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Propagated Energy Containment (PEC): A Dynamical Framework for Identity Preservation Across Transforming Systems

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Abstract

Complex systems continuously undergo transformation. Biological organisms replace their constituent matter, computational systems migrate across architectures, and distributed networks reorganize their internal structures while maintaining recognizable functional continuity. Existing approaches in dynamical systems theory, information theory, resilience engineering, and control theory provide powerful methods for analyzing state evolution, stability, and information preservation. However, they generally do not formalize a central question:

How does a system preserve identity through transformation?

This monograph introduces **Propagated Energy Containment (PEC)**, a theoretical framework for modeling continuity as the propagation of organized energy, information, and structural constraints across successive system states.

PEC defines identity persistence not as the preservation of static components, but as the maintenance of a coherent propagation field:

PEC = Φ(&mathcal;E, &mathcal;I, &mathcal;S, &mathcal;B, t)

where:

- ***&mathcal;E*** represents energetic resources,
- ***&mathcal;I*** represents retained information,
- ***&mathcal;S*** represents system state,
- ***&mathcal;B*** represents boundary and containment constraints,

- t represents temporal evolution.

Continuity is modeled as a nonlinear function of preserved invariants and propagation coherence:

$$\mathcal{C}(t) = \left(M(t)^{\alpha} K(t)^{\beta} P(t)^{\gamma} A(t)^{\delta} \right) \Omega(t)$$

where:

- M represents memory retention,
- K represents causal connectivity,
- P represents structural pattern preservation,
- A represents adaptive continuity,
- Ω represents coherence of the propagation field.

Unlike additive models, PEC treats continuity as a constraint-sensitive nonlinear phenomenon in which the failure of an essential invariant may cause a transition from continuation to succession.

The framework introduces measurable dynamical quantities, including:

- continuity velocity,
- continuity acceleration,
- continuity recovery time,
- continuity half-life,
- identity resilience index.

PEC is presented as a research framework rather than an established physical law. Its validity depends on empirical testing against existing measures of robustness, information retention, network resilience, and adaptive stability.

The central hypothesis of PEC is:

> *Systems that maintain higher propagation coherence will preserve identity-bearing organization more effectively under perturbation, reconstruction, and transformation than systems with equivalent short-term functional performance but lower continuity coherence.*

The objective of PEC is not to replace existing theories of complex systems, but to provide a formal language for studying a distinct problem: the persistence of organized identity through change.

Chapter 1 Draft: The Problem of Continuity

1.1 The Fundamental Question

Every complex system exists within a state of continuous transformation.

Matter changes.
Energy flows.
Information degrades and renews.
Structures reorganize.

Yet many systems appear to maintain an identifiable continuity through these changes.

A human being is not composed of the same atoms throughout life. A software system may migrate between hardware architectures. A civilization can replace institutions while preserving cultural identity.

This creates a fundamental systems question:

What property persists when components do not?

Traditional analysis often focuses on state transition:

$$S_t \rightarrow S_{t+1}$$

The question of PEC is different:

What allows S_t and S_{t+1} to belong to the same continuous process?

1.2 Continuation Versus Succession

PEC introduces a distinction between two forms of transformation.

Succession
A successor inherits characteristics from a previous system but lacks a direct continuity pathway.

$$S_t \rightarrow S'$$

The relationship is historical or informational.

Continuation
A continuation preserves a causal propagation chain.

$$S_t \rightarrow S_{t+1} \rightarrow S_{t+2}$$

The identity-bearing process remains active.

This distinction is central because two systems may be functionally identical while differing in continuity. A copy of a system may reproduce the same outputs while lacking the original system's causal history.

PEC therefore asks: *Is identity contained in the pattern, or in the propagation of the pattern?*

1.3 The Need for a Propagation Model

Existing frameworks provide important pieces:

- Thermodynamics explains energy transformation.
- Information theory explains information transmission.
- Dynamical systems explain state evolution.
- Control theory explains regulation.
- Network science explains connectivity.

PEC begins with the observation that these describe components of persistence, but not necessarily the persistence of the organized whole. The proposed missing layer is propagation.

A system does not merely contain energy and information. It contains a mechanism by which energy and information continue to produce future states consistent with previous states. That mechanism is the proposed PEC field.

