

## **Operator Closure Constraint (OCC): The First Principle**

A substrate-limited rate bound on durable settlement under contestability

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Preprint. Revision: 2025-12-20

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Suggested citation:

Espeleta, Kyle. Operator Closure Constraint (OCC): The First Principle. Preprint, 2025.

Tool-use disclosure: Text-to-text generative AI was used to assist drafting and editing.

The author reviewed and takes full responsibility for all content and references.

### **ABSTRACT**

At any consequence boundary where determinations must remain defensible under credible contestability and accountable human judgment, durable settlement requires auditable verification: a minimum uncertainty reduction per obligation at a declared fidelity. Let  $C_{\text{eff}}(t)$  denote the boundary's effective verification capacity net of drift, and let  $b_{\text{req}}(t)$  denote the required verified uncertainty reduction per obligation to meet the declared fidelity. Then the cohort durable settlement rate satisfies the rate–fidelity bound:

$$(1) \mu_d(t;T) \leq C_{\text{eff}}(t) / b_{\text{req}}(t)$$

When required verification demand persistently exceeds available capacity under fixed boundary conditions, the unmet remainder cannot be eliminated at the boundary. It must manifest as observable outputs: growth and aging of unresolved inventory (delay/tail thickening), increased return-work (reopenings/corrections), displacement of obligations to adjacent ledgers or clients, degraded auditability or actuation, and/or hysteresis after saturation. OCC is a conservation-style constraint: it is structural rather than normative and holds independently of institutional intent.

### **1. SCOPE AND APPLICABILITY**

#### **0.1 Human cognitive substrate**

OCC concerns closure systems that require accountable human verification under contestability. The binding element is the human decision-maker: a nervous system with finite metabolic budget, finite attentional bandwidth, and bounded working memory and decision throughput. Verification is not “paperwork”; it is uncertainty reduction carried

out under time, energy, and social constraints, and—because contestability is real—it must be expressed as defensible, auditable justification. This converts durable closure into a bounded information-processing problem with energetic costs. The verification channel  $C(t)$  is therefore constrained by human cognitive and physiological limits, not merely by institutional design.

### 0.2 Civilization–substrate mismatch (why the constraint binds at scale)

In small-group settings, consequence boundaries were local, state spaces were smaller, drift was slower, coupling was lower, and contestability was immediate. Modern large-scale coordination expands state space, increases coupling across domains, accelerates nonstationarity (drift), increases opacity through specialization and intermediated representations, and raises required standards through legal, reputational, and regulatory contest. These changes raise required verification per obligation  $b_{req}(t)$  and drift load  $u_{drift}(t)$  while decision-maker capacity  $C(t)$  scales weakly. OCC formalizes the resulting mismatch as a rate bound on durable settlement.

### 0.3 Boundary conditions

The Operator Closure Constraint applies only to boundaries that satisfy all of the following conditions:

Accountability: determinations are made by identifiable human decision-makers (or accountable human teams).

Contestability: determinations are credibly contestable within a declared horizon.

Consequence: determinations commit consequence-bearing resources, rights, or actions.

Fidelity: durable settlement is defined relative to an explicit fidelity standard.

If contestability is removed, fidelity is lowered, scope is narrowed, or closure is automated such that accountable human verification is eliminated at the boundary, the constraint may no longer bind at that boundary and will reappear downstream.

#### 1. DECLARATION

Fix a declared consequence boundary  $B$  where obligations are resolved through accountable human judgment under credible contestability.

Declare:

Primary contestability (reopen) horizon  $T > 0$ .

Reopen channels  $R_T$  (all pathways by which an obligation can reopen, be corrected, be reversed, be appealed, or be reworked within  $[t, t+T]$ ).

Declared obligation unit (the unit in which initiation, closure, and stocks are counted).

Declared fidelity standard  $F$  (the minimum defensibility/verification standard required for durable settlement under credible challenge).

Terminology. “Decision-maker” refers to the accountable person or decision cell whose determination must remain defensible under credible contestability; “capacity” refers to the effective auditable verification work that this decision-maker (and supporting review process) can produce per unit time.

All quantities below are defined with respect to  $(B, T, R_T, F)$  and the declared obligation unit.

## 2. ACCOUNTING PRIMITIVES

### 2.1 Rates and cohort quantities

$\lambda(t)$ : initiation rate of new obligations entering  $B$ .

$\mu_a(t)$ : attempted closure rate (attempts to settle obligations at  $B$ ).

$q(t;T)$ : durability fraction of the closure cohort attempted at time  $t$ , defined as:

$$(2) q(t;T) \equiv \Pr[\text{no reopen via } R_T \text{ in } [t, t+T] \mid \text{attempt at } t]$$

Cohort durable settlement rate:

$$(3) \mu_d(t;T) \equiv \mu_a(t) \cdot q(t;T)$$

Cohort-generated return-work:

$$(4) \rho_{\text{gen}}(t;T) \equiv \mu_a(t) \cdot (1 - q(t;T))$$

If multiple reopenings per attempt are admissible within  $T$ , then  $\rho_{\text{gen}}(t;T)$  is defined as the expected number of reopen events generated per closure cohort under an explicitly declared counting rule.

