Operator Closure Constraint (OCC): Formal Specification and Falsification Protocol
Mechanism Specification and Adversarial Test Charter

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Abstract

The Operator Closure Constraint (OCC) is a domain-general constraint mechanism for consequence-bearing coordination systems. It states that durable settlement of obligations is bounded by a finite closure channel at the consequence interface, implemented by bounded human decision-makers operating under credible contestability. When required uncertainty reduction persistently exceeds this channel, the conserved remainder reappears as return-work (reopenings and corrections), tail thickening, off-ledger displacement, auditability and actuation collapse, and slow-variable hysteresis. This document specifies the mechanism in operational terms (observable closure accounting plus coupled dynamics), separates attempted discharge from durable settlement, makes displacement explicit as state (anti-cheat), and provides explicit falsification surfaces and a tiered non-circular empirical protocol.

1. Scope, intended use, and non-claims

0.1 Intended use

This document is a mechanism specification and falsification protocol. It is designed to support regime diagnosis, leading indicators of regime transitions, directional intervention predictions once closure is binding, and adversarial testing in domains with logged closure and reopen channels.

0.2 Boundary of claim

OCC is asserted only at consequence interfaces where three conditions hold simultaneously. Information must be compressed into human-scale representations. Accountability requires identifiable human decision-makers who can defend determinations under credible contestability. Action requires commitment under consequence.

0.3 Non-claims

This is not a physics of society. It does not claim a universal parameter set across domains. It does not forecast dates of collapse or recovery. It does not claim a single driver explains all social outcomes. It does not claim automation eliminates the constraint; it claims automation shifts where the binding interface sits, and can raise drift and opacity while reducing some micro-loop costs.

1. Definitions and measurement primitives

1.0 Accountable decision-maker at the consequence interface

A consequence-interface decision-maker is the identifiable person or small decision cell required to interpret compressed representations, make a contestable determination, and commit or authorize action that allocates or changes consequence-bearing resources. Boundedness refers to finite attention, verification bandwidth, recovery, and the requirement that accountability cannot be fully delegated away when reversals remain possible.

1.1 Consequence-bearing loop

A loop is consequence-bearing if its outcomes change the state of resources that people must steward, directly or indirectly. Resources include material, financial, legal, reputational, attentional, time, safety, and legitimacy reserves. If buffers and reserves exist, the loop remains consequence-bearing at a meta level; reserve trajectories become closure metrics for that meta loop.

1.2 Closure, durable settlement, and the reopen horizon

Closure is a timestampable settlement event in a consequence-bearing process: an outcome accepted as resolved under the system’s norms. Durable settlement is closure that does not reopen within a declared reopen horizon.

Let $T_r > 0$ be the reopen horizon. A closure attempt counts as durable only if it does not return via the declared rework and reopen channels within T_r. T_r is domain-set and must be reported in every deployment.

1.3 Anti-cheat: displacement versus engineered closure

Closure is not achieved when apparent settlement is produced by burden shift or contestability suppression: blocking intake, narrowing eligibility, hidden friction insertion, redefining closed, deterring appeal through exhaustion, breaking reopen linkage, moving obligations into shadow channels, clock-pausing statuses, bulk administrative purges, or abandonment engineered by procedural exhaustion. These moves reduce visible stock while increasing debt elsewhere. OCC counts them as displacement and coercive substitution, not engineered closure.

1.4 Required observable grammar: loop accounting

A valid OCC application declares a loop boundary and measures, at minimum:

Initiation, $\lambda\_exo(t)$: obligations entering the loop per unit time.
Attempted closure, $\mu\_a(t)$: raw discharge attempts per unit time.
Return-work, $\rho(t)$: reopenings and corrections attributable to attempted closures within T_r.
Durable settlement, $\mu\_d(t)$: closures that do not reopen within T_r.
Visible loop debt, $L(t)$: on-ledger inventory of unresolved obligations with age distribution.
Displacement state, $X(t)$: off-ledger or adjacent-ledger obligations shifted outward.
Total debt, $L\_tot(t) = L(t) + X(t)$: debt conserved at the chosen consequence boundary.

The event-level identity that must hold by construction is:
$\mu\_d(t) = \mu\_a(t) - \rho(t)$.

