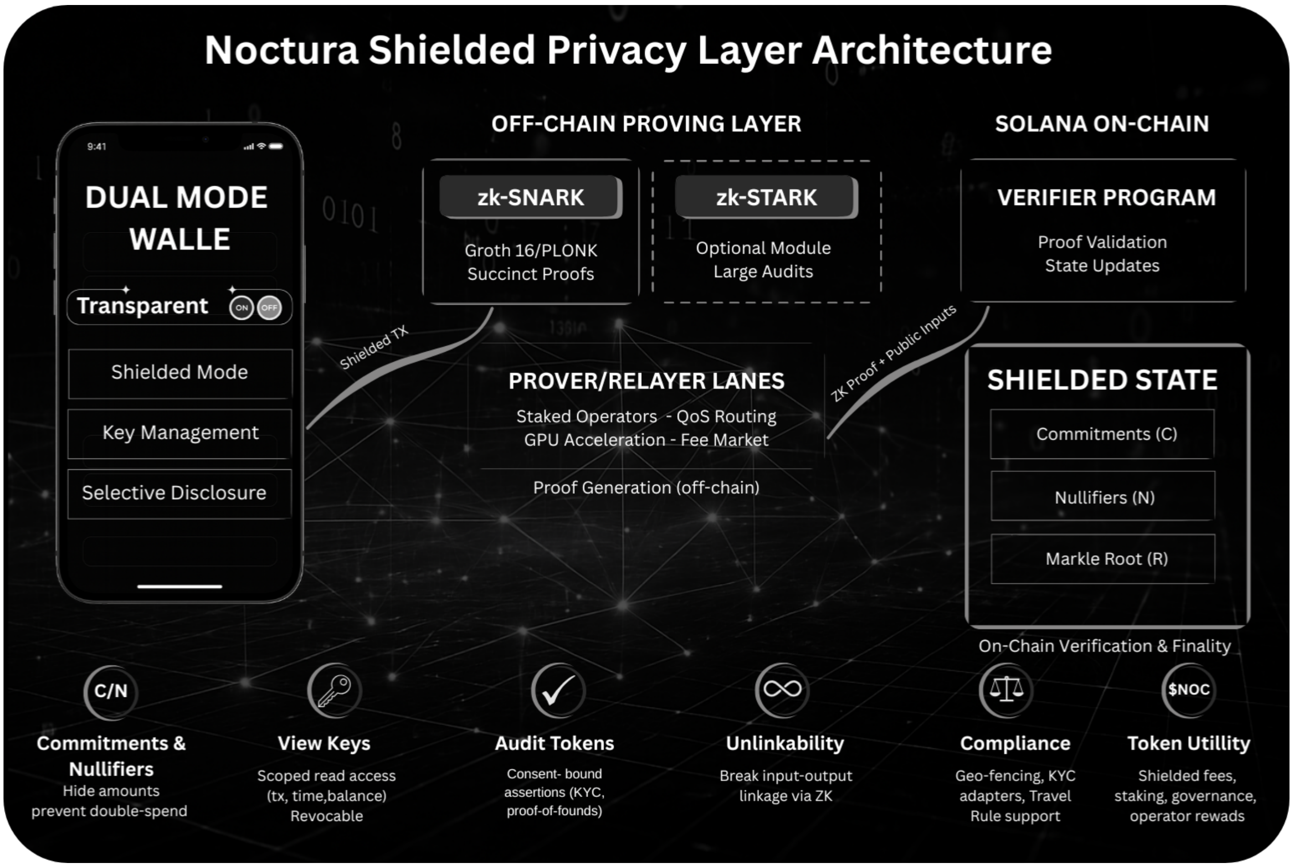

Noctura WhitePaper

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1. Introduction

1.1 Vision & Mission

Noctura is built on a fundamental principle: **privacy is a human right, not a privilege**. In an era where every blockchain transaction is permanently recorded and publicly traceable, financial privacy has become a critical vulnerability rather than a protected freedom.

Our vision is to establish a new paradigm for blockchain privacy—one that doesn't force users to choose between confidentiality and compliance, between security and usability, or between privacy and participation in the mainstream financial ecosystem.

Noctura delivers the first shielded privacy layer on Solana, combining institutional-grade cryptography with a user-friendly dual-mode wallet that makes privacy accessible to everyone—from individual users protecting their financial dignity to enterprises managing confidential treasury operations.

We believe the future of blockchain finance must include privacy as a foundational feature, not an afterthought. Noctura makes this future possible today.

Design goals.

- **Usability first:** one-tap privacy with clear prompts and safe defaults.
- **Provable correctness:** zero-knowledge verification anchored on-chain.
- **Compliance readiness:** selective disclosure when required, not blanket surveillance.
- **Realistic performance:** conservative throughput targets and staged optimizations (batching, aggregation, GPU proving).
- **Security by process:** audits, formal review of circuits, bug bounties, incident response.

1.2 What Noctura Is (Compliance-First Privacy Infrastructure + Dual-Mode Wallet)

Shielded Privacy Layer on Solana.
A protocol that maintains **commitments, nullifiers, and Merkle roots** on Solana. Proofs are generated off-chain and **verified on-chain** by lightweight programs that update shielded state. This is a **privacy overlay**, not an L2 rollup.

Dual-Mode Wallet (primary interface).

- **Transparent Mode (public):** behaves like a standard Solana wallet for full DeFi/NFT compatibility.
- **Shielded Mode (private):** sender, receiver, and amount are hidden; transfers update shielded state via zk proofs.
- **Cross-Mode transfers:** public ↔ shielded with unlinkability guarantees.
- **Selective disclosure: View Keys** (scoped read access) and **Audit Tokens** (consent-bound assertions) let users prove legitimacy to exchanges/partners without exposing their full history.
- **Developer SDKs:** simple methods to send shielded tx, request disclosures, and integrate compliance prompts.

Performance posture (realistic).
We target **hundreds of shielded TPS at launch**, scaling via batching, proof aggregation, and GPU provers. zk proof generation is computationally intensive; on-

chain verification and Solana runtime limits make "65,000 TPS shielded" **not realistic** and we do not claim it.

1.3 Key Differentiators & Compliance-Ready Design

1) Wallet-first UX.
Privacy is a toggle, not a new chain. Clear threshold prompts, geo-fencing where required, and educational tooltips reduce user error.

2) ZK-native unlinkability (no mixer dependency).
Properly constructed shielded transfers already **break linkability**. We avoid "advanced mixing" as a core dependency; any future mixer-style batching would be optional and scoped to UX/fee behavior, not anonymity.

3) Proof system pragmatism.
A **SNARK-first** design provides succinct proofs with fast verification. STARKs are an **optional roadmap module** (e.g., for large batch audits or post-quantum posture) and will only be introduced when there is a clear, measured benefit.

4) Selective disclosure done right.

- **View Keys:** scoped (tx, time window, balance range), revocable.
- **Audit Tokens:** consent-bound, expiring credentials that validate facts (KYC pointer, origin proof) without revealing raw history.

5) Compliance survival, not evasion.

- **Transparent-by-default** onboarding; private mode is opt-in.
- **KYC/Travel-Rule adapters** for partners; **restricted jurisdictions** enforced via geo-fencing/KYC country.
- **Team KYC** and **contract audits** are published before listings.
- **On-chain presale** with public contract address for verifiability.

6) Security process, not slogans.

- Third-party audits of presale/token/verification programs.
- Cryptography reviews of circuits and parameters.
- Bug bounty and runtime anomaly detection.
- Documented incident response and upgrade path via guarded governance.

7) Sustainable economics.

- Token used for shielded fees and prover/relayer incentives.
- Staking tiers post-TGE (APR 128%/68%/34% for 365/182/90-day locks).
- DAO-governed parameters, with optional fee-burn to align long-term value.

Result. Noctura is the **first shielded privacy layer on Solana** with a **dual-mode wallet** that makes private, compliant transactions practical—focusing on usable privacy, measured performance, and verifiable security.

2. Project Overview

2.1 Mission & Principles (Privacy with Legitimacy)

Mission. Make private transactions on Solana **usable, verifiable, and compliant**—so individuals and institutions can choose confidentiality **without** sacrificing speed, security, or market access.

Principles.

- **User choice:** Transparent by default; **opt-in** shielded mode with clear consent.
- **Provable correctness:** Zero-knowledge proofs verified on-chain; no "trust me" privacy.
- **Selective disclosure:** Fine-grained **View Keys** and **Audit Tokens** for lawful proofs without bulk deanonymization.
- **Pragmatism > hype:** Realistic throughput, staged optimizations, measured feature rollout.
- **Security as a process:** Audits, formal reviews, bug bounty, incident response, and guarded governance.
- **Compliance survival:** Geo-fencing, threshold prompts, KYC/Travel-Rule adapters; published legal/audit artifacts.

2.2 Positioning on Solana (Privacy Overlay, not a rollup)

What it is. A **shielded privacy overlay** that maintains commitments, nullifiers, and Merkle roots on Solana. Proofs are generated off-chain and **verified by Solana programs** that update shielded state.

What it is not.

- Not a sidechain, bridge, or EVM-style **rollup**.
- Not a mixer-only system; **unlinkability** derives from robust ZK design.

Why this fits Solana.

- Uses Solana for **finality, availability, and composability**, while moving heavy proving **off-chain**.
- Targets **hundreds of shielded TPS** initially; scales via batching, aggregation, and GPU provers—**not** "65k TPS" claims.
- Integrates with existing DeFi/NFT apps via a lightweight **Wallet SDK** and **Verifier Program** interfaces.

2.3 Users & Use Cases (Individuals, Traders, Enterprises)

Individuals (privacy & safety)

- **Private payments & remittances:** Hide salary, gifts, and recurring payments from public graphs.
- **Financial safety:** Reduce doxxing, extortion risk; keep balances and counterparties confidential.
- **Selective proofs:** Provide scoped proofs of funds to ramps/exchanges **without** revealing history.

Traders & Funds (strategy protection)

- **Front-run resistance:** Execute swaps, reallocations, and rebalances privately to avoid copy-trading and MEV-style inference.
- **Treasury moves:** Move inventory and collateral without telegraphing intent.

- **Audit on demand:** Prove asset origin/solvency to counterparties via **Audit Tokens**.

Enterprises & Institutions (confidential operations)

- **Payroll & vendor settlement:** Confidential flows with verifiable compliance.
- **Treasury & M&A:** Conceal strategic movements; disclose **only** to auditors/regulators as required.
- **Policy controls:** Scoped view access for finance, compliance, and external auditors; revocation and expiry baked in.

Developer & ecosystem integrations

- **Wallet SDK hooks:** sendShieldedTx, crossModeTransfer, generateViewKey, issueAuditToken.
- **dApp patterns:** Private swaps, shielded lending/repayment, NFT settlement with selective provenance.
- **Compliance adapters:** Travel-Rule providers, KYC hash-pointers, and geo-rules enforced at wallet boundary.

