

— INSTITUTIONAL WHITEPAPER · SIX-LAYER DePIN

Hardware-verified *truth* for climate markets and AI compute.

A six-layer DePIN architecture pairing edge-bound cryptographic hardware with a continuous, hardware-signed evidence pipeline, spanning carbon removal, AI compute accountability, energy markets, parametric insurance, supply chain, Smart City, and climate-finance clearing.

STATUS

Pre-Launch

FRAMEWORK

Six-Layer DePIN

MAINNET TARGET

Q4 2026

CARDANO PREPROD

Active

FRONT MATTER · AUTHORS & ABSTRACT

A six-layer DePIN *for* *institutional* climate markets.

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Stewardship**ABSTRACT**

Mālama Labs presents a decentralized physical infrastructure network (DePIN) that addresses the foundational Truth Gap in global environmental markets and high-performance computing. By pairing edge-bound hardware with cryptographic data validation, the protocol establishes a continuous, hardware-signed evidence pipeline across carbon removal, AI compute accountability, energy markets, parametric insurance, supply chain, Smart City, and climate-finance clearing.

The protocol operates across nine commercial verticals sharing a single signing architecture and validator network. A six-layer architectural stack establishes cryptographic provenance at the point of data capture. Scheduled emissions follow a smooth eight-year taper (60.0M MLMA, 12.0% of the 500M hard cap), with protocol revenue scaling to fund operator and staker distributions by Year 4 to 5, after which the protocol operates entirely on revenue. Modeled Year 5 revenue is \$147.44M total, of which \$68.44M is recurring oracle and settlement fees. MLMA is a digital tool under the March 17, 2026 SEC-CFTC Joint Interpretation (S7-2026-09).

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Twenty-five sections. *One signing architecture.*

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Decoupling network growth from *open-ended issuance*.

Legacy decentralized physical infrastructure networks (DePINs) often face structural vulnerabilities driven by token inflation preceding commercial demand. When network incentives drop, node operators capitulate, causing data fragmentation and destroying institutional utility. Mālama Labs corrects this failure mode through a deliberate decoupling of network growth incentives from open-ended token issuance: scheduled emissions are capped at 60.0M MLMA across an eight-year smooth taper, and the protocol transitions to revenue-funded economics from Year 4 onward.

The network architecture is organized into an institutional six-layer DePIN model. While standard decentralized literature details a canonical five-layer layout, Mālama introduces a protocol-specific extension by separating geographic reward scaling and redemption and governance execution into distinct layers. This explicit isolation guarantees granular auditability, system upgradeability, operational execution clarity, and institutional legibility.

Operating on MLMA, a digital tool under the March 17, 2026 SEC-CFTC Joint Interpretation (S7-2026-09), alongside the LCO₂ and VCO₂ environmental instruments, the protocol processes raw telemetry into verified, auditable data packages called SaveCards. Modeled Year 5 revenue is \$147.44M total, of which \$68.44M is recurring oracle and settlement fees across nine commercial verticals.

HARD CAP

500M

SCHEDULED EMISSIONS

60M / 12%

YEAR 5 REVENUE

\$147.44M

PILOT SAVECARDS

2,786+

By deploying hardware-enclosed cryptographic signatures directly to fields, industrial processing centers, and data centers, Mālama moves past speculative infrastructure narratives into a production-grade verification engine for global climate markets.

The accountability gap, and the *nine verticals*.

2.1 The Legacy DePIN Failure Mode

The scaling model of early DePIN initiatives focused on device quantity over strategic placement. Hobbyists deployed duplicate hardware inside well-connected suburban homes, resulting in excess density in regions with low commercial data value, while critical data deserts, remote agricultural land, frontier operations, and underserved industrial corridors, remained unmonitored.

Legacy models also used inflationary emission structures with no distinct termination horizon. When emissions decreased, speculative interest declined, operators disconnected their equipment, and enterprise buyers were left with fragmented data streams that failed corporate audit and compliance requirements.

2.2 The 400 TWh Energy and Carbon Accountability Gap

This fragmentation is most pronounced where high-performance AI data centers meet regional energy markets. Global AI data center electricity consumption is on track to surpass 400 TWh annually, creating an accountability gap around real-time power draw, marginal carbon intensity, and cooling-water attribution. Independent analysis has concluded that some hyperscalers' real-time emissions may be orders of magnitude higher than market-based reports suggest.