The stock–flow identity that must hold by construction is:
$dL\_tot/dt = \lambda\_exo(t) - \mu\_d(t)$.

1.5 Drift, coupling, opacity, auditability, and contestability

Drift $V(t)$: sustained mapping change in the action-to-outcome relationship during the settlement window. Drift forces continuous update, not episodic learning.
Coupling $J(t)$: cross-dependence and interaction density that expand verification scope and cascade exposure.
Opacity $M\_0(t)$: baseline unauditability and entanglement of consequence paths at the interface.
Verification budget $B(t)$: time, attention, and person-hours available inside cycle time for checking and explanation.
Required standard $R(t)$: required verification threshold implied by risk tolerance, legitimacy demands, and contestability.

2. First-principle constraint spine

2.1 Obligation conservation

Unresolved obligations are a stock. At a declared boundary, the stock changes only by initiation, durable settlement, and displacement and re-entry across boundaries. No intervention can improve closure without cashing out in the stock–flow identity.

2.2 Closure as uncertainty reduction

At a consequence interface, closure is not activity. It is reduction of unresolved uncertainty into a defensible settled state. Systems can generate decisions while leaving uncertainty unresolved.

2.3 Finite closure channel and allocation under drift

Uncertainty reduction and defensible ownership inside cycle time consume bounded human bandwidth. Treat this as a finite closure channel that must be allocated between updating the mapping under drift and closing obligations. If drift consumes the channel, closure capacity shrinks. If drift exceeds the channel, residual uncertainty persists and must reappear as error, rework, delay, or coercive simplification.

2.4 Rate–distortion under compression

With finite channel capacity, raising throughput requires compression: reducing per-attempt resolution and verification. In relatively stationary regimes, compression can raise durable settlement. Under drift exceedance, pushing attempted closure above the maximum sustainable rate at required fidelity forces distortion. Distortion returns as reopenings, corrections, and tail thickening.

2.5 Displacement as state

Visible improvement can be produced by moving debt off-ledger. OCC therefore treats displacement as state X with explicit flows, and evaluates closure at the total-debt boundary, not the local ledger alone.

2.6 Hysteresis and capability traps

Under sustained exceedance, systems crowd out preventive work and degrade capability stock. Future capacity shrinks and recovery becomes non-symmetric. Coherence potential can decay even when exogenous forcing later declines.

3. State space and variables

System state:
S(t) = { Omega_s(t), Omega_p(t), q(t), A(t), L(t), X(t), kappa(t), S_unc(t) }.

Fast vs slow:
Omega_s(t): maintained coherence (fast).
Omega_p(t): coherence potential (slow ceiling).
kappa(t): capability stock (slow substrate).
S_unc(t): unresolved uncertainty stock (latent).

Queue stocks:
L(t) >= 0, X(t) >= 0, L_tot(t) = L(t) + X(t).

Control variables:
q(t) in [0,1]: compression intensity.
A(t) in [0,1]: actuation feasibility.

External and interface drivers:
Delta_0(t), V(t), J(t), M_0(t), B(t), R(t).

Capacity proxy:
K(t) in [0,1], independent of contraction outcomes.

Nonlinearities:
sigma(x) = 1/(1+exp(-x)), clip01(x) clamps to [0,1].

Small denominators:
eps_C > 0, eps_mu > 0.

Default parameter sign constraints:
All h_, *f_*, p_, *m_* >= 0.
b_min > 0, b_span > 0.
r, beta, gamma, a, d > 0.
A_min in [0,1), eta > 0.
All eps_* > 0.

4. Mechanism specification: canonical dynamics

4.1 Available uncertainty-reduction channel

C(t) = C0 * K(t) * kappa(t) * Omega_s(t) * A(t).

C(t) is uncertainty reduction per unit time that can be performed and defended at the interface, not tasks touched.

4.2 Required uncertainty inflow

Define required uncertainty inflow as:

Sdot_in(t) = Sdot_exo(t) + Sdot_drift(t) + Sdot_endo(t).

Scope and standard multipliers:

H_S(t) = 1 + h_J * J(t) + h_M * M_0(t).
H_R(t) = 1 + h_R * R(t).

Exogenous uncertainty inflow:

Sdot_exo(t) = h_Delta * Delta_0(t) * H_S(t) * H_R(t).

