Measuring, Monitoring & Documentation Systems

The **Sensors Layer** defines all devices and measurement systems used by AOFS controllers to monitor irrigation, energy usage, water distribution, and environmental conditions. All AOFS-compliant deployments **must implement the sensors and documentation systems specified here**.

1. Sensor Categories

AOFS uses six main sensor categories:

- **Soil Monitoring Sensors**
- **Weather Monitoring Sensors**
- **Water Monitoring Sensors**
- **Power / Energy Sensors**
- **Optical / Camera Monitoring Systems**
- **Human Input / External Event Logging**

Notes:

- “Human Input” refers to events or actions manually logged by farm staff, such as fertilizer application, pruning, or other field activities.
- AOFS treats these logs as **first-class data**, integrated with automated sensor measurements for analytics and experimental comparisons.

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2. Soil Monitoring Sensors

Purpose: Measure soil conditions to optimize irrigation schedules.

Required Measurements:

- Soil moisture (volumetric water content) per zone
- Soil temperature (optional but recommended)
- Electrical conductivity (optional; for salinity monitoring)

Placement Guidelines:

- At least one sensor per irrigation zone
    - Multiple sensors for large or heterogeneous fields
- Sensors should be placed at root depth appropriate to the crop type

Data Collection:

- Sample at a frequency suitable for crop needs (typically 15–60 min)

- Data logged locally in Field Controller and synced with Farm/HQ controllers

Calibration & Maintenance:

- Sensors must be calibrated according to manufacturer recommendations
- Regular inspection to prevent soil compaction or damage

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3. Weather Monitoring Sensors

Purpose: Monitor on-site weather conditions to inform irrigation decisions and safety lockouts.

Required Measurements:

- Rainfall (e.g., tipping bucket rain gauge)
- Ambient temperature
- Relative humidity
- Wind speed (optional but recommended)
- Solar radiation / light intensity (optional)

Placement Guidelines:

- Rain gauges placed in open areas, away from obstructions
- Temperature and humidity sensors shielded from direct sunlight and precipitation
- Wind sensors mounted at standard height for consistent readings

Data Collection:

- Sample at frequency sufficient for crop and irrigation needs (typically 10–30 min)
- Logs sent to Field Controller for local decision-making and later synced with Farm/HQ controllers

Integration with AOFS:

- Rainfall triggers **irrigation suspension / rain lockout**
- Temperature and humidity can refine irrigation thresholds and scheduling
- Optional predictive analytics using solar radiation and wind

Calibration & Maintenance:

- Regular inspection and cleaning of rain gauges
- Sensors must be calibrated according to manufacturer specifications
- Logs of calibration and maintenance events must be maintained

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4. Water Monitoring Sensors

Purpose: Ensure safe and efficient water delivery.

Required Measurements:

- Tank levels: FULL and LOW float switches
- Flow meters on main and zoned pipelines
- Pressure sensors for distribution lines
- Optional: rain gauges (redundant, for additional verification)

Placement Guidelines:

- Tank sensors at critical fill/drain points
- Flow meters before distribution manifolds
- Pressure sensors after pumps and at main lines

Safety Requirements:

- Water sensors must enforce Field Controller fail-safes (pump cutoff, overflow prevention)
- Must function independently of network connection

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5. Power / Energy Sensors

Purpose: Monitor energy consumption and optimize PUE (productive use of electricity).

Required Measurements:

- DC battery voltage and current
- Pump energy consumption
- Valve power usage
- Optional: solar panel output monitoring

Placement Guidelines:

- Measure energy at the main DC bus and key loads
- Optional per-zone energy monitoring for detailed efficiency analysis

Integration:

- Data feeds into Field Controller for fail-safe shutdowns on low voltage
- Logged for auditing and analytics

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6. Optical / Camera Monitoring Systems

Purpose: Supplement sensor data with visual field observations. Cameras are used primarily for **documentation**, not for automated decision-making. Only **still images** are part of AOFS; full video surveillance is outside the standard and can be implemented separately. Images are intended to be reviewed by HQ or Farm staff.

Use Cases:

- Crop growth monitoring
- Pest or disease detection (optional, non-critical for irrigation)
- Soil surface moisture and coverage assessment

Guidance on Operational Schedule (example only):

- Cameras may capture images at key times, e.g.:
  - Daily at a consistent time (e.g., noon)
  - Before and after irrigation events
- AOFS-compliant implementations **must allow configurable capture schedules**; exact timing is left to farm operators.

Requirements:

- Cameras must be oriented for optimal coverage of zones
- Images must be **timestamped and logged**
- Data should integrate with Field Controller for storage and review
- No mandatory AI analysis; **optional AI-based image analysis interfaces** may be implemented
- All AI processing must not interfere with manual review or core logging functions

Data Logging & Access:

- All images must be stored locally on the Field Controller and synced to Farm/HQ controllers
- Metadata must include timestamp, irrigation event reference (if applicable), and camera ID

7. Data Logging & Documentation

- All sensor readings **must be logged locally** on the Field Controller
- Logs include timestamp, sensor ID, measured value, and status/quality flags
- Data must be synced with Farm Controller for aggregation and with HQ Controller for analytics
- Field workers may document crop growth, harvest outcomes, and environmental observations via **Field Survey Interfaces**, complementing automated measurements

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8. Calibration & Maintenance

- All sensors **must be regularly calibrated** according to manufacturer specifications
- Field inspections are required to prevent sensor drift, damage, or misplacement
- AOFS-compliant deployments **must maintain logs of calibration and maintenance events**

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9. Compliance Notes

- All AOFS deployments **must implement at minimum**:
  - Soil moisture per irrigation zone
  - Tank LOW/FULL switches
  - Flow meters and pressure sensors on all irrigation manifolds
  - Power monitoring for pumps and valves
  - Rainfall measurement for irrigation lockout
- Optional sensors (temperature, conductivity, wind speed, solar radiation, cameras) are recommended for **advanced optimization**, but not mandatory
- All data must be **timestamped, logged locally, and synchronized** according to federation rules

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10. External Event Logging

Purpose: Allow farm staff to document activities and events that are **not captured by sensors**, enabling data-driven research and experimental comparisons.

Examples of Loggable Events:

- Fertilizer application (type, amount, field/zone, date/time)
- Manual irrigation or drainage events
- Pest or disease treatments
- Planting, pruning, or harvest activities
- Any other relevant operational actions

Requirements:

- All events **must be timestamped and linked to a field or zone**
- Data entered by farm workers should be integrated with Field Controller logs
- Event entries should be **editable only by authorized personnel**
- Optional tags or categories can be used for easier filtering and analysis

Integration with AOFS:

- Logs can be synchronized with Farm and HQ Controllers for analysis and reporting
- Combined with automated sensor data, these logs enable **farm-level experiments and optimization studies**
- Supports structured comparisons between fields, irrigation regimes, crop varieties, or treatment methods

Best Practices:

- Encourage consistent data entry formats for reliable analysis
- Include guidance for field workers on what to log and how
- Enable audit trails for any edits or deletions

11. References

- Field Controller Layer
- Farm Controller Layer (Local / Federated)
- Hydraulic & Water Systems
- Electrical & Control Interfaces

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