Outcome. Noctura delivers **usable, compliant privacy** for everyday users, competitive traders, and regulated enterprises—**on Solana**, with a dual-mode wallet that makes switching between public and private flows trivial.

3. Noctura Privacy Wallet

3.1 Dual-Mode UX: Transparent (Public) vs Shielded (Private)

- **Transparent Mode (default):** Standard Solana account (Ed25519). Full compatibility with DeFi/NFT apps; transactions are public on-chain.
- **Shielded Mode (opt-in):** Wallet derives **shielded keys** and maintains private balances in the shielded state (commitments/nullifiers/Merkle root). Sender, receiver, and amount are hidden; validity is enforced by zk-proofs.

- **One-tap toggle:** The wallet surfaces a clear **Public ↔ Private** switch with legal/geo prompts where required. Mode and fee estimates are shown prior to signing.
- **Predictable fees:** UX shows (i) shielded fee in $NOC, (ii) expected confirmation window (batch/aggregation latency), and (iii) disclosure requirements if thresholds are crossed.

3.2 Cross-Mode Transfers (Public ↔ Shielded) with Unlink-ability

- **Public → Shielded (Deposit):**
  1. User funds a deposit program; 2) wallet creates a commitment C = Commit(sk, amt, r) and submits zk-proof of well-formedness; 3) on-chain verifier updates Merkle root; 4) shielded note appears in private balance.
     Linkability: Broken at the proof boundary—no public link to the resulting note.
- **Shielded → Public (Withdraw):**
  1. Wallet spends a note using a nullifier N; 2) zk-proof shows note membership + non-spent; 3) verifier marks N and releases public funds to a chosen address.
     Unlinkability: Exit address is not linkable to the original deposit or prior shielded hops.
- **Shielded → Shielded (Transfer):**
  Multi-output spend with change; zk-proof updates commitments and nullifiers atomically. No address/amount reveal.
- **Best practices:** randomized timing, output aliasing, and batch joins to strengthen anonymity sets.

3.3 Selective Disclosure: View Keys & Audit Tokens (Scopes, TTL, Revocation)

- **View Keys (read-only):**
  - **Scope:** single transaction, time window, balance range, or proof-of-funds.
  - **Derivation:** from user's disclosure branch key; never grants spend authority.

    - **Revocation:** local list + on-chain revocation registry (hash pointer) for partners to honor.
- **Audit Tokens (consent-bound assertions):**
    - **Payload:** {auditor_pubkey, scope, ttl, zk_assertions[], nonce, sig_user}.
    - **Use cases:** KYC proof-of-origin, solvency attestations, Travel-Rule data exchange.
    - **Expiry/TTL:** enforced by wallet and partner API; short-lived by default.
- **Privacy guarantee:** Disclosures reveal **facts** (e.g., "origin KYC-verified," "balance ≥ X")—**not** raw transactions or counterparties.

3.4 Developer SDKs: dApp Adapters, Wallet API Hooks

- **Client APIs (TypeScript/Rust):**
    - sendTransparentTx(txSpec) → standard Solana send.
    - sendShieldedTx({outputs[], memo?, feeToken: NOC}) → builds proof client-side; submits to verifier.
    - crossModeTransfer({direction, amount}) → deposit/withdraw helpers with unlinkability defaults.
    - generateViewKey({scope, ttl}) / revokeViewKey(viewKeyId)
    - issueAuditToken({auditor, scope, ttl, assertions[]})
- **Adapter pattern:** Drop-in wrappers for common flows (DEX swap, transfer, repay, NFT settle) with "private preferred" routing if supported.
- **Errors & telemetry:** Standardized codes (ZK_PROOF_TIMEOUT, NULLIFIER_REPLAY, GEO_RESTRICTED) and optional privacy-preserving telemetry for UX improvements (opt-in).

3.5 Compliance UX: Threshold Prompts, Geo-fencing, KYC Pointers

- **Threshold prompts:** Client checks soft/hard thresholds (e.g., value > regional cap). UI suggests creating an **Audit Token** or performing KYC when needed.

- **Geo-fencing:** Wallet disables Shielded Mode in restricted jurisdictions based on IP + KYC country (defense-in-depth); transparent mode remains unaffected.
- **KYC pointers:** For custodial ramps/exchanges, wallet can attach a **KYC hash pointer** within an Audit Token—verifiable by the partner without exposing identity data in-wallet.
- **Travel-Rule adapters:** Optional integration paths to providers (e.g., Notabene/OpenVASP-style) triggered only for applicable flows.

3.6 Security Model: Key Management, Local Secrets, Multi-Sig Options

- **Key hierarchy:**
  - **Public keys:** standard Solana Ed25519 for transparent accounts.
  - **Shielded keys:** derived spend/view keys for commitments/nullifiers; stored locally (Secure Enclave/Keychain/Keystore when available).
  - **Disclosure branch:** separate derivation path for View Keys/Audit Tokens to minimize blast radius.
- **Local security:**
  - Encrypted at rest; biometric/PIN gating for spends; anti-phishing signer screens (human-readable tx intents).
  - Optional passphrase shard (Shamir) for social recovery.
- **Multi-sig / enterprise:**
  - Shielded multi-sig via MPC/threshold signing for spend authorization; view access scoped per role (finance, compliance, auditor).
  - Policy engine: amount/day caps, mandatory dual-control on exits, auto-issuance of Audit Tokens for regulated flows.
- **On-chain safeguards:**
  - **Nullifier set** to prevent double-spends; **rate-limit** guards; **circuit versioning** with upgrade gates.
  - **Slashing** hooks for misbehaving provers/relayers (liveness/validity), with rewards redistributed to honest participants.

- **Operational security:** formal audits (wallet + verifier + circuits), bug bounty, anomaly detection (e.g., unexpected nullifier patterns), and documented incident response with paused-mode fallback under governed controls.

4. Protocol Architecture - Shielded Privacy Layer on Solana

4.1 High-Level Design (Commitments, Nullifiers, Merkle State)

- **Model.** Noctura maintains a **shielded state** on Solana defined by a *commitment set*, a *nullifier set*, and a *Merkle root*:
    - **Commitment (C)**: a binding of note contents (amount, recipient key, randomness) using a collision-resistant hash.
    - **Nullifier (N)**: a one-time marker derived from a spent note's secret to prevent double-spends without revealing the note.
    - **Merkle Root (R)**: the on-chain commitment tree root; membership proofs show a note exists in the tree.
- **Transactions.** A shielded transfer consumes one or more existing notes (proving membership and non-replay via nullifiers) and creates one or more new notes (emitting new commitments). Balances never appear in plaintext; only R, new Cs, and Ns are written on-chain.
- **Privacy guarantees.** Sender, receiver, and amounts are hidden; linkability between inputs and outputs is computationally infeasible under the hash and ZK assumptions.

4.2 Off-Chain Proving, On-Chain Verification (State Anchoring)

- **Proving (off-chain).** Clients (or delegated provers) generate zk proofs for:
    - *Membership:* each input note exists in the current (or recent) R.

    - *Non-replay:* each input emits a unique N unlinked to the note.
    - *Balance conservation:* sum(inputs) = sum(outputs) + fees.
- **Verification (on-chain).** A Solana verifier program checks proof validity, updates the Merkle tree with new commitments, and inserts nullifiers into the nullifier set atomically. Invalid proofs are rejected; duplicated Ns revert.
- **Anchoring & finality.** Every accepted batch updates R deterministically; Solana finality implies **final shielded state** after confirmation. Off-chain UIs track the canonical R and recent roll-forward path.

4.3 Proof System Strategy (SNARK-first; STARK optional roadmap)

- **SNARK-first.** Initial circuits use succinct zk-SNARKs (Groth16/PLONK family) to minimize verification cost and calldata size—well suited to frequent payments.
- **Aggregation.** Support for **proof aggregation** (or succinct batch verification) reduces on-chain verifier cost per transfer as activity grows.
- **STARK as option.** zk-STARKs (transparent setup, PQ posture) are an **optional module** for large audits or compliance proofs where bigger proof size is acceptable. They are *not required* for private payments and are avoided until a clear benefit outweighs complexity.

4.4 Performance Constraints & Realistic Throughput Targets

- **Reality over slogans.** zk proving is compute-heavy; on-chain verification and account updates consume Solana compute units. "65,000 TPS" for fully shielded transfers is **not realistic**.
- **Launch targets.**
    - **Single-tx verification:** tens of **ms** on-chain; practical ceiling limited by CU budget.
    - **Throughput (payments): ~100–300 shielded TPS** with baseline batching/aggregation under typical mainnet limits.
    - **Latency: ~1–3s** median confirmation (proof ready) depending on client hardware/prover lanes.
- **Scale levers.**

  - **Batching & aggregation:** verify k transfers per proof to amortize verifier cost.
  - **Recursive proofs:** aggregate many sub-proofs into one outer proof.
  - **Parallel provers & GPU lanes:** reduce client/prover wait times; marketplace for throughput.
  - **Circuit hygiene:** Pedersen/Poseidon-style hashes; fixed-base MSM optimization; shallow trees for hot paths.
- **Degradation plan.** Under load, the wallet dynamically shifts to larger batches (higher latency, higher TPS) with user-visible estimates.

4.5 State Commitments & Data Availability (Anchors, Epochs, Finality)

- **Anchors & epochs.** Each verified batch references an **anchor root** (recent R) and produces a **new root**; *epoch checkpoints* (e.g., every N slots) are recorded for fast syncing and compact membership proofs.
- **Tree management.** An append-only Merkle tree (sparse or incremental) is maintained on-chain; witnesses are updated off-chain. Clients can follow *proof-carrying updates* (PCU) to refresh paths without full re-sync.
- **Data availability.** On-chain events emit new commitments, nullifiers, and the updated root; indexers (wallets, explorers) mirror these for users. No private data is required for liveness.
- **Reorg handling.** In rare reorgs, clients re-anchor to the latest finalized root and revalidate pending proofs; the verifier rejects stale-anchor submissions.

4.6 Prover/Relayer Participation & Incentives (Staked Roles, Slashing Hooks)

- **Roles.**
  - **Provers:** generate zk proofs on behalf of users/dApps; selectable via a fee market.
  - **Relayers (optional):** submit transactions and pay fees upfront for users who want extra network privacy; reimbursed in-protocol.
- **Staking & fees.**

    - Operators **stake $NOC** to register; misbehavior risks **slashing**.
    - **Fee market:** users pick lanes by *price* × *latency*; wallet defaults to reputable operators.
    - Rewards paid in $NOC (and/or a portion of shielded fees); optional **fee-burn** introduces mild deflation.
- **Slashing conditions.**
    - **Invalid proofs / malformed batches** → verifier-detectable faults.
    - **Relayer theft/fraud** (e.g., non-delivery) → challenge windows with evidence; slashed stake redistributed to affected users and honest operators.
- **Liveness & QoS.** Operators publish SLOs (max queue time, proof latency); wallet health checks route away from degraded lanes; DAO parameters can set minimum stake, maximum share, and emergency throttles.