2.3 The Nine-Vertical Platform Thesis

Mālama Labs replaces unverified data pipelines with one hardware-verified data collection framework that generalizes across nine commercial verticals: carbon verification (dMRV), AI compute emissions verification, energy-market data licensing, parametric insurance triggers, EUDR supply chain attestation, prediction market resolution, smart agriculture, Smart City monitoring, and LCO₂ / VCO₂ settlement. By deploying hardware at the point of resource consumption or carbon removal, the network transforms physical observation into an auditable digital asset class.

Software-based telemetry that runs on the same machines it is measuring cannot resolve the trust gap. Only hardware-signed measurement at the rack, independent of the host software, can.

From five layers in the literature to *six layers* in Mālama.

3.1 The Six-Layer Extension

Academic literature analyzing standard DePIN infrastructure outlines a five-layer layout: Physical, Verification, Storage and Off-Chain, Blockchain, and Application. Mālama explicitly extends this paradigm into a specialized six-layer architecture, separating two functions into independent layers. The Reward Scaling Layer (Layer 5) handles real-time geographic incentives, density limits, and the demand-weighted reward calculation via the H3 spatial index. The Redemption Layer (Layer 6) controls user claims, vote-escrowed staking, fee distribution, data retrieval authorizations, and corporate procurement access.

3.2 Why This Separation Matters

Conflating geographic optimization and treasury distribution inside one generalized application layer obscures risk and reduces modular efficiency. Separating them delivers four advantages. **Granular auditability:** compliance officers, regulators, and registries can evaluate each component of the data and value lifecycle independently. **Targeted upgradeability:** the verification stack can change without disturbing settlement or governance state. **Execution clarity:** edge cryptography never competes with settlement logic. **Institutional legibility:** a clean trace from a field measurement to an unalterable on-chain settlement asset.

Hardware-rooted identity, *isolated at silicon.*

4.1 Hardware Specification Status and Design Lineage

The hardware described throughout Sections 4, 10, and 11 represents the current reference design for Mālama's field signing nodes, rack-form-factor signing devices, and associated sensor modules. Final production specifications remain subject to engineering iteration through Genesis 200 hardware delivery at the end of Q4 2026. Specific component selections and bill-of-materials are maintained under engineering and supplier confidentiality; the architectural functions described here are the public commitments, and component substitution within the same functional envelope is preserved as an engineering prerogative.

4.2 Field Signing Node Specification

The physical architecture is built on the Genesis Hex Node, a modular platform engineered for flexible field deployment. As a Physical Resource Network primitive, the node relies on localized geographic density to resist replication and on hardware-rooted cryptographic identity to resist data forgery. Each node contains a tamper-resistant secure element with a non-exportable ECDSA signing key, provisioned at manufacture via an onboard hardware true random number generator. The key is physically isolated from the file system and application processor; signing happens inside the secure element and the key never leaves silicon, giving an unforgeable hardware identity that signs every telemetry packet before it leaves the device.

4.3 Interchangeable Sensor Modules

Each node features an industrial, weatherproof plug-and-play bus supporting external modules. The weather station module tracks ambient temperature and humidity, barometric pressure and air quality, and wind and rainfall, for micro-climate, grid, and parametric use. The soil station module monitors volumetric water content, soil temperature at depth, electrical conductivity, pH, and nutrient dynamics, mapping to frameworks such as Verra VM0042.

4.4 Hardware Resilience and Offline Buffering

An encrypted non-volatile queue inside the secure operating layer lets the unit continue logging, signing, and sequence-counting through a complete backhaul outage. On reconnection, a throttled transmission queue cross-checks sequence nonces against the public ledger to prevent replay or duplication.

Multilayer pipeline. *Five threat classes.*

5.1 The Multilayer Verification Pipeline

Data packets from Layer 1 pass through an asynchronous verification pipeline before being acknowledged or written to any storage layer. The pipeline filters malicious actors, faulty hardware, and anomalous environmental events.