Drift uncertainty inflow:

Sdot_drift(t) = h_V * V(t) * H_S(t) * H_R(t).

Endogenous uncertainty inflow:

Sdot_endo(t) = h_F * (Omega_p(t) - Omega_s(t)) + h_L * L_tot(t).

Empirical constraint: in Charter-compliant tests, contraction signatures including L_tot are not placed on the right-hand side as drivers. Endogenous-burden pathways are tested only with independent carriers U(t) in Tier 3, or are set to zero or held fixed in Tier 1 and Tier 2. The mechanism permits endogenous feedback; Charter-compliant tests restrict right-hand-side drivers to avoid circular validation.

4.3 Uncertainty stock and binding remainder

$$dS\_unc/dt = Sdot\_in(t) - C(t).$$
$$E(t) = \max(0, Sdot\_in(t) - C(t)).$$
$$Gamma(t) = Sdot\_in(t) / (C(t) + eps\_C).$$

Gamma > 1 defines binding exceedance at the interface.

4.4 Channel allocation: update versus closure

Define update demand:

$$Sdot\_upd(t) = Sdot\_drift(t).$$

Allocate channel to update first:

$$C\_upd(t) = \min(C(t), Sdot\_upd(t)).$$
$$C\_close(t) = C(t) - C\_upd(t).$$

Define drift exceedance remainder:

$$Pi(t) = \max(0, Sdot\_upd(t) - C(t)).$$

Pi > 0 means drift is outrunning the channel.

4.5 Compression, attempted closure, required fidelity, and rate–distortion overshoot

Per-attempt resolution under compression:

$$b(q(t)) = b\_min + (1 - q(t)) * b\_span.$$

Attempted closure throughput:

$$mu\_a(t) = C\_close(t) / b(q(t)).$$

Required per-attempt fidelity:

$$b\_req(t) = b\_min + b\_span * sigma((F\_req(t) - F\_star) / eps\_F)$$

with

$$F\_req(t) = f\_0 + f\_J * J(t) + f\_M * M\_0(t) + f\_R * R(t) + f\_Pi * Pi(t) + f\_L * L\_tot(t).$$

Empirical constraint: in Charter-compliant tests, the $f_L * L_{tot}$ term is not placed on the right-hand side. Replace with $f_U * U(t)$ only in Tier 3 when $U(t)$ is independently observed; otherwise set $f_L = 0$.

Maximum sustainable attempted rate at required fidelity:

$$\bar{\mu}_a(t) = C_{close}(t) / b_{req}(t).$$

Normalized rate-above-fidelity overshoot:

$$O(t) = \max(0, \mu_a(t) - \bar{\mu}_a(t)) / (\bar{\mu}_a(t) + \epsilon_\mu).$$

Distortion index:

$$D_{dist}(t) = D0 + d_O * O(t).$$

Reopen probability:

$$p_r(t) = \mathrm{clip01}(p0 + p_D * D_{dist}(t) + p_J * J(t) + p_L * L_{tot}(t)).$$

Empirical constraint: in Charter-compliant tests, the $p_L * L_{tot}$ term is not placed on the right-hand side. Replace with $p_U * U(t)$ only in Tier 3; otherwise set $p_L = 0$.

Return-work and durable settlement:

$$\rho(t) = \mu_a(t) * p_r(t).$$
$$\mu_d(t) = \mu_a(t) * (1 - p_r(t)).$$

This enforces the attempted-versus-durable separation structurally.

4.6 Debt dynamics with explicit displacement

Visible ledger:

$$dL/dt = \lambda_{exo}(t) + \omega(t) + \rho(t) - \mu_a(t) - \delta(t).$$

Displacement state:

$$dX/dt = \delta(t) - \omega(t).$$

Total debt:

$$L_{tot}(t) = L(t) + X(t).$$
$$dL_{tot}/dt = \lambda_{exo}(t) - \mu_d(t).$$

Optional endogenous displacement response:

$\text{delta}(t) = \text{delta}_0 * \text{sigma}((E(t) - E_{\text{delta}}) / \text{eps}_{\text{delta}})$.
$\text{omega}(t) = \text{omega}_0 * \text{sigma}((X(t) - X_{\text{omega}}) / \text{eps}_{\text{omega}})$.