Result. The architecture prioritizes **provable privacy, realistic performance, and operational safety**: succinct SNARK payments today, optional STARKs later; off-chain proving with on-chain finality; clear incentives and guardrails for the operators who keep the shielded layer fast and reliable.

5. Security Model & Threat Analysis

5.1 Adversary Model (Network, Cryptographic, Economic)

Network adversaries.

- **DoS/Spam:** saturate verifier CUs or prover queues to degrade UX.
- **Traffic analysis:** correlate timing, size, and network paths to infer parties.
- **Relayer abuse:** censor, reorder, or front-run user submissions (for public exits).

Cryptographic adversaries.

- **Soundness attacks:** attempt to forge zk proofs / bypass nullifier checks.

- **Collision attacks:** target hash primitives (commitments, Merkle tree).
- **Key compromise:** exfiltrate wallet keys (public or shielded); side-channel on client devices.

Economic adversaries.

- **Operator misbehavior:** provers/relayers deliver low quality, stall, or cheat fees.
- **MEV-style inference:** correlate shielded exits with public market activity.
- **Sybil concentration:** many small operators controlled by one actor to bias routing.

Assumptions.

- Standard hardness for chosen zk proof system (SNARK today; STARK optional).
- Collision resistance of chosen hash (Poseidon/Pedersen family).
- Solana consensus/finality and L1 availability.
- Honest-majority **not required** for privacy/soundness (verification is on-chain).

5.2 Formal Verification & Circuit Audits (Plan & Scope)

Specification first.

- **State machine spec:** commitments, nullifiers, Merkle updates, anchor rules, and rejection conditions.
- **Conservation invariant:** Σinputs = Σoutputs + fees (mod base units).
- **Replay invariant:** nullifier uniqueness is required and sufficient to prevent double-spends.

Circuit reviews.

- **Math review:** constraint systems, range proofs (amount), membership proofs (Merkle path), spend authorization.
- **Witness handling:** zeroization, bounds checks, domain separators, transcript binding.

- **Test vectors:** pathological inputs (duplicate paths, stale roots, zero-amounts, max amounts).

Program verification.

- **On-chain verifier:** formal properties (reject-on-fail, atomicity of R, C[], N[] updates).
- **Tree logic:** append, root rotation, epoch checkpoints.
- **Access control:** parameter governance, pause gates, upgrade keys with timelock.

Audit cadence.

- **Phase I (presale/token):** presale & token mint programs.
- **Phase II (testnet privacy):** verifier, tree ops, nullifier set.
- **Phase III (pre-mainnet):** circuits + wallet cryptography + SDK signing flows.
- **Continuous:** re-audit after circuit or parameter changes.

5.3 Replay/Linkability Risks & Mitigations

Replay & double-spend.

- **Nullifier set** is on-chain; duplicates revert atomically.
- **Anchor freshness:** proofs must reference a recent root within an **epoch window**; stale-anchor proofs rejected.
- **Nonce discipline:** unique randomness per note & proof transcript binding.

Linkability vectors.

- **Timing correlation:** deposits/exits aligned in time. → **Mitigation:** randomized submit windows, relayer batching, optional delays.
- **Amount correlation:** exact amounts across modes. → **Mitigation:** output aliasing (split/join), wallet rounding bands, change outputs.
- **Network metadata:** IP/ASN persistence. → **Mitigation:** relayers as privacy egress, optional Tor/VPN guidance, transport padding.

- **UI fingerprints:** deterministic behavior. → **Mitigation:** randomized fees within band, jittered batching thresholds.

Exit hygiene.

- Prefer **fresh public addresses** for exits; avoid immediate reuse; optional delay before exit settlement.

5.4 Runtime Monitoring, Anomaly Detection, Incident Response

Monitoring.

- **On-chain signals:** nullifier collision rate, proof failure ratio, root-advance cadence, verifier CU burn, queue depth.
- **Operator SLOs:** prover/relayer latency distributions, timeouts, error codes.
- **Pattern detection:** bursts near thresholds, unusual tree growth, repeated anchor staleness.

Alerts & thresholds.

- Automated alerts on: excessive proof rejects, root stagnation, spike in duplicate nullifiers, CU saturation, operator liveness failures.

Incident response.

- **Playbooks:** categorization (P0–P3), communication templates, rollback/patch guidance.
- **Controls:**
    - **Rate limits** (per account/per epoch) to throttle abuse.
    - **Emergency pause** on shielded submit while preserving read access.
    - **Circuit/param rollback** behind timelocked governance; hotfix key used only under DAO-defined conditions.
- **Forensics:** retain minimal, privacy-preserving logs (hashes, event IDs) for post-mortems; never store plaintext notes.

5.5 Bug Bounties & Responsible Disclosure

Program scope.

- Wallet cryptography (key derivation, signing prompts, disclosure branch).
- Verifier programs (proof checks, tree ops, nullifier uniqueness).
- Circuits (soundness, constraint completeness, witness mishandling).
- SDK (transaction intent encoding, replay protection).
- Website/presale contracts (authZ/authN, funds safety).

Rewards & process.

- **Tiered payouts** by severity (RCE/Key exfiltration > forging spend > DoS > info leak).
- **Safe harbor:** good-faith research protected; coordinated disclosure timelines.
- **Hall of Fame:** optional public credit, with consent.
- **Re-audit trigger:** critical findings mandate third-party re-audit and changelog publication.

Submission hygiene.

- Minimal PoCs preferred; no user data collection; reproduce with test vectors.
- Provide environment details (SDK version, device/OS, RPC cluster).
- Use dedicated security email + PGP; response SLA published.

Goal. Create a **continuous security feedback loop** where independent researchers, auditors, and the community can verify—and improve—the safety of Noctura's shielded layer without compromising user privacy.

6. Compliance & Selective Disclosure

6.1 Opt-In Privacy Model (Transparent by Default)

- **Default posture:** Wallet initializes in **Transparent Mode** (standard Solana account). Shielded Mode is **explicitly enabled** by the user with an in-wallet consent screen outlining jurisdictional limits and disclosure options.
- **Granularity:** Privacy can be applied **per-account** or **per-transaction**. The wallet surfaces when a flow may require selective disclosure (e.g., fiat off-ramp, large exits).

- **Data minimization:** The protocol never stores PII. Compliance is achieved via **cryptographic attestations** and user-controlled disclosures, not persistent identity records.

6.2 View Keys & Audit Tokens (Interfaces, Scoping, Revocation)

Purpose. Allow users to prove facts (funds, origin, solvency) **without** exposing their full transaction graph.

A) View Keys (read-only, scoped)

- **Scope types:** tx_id, time_window, balance_threshold, proof_of_funds.
- **Derivation:** From a **disclosure branch** key; **cannot** spend or reveal secrets.
- **Revocation:** Local revocation + optional **on-chain revocation hash** partners must honor.

Interface (wallet SDK):

```
type ViewScope =
  | { kind: "tx_id"; ids: string[] }
  | { kind: "time_window"; from: number; to: number }
  | { kind: "balance_threshold"; token: string; gte: string }
  | { kind: "proof_of_funds"; token: string; amount: string };

generateViewKey(scope: ViewScope, ttlSec: number):
Promise<{ viewKeyId: string; key: string; expiry: number }>;
revokeViewKey(viewKeyId: string): Promise<{ revoked: boolean }>;
```

B) Audit Tokens (consent-bound assertions)

- **Payload (example):** { auditor_pubkey, scope, ttl, zk_assertions[], nonce, sig_user }
- **Use cases:** KYC pointer proof, origin proof for exchange withdrawal, Travel-Rule partner checks.
- **Expiry:** Short-lived by default; partners must refresh with user consent.

Interface (wallet SDK):

```
type AuditAssertion =
  | { kind: "kyc_pointer"; hash: string }            // proof
user passed KYC at provider X
  | { kind: "origin_clean"; policy: string }         // not from
sanctioned sets per policy
  | { kind: "proof_of_funds"; token: string; gte: string };

issueAuditToken(auditorPk: string, scope: ViewScope, assertions:
AuditAssertion[], ttlSec: number)
  : Promise<{ auditToken: string; expiry: number }>;
```

Partner verification (server API sketch):

```
POST /audit/verify
Body: { auditor_pk, audit_token, request: { tx_ids?: string[], amount?: string } }
→ 200 { valid: true, zk_assertions: [...], scope: {...}, expires_at }
```

6.3 KYC / Travel-Rule Integrations (Partner Adapters)

- **KYC pointers (hash, not PII):** When a regulated partner requires identity, the wallet can attach a **KYC pointer hash** inside an Audit Token; the partner resolves it with their own records.
- **Travel-Rule adapters:** Optional connectors (e.g., Notabene/OpenVASP-style) can be invoked **only** for covered transactions and **only** with user consent.
- **Policy control:** Adapters are **off by default**; enabling requires an explicit toggle and a per-transfer prompt showing what will be disclosed.

Adapter concept:

```
enableTravelRuleAdapter(providerId: "notabene" | "openvasp",
configRef: string): Promise<void>;
requestTravelRuleDisclosure(params): Promise<{ required: boolean;
fields: string[] }>;
```

6.4 Geo-Fencing & Restricted Jurisdictions

- **Blocked regions list:** Maintained and updated in-app; includes hard bans and conditional allowances per legal counsel.
- **Enforcement points:**
    1. **App level:** Shielded Mode toggle disabled; transparent mode unaffected.
    2. **Server adapters:** Prover/relayer lanes can deny requests from restricted locales.
    3. **On-chain checks:** Where applicable, program parameters may restrict specific flows.
- **Signals used:** IP geolocation, user-declared country, and (if present) KYC country. **Fail-safe:** If ambiguous, default to **deny shielded** / allow transparent.

6.5 Compliance Transparency Page & Reporting

- **Public transparency page:**
    - **Presale contract address:** B61SyRxF2b8JwSLZHgEUF6rtn6NUikkrK1EMEgP6nhXW
    - Current **restricted jurisdictions** and rule rationale
    - **KYC providers**, **audit firms**, and links to **audit reports** (presale, token, verifier)
    - **DAO-ratified parameters:** thresholds, fee-burn %, staking minimums
- **Operational metrics (privacy-preserving):**
    - Root update cadence, proof accept rate, duplicate nullifier rejects, verifier CU usage
    - Adapter invocation counts (no PII), audit-token issuance totals by scope
- **Change control:** Changelogs for circuit versions, parameter updates, and adapter configurations with effective dates.
- **Contacts:** Security PGP, responsible disclosure policy, and legal inquiries channel.