5.2 Anti-Spoofing Taxonomy (Class A to E) and Proof-of-Truth

The Verification Layer maps incoming packets against five threat classes, reproduced in full in Appendix C. By enforcing cryptographic validation at this layer, the network establishes reliability economics: validators participate under a non-transferable PONO credential earned through KYB and operational milestones, and falsification or anti-protocol behavior results in PONO revocation and forfeiture of unvested operator rewards. Validators reach Proof-of-Truth consensus, and the geographic consensus layer (H3 k-ring BFT attestation) makes single-validator falsification detectable by neighboring nodes.

5.3 Validator Ensemble Logic

The network computes a weighted data-quality score for every telemetry epoch across cryptographic, protocol, physical, spatial, temporal, and methodology checks, each normalized dynamically. Epochs below a strict minimum threshold are dropped from the active reward loop and flagged for manual review.

PONO credentials are non-transferable, KYB-gated, and tied to ongoing service. Operator vesting is forfeitable. Single-validator falsification is detectable by neighbors; cluster falsification is suppressed by spatial-variance correlation.

Decoupling raw telemetry *from* *execution*.

6.1 Data Availability and Scale Logic

To prevent ledger bloat and insulate the network from variable transaction fees, raw telemetry is decoupled from execution. Detailed payloads are compiled off-chain and archived within decentralized data-availability layers (Arweave, Celestia, or equivalent) for long-horizon retrievability. To anchor datasets on public ledgers with constant-time scaling, the Oracle Layer packages thousands of validated Layer 2 packets into geographic and temporal epochs and constructs a Merkle tree.

6.2 SaveCard Production Data Primitive

The output of this aggregation is the SaveCard, the protocol's primary evidence asset: a portable, cryptographically sealed, fully auditable package of verified environmental telemetry for a distinct time and place. Instead of forcing an auditor through billions of unorganized entries, the SaveCard packages a window into a standardized object anchored on Cardano via CIP-68.

Two chains. *One signing architecture.*

7.1 Two-Chain Ledger Architecture

Archival and Custody Layer (Cardano Mainnet). Cardano's Extended UTXO design, deterministic gas mechanics, and rich native-token metadata host the permanent SaveCard audit trail and international carbon-registry connections. **Execution and Incentive Layer (Base).** Base, the Coinbase-developed Ethereum Layer 2, delivers EVM-native execution, deep liquidity, and low transaction friction for continuous reward distribution, MLMA activity, and veMLMA governance.

7.2 Cardano Asset Representation (CIP-68)

SaveCards are minted on Cardano using CIP-68, which splits the asset into an unalterable reference token carrying the cryptographic data roots and a user-facing token governing access, so metadata states advance through programmatic governance while the evidence record stays immutable.

7.3 Independent Operation, Not Bridged

The two chains operate independently. SaveCards live on Cardano; the MLMA token, veMLMA staking, governance, and reward distribution live on Base. The protocol does not require the chains to share state through a bridge, and none is deployed at the Token Generation Event. A Cardano-side MLMA representation is a Phase 2 question contingent on bridge selection and security audit, and is not on the critical path.

The map problem, *solved with H3.*

8.1 H3 Geographic Optimization

To prevent clustering in hyper-connected urban locations, the protocol maps Earth's surface into hexagonal cells using the H3 spatial index (open-source, originally developed at Uber), tracking all reward coefficients at Resolution 5. Resolution 5 balances regional granularity against governance manageability.

H3 RESOLUTION	UNIQUE CELLS	AVG AREA	AVG EDGE
5	2,016,842	252.9 km ²	8.54 km

This solves the map problem: generic incentive designs fall in the physical world when they reward duplicate density inside one affluent neighborhood. Mālama anchors rewards to geographic and demand value, not population density.

8.2 Hex Type and Data Demand Score

Two bounded multipliers set a hex's relative value, both governance-voted. The Hex Type multiplier runs from 0.95× (Urban Core) through Urban 1.00×, Suburban 1.10×, Rural 1.20×, to Remote 1.30×, rewarding the premium value of undermonitored coverage. The Data Demand Score, from 0 to 100 and recomputed quarterly, measures what commercial, regulatory, and research buyers would pay for hardware-signed data from a cell, and maps to a 0.70× to 1.30× multiplier (DDS Multiplier = 0.70 + DDS × 0.006).