Reopen probability (convenience):

$$(5) p_r(t;T) \equiv 1 - q(t;T)$$

Realized durable outflow (matured durability)

If durability is defined at horizon  $T$ , then obligations that become known-durable at time  $t$  are those attempted at time  $t - T$  that did not reopen:

$$(6) \mu_d^{\text{real}}(t;T) \equiv \mu_a(t - T) \cdot q(t - T;T)$$

This distinction is purely temporal:  $\mu_d(t;T)$  is a cohort attribute at attempt time;  $\mu_d^{\text{real}}(t;T)$  is the matured outflow used in stock conservation when “unresolved” includes provisionally closed obligations inside the horizon.

## 2.2 Stocks

$L(t)$ : on-ledger unresolved obligation stock at B, defined as obligations that have not yet achieved durability at horizon T. This includes open obligations and provisionally closed obligations still inside the contestability horizon.

$X(t)$ : off-ledger displacement counted as unresolved at B when evidenced or bounded (e.g., shifted to adjacent ledgers, clients, shadow channels) under the declared accounting rules.

Total unresolved obligation stock:

$$(7) L_{tot}(t) \equiv L(t) + X(t)$$

## 2.3 Unit compatibility

All rates and stocks must be measured in the same declared obligation unit. Any splits, merges, reclassification, or versioning of the obligation unit must be logged and reconciled. Without reconciliation, the accounting identities below are not interpretable.

## 3. ACCOUNTING AXIOMS

### 3.1 Durability axiom

A closure attempt at time t is durable at horizon T if and only if it does not reopen via  $R_T$  in  $[t, t+T]$ .

### 3.2 Cohort identity

For each closure cohort at time t:

$$(8) \mu_a(t) = \mu_d(t;T) + \rho_{gen}(t;T)$$

This is definitional given  $q(t;T)$  (and the declared reopen channels and counting rule).

### 3.3 Boundary conservation (conditional on displacement treatment)

If total unresolved stock  $L_{tot}(t)$  is asserted, and “unresolved” is defined as “not yet durable at horizon T,” then conservation uses matured durable outflow:

$$(9) dL_{tot}/dt = \lambda(t) - \mu_d^{\text{real}}(t;T)$$

If  $X(t)$  is unknown and  $L_{tot}(t)$  is not asserted, conservation is evaluated on-ledger:

$$(10) dL/dt \approx \lambda(t) - \mu_d^{\text{real}}(t;T)$$

Any residual is treated as a boundary/definition/instrumentation artifact rather than evidence.

These are boundary accounting identities. If they fail under the declared obligation unit, reopen channels, horizon, and boundary definition, measurement is invalid or the boundary is misdeclared.

#### 4. VERIFICATION-CHANNEL MODEL

##### 4.1 Finite verification capacity

Let  $C(t)$  denote the effective auditable verification capacity available at B, measured as verification-work per unit time; its magnitude is constrained by the decision-maker substrate described in §0.1 and by the supporting review process at the boundary.  $C(t)$  may be expressed in information units (e.g., bits per unit time) or in auditable work proxies tied to contestability (e.g., review minutes, evidence-check steps, documented justification load).

##### 4.2 Drift cost and effective capacity

Let  $u_{\text{drift}}(t)$  denote verification demand required to maintain a valid action-to-outcome mapping during settlement (nonstationarity from environmental change, policy churn, adversarial behavior, model decay, or shifting standards).

Net effective capacity:

$$(11) C_{\text{eff}}(t) \equiv \max\{ 0, C(t) - u_{\text{drift}}(t) \}$$

##### 4.3 Required verified uncertainty reduction per obligation

Let  $b_{\text{req}}(t)$  denote the verified uncertainty reduction required per obligation to achieve durable settlement at declared fidelity F under credible contestability (with  $R_T$  and horizon T fixed).

##### 4.4 Rate–fidelity frontier and the OCC inequality

Maximal sustainable cohort durable settlement rate:

$$(12) \bar{\mu}_d(t;T) \equiv C_{\text{eff}}(t) / b_{\text{req}}(t)$$

Operator Closure Constraint (OCC):

$$(13) \mu_d(t;T) \leq \bar{\mu}_d(t;T)$$

Attempted closure can exceed this bound only by lowering effective verification per attempt below  $b_{\text{req}}(t)$ , which reduces  $q(t;T)$  and converts apparent throughput into return-work and tail thickening.

##### 4.5 Latent-channel clause

Direct measurement of  $C(t)$  is not required. Any capacity proxy claim must be auditably

tied to contestability-relevant verification work. “Capacity increased” is not a permitted post-hoc explanation unless anchored in measured or auditable proxy changes.