Outcome. Compliance is delivered via **user-consented, scoped proofs**—not blanket deanonymization—backed by transparent policies, auditable artifacts, and opt-in integrations that keep Noctura usable in regulated markets.

7. Tokenomics

7.1 Supply & Allocation

Total Supply: 256,000,000 $NOC (fixed)

Distribution Model:

Category	Percentage	Tokens	Unlock Details
Community	40%	102,400,000	Released through presale
Staking	20%	51,200,000	Reward pool for stakers
Liquidity	14%	35,840,000	DEX & CEX liquidity
Marketing	6%	15,360,000	Growth, outreach, strategic partners
Community Rewards	5%	12,800,000	Airdrops, contests, engagement
Team	8%	20,480,000	1.5 year lockup after TGE
Reserve	7%	17,920,000	Emergency & protocol upgrades
Total	100%	256,000,000	

Notes:

- **Team tokens** are locked for 18 months after launch, ensuring alignment with project success.
- **Reserve** is for critical upgrades or unforeseen events and remains untouched unless approved by governance.

7.1.1 Unlock & Vesting Schedule:

- **Presale (40% / 102,400,000)**: Locked until TGE, then claimable. Buyers may optionally lock into post-TGE staking tiers (365/182/90 days).
- **Team (8% / 20,480,000)**: 18-month lock after TGE, followed by linear vesting over [specify period, e.g., 12-24 months].
- **Staking Rewards (20% / 51,200,000)**: Released through emissions pool according to epoch-based distribution (see §7.4 & §9.3).
- **Liquidity (14% / 35,840,000)**: [Specify unlock - e.g., "Released at TGE for DEX/CEX liquidity provisioning" or staged release].
- **Marketing, Community Rewards, Reserve**: Linear or cliff vesting based on allocation category with automatic release according to predetermined schedule.

Note on Vesting Implementation: This version of the whitepaper does not publish an exact %-per-month (or full category-by-category) unlock schedule. Vesting follows predetermined schedules with no early withdrawal mechanisms to prevent manipulation. Detailed unlock schedules will be published on the Transparency Page prior to TGE with on-chain verification.

7.2 $NOC Utility (Fees, Staking/Gov, Discounts, Fee-Burn Option)

- **Shielded Transaction Fuel.**
  $NOC pays **shielded transfer fees** and compensates **prover/relayer lanes**. Wallet surfaces fee quotes in $NOC before signing.

- **Staking & Governance.**
  Stake $NOC to (i) earn emissions and operator fees, (ii) participate in **DAO** votes (parameters, fee-burn %, operator minimum stake, circuit upgrades), and (iii) back relayer/prover roles (slashing risk → honest behavior).

- **Discounts & Priority.**
  Paying fees in $NOC can **discount** shielded fees and unlock **priority lanes** (faster aggregation/proving).

- **Ecosystem Access.**
  dApps integrating Noctura SDK (private swaps, shielded lending, scoped audits) consume/route $NOC as the default privacy fuel.

- **Fee-Burn (optional, DAO-gated).**
  A programmable fraction of shielded fees (e.g., **0.25–1.00%**) can be **burned**

to create mild deflation aligned with usage. Rate is visible on-chain and adjustable only via DAO.

7.3 Transaction Fees

Transparent Mode: ~$0.0005

- Standard Solana-level fees
- Full DeFi/NFT compatibility

Shielded Mode: $0.05–$0.10

- Covers on-chain verification (~150-300k compute units)
- Compensates prover/relayer operators
- Includes optional fee-burn (0.25-1%)

Priority Lanes: $0.15–$0.25

- GPU-accelerated proof generation
- Faster confirmation (1-2s typical)

7.4 Emissions Policy & Treasury Controls (DAO-governed)

A. Emissions (Staking & Operators)

- **Pool cap:** 51,200,000 $NOC total (20% of supply).
- **Curve:** Front-weighted but decaying emissions with epoch updates; parameters on-chain (epoch length, base rate, decay).
- **Operator share:** Portion of emissions/fees earmarked for **prover/relayer** operators proportional to delivered QoS (latency, reliability).
- **Auto-adjust:** If total staked rises, **APR falls** proportionally; if it falls, APR rises—keeping issuance predictable.

B. Staking Tiers (defined in Staking section)

- Post-TGE APR options are enforced via lock contracts (e.g., **128%/365d**, **68%/182d**, **34%/90d**), with DAO authority to tune base rates and lock multipliers within published bounds.

C. Treasury Policy

- **Multisig + Timelock:** Treasury movements require multi-party approval and **time-delayed** execution; all txs labeled and disclosed.
- **Budget rails:** % caps for liquidity, audits, integrations, and grants; any override requires DAO vote.
- **Stability tools:** Treasury may supply/withdraw liquidity to meet depth targets (slippage caps), not for price support.
- **Reporting:** Quarterly on-chain reports: remaining runway, emissions paid, fee-burn totals, grants issued.

D. Parameter Governance

- **DAO motions** (quorum/threshold defined in Governance):
    - Emission decay/epoch length; operator reward split
    - Fee-burn % and fee bands
    - Minimum operator stake & slashing schedule
    - Circuit version activation (post-audit)
- **Safety rails:** Emergency pause and parameter ceilings/floors are hard-coded and can only be changed by supermajority with a timelock.

Outcome. $NOC economics are **usage-driven** (fees + operators), **transparent** (on-chain parameters, reports), and **governable** (DAO), balancing incentives for users, operators, and long-term protocol resilience.

8. Presale Structure

The Noctura presale is structured to reward early adopters and foster a wide community.
A total of 102,400,000 $NOC (40% of total supply) will be distributed across 10 stages, with a gradually increasing price per stage to incentivize early participation.

Stage	Price ($)	Stage Increase (%)	Cumulative Gain (%)	Tokens per Stage
1	$0.1501	0.00%	0.00%	10,240,000
2	$0.1723	14.79%	14.79%	10,240,000
3	$0.1945	12.88%	29.58%	10,240,000
4	$0.2167	11.41%	44.37%	10,240,000
5	$0.2389	10.24%	59.16%	10,240,000
6	$0.2611	9.29%	73.95%	10,240,000
7	$0.2833	8.50%	88.74%	10,240,000
8	$0.3055	7.84%	103.53%	10,240,000
9	$0.3277	7.27%	118.32%	10,240,000
10	$0.3499	6.77%	133.11%	10,240,000

Presale Highlights:

- **Fair Launch:** No VCs, no insiders, no early privileges — just equal access tfor everyone through our transparent presale.
- **Multi-stage Incentives:** Early buyers receive the lowest price, creating organic demand and buzz.

Vesting Implementation:

- Presale tokens locked until TGE
- Linear or cliff vesting based on allocation category
- Automatic release according to predetermined schedule
- No early withdrawal mechanisms (prevents manipulation)

Accepted Payment Options

The presale supports multiple blockchain networks and payment methods to maximize accessibility:

- **Solana Network:** SOL, USDT (Solana), USDC (Solana)
- **Ethereum Network:** ETH, USDT (Ethereum), USDC (Ethereum)
- **BNB Chain:** BNB, USDT (Binance Chain), USDC (Binance Chain)
- **Fiat Payments:** Secure **card payment option** available for non-crypto participants

Purchase Limits

- **Minimum Buy:** $25 USD
- **Maximum Buy:** $25,600 USD

This on-chain, 10-stage structure provides **transparent pricing**, **exact arithmetic to the cent**, and clear compliance hooks—ready for investors, auditors, and exchange review.

8.1 Referral Program (Community Growth Incentive)

To further encourage organic adoption and community participation, Noctura introduces a **Referral Program** during the presale phase.
Each registered participant receives a unique referral link that can be shared with others. When a new buyer participates in the presale through a referral link, the referrer automatically earns a **10% bonus** in **$NOC tokens**, calculated based on the total value of the referred purchase.

Program Highlights:

- **Reward:** 10% of the referred purchase amount, paid in $NOC tokens.
- **Distribution:** Bonuses are automatically credited to the referrer's wallet after the referred transaction is confirmed.
- **Eligibility:** Available to all verified presale participants.

This referral program aligns with Noctura's vision of decentralized community growth and equitable participation while maintaining full transparency and auditability.

9. Staking & Rewards

9.1 Pools, Eligibility, and Slashing (Provers/Relayers)

- **Pools**
    - **Stake Pool — Users:** Non-custodial pool for $NOC holders. Locks enforce APR tier (see §9.2).

    - **Operator Pool — Provers/Relayers:** Operators must **stake $NOC** to register lanes and earn a share of protocol fees; subject to slashing.

- **Eligibility**
    - Wallet signature + lock commitment on-chain; address-bound.
    - Presale stakers auto-migrate to post-TGE tiers at claim (no action required).
    - Operators publish service endpoints and SLOs (latency, availability) signed with their staked identity.

- **Slashing (operators)**
    - **Validity faults:** malformed/invalid proof batches submitted → proportional slash.
    - **Liveness faults:** repeated SLO violations (timeouts, abandonment) → escalating penalties.
    - **Fraud/replay:** double-spend relay attempts, user funds theft → maximum slash + registry ban.
    - Slashed funds are redistributed to **honest stakers** and/or burned per DAO policy.

9.2 APR Options

APR tiers are **fixed-rate targets** for the lock duration, funded from emissions and fees. The DAO may adjust tier rates/limits within published bounds (see §9.3).

Tier	Lock	Target APR (nominal)	Notes
A	365 days	128%	Highest reward; longest lock; priority in fee rebates
B	182 days	68%	Medium lock/return
C	90 days	34%	Shortest lock; flexible entry/exit cadence

Notes

- APRs are **nominal targets** funded from the emissions pool + protocol fees; actual realized APY depends on compounding choice and epoch timing.
- Operator fees and fee-burn (if enabled) can shift effective yield; all parameters are on-chain and transparent.

9.3 Reward Funding, Emission Curves, and DAO Parameters

- **Funding sources**
    - **Emissions pool: 51,200,000 $NOC** (20% of supply) allocated to staking & operators.
    - **Protocol fees:** Portion of shielded transaction fees routed to stakers and operator lanes.
    - **Optional fee-burn:** 0.25–1.00% of fees burned (DAO-set) for deflationary pressure.
- **Emission mechanics**
    - **Epoch-based accounting** (e.g., daily): rewards minted/credited per epoch.

    - **Auto-balancing:** If total staked rises, per-unit rewards fall (and vice-versa) to keep issuance within budget.
    - **Curve stewardship:** DAO can tune epoch length, base rate, and operator split within **guardrails** (caps, floors, timelock).
- **Operator share**
    - A fixed slice of epoch rewards (or fees) pays **registered provers/relayers** based on delivered throughput/reliability (oracle-reported SLOs).
- **Transparency**
    - Live dashboard: emissions spent, fee revenue, burn totals, and pool APRs; historical CSVs/IPFS snapshots published quarterly.

