

7.6.1.3 Evolution Deliverables & Phase Gates

Effective date: 2025-08-12 **Applies to:** All Evolutions under 7.6 Engineering **Audience:** Engineers, Test, QA, Safety/Security, Ops, EVOL Board **Purpose:** Define the complete, auditable deliverables required to pass the four phase gates of an Evolution—**Proposal** → **Work** → **Review** → **Freeze**—for both **documents** and **products** (RIG/SIM/SUBSYS/SYS/DECK/SPHERE).

1. Scope & Principles

- Evolutions are **controlled change waves**. Each wave produces a **complete, releasable set** of documents and (where applicable) product artifacts.
 - Every artifact must be **versioned, stateful** (DRAFT → REVIEW → FROZEN), and **traceable** to requirements and evidence.
 - Phase gates are **Go/No-Go decision points** owned by the EVOL Board.
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2. Roles (responsibility summary)

- **Evolution Owner:** accountable for scope, schedule, quality; maintains the Evolution index.
 - **Technical Reviewers** (discipline leads): approve content and test adequacy.
 - **QA/Compliance:** verify format, metadata, traceability, and standards mapping.
 - **Safety/Security:** own hazard analyses, threat models, and waivers.
 - **Ops:** own runbooks, training, and operational readiness inputs.
 - **EVOL Board:** gate decisions and conflict resolution.
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3. Lifecycle Overview

1. **Proposal** — frame the problem, options, and plan. Output: *PDR-quality* bundle.
 2. **Work** — build, integrate, and prove feasibility. Output: *working drafts* + *demo evidence*.
 3. **Review** — formal acceptance review. Output: *rc-labeled packages* + *V&V evidence*.
 4. **Freeze** — release, baseline, and archive. Output: *immutable v1.0.0* + *manifest*.
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4. Deliverables by Phase (Documents)

4.1 Proposal → Gate: EVOL Board “Go” Required

- **RFC.md** (problem, goals/non-goals, scope, constraints, success criteria).
- **Options & Decision Drivers** (trade study / alternatives matrix).
- **High-Level Architecture** (1–2 diagrams; interfaces touched).
- **Initial Budgets:** mass, power, heat, volume (coarse).
- **Risk Register (init)** + key assumptions.
- **Plan & Resources:** milestones, owners, review window.
- **Tracking:** Epic created; links recorded in front matter.

Exit criteria: EVOL Board approves “Go”; owners/reviewers assigned; epic/backlog exists.

4.2 Work → Gate: “Review Package Ready” Required (versioned drafts)

- **SPEC/** (updated specs, DRAFT, SemVer 0.x).
- **ICD/** (interfaces changed/pinned, DRAFT).
- **ADR/** (records of key architecture choices).
- **CALC/** (calculations, models, scripts; inputs/outputs checked-in).
- **MODEL-SIM/** (simulation configs with seeds; reproducible runs).
- **TST/** (verification plan + procedures; benches/rigs if HW).
- **CHANGELOG.md** (human-readable since last freeze).
- **Compliance notes** (standards mapping started).
- **Risk Register** (updated mitigations).

Exit criteria: CI green (lint, schema/front-matter, links, unit tests); demo evidence of feasibility (sim run, prototype, or analytical proof); no open P0/P1 defects.

4.3 Review → Gate: Sign-offs Complete Required (review bundle)

- **Review Package** (index/cover sheet linking all items).
- **SPEC/ v1.0.0-rc** (REVIEW) with redlines resolved.
- **ICD/ v1.0.0-rc** with data dictionary & contracts.
- **V&V Matrix** (requirements ↔ tests ↔ evidence).
- **Test Results** (logs, measurements, sims, tolerances, seeds).
- **Budgets** updated vs. proposal deltas.
- **Safety/Security:** FMEA/HAZOP, threat model, waivers/deviations.
- **Ops Readiness:** runbook draft, rollback, training outline.
- **Compliance Matrix** (regulatory/standard mapping).
- **Review Minutes** (actions, dispositions, final sign-offs).

