

Scientific completeness and reproducibility requirements

Revision 1.2.1, 27 September 2026. Status: engineering screening, not scientific release. The requirement register contains 44 open evidence categories. It is a structured starting scope, not an exhaustive list of all scientific methods or all failure modes.

Completeness must be assessed against an agreed system boundary, operating envelope, interfaces, hazards, outputs and acceptance criteria. Millions of equations do not establish completeness. Repeated copies of equations are not additional theorems. No finite software package can honestly claim to implement all science or ensure life-friendly conditions everywhere.

A numerical result must record the exact equation/model revision, input values and units, data provenance and timestamp, solver settings, mesh/time step when relevant, convergence result, uncertainty and valid domain. Approximation and empirical correlation must not be mislabeled as a universal theorem.

Reproducibility requires a specified protocol and reference data; repeatability requires repeated outcomes under stated conditions. External validity requires independent sites, operators and conditions. A one-off success cannot close any industrial qualification gate. Statistical independence and representative sampling must be justified.

The 99 percent target needs a defined event, population, operating envelope and confidence level. The zero-failure Bernoulli example elsewhere in the app is only a narrow statistical calculation; it cannot establish whole-system feasibility, component dependence, environmental suitability or lifetime reliability.

Current software tests are useful implementation evidence. They are not measured verification of nozzle coverage, 28 degC, uniform regulated pressure, V-tail stability, buoyancy safety, ecological outcomes or profitable operation. All physical qualification gates therefore remain open.

State of the art requires a maintained, dated review of primary literature, standards, manufacturer qualification data and independent comparisons. This deliverable includes selected primary sources and targeted checks, not an exhaustive systematic literature review. Updating a model must trigger regression and scientific review before any gate is closed.

Mathematics

OPEN — Dimensional consistency and domain specification

OPEN — Conservation residuals and analytic limiting cases

OPEN — Spatial and temporal convergence with uncertainty bounds

OPEN — Independent solver comparison and sensitivity analysis

Water Spray

OPEN — Measured droplet size distribution and nozzle curves

OPEN — Coupled evaporation, breakup, deposition and wind profiles

OPEN — Humidity and heat balance closure across independent weather regimes

OPEN — Replicated local temperature measurements including extremes

Irrigation

OPEN — Soil retention, conductivity and wetting depth across field samples

OPEN — Crop and root-zone demand with salinity and drainage balance

OPEN — Emitter pressure-discharge curves and distribution uniformity

OPEN — Long-duration clogging, filtration, maintenance and water-quality evidence

Hydraulic Network

OPEN — Surveyed topology, elevation and simultaneous demands

OPEN — Pump, valve and regulator curves with pressure-dependent demands

OPEN — Surge, water hammer, air pockets, cavitation and outage cases

OPEN — Independent network solver benchmark and field pressure verification

Desalination

OPEN — Measured feed salinity, temperature and quality

OPEN — Qualified membrane performance and recovery limits

OPEN — Intake and brine environmental assessment

OPEN — Energy recovery, fouling, redundancy and delivered-water quality

Buoyancy And Structure

OPEN — Envelope gas, permeability, seams and pressure qualification

OPEN — Wind load spectra, yaw dynamics, flutter and fatigue

OPEN — Cables, anchors, geotechnics and pipe-envelope load transfer

OPEN — Fire, loss of lift, component failure and maintainability assessment

Materials Manufacturing

OPEN — Traceable material properties and allowable stresses

OPEN — Creep, UV, corrosion, cyclic load and joining qualification

OPEN — Full toleranced geometry and controlled process specification

OPEN — Supplier evidence, nondestructive inspection and part acceptance

Ecology And Climate

OPEN — Species-specific requirements, land use and exclusions

OPEN — Seasonal local and regional water/energy budgets

OPEN — Independent impact assessment including marine and downstream effects

OPEN — No extrapolation from local temperature to global habitability

Software

OPEN — Versioned inputs, equations, outputs and dependencies

OPEN — Unit, integration and invalid-state tests

OPEN — Independent reference cases and numerical error bounds

OPEN — Platform-specific execution and release integrity

Reproducibility

OPEN — Predefined protocol, measured endpoints and acceptance limits

OPEN — Replicates across independent runs, operators and relevant seasons

OPEN — Between-site or between-laboratory replication where applicable

OPEN — Raw data, calibration, missing-data handling and uncertainty record

Economics

OPEN — Dated supplier quotes and defined delivered service

OPEN — Lifecycle replacement, maintenance, energy and water scenarios

OPEN — Sensitivity to capacity factor, yield, climate and financing

OPEN — No revenue or ROI guarantee from engineering assumptions