9.4 Unstaking & Cool-Down, Auto-Compound, Fee-Burn Tie-ins

- **Unstaking**
    - **Lock-enforced:** Funds are unlockable only after the chosen lock term (365/182/90 days).
    - **Cool-down:** A **48-hour** cool-down applies before withdrawal to deter flash-stake gaming.
    - **Early exit:** Not permitted (principal protected); DAO may define emergency early-exit with penalty in extraordinary circumstances.
- **Reward handling**
    - **Auto-compound (opt-in):** Reinvest epoch rewards into the same lock band to increase effective APY.
    - **Manual claim:** Claimable at any time without resetting lock; claimed rewards follow wallet's current mode (transparent by default).
- **Fee-burn integration**
    - If **fee-burn** is enabled, burn events occur **before** reward splits, slightly reducing inflation and supporting long-term value accrual.

- **Security & operations**
    - All staking contracts are **audited**, parameter changes are **timelocked**, and emergency pause affects **new stakes only**; existing stakes continue accruing per schedule.

Outcome. Staking aligns users, operators, and protocol health: clear lock-based APR choices for holders, service-quality incentives for operators, and DAO-governed emissions that stay within budget and adapt as real fee revenue grows.

10. Technical Feasibility Notes - Corrections & Rationale

10.1 Throughput Reality: Why "65,000 TPS shielded" is unrealistic

- **ZK cost isn't free.** Even with off-chain proving, **on-chain verification** consumes compute units (CUs), account writes (Merkle root, nullifiers), and transaction bandwidth.
- **Account update bound.** Each shielded spend touches: verifier program, nullifier set, Merkle tree accounts, and fee accounts. These state writes, not just proof checks, cap throughput.
- **Practical ceiling (launch).** With per-tx verification + tree updates, we target **~100–300 shielded TPS** under typical mainnet limits. Higher TPS requires batching/aggregation (below).
- **Claim withdrawn.** We **do not** claim "65,000 TPS shielded." That figure ignores on-chain state and verification costs.

10.2 Proving & Verification Bottlenecks (Cost Model; Batch/Aggregate/Recursive Proofs)

- **Cost model (simplified):**

    - Proving time (client/prover): `T_prove ≈ α·C_circuit + β·log2(MerkleDepth)`
    - Verify time (on-chain): `T_verify ≈ γ·Constraints + δ·verify_key_load + ε·proof_elements`
    - State cost: `W_state ≈ writes(nullifiers + commitments + root)`
- **Single-tx verification** yields predictable latency but lower TPS due to fixed per-tx costs.
- **Batch verification**: Combine **k** transfers into one proof → amortizes `T_verify` and **W_state** per transfer; increases latency per user slightly.
- **Aggregation/recursive proofs**: Aggregate many sub-proofs into one outer proof; best TPS per CU, at the expense of prover complexity and longer batch windows.
- **Conclusion:** We start with single-tx + small batches; graduate to aggregation as demand grows.

10.3 Proof System Simplification: SNARK-first; STARKs optional

- **SNARK-first (Groth16/PLONK family):** Small proofs, cheap verification, well-understood tooling. Ideal for **frequent private payments**.
- **Why not dual-stack at launch?** Maintaining both SNARK + STARK circuits doubles engineering and audit scope with limited initial benefit.
- **STARKs (optional module):** Considered for **large audit assertions** or **post-quantum posture** where proof size is acceptable and transparency is valued. Introduced only when there is a **clear, measured benefit** and dedicated budget for audits.

10.4 On Unlinkability: ZK already provides it; "Advanced Mixing" is redundant

- **Robust shielded transfers** (commitments/nullifiers + balance conservation + membership proofs) already **break input→output linkability**.
- **Mixing adds little** beyond timing/fee smoothing and larger anonymity sets; it **does not replace** sound ZK design.

- **Policy:** Noctura **does not depend** on mixer semantics for privacy. If ever used, mixing-like batching is **opt-in UX** (fee/timing), not the anonymity primitive.

10.5 Performance Optimizations Roadmap (Batching, Aggregation, GPU Provers, Caching)

- **Phase A — Launch**
  - Circuit hygiene (Poseidon/Pedersen), fixed-base MSM optimization
  - Merkle depth tuned for proof speed vs. anonymity set
  - Modest **k-batch** verification (e.g., 4–8 transfers/proof)
- **Phase B — Scale**
  - **Proof aggregation/recursive SNARKs** to amortize on-chain verification
  - **GPU/ASIC prover lanes**; prover marketplace with price×latency routing
  - Witness caching & incremental path updates (PCU) for faster re-proofs
- **Phase C — Maturity**
  - Adaptive batch sizing (load-aware), epoch checkpoints for fast sync
  - Optional STARK module for large, infrequent attestations
  - DAO-tuned parameters: batch windows, operator minimum stake, fee bands

Bottom line: We ship **SNARK-first** with conservative, real-world throughput; scale via **batching and aggregation**; and only add complexity (e.g., STARKs, mixer-style batching) when the **measured** benefit justifies the audit and maintenance cost.

11. Developer References — Section B (API Schemas, zk Proof Formats)

11.1 Wallet API (Transparent vs Shielded Ops; Params & Error Codes)

Ops (TypeScript)

```
// Transparent (public) operations
sendTransparentTx(tx: { to: string; mint: string; amount: string;
memo?: string }): Promise<TxId>;
getTransparentBalance(owner: string, mint: string):
Promise<string>;

// Shielded (private) operations
sendShieldedTx(tx: {
  outputs: Array<{ pk_shielded: string; mint: string; amount:
string; memo?: string }>;
  feeMint?: "NOC";            // fee token (default NOC)
  anchor?: string;            // recent merkle root (hex32)
  prover?: string;            // optional prover lane id
  maxLatencySec?: number;     // user QoS bound
}): Promise<{ txId: TxId; newRoot: string }>;

crossModeTransfer(req: {
  direction: "public_to_shielded" | "shielded_to_public";
  mint: string; amount: string; recipient?: string;
}): Promise<TxId>;

getShieldedBalance(ownerViewKey: string, mint: string):
Promise<string>;
getRecentAnchor(): Promise<string>; // current merkle root
(hex32)

// Selective disclosure
generateViewKey(scope: ViewScope, ttlSec: number):
Promise<{ viewKeyId: string; key: string; expiry: number }>;
revokeViewKey(viewKeyId: string): Promise<{ revoked: boolean }>;
issueAuditToken(input: AuditTokenRequest): Promise<{ token:
string; expiry: number }>;
```

Common error codes

```
 ZK_PROOF_TIMEOUT, ZK_PROOF_INVALID, ANCHOR_STALE,
NULLIFIER_REPLAY,
GEO_RESTRICTED, KYC_REQUIRED, SLA_UNAVAILABLE, FEE_QUOTE_EXPIRED,
INSUFFICIENT_FUNDS, MINT_UNSUPPORTED, RATE_LIMITED,
INTERNAL_ERROR
```

11.2 Transaction/State APIs (Commitments, Nullifiers, Merkle Paths)

Indexer/Node (REST/JSON)

```
GET /v1/state/anchor
→ { root: "0x<32>" , slot: 259921430 }

GET /v1/state/commitments?fromSlot=...&toSlot=...
→ { items: [{ C: "0x<32>", slot: ..., idx: ... }],
nextPage: ... }

GET /v1/state/nullifiers?fromSlot=...&toSlot=...
→ { items: [{ N: "0x<32>", slot: ... }], nextPage: ... }

POST /v1/state/merkle-path
Body: { C: "0x<32>", root: "0x<32>" }
→ { path: ["0x<32>", ...], indices: [0|1,...], depth: 32 }
```

Event topics (on-chain logs)

```
ShieldedCommit(C, newRoot, slot)
NullifierSet(N, slot)
RootRotated(oldRoot, newRoot, epochId)
```

1.3 zk Proof Object Formats (commitment, nullifier, merkle_root, proof_bytes)

Note & Commitment (conceptual)

```
note = (pk_recipient, mint, amount, r)
C    = H(pk_recipient || mint || amount || r)          //
Poseidon/Pedersen
N    = PRF(sk_spend, note_id)                          //
unlinkable nullifier
```

Spend Proof (binary envelope → base64/hex in APIs)

```
type SpendProof = {
  // Public inputs
  merkle_root: string;          // hex32
  nullifiers: string[];         // array of hex32
  commitments: string[];        // new notes: array of hex32
  fee_commitment: string;       // hex32 (masked fee)
  memo_commitment?: string;     // hex32 (optional)

  // Proof bytes
  proof: string;                // hex; Groth16/PLONK proof
  vk_id: string;                // verifier key id / hash (hex32)
  anchor_slot: number;          // L1 slot used for the root
};
```

Verification constraints (summary)

- `merkle_path(note) → merkle_root`
- all `nullifiers` unique & not in set
- `Σinputs = Σoutputs + fee` (range-checked)
- authorized spend under `sk_spend` (witness)

11.4 Verifier Program Interface (On-Chain) & Gas/Fee Estimates

Solana instruction layout (Anchor-like pseudo-IDL)

```
pub fn submit_shielded_batch(
    ctx: Context<SubmitBatch>,
    proof: Vec<u8>,                    // zk proof bytes
    vk_id: [u8; 32],                   // verifier key id
    merkle_root: [u8; 32],
    nullifiers: Vec<[u8; 32]>,
    commitments: Vec<[u8; 32]>,
    fee_commitment: [u8; 32],
    anchor_slot: u64,
) -> Result<()>;
```

Accounts

- VerifierState (holds current root, vk registry, epoch params)
- NullifierSet (probabilistic or bitmap shards; write-once)
- CommitmentTree (incremental tree nodes)
- FeeVault, Treasury, OperatorRegistry

Fee/compute guidance (targets, not promises)

- Single-spend tx verify + state writes: **~150–300k CU**
- Small batch (4–8 spends): **~350–700k CU**
- Tx fee quote exposed in wallet (includes L1 fees + prover/relayer fee)

11.5 Audit/Disclosure API (Scopes, ZK Assertions, Consent Tokens)

Scopes

```
type ViewScope =
  | { kind: "tx_id"; ids: string[] }
  | { kind: "time_window"; from: number; to: number }
  | { kind: "balance_threshold"; mint: string; gte: string }
  | { kind: "proof_of_funds"; mint: string; amount: string };
```

Audit assertions

```
type AuditAssertion =
  | { kind: "kyc_pointer"; hash: string }            // partner-
resolvable
  | { kind: "origin_clean"; policy: string }         // policy
id/version
  | { kind: "proof_of_funds"; mint: string; gte: string };
```

Token issuance & verify

```
issueAuditToken(auditorPk: string, scope: ViewScope, assertions:
AuditAssertion[], ttlSec: number)
  → { token: string(base64), expiry: number }

POST /v1/audit/verify
Body: { auditor_pk, token }
→ { valid: boolean, scope, assertions, expires_at }
```

Revocation

```
POST /v1/audit/revoke
Body: { token_id }
→ { revoked: true }
```

11.6 Example Flows (Transparent→Shielded, Private Payment, Scoped Audit)

A) Transparent → Shielded (Deposit)

1. `getRecentAnchor()`
2. `crossModeTransfer({ direction: "public_to_shielded", mint, amount })`
3. Wallet builds `SpendProof` (membership of deposit UTXO, fee concealment), submits `submit_shielded_batch`.