8.3 Genesis 200 Reward Calculation

Genesis 200 operator rewards follow the ratified Genesis Pricing v1.0 model. Each operator's eligibility is a 125,000 MLMA base scaled by the multipliers, then normalized across the cohort to the 25M Genesis pool:

```

Calculated Eligibility = 125,000 base
    × Genesis Year 1 (1.5×)
    × Hex Type (0.95-1.30×)
    × Data Demand Score (0.70-1.30×)

Final Earned = Calculated Eligibility × (25,000,000 / total cohort eligibility)
  
```

Rewards are relative and cohort-normalized, not fixed, and vest against operational milestones (15 / 15 / 20 / 20 / 30) over twelve months from hardware activation. The Genesis 200 bundle includes no pre-allocated MLMA grant; operators earn exclusively through this formula based on sustained service.

Six gateways and a *programmatic waterfall.*

9.1 Core Functional Gateways

The Redemption Layer handles enterprise data access and public economic distribution through six gateways: the historical SaveCard retrieval portal for auditors and buyers; the programmatic MLMA claiming engine on Base; veMLMA vote-escrowed lockups gated by the PONO credential and the 10% per-UBO cap; decentralized parameter adjustment under tiered governance thresholds; live calibration analytics; and the LCO₂ collateral management framework for carbon-finance pre-funding.

9.2 Programmatic Revenue Waterfall

All external enterprise capital from data licensing, verification fees, and oracle operations passes monthly through an unalterable smart-contract waterfall, in two phases separated by the 250M circulating-supply burn floor.

PHASE	BURN	OPERATORS	VEMLMA	FOUNDATION
Pre-burn-floor, until 250M circulating	45%	20%	15%	20%
Post-burn-floor, after 250M reached	0%	20%	15%	65%

Separately, validator fees, real commercial revenue paid in USDC, are distributed continuously to the operators whose hexes produced the data, weighted by uptime and PONO standing, entirely outside the MLMA emissions cap. The burn is the structural deflationary feature: emissions expand supply during cold-start while the burn contracts it as revenue scales, approaching the 250M floor from below.

Commercial product catalog and *unit economics*.

To align the whitepaper with the companion financial model, the network is commercializing across a structured product catalog. The entries below are reference categories rather than locked SKUs, with final pricing and margins finalizing through Genesis 200 delivery.

PRODUCT CATEGORY	VERTICAL / APPLICATION	TIER
Field Signing Node (Core)	Core signing platform	Entry
ERW Soil Sensor	Enhanced rock weathering	Mid
ERW Aqueous Sensor	Ocean alkalinity tracking	Mid
Biochar Process Controller	Pyrolysis control (basic to industrial)	Mid / Premium
Direct Air Capture Monitor	DAC facility monitor	Enterprise
Energy Substation Tracker	Grid telemetry	Mid
Rack-Mount AI Compute Monitor	AI compute facility	Enterprise
Genesis 200 Hex-Zone Bundle	Geographic operating rights	\$2,000

On spatial bundling. For institutional deployments requiring exclusive regional rights, the field signing node is commercialized as the Genesis 200 Hex-Zone Bundle at \$2,000, providing the hardware, a non-exclusive geographic operating license for one H3 Resolution 5 cell, and validator registration. The bundle does not include a pre-allocated MLMA token grant; operators earn MLMA exclusively through the validation reward formula based on service performance.

Rack-level signing for *hardware-attested* AI compute.

11.1 The Rack Attestation Architecture

Mālama's rack-form-factor signing device audits high-performance computing facilities. Rather than inferring emissions from historical invoices, it records energy draw at the power distribution unit at the rack, signs every record inside a tamper-resistant secure element before release, and anchors the signed record to a public ledger. It integrates a high-precision energy metrology IC for real-time voltage, current, and phase, with a dedicated processor running an isolated trusted execution environment; every signed packet binds device identity, timestamp, energy reading, and a monotonic counter into one cryptographic digest.

11.2 Real-Time Emission Flow Oracle Mapping

The device cross-references real-time power draw against live spatial emission indices via regional grid APIs such as ElectricityMaps and WattTime, mapping the marginal carbon intensity of operations down to the hour and location. Telemetry feeds directly into the Mālama Hex Node validator network and produces hardware-verified Scope 2 disclosure records for the operator, rather than a separate carbon instrument.

11.3 The Green-Grid Cross-Vertical Bridge

Rack-level data is synchronized with grid-meter deployments at adjacent substations, creating a multi-point ledger that maps energy generation to compute consumption so buyers and auditors can verify that AI compute claims align with verified upstream generation.

