Field Controller Layer

See overview: System Architecture Overview

The **Field Controller Layer** is the on-site, **safety-authoritative AOFS controller**. It is responsible for executing irrigation schedules, monitoring sensors, enforcing fail-safes, and ensuring reliable operation even **without network connectivity**.

All AOFS deployments **must** include a Field Controller for each irrigation site or zone.

1. Purpose

The Field Controller:

- Executes irrigation schedules in real time.
- Reads all field sensors and enforces safety logic.
- Operates autonomously offline; cannot be bypassed by Farm or HQ Controllers.
- Provides local operator monitoring for **non-critical functions only**.
- Logs all events, including safety triggers, irrigation actions, and manual operator inputs.

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2. Core Responsibilities

1. **Irrigation Execution**

- Opens and closes valves according to schedules.
- Controls pumps based on tank levels, flow, and pressure.
- Stops irrigation when safety thresholds are exceeded.

2. **Sensor Monitoring**

- Soil moisture per zone
- Water tank levels (FULL / LOW floats)
- Flow meters and pressure sensors
- Battery voltage / current
- Rain detection (e.g., tipping bucket)
- Optional: Optical / camera data for local analytics

3. **Fail-Safe Enforcement**

- Prevent over-irrigation, flooding, and pump damage.
- Stop pumps when tank is LOW or battery voltage below minimum.
- Stop irrigation during rain lockout or safety-triggered conditions.
- Operates independently of software updates or network availability.

4. **Local Operator Interaction**

- Embedded interface (small touchscreen, local web UI, or buttons + display).
- Operators may view data, acknowledge alerts, or trigger **non-critical overrides** only.
- Critical irrigation decisions **cannot be overridden** by the operator.

5. **Event Logging & Auditability**

- All irrigation events, sensor readings, alerts, and operator interactions must be logged with timestamps.
- Logs are persisted locally and later transmitted to Farm/HQ Controllers during sync.

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3. Offline Operation Requirements

- The Field Controller **must operate independently** of LAN, WiFi, or cellular connections.
- Irrigation, safety enforcement, and data collection must **continue uninterrupted**.
- Any local operator interface functions must **not compromise safety-critical rules**.

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4. Optional Weather-Aware Control

- Field Controllers operate fully offline by default using local sensors, operational logic, and historical data
- When internet connectivity is available, controllers may fetch local or global weather forecasts
    - High wind, storm, or extreme precipitation warnings trigger automated alerts to operators
    - Controllers can temporarily maintain minimum water levels in tanks, suspend irrigation, or adjust equipment operation to prevent structural damage
    - Forecasts may also inform reservoir management, overflow routing, irrigation sequencing, and protective actions for farm structures
- Local wind measurement devices are recommended at every farm to provide **real-time, farm-wide risk assessment**
    - Controllers evaluate wind conditions continuously for all critical infrastructure
    - Immediate actions are triggered if an asset is at risk (e.g., tanks, greenhouses, solar panels, or lightweight structures)
    - Actions may include maintaining minimum ballast, suspending irrigation, adjusting movable structures, or sending operator alerts
- All forecast- and wind-informed actions are **non-normative** and optional; offline/manual operation remains fully functional
- Actions based on wind measurements or forecasts **must never override core safety-critical rules**
- All such preventive actions and alerts are logged for auditability

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5. Authority Rules

- Field Controller is **fully authoritative** for all safety-critical operations.
- No remote controller or operator input can bypass Field Controller fail-safes.
- Farm or HQ Controllers may **suggest configuration or irrigation adjustments**, but Field Controller rules take precedence.

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6. Human Interface

- Minimal embedded UI for operators:
  - View irrigation status per zone
  - See safety alerts (tank LOW/FULL, battery low, rain lockout)
  - Acknowledge alerts
- Operators **cannot override critical safety logic**.
- Operator actions are logged for audit purposes.

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7. Hardware & Integration

- Embedded microcontrollers (ESP32, Arduino, or industrial equivalent).
- Interfaces:
  - PIO/relay control for pumps and valves
  - Analog/digital inputs for sensors
  - Optional serial / I2C / SPI for additional modules
- Power: must tolerate brownouts, low-voltage conditions, and recover automatically.
- Optional backup: small local battery or UPS to maintain control during power interruptions.

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8. Compliance Notes

- AOFS compliance **requires each field site to have a Field Controller**.
- All safety and irrigation decisions must be logged locally.
- Any attempt to bypass Field Controller logic by higher-layer controllers **invalidates AOFS compliance**.
- Field Controller must remain fully functional **even if disconnected from Farm or HQ controllers**.

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9. References

- System Architecture Overview
- Farm Controller Layer (Local / Federated)
- Hydraulic & Water Systems
- Electrical & Control Interfaces
- Measuring, Monitoring & Documentation Systems