Exit criteria: required sign-offs recorded; all actions closed or waived; versions/states aligned for freeze.

4.4 Freeze → Gate: Release & Archive Done Required (frozen artifacts)

- **SPEC/ & ICD/ v1.0.0** FROZEN (immutable).
- **Release Notes** (scope, breaking changes, migration notes).
- **Parameter Baseline:** parameters-baseline.json.
- **Interface Locks:** interfaces.lock (exact versions/hashes).
- **BOM/SBOM** (SPDX/CycloneDX where SW involved).
- **Geometry/Models** (neutral exports: STEP/GLTF as applicable).
- **Test Evidence Archive** (datasets, configs, seeds, checksums).
- **Ops Runbook (final)**, training pack, SLO/monitoring hooks.
- **Archive Manifest:** manifest.sha256 + provenance list.
- **Tag & Archive:** repo tag (e.g., EVOL-07.FROZEN.2025-08-12); copy to 7.6.3 History/EVOL-07/.

Exit criteria: read-only flag applied; traceability report passes; ops handover acknowledged.

5. Deliverables by Phase (Products)

Product classes: RIG (test rigs), SIM (simulators/digital twins), SUBSYS (modules), SYS (integrated systems), DECK (station decks/sections), SPHERE (whole station).

5.1 Product IDs & configuration keys

- **ID schema:** CLASS-PRODID-VAR-REV + **ASN** (physical serial) + **CFGHASH** (configuration hash). Examples: RIG-THERM-01-A2 / ASN 0007 / CFGHASH 3f9c..., DECK-015-PWR-01-B0 / ASN 0001 / CFGHASH 91ab....

5.2 Proposal (products) All classes: PDR (product decision), top-level PBS/BOM (10-line granularity), budget draft, conformity plan, initial risks, block diagrams, build plan (milestones, required rigs/sims, resources). **Class-specific:**

- **RIG:** measurands & target accuracies; calibration strategy.
- **SIM:** model boundaries; **fidelity metrics** (Δt , numerical error, deviation vs. test data).
- **SUBSYS/SYS:** interface briefs; preliminary ICD deltas.
- **DECK/SPHERE:** integration/assembly concept; logistics constraints.

Exit: EVOL Board “Go”; product ID reserved; epic/backlog created.

5.3 Work (products) All classes: detailed **BOM v0.x**; fabrication packages (drawings, CAM/GERBER, STEP/STL as relevant); configuration files + **CFGHASH**; **ASN** assigned; V&V plan and test procedures; interim evidence (photos, logs, sim runs with seeds). **Class-specific:**

- **RIG:** calibration log v0.x; uncertainty budget; lab safety clearance.
- **SIM:** validation vs. rig/flight data; **Golden Runs** + tolerances.
- **SUBSYS:** EVT/DVT builds; firmware artifacts; bring-up logs.
- **SYS:** HIL/CHIL proofs; interface tests; EMV/leak/pressure as applicable.
- **DECK:** structural assembly evidence; piping/electrical isometrics; leak tests.
- **SPHERE:** integration timeline; cross-deck tests; emergency power/LC drills.

Exit: CI green; demo/functional proof; no open P0/P1 defects.

5.4 Review (products) All classes: review package; **SPEC/ICD v1.0.0-rc**; V&V matrix with results; updated budgets & risks; safety/security artifacts; ops drafts. **Acceptance tests:**

- **RIG: FAT-RIG** (factory acceptance), calibration certificates, standards trace.
- **SIM: FAT-SIM** (reproducibility, scenario coverage, fidelity report).
- **SUBSYS: FAT-SUB** (interfaces & performance), environmental/stress tests.
- **SYS: FAT-SYS** + HIL proof, controller stability, safe-state tests.
- **DECK: FAT-DECK** (pressure, leak, EMV/structure), evacuation/ops drills.
- **SPHERE: ORR-Draft** (Operational Readiness Review pre-stage), end-to-end exercises.