B) Private Payment (Shielded → Shielded)

1. Sender builds outputs `{ pk_shielded_recipient, mint, amount }` (+ change).

2. `sendShieldedTx({ outputs, feeMint: "NOC", anchor })`.
3. Verifier checks proof, inserts nullifiers, appends new commitments, rotates root.

C) Shielded → Transparent (Withdrawal)

1. `crossModeTransfer({ direction: "shielded_to_public", mint, amount, recipient })`.
2. Proof shows membership & nullifier uniqueness; L1 program releases funds to `recipient`.

D) Scoped Audit (Proof-of-Funds)

1. Exchange requests: "prove ≥ X without history."
2. User: `issueAuditToken({ auditorPk, scope: {kind:"proof_of_funds", mint, amount:X}, assertions: [...] , ttlSec })`.
3. Exchange: POST /v1/audit/verify → receives **valid**, scope, assertions; no raw tx graph exposed.

Versioning & Stability

- All objects carry `vk_id`/`schema_v`. Circuit or API changes bump versions; old paths deprecate with notice.
- Open-source IDLs/SDKs are published with test vectors and conformance tests.

12. Roadmap

Stage 1 - | Foundation & On-Chain Presale

Deliverables

- On-chain presale live (10 stages), transparency page, team KYC published.
- Presale & token programs **audited**; incident-response + timelock upgrade playbooks.
- Verifier program skeleton + Merkle/Nullifier accounts on **devnet** (no funds risk).
- Wallet SDK preview (transparent ops + stubs for shielded ops).

- Selective Disclosure v0 (View Key/Audit Token schemas, mock verifier).
- Operator registry spec (staking & SLOs) and slashing policy draft.

End-of-Stage Goal: Noctura Wallet Beta (Testnet)

- Dual-mode UI (Transparent/Shielded toggle), deposit/withdraw flows wired to test contracts, basic proofs via hosted prover lane, scoped View Key issuance.

Ready-to-Ship Criteria

- Presale contract: audit signed; public contract address posted.
- Wallet Beta passes smoke tests on **testnet**; public test build + docs.

Stage 2 | Devnet Shielded Pools; Alpha Prover Lanes

Deliverables

- Shielded pools live on **devnet** with real circuits (SNARK-first).
- Small-batch verification (4–8 spends/proof); epoch checkpoints.
- Prover/relayer **alpha marketplace** (price × latency), operator staking MVP.
- Selective Disclosure **v1** (scoped View Keys, Audit Tokens; verify endpoint).
- Compliance adapters (Travel-Rule/KYC pointer) behind **opt-in** toggles.

Ready-to-Ship Criteria

- ≥3 external operators staked; latency/throughput SLO dashboards live.
- End-to-end private payment demo (devnet) with scoped audit at partner sandbox.

Stage 3 | Testnet Verifiers; Wallet RC (Dual-Mode)

Deliverables

- Verifier program on **public testnet**; batching + aggregation benchmarks.
- Wallet **Release Candidate** with full dual-mode flows and cross-mode unlinkability.
- Proof aggregation roadmap; GPU prover lanes pilot; witness caching (PCU).

- Security pass: circuit review, verifier review, SDK signing flows audit.

Ready-to-Ship Criteria

- Private payments at **100–300 shielded TPS** (testnet), 1–3 s median latency.
- Bug bounty program launched; P0/P1 triage + disclosure SLAs published.

Stage 4 | Mainnet Shielded Layer; Listings & Partners

Deliverables

- Mainnet launch of **Shielded Privacy Layer** (SNARK-first).
- Staking program live (post-TGE tiers: **128%/365d**, **68%/182d**, **34%/90d**).
- Fee routing (stakers + operators), optional **fee-burn** parameter exposed to DAO.
- Initial CEX/DEX liquidity (from 14% allocation), partner integrations (wallets/ DEXs).

Ready-to-Ship Criteria

- Two independent audits signed (verifier + circuits).
- ≥2 exchange listings (one tier-1/2), ecosystem partner live (DEX or lender).

Stage 5 | Enterprise Console; DAO Bootstrap; Grants

Deliverables

- **Enterprise Console**: policy engine (limits, dual-control), scoped view management.
- DAO bootstrap: quorum/thresholds, parameter caps/floors, timelock governance.
- Grants program (privacy dApps, explorers, analytics with privacy guarantees).

- Transparency: quarterly emissions/fees/burn reports; circuit versioning policy.

Ready-to-Ship Criteria

- First DAO votes executed (operator min-stake, fee-burn %, batch windows).
- 3rd-party ecosystem apps using the Audit/Disclosure API in production.

Stage 6 | Scale-Out; Cross-Chain Privacy; Institutional Pilots

Deliverables

- Throughput scale: **aggregation/recursive SNARKs** enabled; adaptive batch sizing.
- Cross-chain privacy R&D (bridged attestations; STARK module for large audits if justified).
- Institutional pilots (treasury/payroll, PoF attestations with custodians).
- Operator marketplace expansion, SLO enforcement & slashing in production.

Ready-to-Ship Criteria

- Sustained mainnet throughput improvements; operator churn < X%/quarter.
- Pilot case studies published; measurable fee revenue covering ≥Y% emissions.

KPI Hints (internal, optional to publish)

- Stage 1: ≥10k testnet wallet installs; presale progress by stage.
- Stage 2–3: ≥100–300 shielded TPS testnet; ≥3 external operators.
- Stage 4: Mainnet MAU ≥25k; shielded tx share ≥20% of wallet tx.
- Stage 5–6: DAO participation rate ≥10% of staked supply; fee revenue covers ≥30–50% of emissions.

13. Investor Benefits & Presale Rationale

13.1 Why Invest in $NOC Now

Noctura delivers the **first shielded privacy layer on Solana** with a **dual-mode wallet** (Transparent ↔ Shielded). It's engineered for **usable privacy** and **selective disclosure**, making it compatible with exchanges and regulated partners while preserving strong confidentiality on-chain.

Why $NOC at this stage:

- **Wallet-first adoption engine**
  Privacy is not a separate chain—it's a **toggle in the wallet**. That UX, plus SDK hooks for dApps, is the fastest path to real usage.

- **Compliance-ready by design**
  View Keys and **Audit Tokens** let users prove facts (proof-of-funds, origin) **without** exposing their history—making Noctura far more exchange-friendly than legacy privacy tools.

- **SNARK-first, realistic performance**
  Off-chain proving with **on-chain verification** targets **hundreds of shielded TPS** at launch, scalable via batching/aggregation and GPU provers. No hype TPS; only what Solana and ZK can credibly support.

- **Direct economic flywheel**
  Every shielded transfer and operator lane is **powered by $NOC** (fees, staking, incentives). Optional **fee-burn** can add deflationary pressure as usage rises.

- **Institutional fit**
  Dual-mode wallet + selective disclosure enables **payroll, treasury, compliance attestations**, and **private DeFi**—use cases that Monero/Zcash/mixers struggle to support in regulated venues.

- **On-chain presale, transparent math**
  10 fixed stages (4-dec prices) sum exactly to **$25.6M** hard cap; **40%** supply allocated to presale. Parameters are public and auditable.

- **Presale Buyer Benefit: Zero $NOC transaction fees on both modes for 18 months post-wallet launch.**

Why Noctura Succeeds Where Others Failed

Feature	Monero	Zcash	Tornado Cash	Noctura
Exchange Compatibility	❌ Delisted	⚠️ Limited	❌ Sanctioned	✅ Designed for listings
Compliance Tools	❌ None	⚠️ Minimal	❌ None	✅ Selective disclosure
User Experience	⚠️ Complex	⚠️ Complex	⚠️ Technical	✅ One-tap privacy
Scalability	⚠️ Moderate	⚠️ Low	⚠️ Limited	✅ Solana-native speed
Institutional Adoption	❌ Blocked	⚠️ Limited	❌ Impossible	✅ Enterprise-ready
Ecosystem Integration	❌ Standalone	❌ Standalone	⚠️ ETH only	✅ Full Solana ecosystem

Bottom line: Noctura is **privacy that can survive in the real world-**usable, verifiable, and partner-friendly, on Solana's performance rails.

14. FAQ

Q1: What is Noctura, exactly?
Noctura is the **first shielded privacy layer on Solana** with a **dual-mode wallet**. Users can transact in **Transparent (public)** or **Shielded (private)** mode, and selectively disclose facts (e.g., proof-of-funds) without exposing their full history.

Q2: Is this a Layer-2/rollup?
No. It's a **privacy overlay**, not an L2 rollup. Proofs are generated **off-chain** and **verified on-chain** by Solana programs that update shielded state (commitments, nullifiers, Merkle root).

Q3: How is this different from Monero, Zcash, or Tornado Cash?

- **Monero:** strong privacy, limited selective disclosure → exchange friction. Noctura provides **view keys/audit tokens** for scoped, consented proofs.

- **Zcash:** has view keys, but adoption hampered by UX fragmentation. Noctura's **dual-mode wallet** makes switching trivial.
- **Tornado Cash:** mixer semantics are non-compliant by default. Noctura's **ZK-native unlinkability** avoids mixer heuristics and supports **compliance-ready** attestations.

Q4: What's the realistic private TPS?
Launch targets are ~**100–300 shielded TPS**, with **1–3s** median confirmation, scaling via batching, aggregation, and GPU provers. We **do not** claim "65k TPS shielded."

Q5: Do I need KYC to use Noctura?
Transparent mode: typically **no**. Shielded mode or presale participation may require **KYC/geo checks** depending on your jurisdiction and thresholds. The protocol stores **no PII**—partners hold their own records; the wallet uses **hash pointers** inside audit tokens when needed.

Q6: How does selective disclosure work?
Users can issue **View Keys** (read-only, scoped by tx/time/balance) and **Audit Tokens** (consent-bound, expiring assertions like proof-of-funds or KYC pointer). Partners verify these without accessing the full transaction graph.

Q7: Is the presale on-chain? Where?
Yes. **Presale contract (SPL/Solana):**
B61SyRxF2b8JwSLZHgEUF6rtn6NUikkrK1EMEgP6nhXW.

