ETEC Lab — Canonical System Reference (Full)

Local-First Cyber-Physical Observatory for Environmental Telemetry, Event Correlation, and Forensic Analysis

1. Purpose & Intent

ETEC Lab is a local-first cyber-physical observatory designed to measure, record, and correlate environmental and network events without reliance on external cloud infrastructure. The system prioritizes truth preservation over automation and separates observation, enrichment, storage, and interpretation into discrete roles.

The system is explicitly forensic in nature. All observations are preserved in append-only form, enriched through non-destructive analysis layers, and correlated after the fact using trusted temporal and physical anchors.

2. Core Architectural Principles

ETEC Lab is event-based rather than stream-based. Sensors emit discrete observations rather than continuous recordings. Each observation is treated as evidence, not as an assertion of meaning.

Interpretation is layered and reversible. Raw observations are never overwritten. Readable, confidence-scored, and recommendation-bearing artifacts always reference their raw origin via explicit provenance pointers.

Failure modes are expected and logged. Power loss, network absence, or sensor failure must produce data rather than ambiguity.

3. Tiered System Architecture (Locked)

Tier 0 — Brain / Cockpit: The Mac serves as the primary compute, visualization, correlation, and operator interface. It runs sensor applications such as CamUtil, produces enriched and readable artifacts, and provides human-facing control and analysis. The Mac is not a source of authoritative time and is not the sole keeper of raw truth.

Tier 0.5 — Truth Anchors: Independent witnesses constrain reality. GPS provides absolute time, Ghost provides local temporal and presence anchoring via BLE, and UPS telemetry provides power-state truth. These anchors do not interpret events; they bound interpretation.

Tier 1 — Aggregator (Raspberry Pi #1): Collects events from edge sensors and Mac-based sensors, normalizes formats, applies trusted timestamps, and forwards events downstream. This node does not provide long-term storage or user interfaces.

Tier 1 — Vault (Raspberry Pi #2): Acts as the append-only source of record. Events are persisted to local high-capacity storage for retention, replay, and forensic review. The vault survives Mac sleep or absence.

Tier 2 — Edge Sensors: ESP32 nodes, BLE radios, cameras, and audio triggers observe and emit events. They do not decide meaning and are treated as untrusted witnesses.

4. Event Model & Schema Alignment

ETEC Lab events preserve a strict separation between raw observation and derived interpretation. Raw files contain minimally processed sensor output. Readable and enriched files add confidence scoring, identity hints, proximity buckets, and recommendations without mutating the original evidence.

Each enriched artifact references its raw origin using explicit provenance fields and stable fingerprint identifiers to support long-term correlation.

5. Persistence & Ingest Contract (Canonical)

ETEC Lab defines a single authoritative persistence contract implemented by the Vault node (Raspberry Pi #2). Any node that requires durable storage must use this contract. Direct disk writes by sensors, aggregators, or Mac applications are explicitly forbidden for canonical storage.

Write Path (Ingest): POST http://pi-logger.local:8088/v1/ingest. This endpoint accepts append-only event submissions. The Vault is responsible for validating, timestamping if required, and persisting events without mutation.

Read Path (Readback / Debug / UI): GET http://pi-logger.local:8088/v1/events?node_id=&limit;=. This endpoint provides controlled, bounded access to stored events for debugging, visualization, and forensic replay.

This explicit contract enforces a single choke point for truth persistence, prevents side-channel storage, and guarantees that all long-term records are discoverable, auditable, and replayable.

6. Canonical Data Flow

Edge Sensors $\rightarrow$ Aggregator $\rightarrow$ Vault $\rightarrow$ Mac. Mac-based sensors also forward their observations through the Aggregator and Vault to preserve a unified truth pipeline. Visualization and correlation always occur after data has been safely recorded.

7. Naming & Canonical Vocabulary

Formal Name: Local-First Cyber-Physical Observatory for Environmental Telemetry, Event Correlation, and Forensic Analysis.

Internal Working Name: ETEC Lab (Environmental Telemetry & Event Correlation).

8. Canonical Principle

The Mac thinks. The Pis remember. The sensors observe. The UI explains. The anchors constrain reality.