4.7 Auditability and actuation boundary as a budget gap

Required explanation and verification burden:

$$M_{\text{req}}(t) = M_0(t) + m_J * J(t) + m_L * L_{\text{tot}}(t) + m_{\text{Pi}} * \text{Pi}(t) + m_O * O(t).$$

Empirical constraint: in Charter-compliant tests, the $m_L * L_{\text{tot}}$ term is not placed on the right-hand side. Replace with $m_U * U(t)$ only in Tier 3; otherwise set $m_L = 0$.

Actuation function:

$$A(t) = A_{\min} + (1 - A_{\min}) * \text{sigma}((B(t) - M_{\text{req}}(t)) / \text{eps}_A).$$

A collapses when explanation burden exceeds verification budget inside cycle time.

4.8 Coherence dynamics and hysteresis

Maintained coherence:

$$d\text{Omega}_s/dt = r * A(t) * (\text{Omega}_p(t) - \text{Omega}_s(t)) - \text{beta} * E(t) * \text{Omega}_s(t).$$

Coherence potential:

$$D_{\text{def}}(t) = (\text{Omega}_p(t) - \text{Omega}_s(t)) / (\text{Omega}_p(t) + \text{eta}).$$
$$d\text{Omega}_p/dt = -\text{gamma} * \text{Omega}_p(t) * \text{sigma}((D_{\text{def}}(t) - D_{\text{star}}) / \text{eps}_p).$$

4.9 Capability stock and trap channel

$$d\text{kappa}/dt = a * I_{\text{cap}}(t) - d * \text{kappa}(t).$$

Preventive investment collapses under exceedance and compression:

$$I_{\text{cap}}(t) = I0 * (1 - q(t)) * \text{sigma}((E_I - E(t)) / \text{eps}_I).$$

4.10 Compression dynamics

$$dq/dt = k_{\text{up}} * (1 - q(t)) * \text{sigma}((E(t) - E_q) / \text{eps}_q) - k_{\text{down}} * q(t) * \text{sigma}((E_q - E(t)) / \text{eps}_q).$$

5. Regimes and operational signatures

5.1 Regime I: sustainable

$\text{Gamma} < 1$, $\text{Pi} = 0$, $B > M_{\text{req}}$. O approximately 0. p_r low. mu_d tracks mu_a. L_{tot} stable or falling. Tails remain controlled and return-work is low.

5.2 Regime II: acute stress, reversible

Sdot_exo spikes and temporarily pushes Gamma above 1. Omega_s drops and L_tot rises temporarily. If slack remains, Gamma returns below 1, debt pays down, and Omega_p remains approximately intact.

5.3 Regime III: drift exceedance trap

Pi > 0 sustained. C_close shrinks and required fidelity rises. mu_a_bar falls. Raising q can increase mu_a but increases O, which increases distortion and return-work. rho rises and mu_d stalls or falls. Tails thicken. Debt becomes self-reinforcing.

5.4 Regime IV: auditability cliff and actuation collapse

B < M_req collapses A, collapsing C even if K is unchanged. Decisions may still be produced, but accountable actuation becomes delay, escalation, shielding, or symbolic substitutes. Correction burden and reversals rise.

5.5 Regime V: hysteresis and capability trap

Exceedance persists long enough to suppress I_cap and erode kappa and Omega_p. Recovery fails to reset to prior baseline bands without structural change that reduces required uncertainty inflow or increases channel capacity.

5.6 Regime VI: displacement spiral

Exceedance raises delta, shifting obligations from L into X. Visible L can improve while L_tot does not. Re-entry omega returns obligations later with higher stakes and thicker tails.

6. Tiered inference and identifiability discipline

6.1 Tier 1: observable-only regime classification

Tier 1 requires only observable closure accounting and tail measures. It does not require direct measurement of C(t), A(t), K(t), kappa(t), Omega_s(t), Omega_p(t), or S_unc(t). In Tier 1, mu_a and mu_d are taken from operational counts; drift, coupling, and auditability are treated as unseparated latent drivers.

Tier-1 hinge signature: divergence between attempted closure mu_a and durable settlement mu_d via rho is the diagnostic signature of rate–distortion failure under compression, especially when tails thicken.