Q8: How is the presale priced?
10 stages, each selling **10,240,000 $NOC** at **4-decimal fixed prices** that sum to an exact **$25,600,000** hard cap. Stage-to-stage increases are ~6–12%, with Stage-10 ≈ **+133%** vs Stage-1.

Q9: When and how do I claim tokens?
At **TGE**, via the Noctura dApp. You can optionally **auto-stake** into a lock tier at claim.

Q10: Does staking start during presale?
Yes—staking **opens at presale start**. Presale positions accrue eligibility and roll forward to post-TGE options; principal/rewards are **claimable at/after TGE**.

Q11: What are the staking options after TGE?

- **128% APR — 365-day lock**
- **68% APR — 182-day lock**

- **34% APR — 90-day lock**
  APRs are funded by emissions + protocol fees and governed by the DAO within published bounds.

Q12: Is there a presale boost (256% APR)?
If enabled, it's **time-boxed to the presale accrual window only** and stops at TGE; rewards are claimable after the post-launch unlock. Post-TGE, the fixed lock-tier APRs apply (see Q11).

Q13: What gives $NOC real utility?
$NOC powers **shielded fees**, **prover/relayer incentives**, **staking/DAO governance**, and **premium wallet features** (e.g., instant proving lanes). Optional **fee-burn** (DAO-set) can add mild deflation tied to usage.

Q14: How are tokens allocated?
Total supply **256,000,000 $NOC**: **40% Presale**, **20% Staking & Rewards**, **14% Liquidity**, **8% Core Team (12-month lock + vest)**, **7% Reserve/Upgrades**, **6% Marketing/Partnerships**, **5% Community Engagement**.

Q15: Are contracts and circuits audited?
Yes. Audits cover **presale/token programs**, **verifier/tree logic**, **wallet cryptography/SDK**, and **ZK circuits**. Reports (and re-audits after material changes) are published on the transparency page.

Q16: How are operators (provers/relayers) kept honest?
They **stake $NOC** to register. Misbehavior (invalid proofs, liveness failures, fraud) can be **slashed**, with proceeds redistributed/burned per DAO policy.

Q17: What data does Noctura store on-chain?
Only **public artifacts** needed for verification: **commitments**, **nullifiers**, and the **Merkle root**. No private notes/PII are written on-chain.

Q18: Can enterprises use this without breaking compliance?
Yes. The wallet supports **policy controls** (dual-control, limits), **scoped view access** for finance/compliance, and **audit tokens** for regulators/partners.

Q19: What's on the near-term roadmap?
Stage 1 (2025 Q4): On-chain presale + **Wallet Beta on testnet**.
Then: devnet shielded pools, testnet verifiers, mainnet shielded layer, listings, DAO bootstrap, and scale-out via proof aggregation.

Q20: How are treasury and parameters governed?
By the **DAO** with multisig + timelock rails. Voters control **emission curves, fee-burn**

%, operator min-stake, batch windows, and circuit activations; safety caps/floors and emergency pause are hard-coded.

Q21: Where can I see transparency data?
The transparency page publishes **contract addresses, audits, restricted-jurisdiction policy, DAO parameters, quarterly emissions/fees/burn reports**, and changelogs for circuits/parameters.

Q22: What are the main risks?
Regulatory changes, cryptographic/implementation bugs, market volatility, and operator centralization. Mitigations include audits, bug bounties, guarded upgrades, staking/slashing, and conservative throughput targets.

Q23: How do I build on Noctura?
Use the **Wallet SDK** (transparent & shielded ops, cross-mode transfers, disclosure APIs). See **Section 11** for schemas, proof formats, verifier interface, and example flows.

Q24: Support & security contact?
Security disclosures via **PGP email** (listed on the transparency page). General support via docs, Discord/Telegram, and issue trackers linked from the website.

15. Governance

15.1 Phased Governance (Core → DAO)

Phase 0 — Launch Controls (pre-mainnet & presale).

- Multisig (core contributors + independent advisors) manages: presale program, token mint, audit sign-offs, and non-contentious ops (e.g., transparency page).
- Scope intentionally narrow; no discretionary treasury moves beyond budget rails.

Phase 1 — Guarded Parameters (mainnet TGE → stability).

- Multisig + **timelock** administer protocol parameters within **hard guardrails** set on-chain (caps/floors).
- Community signaling via off-chain snapshot; non-critical changes (e.g., fee-burn %, batch windows, operator min-stake) require timelocked execution.

Phase 2 — DAO Control (post-audit, stable ops).

- **On-chain DAO** assumes control of: emissions schedule knobs, operator policy, fee-split, treasury grants, and circuit activation after audits.
- Multisig remains as **executor** of DAO-passed proposals only; no unilateral authority.

Phase 3 — Mature Decentralization.

- DAO governed end-to-end with **constitutional guardrails** (immutables): emergency pause scope, max issuance rate, circuit security invariants, and disclosure API baselines.

15.2 Use of Proceeds

Noctura's treasury is deployed to accelerate delivery of the dual-mode wallet, harden security, grow ecosystem adoption, and ensure deep, healthy liquidity for launch and expansion. All treasury movements follow governance controls (e.g., multisig + timelock) and are executed within predefined budget rails, with periodic transparency reporting.

Allocation breakdown

1) Liquidity provisioning (DEX/CEX depth; not for price support) — 22%
Used for initial liquidity deployment, market-making tooling, and exchange liquidity requirements where applicable. This allocation is strictly for liquidity health and operational readiness—not artificial price support.

2) Security, audits & bug bounty — 18%
External audits across wallet code, smart contracts/programs, zk circuits/verifier logic, and infrastructure. Includes an ongoing bug bounty reserve.

3) Core engineering & infrastructure — 20%
Wallet development (Transparent + Shielded UX), performance engineering, prover/relayer lanes, monitoring, redundancy, and production-grade reliability.

4) Integrations & SDK adoption — 12%
Developer SDKs, documentation, reference integrations, partner engineering, and tooling to enable dApps and wallets to integrate Noctura privacy primitives safely.

5) Ecosystem grants — 8%
Grants to teams building privacy-enabled Solana apps, integrations, analytics that preserve privacy, and community tooling that expands the Noctura ecosystem.

6) Marketing & partnerships — 10%
Growth campaigns, partnerships, community expansion, and strategic distribution to drive adoption and awareness through measurable, trackable channels.

7) Legal & compliance operations — 5%
Legal structuring, policy work, restricted-jurisdiction controls, and compliance adapter support as required by partners and listing venues.

8) Reserve / contingency — 5%
Buffer for unforeseen events, security incidents, critical upgrades, and operational continuity—deployed only under governance controls.

Flexibility & controls

To remain adaptive, allocations may shift modestly based on real-world needs (e.g., audit scope expansion, integration demand, listing requirements). Any material reallocation is executed under governance controls and recorded in treasury reporting.

15.3 Voting Power (Staked $NOC), Quorums, Safeguards

Voting power.

- **1 staked $NOC = 1 vote** (at proposal snapshot).
- Optional **longer-lock multiplier** (bounded, e.g., up to 1.5×) to reward long-term alignment without plutocracy.

Quorum & thresholds.

- **Standard proposals:** quorum ≥ **10%** of staked supply; **simple majority** to pass.
- **Sensitive proposals** (emissions curve, fee-burn %, operator min-stake): quorum ≥ **15%**; **60% supermajority**.
- **Critical proposals** (circuit activation, verifier upgrade, emergency powers): quorum ≥ **20%**; **66% supermajority**.

Safeguards.

- **Timelock** (e.g., 72h–7d) on all state-changing executions; immutable minimum enforced in contracts.
- **Parameter guardrails**: caps/floors embedded on-chain (e.g., max fee-burn %, max emission rate, min operator stake).

- **Conflict checks**: proposals auto-rejected if violating invariants (e.g., spend > treasury, emission > cap).
- **Sybil/flash-loan resistance**: snapshot voting (block-height), stake lock requirement during voting window.

Transparency.

- Public proposal texts, diffs, on-chain simulations, and risk notes; all executed actions linked to proposal IDs.

15.4 Upgrade Process & Emergency Controls

Upgradeable components.

- **Verifier program** (proof verification, tree ops)
- **Circuit registry** (vk ids, circuit versions)
- **Operator/treasury modules** (staking, fee routing)

Standard upgrade pipeline.

1. **Spec & audit** published (diff, test vectors).
2. **DAO vote** approves upgrade; includes parameter diffs and activation conditions.
3. **Timelock** starts; binaries/IDLs pinned (IPFS/commit hash).
4. **Shadow deploy** to canary/testnet; monitoring window.
5. **Activation** via DAO executor; automatic rollback plan defined.

Circuit activation.

- New circuits (vk ids) **registered alongside** current versions; **dual-acceptance window** permits safe migration.
- Deactivation of old circuits only after **cutover quorum** (usage threshold) or time-based sunset, whichever first.

Emergency controls (narrowly scoped).

- **Emergency Pause** (shielded submit only): freezes *new* shielded transactions while preserving read access, staking accrual, and claims.

- **Triggers:** verified critical vulnerability, integrity loss (e.g., proof forgery), or exploit in progress.
- **Process:** 2-of-N emergency council (multisig subset) → immediate pause; **mandatory DAO ratification** within a fixed window (e.g., 7 days) or auto-unpause.
- **User safety:** funds remain accessible; exits via transparent paths stay available if not implicated.

Post-incident.

- Public **post-mortem** with timelines, root cause, and remediation.
- **Re-audit** required for affected modules; resume via timelocked DAO approval.

Immutable invariants.

- Cannot be changed by any vote: max supply, nullifier uniqueness rule, conservation constraint (Σinputs = Σoutputs + fees), minimum timelock floor, and disclosure API consent requirement.

Outcome. Governance balances **agility** (shipping upgrades, responding to incidents) with **credible neutrality** (DAO control, hard guardrails, and transparent processes) so the protocol can evolve safely without compromising user trust.

16. Risks & Disclosures

16.1 Regulatory, Technical, and Market Risks

- **Regulatory**
  - **Policy shifts.** Privacy tooling may face new restrictions, licensing, reporting, or geo-fencing mandates. Jurisdictional divergence can limit features or access.
  - **Exchange posture.** Listings and fiat ramps may require additional attestations (view keys, audit tokens, KYC pointers). Loss of listings/liquidity is possible.
  - **Sanctions/blacklists.** Counterparty controls and Travel-Rule obligations can change with little notice; adapters may be disabled regionally.