ENERGY (EXEMPLAR)

944 Wh

WATER

0.74 L

GRID CARBON

412 g/kWh

VS SELF-REPORT

**orders of
magnitude**

Two instruments. *One provenance chain.*

Mālama issues two carbon instruments, both backed by SaveCard evidence and sharing a common cryptographic provenance chain back to hardware-signed source data.

INSTRUMENT	CLASS	WHAT IT REPRESENTS
LCO ₂	Pre-finance	A tokenized pre-finance instrument issued against the live, verified data stream at a protocol-set discount to expected verified value.
VCO ₂	Compliance	A verified compliance-grade credit issued on registry approval and full methodology validation, with cryptographic chain of custody from device signature to ledger record.

AI compute and the other verticals do not mint separate carbon instruments; they produce hardware-signed disclosure records formatted for SEC climate disclosure, EU CSRD, and SBTi reporting. Both instruments and all disclosure records inherit the same property as the SaveCards beneath them: they can be checked, not just believed.

Nine markets. *One signing architecture.*

Mālama's commercial structure aligns with a broader maturation of the DePIN sector, which has surpassed \$10 billion in circulating market capitalization and now trades at sustainable 10 to 25× revenue multiples rather than the speculative cycles of earlier eras. The protocol monetizes across nine verticals on one signing architecture:

Carbon verification (dMRV) for biochar and enhanced rock weathering, cutting registry validation timelines. **AI compute emissions verification** via per-rack Scope 2 attestation. **Energy-market data licensing** for grid forecasting. **Parametric insurance triggers** for index-based contracts. **EUDR supply chain attestation** for regulated production zones. **Prediction market resolution** on environmental events. **Smart agriculture** data and soil intelligence. **Smart City** municipal and grid environmental data. **LCO₂ / VCO₂ settlement** for cross-border climate-finance clearing.

Per-vertical market sizing, current data reliance, and the trust gap each market faces are detailed in the companion Markets deep-dive. Modeled figures are grounded in unit economics, not headline addressable-market claims.

500M hard cap. 60M emissions. *Eight years.*

14.1 Fixed MLMA Supply and Allocation

MLMA is a digital tool: an asset used to perform a function in the network, the validation credential and access right, not held as an investment instrument. Total supply is hard-capped at 500,000,000 MLMA, enforced on-chain via an immutable cap parameter that governance cannot modify.

HARD CAP	EMISSIONS	WINDOW	PUBLIC SALE
500M	60M / 12%	8 years	0 at TGE

POOL	ALLOC	TOKENS	VESTING
Community	45.0%	225,000,000	Itemized below
Investors	20.0%	100,000,000	12-mo cliff + 48-mo S-curve
Insiders (Team + Advisors)	20.0%	100,000,000	12-mo cliff + 48-mo S-curve
Foundation / Treasury	15.0%	75,000,000	Governance-directed
Public Sale	0%	0	None at TGE

COMMUNITY SUB-ALLOCATION

COMPONENT	ALLOC	TOKENS	FUNCTION
Network emissions (Yrs 1-8)	12.0%	60,000,000	KPI-scaled validator rewards
Genesis 200 operators	5.0%	25,000,000	200 hex zones, formula-earned
Stewardship Pool	1.75%	8,750,000	Indigenous community-led, FPIC-gated
Post-emission governance reserve	26.25%	131,250,000	Unreleased after Year 8; governance-directed

14.2 Eight-Year Smooth Emission Taper

YEAR	CEILING	MONTHLY	PHASE
1	12.0M	1.000M	Cold-start
2	14.0M	1.167M	Scaling
3	12.0M	1.000M	Transitioning
4	9.0M	0.750M	Revenue-majority
5	6.0M	0.500M	Revenue-funded
6	4.0M	0.333M	Revenue-funded
7	2.0M	0.167M	Revenue-funded
8	1.0M	0.083M	Final emission year
9+	0	0	Permanent revenue-funded
Total	60.0M		12.0% of supply

Monthly release scales with on-chain growth (validator count, SaveCard count, veMLMA TVL) under a smooth function with a 25% floor and 100% ceiling, preventing emission cliffs and threshold-edge gaming. Honestly framed: the protocol does not survive emission cessation in Year 1; it survives by Year 4 to 5, the standard DePIN cold-start pattern, as revenue scales to fund operator and staker distributions.