6.2 Tier 2: displacement-discriminating inference

Tier 2 adds displacement proxies sufficient to approximate X, delta, omega, plus at least one costly-to-fake anchor outcome. Tier 2 supports discrimination between engineered closure and cost-shifted apparent improvement.

6.3 Tier 3: driver separation

Tier 3 adds at least one independent drift proxy for V, one coupling proxy for J, and one auditability proxy for $B - M_{req}$. Tier 3 is the only tier where endogenous-burden carriers $U(t)$ can be used without circularity.

7. Non-circularity and metric contamination constraints

7.1 Non-circularity constraint

In Charter-compliant empirical tests, contraction signatures including $L(t)$, $X(t)$, $L_{tot}(t)$, tail metrics, aging curves, and rework and reopen rates are treated as outputs and may not be used as right-hand-side drivers or proxy carriers in fitted or evaluated equations. Where the mechanism includes endogenous-burden feedback terms that are naturally functions of internal debt burden, tests must either substitute an independent observable carrier $U(t)$ in Tier 3, or set the associated coefficients to zero or hold the term fixed in Tier 1 and Tier 2.

7.2 Metric contamination constraint

If a quantitative indicator is used for allocation, status, or punishment, it becomes a control signal and is presumed strategically contaminated. Closure improvements are credited only when reopen channels and displacement proxies remain stable or fall and when at least one costly-to-fake anchor outcome does not worsen.

8. Canonical reduced cores

8.1 Tier 1 reduced core

Total debt conservation at the chosen boundary remains binding:

$$dL_{tot}/dt = \lambda_{exo}(t) - \mu_d(t).$$

Diagnostic hinge:

If μ_a rises while μ_d stalls or falls, and ρ rises and tails thicken, then increased attempted throughput is converting into distortion and return-work rather than durable settlement.

8.2 Tier 3 reduced core

If Tier 3 proxies exist, the following mechanistic core can be used as a regime classifier rather than a fitted forecaster:

$$C(t) = C0 * K(t) * \kappa(t) * \Omega_s(t) * A(t).$$
$$C_{close}(t) = C(t) - \min(C(t), \dot{S}_{drift}(t)).$$
$$\mu_a(t) = C_{close}(t) / b(q(t)).$$
$$O(t) = \max(0, \mu_a(t) - \bar{\mu}_a(t)) / (\bar{\mu}_a(t) + \epsilon_\mu).$$

9. Disconfirmation criteria

9.1 Rate–distortion sign test

Under sustained drift exceedance with Pi > 0, interventions that raise mu_a by increasing q should not reliably reduce rho and stabilize L_tot and tails without increasing displacement delta or suppressing contestability. If mu_a rises while mu_d rises and rho falls under sustained Pi > 0 with stable measurement of reopen channels and displacement, then the overshoot-to-distortion construction is wrong or mis-scoped.

9.2 Channel allocation test

If drift proxies rise while durable settlement improves without increased verification budget B, without increased independent capacity proxies K and kappa, and without reduced coupling or opacity, then the update-allocation claim is wrong or the drift proxy is not measuring mapping change relevant to the closure interface.

9.3 Auditability cliff test

If B < M_req yet A remains high and accountable actuation scales without rising downstream correction and liability burdens, the actuation boundary is wrong or missing a compensating mechanism that reduces M_req inside cycle time.

9.4 Hysteresis and reset test

After prolonged exceedance with E positive for sustained periods, if Omega_p and kappa reliably return to prior baseline bands quickly once forcing declines without structural change that reduces uncertainty inflow or increases channel capacity, then the hysteresis pathways are overstated.

9.5 Displacement accounting test

If delta rises and visible L improves while L_tot does not, and omega later returns obligations with higher correction burden, that is a predicted displacement spiral. If delta rises and neither downstream burdens nor omega re-entry occurs over the declared horizon, then either the chosen boundary for consequence-bearing is wrong, or the mechanism is misclassified as displacement when it is engineered elimination.

10. Compatibility reduction

If S_unc is collapsed by assuming average uncertainty per obligation is constant so S_unc is proportional to L_tot as a conceptual reduction only, channel allocation is collapsed by treating C_upd as an implicit reduction in effective capacity, overshoot O is replaced by an additive penalty term proportional to q * Pi, and scope and standard multipliers are linearized, then this specification reduces to earlier algebraic OCC cores while preserving regime semantics.