Exit: sign-offs complete; actions closed or waived.

5.5 Freeze (products) All classes: v1.0.0 FROZEN release; release notes; traceability report; parameter baseline; interfaces.lock; BOM/SBOM; provenance manifest; final ops runbook; training; spares & tools list; evidence archive (datasets, seeds, photos, build logs). **Site acceptance:**

- **RIG: SAT-RIG**; in service; maintenance interval set.
- **SIM: SAT-SIM**; reference Golden Runs stored; regression CI hook.
- **SUBSYS: SAT-SUB**; serial ASN range opened; spares kit defined.
- **SYS: SAT-SYS**; emergency procedures verified; telemetry thresholds set.
- **DECK: SAT-DECK**; handover to integration lead; artifacts set to read-only.
- **SPHERE: ORR/FRR** completed; operational authorization; tag SPHERE.FROZEN.YYYY-MM-DD.

6. Evidence & Traceability

- **V&V Matrix** is mandatory: requirement → spec clause → test case → result → dataset/seed.
 - **Definition of Evidence (DoE)**: evidence must be **reproducible** (configs + seeds), **attributed** (who/when/tool-version), and **integrity-checked** (hashes).
 - **Parameter Baseline** holds numerical knobs; changes require SemVer bump + re-test scope.
 - **Interface Locks** pin all external contracts by version and checksum.
 - **Asset Map** ties ASN ↔ CFGHASH ↔ Release-Tag ↔ Documents/Tests in machine-readable form.
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7. Versioning & States

- **SemVer** for documents and products (MAJOR.MINOR.PATCH). - MAJOR: incompatible changes; - MINOR: added functionality; - PATCH: fixes/no interface change.
 - **States**: DRAFT → REVIEW → FROZEN. Release candidates use -rc suffix.
 - **Freeze** sets immutability; hotfixes require new patch release + minimal re-tests.
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8. Configuration Management

- **Product identity**: CLASS-PRODID-VAR-REV (human-readable), **ASN** (serial), **CFGHASH** (config hash).
- **product.yaml** is the single source of truth for each physical/simulated asset.
- **Digital twin**: every physical ASN points to a SIM snapshot + Golden Runs.

Example product.yaml

```
id: DECK-015-PWR-01
class: DECK
variant: "01"
revision: "B0"
asn: "0001"
cfg_hash: "91ab72d4..."
release_tag: "DECK-015-PWR-01_v1.0.0"
interfaces:
  - id: ICD-015-PWR-CTRL_v1.0.0
  - id: ICD-015-THERM-LOOP_v1.0.0
budgets:
  mass_kg: 128000
  power_kw: 45
  heat_kw: 38
  volume_m3: 2100
evidence:
  photos: ["evidence/photos/2025-08-01_installation.jpg"]
  tests: ["tests/FAT-DECK/results-2025-08-05.csv"]
  datasets: ["evidence/data/pressure-leak-logs.parquet"]
ops:
  runbook: "ops/runbook.md"
  maintenance_interval_days: 180
```

9. CI & Quality Gates

- **Front-matter lint** (required fields), **filename regex**, **cross-link checks**, **schema validation** for `product.yaml`.
 - **Build/test**: unit tests; model/sim reruns; Golden Run regression; doc link checker.
 - **Security/Safety**: minimum checklists (threat model/FMEA present) before review.
 - **Blocking rules**: merge blocked until all required checks pass and required reviewers sign.
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10. Acceptance & Readiness Reviews

- **FAT** (Factory Acceptance): performed in Review phase; per-class variants (RIG/SIM/SUB-SYS/SYS/DECK).
 - **SAT** (Site Acceptance): performed in Freeze phase; installation/ops readiness confirmed.
 - **ORR/FRR** (Operational/Flight Readiness Reviews): required for **SPHERE** releases.
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11. Release & Archival