Recurring oracle fees. *Not asset sales.*

15.1 The Core Distinction

Mälama separates recurring oracle and data revenue from non-recurring asset sales. Genesis 200 Hex-Zone sales (\$390,000 external at the Phase 1 cap, 195 external nodes at \$2,000) are recognized as non-recurring infrastructure revenue at delivery. Validation fees, oracle subscriptions, and settlement fees are recurring.

15.2 Year 5 Recurring Revenue Profile

VERTICAL	YEAR 5 ORACLE/SETTLEMENT
Carbon verification (dMRV)	\$10.80M
AI compute emissions verification	\$18.00M
Energy-market data licensing	\$8.06M
Parametric insurance triggers	\$1.80M
EUDR supply chain attestation	\$5.50M
Prediction market resolution	\$1.50M
Smart agriculture SaaS	\$9.00M
Smart City (municipal / grid)	\$12.50M
LCO ₂ / VCO ₂ settlement fees	\$1.28M
Total oracle / settlement	\$68.44M

Total Year 5 modeled revenue, adding hardware sales and recurring SaaS on the installed base, reaches \$147.44M. All figures are modeled base-case estimates, not audited projections, subject to material variance based on market penetration, deployment, and pricing. The protocol publishes no MLMA price forecasts or projected per-operator distributions.

Serviceable revenue, *per vertical.*

Institutional credibility requires rejecting vague, trillion-dollar addressable-market claims in favor of unit economics, realistic corporate buying patterns, and documented friction. Each vertical is modeled from a defined monetized unit and commercial mechanism.

SEGMENT	MONETIZED UNIT	COMMERCIAL MECHANISM
Carbon verification	Verification data access	Fixed fee per verified ton of removal via SaveCards
AI compute	PDU energy and emission maps	Enterprise SaaS per audited server rack
Energy-market data	Weather and grid API streams	Multi-year B2B licensing for grid forecasting
Parametric insurance	Threshold logs	Oracle fees embedded in insurance smart contracts
EUDR supply chain	Hardware-verified baselines	Per-region deforestation-free attestation
Prediction markets	Resolution data	Oracle resolution fees on environmental events
Smart agriculture	Soil and field intelligence	Subscription
Smart City	Localized environmental profiles	Public-sector data procurement agreements
LCO ₂ / VCO ₂	Settlement verification	Settlement fees on conversions

— 17 · LIVE PILOTS AND FINANCIAL PROFILE

2,786 SaveCards. *Live since June 2024.*

17.1 Live Field Operational Status: Texas Pilot Node #1

Mālama anchors its methodology in active field data. Since June 2024, the protocol has operated the Texas Pilot Node #1, an agricultural deployment monitoring soil and environmental conditions continuously, confirming edge compute stability, backhaul durability, and script security across multiple seasonal horizons.

SAVECARDS

2,786+

LEDGER

**Cardano
preprod**

SINCE

June 2024

GAPS

Zero

17.2 Active Financing Profile

Expansion is backed by an active \$5,000,000 seed round at a \$20,000,000 post-money valuation cap via SAFE with token side letter, funding hardware manufacturing, the core technical team, and third-party security audits across the Cardano and Base implementations. The Genesis 200 operator sale opens June 1, 2026, with hardware delivery at the end of Q4 2026, mainnet activation in Q4 2026 ahead of TGE, and an independent Genesis Hex Sale audit in early 2027.

Parallel onboarding to *Puro.earth and Isometric.*

Mālama's dMRV platform is an implementation layer that works with major registries, running parallel onboarding with both Puro.earth and Isometric so SaveCard data meets the demands of nature-based and durable industrial removals simultaneously. Mālama is co-authoring a methodology amendment for the Isometric v2 enhanced-weathering protocol, introducing rules for edge-enclave data logging that shift authentication from periodic manual sampling toward continuous, cryptographically-signed observation.

Scarcity allocation, the delegation flywheel, *and FPIC.*

19.1 Phase 1: Scarcity Allocation

Initial access is restricted to strategic deployment zones, with NFT-HEX rights prioritized to regions with active carbon removal or acute data shortages. The Genesis 200 release covers 200 hex zones, 195 external and 5 reserved by Mālama Labs, across launch markets including Los Angeles, New York, London, Tokyo, and Idaho / Sun Valley.