## 5. CONSERVED REMAINDER UNDER EXCEEDANCE

Required verification demand:

$$(14) u_{\text{req}}(t) \equiv u_{\text{drift}}(t) + \lambda(t) \cdot b_{\text{req}}(t)$$

Exceedance remainder:

$$(15) E(t) \equiv \max\{ 0, u_{\text{req}}(t) - C(t) \}$$

If  $E(t) > 0$  persists under fixed boundary conditions ( $B, T, R_T, F$ ) and stable obligation-unit definitions, the unmet remainder cannot be eliminated within  $B$ . It must appear as measurable outputs at  $B$  or as displacement to adjacent boundaries.

## 6. NECESSARY OUTPUTS UNDER SUSTAINED EXCEEDANCE

Under persistent  $E(t) > 0$ , at least one of the following must rise (under fixed boundary conditions and stable accounting):

Delay / tail thickening: growth and aging of  $L_{\text{tot}}(t)$  when asserted; otherwise of  $L(t)$ .

Return-work increase: growth in  $p_{\text{gen}}(t; T)$  (or its lagged observed counterpart).

Displacement: growth in  $X(t)$  or transfer of obligations to adjacent ledgers/clients without commensurate reduction in  $L_{\text{tot}}(t)$ .

Auditability or actuation collapse: degradation of defensibility or execution under verification deficits (explanation burden overwhelms cycle-time budgets; decisions become less contest-proof or less executable).

Hysteresis: asymmetric degradation of capability that does not reverse when load later declines (capacity loss, coherence loss, institutional memory loss, decision fatigue).

If none of these rise while verification demands are materially present and contestability remains real, then a boundary condition has changed (scope, fidelity, contestability, obligation-unit definition, reopen-channel definition, or logging/measurement validity).

## 7. COROLLARIES

Corollary 1 — Illusion of efficiency

An increase in attempted closure  $\mu_a(t)$  does not imply an increase in durable settlement  $\mu_d(t; T)$ . When attempts are forced beyond the rate–fidelity frontier, durability  $q(t; T)$  must fall. Observable throughput can rise while durable outcomes stagnate or decline, accompanied by increased return-work.

### Corollary 2 — Displacement trap

Local reductions in on-ledger unresolved stock  $L(t)$  do not imply reductions in total unresolved stock  $L_{tot}(t)$ . Under sustained exceedance, pressure to reduce visible backlog induces displacement  $X(t)$ . Measured performance improves locally while global unresolved obligations persist, reappear, or age.

### Corollary 3 — Contestability paradox

Increasing contestability or detection sensitivity can increase observed return-work while improving true durability. Newly surfaced reopenings worsen short-run metrics despite higher long-run settlement quality. Valid comparisons therefore require conditioning on contestability proxies, declared reopen channels, and horizon set.

## 8. MEASUREMENT PROTOCOL (MINIMAL SUFFICIENCY)

A minimally sufficient empirical implementation requires:

Declared obligation unit and transformation log.

Declared reopen channels  $R_T$  and horizon set  $T$  (including a primary horizon  $T_r$ ).

Time-stamped  $\lambda(t)$  and  $\mu_a(t)$ .

Cohort-wise measurement of  $q(t;T)$  (or explicit tier limitation if linkage is missing).

Construction of  $L(t)$  consistent with the durability definition (unresolved until durable at  $T$  if using the conservation identity above).

$X(t)$  only if  $L_{tot}(t)$  is asserted (must be evidenced or bounded).

Reporting durability across multiple horizons rather than a single horizon.

## 9. FALSIFIER

OCC is falsified at boundary B if a sustained regime is observed in which: accountability and contestability remain real (not trivially suppressed), verification demands are materially present or increasing (drift, coupling, standards, or challenge load),

durable settlement improves across relevant horizons (not just short-horizon optics), and

none of the conserved outputs in Section 6 increase,

without any boundary-trivializing change in scope, fidelity, obligation-unit definition, reopen-channel definition, contestability regime, or accounting/logging rules.

Falsification requires adherence to the measurement protocol, including instrumentation validity and non-circular proxy constraints.

## 10. APPLICATIONS

OCC applies to consequence boundaries where durable settlement must pass through accountable human review under credible challenge, including courts,

healthcare administration, permitting and regulation, insurance adjudication, safety certification, and high-stakes review gates in software and operations. Interventions that increase headcount or automation without increasing effective verification capacity  $C_{\text{eff}}$  or reducing required verification per obligation  $b_{\text{req}}$  predictably yield temporary gains followed by return-work, displacement, tail thickening, auditability loss, and/or hysteresis.

## 11. RELATION TO ESTABLISHED THEORY

OCC composes four established constraints:

1. Boundary flow conservation and heavy-traffic queueing behavior.
2. Fidelity-constrained information processing (rate–distortion / minimum uncertainty reduction required per obligation to meet declared fidelity under challenge).
3. Empirically documented limits on human decision throughput and attention under speed–accuracy tradeoffs, and the metabolic costs of cognition.
4. Evolutionary mismatch: modern coordination increases drift, coupling, and opacity, raising verification demand per obligation  $b_{\text{req}}(t)$  faster than decision-maker capacity  $C(t)$  can scale.

OCC is therefore a structural constraint, not a normative claim, and does not require assumptions about institutional intent.

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