- Tag the release (e.g., `EVOL-07.FROZEN.2025-08-12`).
 - Copy frozen set to `7.6.3 History/EVOL-XX/` with `manifest.sha256`.
 - Apply repository read-only protection to frozen artifacts.
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12. Templates & References

- Short-form templates exist for **SPEC, ICD, ADR, RFC, TST, CALC**; start from those.
 - Use the **Evolution index** (README of the Evolution) to link all deliverables.
 - For acceptance checklists, use the minimal **FAT/SAT** templates provided under `templates/acceptance/`.
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Appendix A — Filename Pattern (documents)

Use the following pattern (illustrative; adapt discipline/scope codes as needed):

```
^(SPEC|ICD|ADR|RFC|TST|CALC) - (\d+) - ([A-Z]{2,5}) - ([A-Z0-9\-\ ]+) - EN-v(\d+\.\d+\.\d+) (- (DRAFT|REVIEW|FROZEN|RC\d+))?$
```

Examples `SPEC-07-PWR-DECK015-PWR-CTRL-EN-v0.4.0-DRAFT` `ICD-07-CTRL-DECK015-THERM-EN-v1.0.0-REVIEW`

Appendix B — Directory Skeleton (per Evolution)

```
EVOL-XX/  
  00-proposal/  
    RFC.md  
    options-trade-study.md  
    arch-overview.drawio  
    initial-budgets.xlsx  
    risks-init.csv  
  01-work/
```

```

SPEC/
ICD/
ADR/
CALC/
MODEL-SIM/
TST/
CHANGELOG.md
02-review/
  review-package.md
  vv-matrix.xlsx
  compliance-matrix.xlsx
  review-minutes.md
03-freeze/
  release-notes.md
  parameters-baseline.json
  interfaces.lock
  sbom.spdx
  bom.csv
  manifest.sha256
products/
  RIG/<RIG-ID>/...
  SIM/<SIM-ID>/...
  SUBSYS/<SUBSYS-ID>/...
  SYS/<SYS-ID>/...
  DECK/<DECK-ID>/...
  SPHERE/<release-tag>/...

```

Appendix C — Review Package Checklist (minimum)

- ☐ Review Package index present and link-clean.
- ☐ SPEC/ICD at v1.0.0-rc, REVIEW state.
- ☐ V&V Matrix complete and consistent with evidence.
- ☐ Test results (logs, seeds, tolerances) attached.
- ☐ Budgets updated; deltas vs. Proposal highlighted.
- ☐ Safety/Security artifacts present (FMEA/HAZOP, threat model, waivers).
- ☐ Ops drafts (runbook, training outline, rollback) attached.
- ☐ Compliance matrix present.
- ☐ Review minutes template ready.

Appendix D — Freeze Manifest (example)

Release: EVOL-07.FROZEN.2025-08-12

Artifacts:

```

- SPEC/DECK015-PWR-CTRL_v1.0.0.pdf  sha256: a1b2...
- ICD/DECK015-THERM_v1.0.0.yaml      sha256: c3d4...
- parameters-baseline.json           sha256: e5f6...
- interfaces.lock                    sha256: 9abc...
- sbom.spdx                          sha256: dede...
- bom.csv                            sha256: 4444...

```

Evidence:

```

- tests/FAT-DECK/results-2025-08-05.csv  sha256: 7777...
- evidence/data/pressure-leak-logs.parquet sha256: 8888...

```

Provenance:

```

- commit: 3b1c2d4

```

- built_by: j.smith
- built_at: 2025-08-12T10:11:00Z

Definition of Done (Evolution) An Evolution is *done* when all phase deliverables are present, signed off, and archived; frozen artifacts are immutable and linked in the Evolution index; Ops acknowledges handover; traceability report is clean.