19.2 Phase 2: The Delegation Flywheel

An automated delegation economy lets capital providers secure geographic rights via NFT-HEX assets and delegate physical node operation to local field operators, matching capital with on-the-ground operation without centralized deployment teams.

19.3 Free, Prior, and Informed Consent

FPIC frameworks and Indigenous land stewardship rules are a structural boundary for global scaling, under final review led by Jeffrey Wise (COO, Hawai'i Field Operations and Indigenous Stewardship). The protocol reserves expansion within native land boundaries until these gates are finalized.

How Mālama maps against *legacy open architecture.*

DOMAIN	LEGACY OPEN ARCHITECTURE	MĀLAMA IMPLEMENTATION
Physical node substrate	White-box switches, commodity racks	Field signing nodes with hardware secure element and interchangeable sensor modules
Core edge intelligence	Virtualized components, central operators	Edge processors with local inference and integrated GNSS boundary verification
Data provenance and control	In-band telemetry via programmable switches	Multi-tier Class A-E validation generating cryptographic SaveCards
Control plane distribution	Central cloud multi-tenant control plane	Two-chain ledger: fast settlement on Base, archival custody on Cardano
Ecosystem scaling	Central cloud management platform	Emissions bootstrap paired with a smart-contract revenue waterfall

Three gateways. *One summit.*

21.1 Core Engineering Gateways

Before public mainnet, the core team must clear three milestones: independent smart-contract and cryptographic audits across both the Cardano (Aiken / Plutus V3) and Base (Solidity) implementations; extended environmental stress testing of the sensor bus across the full operational temperature envelope; and anomaly-detection model tuning on expanded pilot data to minimize false positives.

21.2 Sun Valley Forum Milestone

The production-readiness compliance and engineering review is scheduled around the Sun Valley Forum (June 15 to 18, 2026), a primary technical review gate ahead of the Q4 2026 launch window.

SUN VALLEY REVIEW

Jun 2026

HARDWARE SHIPS

**End Q4
2026**

MAINNET

Q4 2026

BOOT + AUDIT

Early 2027

Digital tool under *S7-2026-09*.

This section is a preliminary statement of posture, not legal advice. Mālama is engaged with qualified securities counsel to finalize the analysis against S7-2026-09 before any US-facing offering; no US public token sale proceeds until that analysis is complete.

22.1 MLMA as a Digital Tool

Under the March 17, 2026 SEC-CFTC Joint Interpretation, crypto assets fall into five categories: digital commodities, digital collectibles, digital tools, stablecoins, and digital securities. Digital tools are assets that perform a practical function, credentials, memberships, title instruments, or identity badges, used or consumed rather than held as investment instruments. MLMA fits this category: it is the functional credential to validate data and participate in governance, an access right for protocol services payable in MLMA or stablecoin, and an operational coordination mechanism. Staker distributions are paid in stablecoin from protocol fees, not as an MLMA-denominated yield, and validator rewards are minted by an immutable contract against on-chain metrics. The Interpretation separately treats crypto network validation activities, including proof-of-stake, as generally outside the securities laws, and validation is the activity for which operators earn MLMA. MLMA is not a "utility token" in the loose pre-Interpretation sense, which is not a category under S7-2026-09.

22.2 Decentralization Milestone Registry

The Interpretation judges decentralization against the issuer's own published definition. Mālama publishes a Decentralization Milestone Registry of objective, on-chain-attested milestones, from mainnet through firmware open-sourcing, permissionless onboarding, oracle decentralization, and governance handoff, whose completion marks the cessation of essential managerial efforts. The registry, not the date of mainnet or TGE, is the controlling definition.

22.3 Labs and Foundation Separation, and Instruments

The Interpretation's collusion concept requires substantive separation between Mālama Labs (Delaware C-Corp) and the Mālama Foundation (501(c)(3)): independent boards and counsel on material matters, distinct communications, no coordinated promotion of token economics, and separated treasury administration. The Genesis 200 bundle is structured as hardware plus a non-exclusive geographic operating license, with MLMA earned only through the validation reward formula, which anchors token receipt to substantial ongoing service. SaveCards are verified digital evidence, not investment products; LCO₂ and VCO₂ are environmental settlement instruments whose transfer is governed by smart-contract authorization consistent with registry and cross-border climate-finance rules.