- **Technical**
    - **Cryptographic assumptions.** Soundness relies on hardness of chosen curves/hashes and SNARK security. A break or implementation flaw could compromise privacy or integrity.
    - **Implementation bugs.** Verifier logic, circuit constraints, Merkle/tree updates, or wallet key management could contain defects despite audits and testing.
    - **Throughput/latency limits.** Shielded TPS and confirmation times depend on proof generation, on-chain verification, and network load; targets (hundreds TPS) are not guarantees.
    - **Operator centralization.** Prover/relayer concentration may degrade censorship resistance or quality of service if not countered by incentives and staking policy.
    - **Upgrades & compatibility.** Circuit/version migrations may cause temporary disruptions; clients must update to maintain functionality.
- **Market**
    - **Price volatility.** $NOC may fluctuate significantly due to market conditions, liquidity depth, or sentiment.
    - **Adoption uncertainty.** User/partner uptake of shielded flows and disclosure APIs may be lower or slower than expected.
    - **Competition.** Alternative privacy solutions or L1/L2 roadmap changes could reduce Noctura's relative advantage.

16.2 Operational & Treasury Risks

- **Treasury management.** Misallocation, custodial failures, or market drawdowns can reduce runway. Treasury actions are timelocked and public but cannot eliminate loss risk.
- **Liquidity provisioning.** Initial pool depth and market-maker performance may be insufficient, causing slippage and volatility.
- **Key management & governance.** Multisig/DAO keys may be compromised through phishing, device loss, or collusion. Safeguards include role separation, hardware keys, timelocks, and immutable guardrails.
- **Third-party dependencies.** RPC providers, KYC vendors, and Travel-Rule partners can introduce outages or policy changes that affect UX or availability.

- **Incident response.** Emergency pause halts new shielded submits but may not prevent all loss modes. Recovery may require contract upgrades subject to governance and re-audit.

16.3 Investor Disclaimer (No Guaranteed Yields)

- **No promises of profit.** $NOC is a utility token for fees, staking, governance, and operator incentives within the Noctura ecosystem. It is **not** an investment contract, deposit, or security claim on protocol revenues.
- **Variable rewards.** Staking APR bands (e.g., **128%/365d**, **68%/182d**, **34%/90d**) and any time-boxed presale boosts are **targets**, not guarantees. Actual returns vary with total staked, emissions schedules, protocol fees, and DAO decisions.
- **Risk of total loss.** Token value can go to zero. Smart-contract or cryptographic failures, regulatory bans, market crashes, or operational incidents can result in partial or total loss of funds.
- **Jurisdictional limits.** Access to features (shielded mode, presale, staking) may be restricted by location, KYC status, or partner policy. Users are responsible for complying with local laws and tax obligations.
- **Forward-looking statements.** Roadmap items, throughput targets, listings, and integrations are goals that may change without notice based on audits, feasibility, and governance outcomes.

Proceed only if you fully understand and accept these risks. Always use hardware-secured wallets, verify contract addresses (presale: B61SyRxF2b8JwSLZHgEUF6rtn6NUikkrK1EMEgP6nhXW), and never commit more than you can afford to lose.

17. Appendices

A. Glossary & Notation

- **Anchor / Root (R)** – Current Merkle tree root for shielded commitments used as the public reference in proofs.
- **Commitment (C)** – Hash binding a note's contents (recipient key, mint, amount, randomness).

- **Nullifier (N)** — One-time, unlinkable marker proving a note was spent (prevents double-spend).
- **Note** — Private record of value in the shielded set.
- **Spend Proof** — ZK proof showing membership, authorization, balance conservation, and uniqueness of nullifiers.
- **Verifier Program** — Solana on-chain program that validates proofs and updates state (R, C[], N[]).
- **View Key** — Read-only key granting scoped viewing (tx/time/balance) without spend authority.
- **Audit Token** — Consent-bound, expiring assertion (e.g., proof-of-funds, KYC pointer) verifiable by partners.
- **Operator (Prover/Relayer)** — A staked service that generates proofs / relays shielded txs; subject to slashing.
- **DAO** — On-chain governance controlling parameters (emissions, fee-burn %, operator policy).
- **TGE** — Token Generation Event.

B. Cryptographic Parameters (Curves, Hashes, Tree Depths)

Parameters are versioned. Final values are pinned in the verifier registry and audit reports.

- **Proof System (launch):** zk-SNARK (Groth16/PLONK family) on **BLS12-381**.
- **Hash Function (commitments / Merkle): Poseidon** (field-friendly), domain-separated for C, N, and tree nodes.
- **PRF for Nullifiers:** Poseidon-based PRF keyed by sk_spend with explicit domain tags.
- **Merkle Tree:**
    - **Depth:** 32 (launch) with upgrade path to 40/48 via versioned trees.
    - **Arity:** Binary.
    - **Witness Format:** sibling hashes + bit-indices (LSB first).

- **Range Proofs:** Amount range constrained in-circuit (non-negative, cap < 2^64) with overflow checks.
- **Transcript Binding:** Fiat-Shamir with domain tags for spend, deposit, withdraw circuits.
- **Key Derivation:** Ed25519 (transparent), shielded spend/view keys from master seed via hardened paths; disclosure branch separated.

C. Economic Parameters (Stage Prices, Emission Caps)

- **Total Supply:** 256,000,000 $NOC (fixed).
- **Presale Allocation:** 102,400,000 (40%), sold in **10 equal stages** (10,240,000 each).
- **Price Ladder (4-dec; exact hard cap $25,600,000):**
  1. **$0.1501** → $1,537,024.00
  2. **$0.1723** → $1,764,352.00
  3. **$0.1945** → $1,991,680.00
  4. **$0.2167** → $2,219,008.00
  5. **$0.2389** → $2,446,336.00
  6. **$0.2611** → $2,673,664.00
  7. **$0.2833** → $2,900,992.00
  8. **$0.3055** → $3,128,320.00
  9. **$0.3277** → $3,355,648.00
  10. **$0.3499** → $3,582,976.00
  Totals: 102,400,000 tokens • **$25,600,000.00**
- **Staking Emissions Pool: 51,200,000 $NOC** (20% of supply).
- **Post-TGE Staking APR Bands: 128% (365d), 68% (182d), 34% (90d)**; DAO-tunable within capped ranges.

- **Operator Rewards:** Share of protocol fees/emissions split per delivered QoS; DAO-tunable.
- **Optional Fee-Burn: 0.25–1.00%** of shielded fees (DAO-set), burned prior to reward splits.

D. Contract Addresses & Registry

All addresses are published on the transparency page and versioned in a registry account. Only the presale address is final at this time.

- **Presale Program (Mainnet):** B61SyRxF2b8JwSLZHgEUF6rtn6NUikkrK1EMEgP6nhXW
- **$NOC SPL Mint:** *TBA (post-audit, pre-TGE)*
- **Verifier Program (Shielded):** *TBA (testnet → mainnet after audits)*
- **Commitment Tree Account(s):** *TBA*
- **Nullifier Set Account(s):** *TBA*
- **Treasury / Multisig:** *TBA (DAO bootstrap stage)*
- **Registry Account (pins current versions):** *TBA*

Change control: New deployments are added; old ones marked **deprecated** only after cutover. Each entry includes program id, commit hash/IPFS ref, audit link, and activation slot.

E. Example JSON Schemas (API/Proof Objects)

Canonical schemas live in the SDK repo; below are abridged, human-readable versions for integrators.

E.1 Spend Proof Envelope

```
{
  "schema_v": "spend.v1",
  "vk_id": "0x<32>",
  "anchor_slot": 259921430,
  "merkle_root": "0x<32>",
  "nullifiers": ["0x<32>", "0x<32>"],
  "commitments": ["0x<32>", "0x<32>"],
  "fee_commitment": "0x<32>",
  "memo_commitment": "0x<32>",
  "proof": "0x<bytes>"   // Groth16/PLONK bytes
}
```

E.2 Merkle Path Request/Response

Request

```
{ "C": "0x<32>", "root": "0x<32>" }
```

Response

```
{
  "path": ["0x<32>", "..."],
  "indices": [0,1,1,0, "..."],
  "depth": 32
}
```

E.3 View Key & Audit Token

View Key (scoped)

```
{
  "schema_v": "viewkey.v1",
  "id": "vk_01H...",
  "scope": { "kind": "time_window", "from": 1700000000, "to":
1700600000 },
  "key": "base64...",
  "expiry": 1701200000
}
```

Audit Token (consent-bound assertions)

```
{
  "schema_v": "audit.v1",
  "token_id": "at_01H...",
  "auditor_pk": "0x<32>",
  "scope": { "kind": "proof_of_funds", "mint": "So111...",
"amount": "10000" },
  "zk_assertions": [
    { "kind": "kyc_pointer", "hash": "0x<32>" },
    { "kind": "origin_clean", "policy": "v1.2" }
  ],
  "ttl": 86400,
  "sig_user": "0x<64>"
}
```

E.4 Wallet Operations (abridged)

Shielded Send

```
{
  "op": "sendShieldedTx",
  "req": {
    "outputs": [
      { "pk_shielded": "0x<pk>", "mint": "So111...", "amount":
"250" }
    ],
    "feeMint": "NOC",
    "anchor": "0x<32>",
    "prover": "lane:gpu11",
    "maxLatencySec": 3
  }
}
```

Cross-Mode Transfer

```
{
  "op": "crossModeTransfer",
  "req": { "direction": "public_to_shielded", "mint": "So111...",
"amount": "1000" }
}
```

Errors (enum)

```
{
  "error": "ANCHOR_STALE",
  "details": "Provided anchor 0x... is older than allowed epoch
window"
}
```

These appendices provide the pinned vocabulary, cryptographic and economic knobs, canonical addresses, and integration schemas needed to build, audit, and operate against Noctura's shielded privacy layer on Solana. As components graduate from testnet to mainnet, the registry and transparency page will be updated with final IDs and audit links.

18. Call to Action

Privacy that survives the real world starts here. Noctura delivers a **shielded privacy layer on Solana** with a **dual-mode wallet** and **selective disclosure**—usable for everyone, acceptable to partners, and verifiable on-chain.

Start now

- **Join the presale: noc-tura.io/presale**
- **Claim at TGE & optionally auto-stake** into your chosen lock (128%/365d, 68%/182d, 34%/90d).
- **Test the Wallet Beta (testnet):** try Transparent ↔ Shielded, deposits/withdrawals, and View Keys.

Build with us

- **Developers:** integrate private settlement and scoped audits via the **Noctura Wallet SDK** (Section 11).
- **Operators:** apply to run **prover/relayer lanes** (stake $NOC, earn fees; slashing-secured).
- **Enterprises:** enable **policy controls** (dual-control, limits) and **Audit Tokens** for compliance workflows.

Stay aligned

- Track audits, parameters, and addresses on the **Transparency Page**.
- Participate in **DAO** votes (emissions, fee-burn %, operator policy) once governance opens.
- Join the community channels for releases, bounty calls, and partner programs.

Choose privacy-without losing legitimacy.
Noctura — the first shielded privacy layer on Solana,
powered by a dual-mode wallet and the $NOC economy.