Formal Definition Section (Initial)

DEFINITION 1 — PROPAGATED ENERGY CONTAINMENT

$$PEC(t) = \Phi(\&mathcal;E(t), \&mathcal;I(t), \&mathcal;S(t), \&mathcal;B(t), t)$$

where Φ is the propagation operator governing transformation while preserving system-specific constraints.

DEFINITION 2 — CONTINUITY

$$\&mathcal;C\}(t) = \prod_i X_i(t)^{w_i} \cdot \Omega(t)$$

where X_i are continuity invariants, w_i are weighting coefficients, and $\Omega(t)$ is propagation coherence.

DEFINITION 3 — PROPAGATION COHERENCE

$$\boxed{\Omega(t): PEC(t) \rightarrow [0, 1]}$$

where 1 represents maximal coherent propagation, and 0 represents loss of identity-bearing continuity.

The comparative theories chapter would be the next major section because it establishes PEC's intellectual position: PEC is not a replacement for thermodynamics, information theory, or dynamical systems. It is a proposed layer concerned specifically with continuity of organized identity across transformations.

Chapter 6: The Continuity Manifold and the PEC Propagation Operator

This is the point where the order of operations matters. We formalize the continuity invariants X_i first, then construct Φ. The reason is mathematical: an operator cannot be meaningfully defined until we know what properties it is required to preserve. A Hamiltonian is not defined first and then given conservation laws afterward; the conserved quantities and symmetries help determine the structure of the evolution operator. PEC follows the same discipline.

$$\boxed{X_i(t) = \{ M(t), K(t), P(t), A(t), \ldots \}}$$

$$\boxed{\Phi: S(t) \rightarrow S(t + \Delta t)}$$

subject to $X_i(t + \Delta t) \approx X_i(t)$ within acceptable transformation bounds.

6.1 The Identity State Vector

Instead of treating the invariants as independent scalars, we define the continuity state vector:

$$X(t) =$$

$M(t)$
$K(t)$
$P(t)$
$A(t)$

Memory Preservation $M(t)$
Measures retained identity-bearing information. Possible operational form:

$$M(t) = \frac{I(S_t, S_{t + \Delta t})}{I(S_t, S_t)}$$

where I is an information similarity measure.

Connectivity Preservation $K(t)$
Measures preservation of causal structure. For networked systems:

$$K(t) = \frac{|E_t \cap E_{t + \Delta t}|}{|E_t \cup E_{t + \Delta t}|}$$

A Jaccard-style graph continuity measure.

Pattern Preservation $P(t)$
Measures structural organization. Possible formulation:

$$P(t) = \operatorname{sim}(\mathcal{G}_t, \mathcal{G}_{t + \Delta t})$$

where $\mathcal{G}$ represents system organization.

Adaptive Continuity $A(t)$
Measures whether the system can continue responding according to its previous operational logic. A possible form:

$$A(t) = \frac{\text{functional capacity after perturbation}}{\text{functional capacity before perturbation}}$$

Now the continuity equation becomes:

$$\mathcal{C}(t) = M(t)^{\alpha} K(t)^{\beta} P(t)^{\gamma} A(t)^{\delta} \Omega(t)$$

6.2 The Continuity Manifold and Geometry of Identity Preservation

We introduce the geometric structure $\mathcal{M}_C$ representing the continuity manifold. Each point represents a possible identity configuration $S(t) \in \mathcal{M}_C$.

A transformation is not merely movement through state space ($S_t \rightarrow S_{t+1}$), but a trajectory $\gamma(t) \subset \mathcal{M}_C$ where continuity depends on whether the trajectory remains within the allowable identity-preserving region.

6.3 The PEC Flow Equation and Perturbation

Only now do we formalize the operator via the first candidate:

$$S(t + \Delta t) = \Phi(S(t), \Pi(t))$$

where $S(t)$ is the current system state and $\Pi(t)$ is the perturbation field. The identity-preserving condition becomes $\Phi: \mathcal{M}_C \to \mathcal{M}_C$, meaning the propagation operator maps valid continuity states into other valid continuity states.

While a Hamiltonian path is interesting (rac{dS}{dt} = \{S, H\}), PEC may eventually have an analogous generator of identity-preserving transformations:

rac{dS}{dt} = \mathcal{L}_{PEC}(S)

In the ideal case, conserved quantities satisfy rac{dX_i}{dt} = 0. However, real adaptive systems evolve, leading to the more realistic condition:

\left| rac{dX_i}{dt} ight| < \epsilon_i

where ε_i represents allowable identity drift, governing the conditions for continuation versus succession.