The token serves *the protocol*.

Mālama Labs delivers a hardware-verified infrastructure network for the parts of the climate and compute economy that currently run on estimates. Edge-bound cryptography on Mālama field signing nodes, a six-layer architecture, a 500M-capped digital tool that emits for eight years and then lives on revenue, and a regulatory posture built for the 2026 framework together make a network where the data can be checked, not just believed. With nine markets on one signing architecture, a smooth eight-year taper transitioning to revenue-funded economics, and live validation from the Texas Pilot Node, Mālama establishes a scalable, sustainable data platform for the global climate economy.

The token serves the protocol, not the speculation. The validators serve the network, not the token.

SaveCard structural *payload*.

The standardized schema generated by Mālama field signing nodes at the close of every collection interval, integrating hardware identity, sensor state, spatial index, and cryptographic signature.

```
{
  "savecard_metadata": { "version": "1.0", "batch_id": "0x7a9c8b2d...",
    "epoch_timestamp_start": 1773881041, "epoch_timestamp_end": 1773884641 },
  "hardware_identity": { "node_id": "0x00F1A9B2C3D4E5F6...",
    "secure_element_attestation": "ECDSA-signed at silicon", "firmware_version": "1.0.0" },
  "spatial_index": { "h3_resolution": 5, "h3_cell_id": "85283473ffffffff",
    "hex_type": "Rural", "data_demand_score": 71, "average_cell_area_km2": 252.9 },
  "validation": { "ensemble_score": 0.945, "anti_spoofing": "PASSED_CLASS_A_E",
    "proof_of_truth": "reached" },
  "anchoring": { "chain": "Cardano", "standard": "CIP-68", "lifecycle_state": "Verified" },
  "cryptographic_signature": "0x7F2A3B4C..." }
```

Six phases to a *settled* SaveCard.

A reading becomes a settled SaveCard through six sequential phases. The chains operate independently; no cross-chain bridge is deployed at TGE.

01 Edge signing at the field signing node. **02 Edge verification** across the Class A-E threat taxonomy and Proof-of-Truth consensus. **03 Merkle aggregation** in the Oracle Layer. **04 SaveCard issuance** on Cardano via CIP-68. **05 Reward computation and distribution** on Base under the Genesis Pricing formula and the revenue waterfall. **06 Governance-controlled redemption** of operator claims, veMLMA distributions, and treasury actions.

C · OPERATIONAL THREAT MODEL

Five classes. *Two systemic vectors.*

THREAT	VECTOR	DETECTION	MITIGATION
Class A · RF/GPS spoofing	Forge location for multipliers	Multi-tower GNSS timing deltas	Reject packet, flag cell, manual review
Class B · Stream injection	Simulate sensor values	Secure-element signature check	Drop unsigned data, blacklist keys
Class C · Neighbor spoofing	Many nodes simulate coverage	H3 spatial variance correlation	Down-weight cell, PONO revocation, vesting forfeiture
Class D · Historical replay	Re-transmit old data	Monotonic sequence nonces	Invalidate epoch, expire nonces
Class E · Environmental cloning	Manipulate local environment	Edge plausibility and drift filters	Flag anomalies, require recalibration
Sybil deployment	Virtualize nodes from templates	Hardware provisioning handshake	Deny registration, KYB-gated PONO
Outlier flooding	Overload validators	Per-hex ingestion rate limits	Throttle endpoints, isolate node IDs

Sources, *and the fine print.*

[1] Lin et al., DePIN: Challenges and Opportunities (2024). [2] H3 Spatial Indexing Documentation (open-source, originally developed at Uber). [3] Messari Research, State of DePIN (2025). [4] World Economic Forum, Technology Convergence Report (2025). [5] Puro.earth, Durable Carbon Removal Frameworks. [6] Verra VM0042 v2.2. [7] Helium Network, Physical Resource Networks (2024). [8] Filecoin, Proof-of-Physical-Work Frameworks. [9] ElectricityMaps and WattTime grid-intensity APIs. [10] ESMA, Markets in Crypto-Assets (MiCA) Operational Guidance. [11] SEC-CFTC Joint Interpretation S7-2026-09 (March 17, 2026).

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