Non-Equilibrium Existence Under Partial Observability: Structural Diagnostics, Coupling Regimes, and the Limits of Design

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Abstract Across physical, biological, and Socio-technical domains, many long-lived systems operate neither near thermodynamic equilibrium nor as short-lived non-equilibrium transients. Instead, they persist as nonequilibrium steady states sustained by irreversible processes, continuous throughput, and finite structural carrying capacity. Despite this, prevailing analytical and design frameworks often rely on equilibrium references, point-valued state descriptions, or optimality-based objectives. While effective for short-term or approximately closed systems, these approaches become systematically mismatched for systems operating over extended durations under irreversible dissipation, where statistical stationarity may coexist with structural degradation. We adopt the premise that observation is inherently embedded within the system and remains valid only relative to explicitly declared observational frames and temporal scales. Under unavoidable partial observability, non-equilibrium existence is diagnosed not by trends or performance metrics, but by the persistence of irreversible directional structures that survive statistical stabilization and are invalidated under time reversal. We introduce a structural diagnostic framework based on (i) observation–structure mismatch, (ii) inner–outer cycle coupling admitting discrete regimes, and (iii) pathology localization at high-coupling nodes. When driving fields are not directly measurable, an inverse-measurement perspective is employed, treating structural stress responses as probes of system-wide pressures. Within this framework, resilience is redefined as the preservation of reversible coupling intervals, and design is repositioned as a bounded structural modulator rather than an optimization mechanism.

Keywords Non-equilibrium steady states; Irreversibility and directional structure; Partial observability; Inner-outer cycles; Pathology localization; Inverse measurement

Across a wide range of physical, biological, and Socio-technical systems, long-term operation does not correspond to thermodynamic equilibrium, nor to short-lived non-equilibrium transients. Instead, such systems persist through sustained throughput, irreversible processes, and finite structural carrying capacity, forming what are commonly referred to as nonequilibrium steady states (NESS) under continuous driving and dissipation (Prigogine, 1977; Gaspard, 2004). Their existence is not marked by convergence to a stable state or an optimal solution, but by the continuous generation, dissipation, and reorganization of internal processes over time,

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accompanied by positive entropy production.

Nevertheless, many prevailing analytical frameworks continue-often implicitly-to rely on equilibrium references, point-valued state descriptions, or optimality-based objectives. While such assumptions remain operational for short-term perturbations or approximately closed systems, they become systematically mismatched when applied to systems operating over extended durations under structural constraints and continuous dissipation. In these regimes, observations may appear statistically stationary while failing to indicate whether the system still sustains the irreversible mechanisms that define its non-equilibrium character (Seifert, 2012).

This study adopts the premise that observation is projection, asserting that empirical analysis is valid only within explicitly declared observational frames, temporal scales, and intervention conditions. Observation does not constitute a direct reading of system state; rather, it arises as a projection shaped by finite sampling, temporal windowing, and structural selection. As observational position, time scale, or degree of intervention shifts, the resulting system representation necessarily changes. This view is consistent with modern formulations of nonequilibrium statistical mechanics, where measurable quantities are defined relative to coarse-graining procedures and observational protocols rather than underlying microstates (Maes & Netočný, 2014).

Under conditions of unavoidable partial observability, a more fundamental question emerges: how can one determine whether a system remains in a sustainable non-equilibrium mode of existence, without reconstructing hidden states, assuming optimality, or relying on equilibrium references? This question does not concern the system's eventual trajectory, nor does it seek to recover a complete mechanistic description. Instead, it focuses on whether, under present conditions, the system continues to support the irreversible processes it carries-a concern increasingly emphasized in recent work on nonequilibrium steady states and dynamical activity beyond entropy production alone (Maes, 2020; Polettini & Esposito, 2017).

Within this framework, non-equilibrium existence is no longer identified through trends, fluctuation magnitudes, or performance metrics. Rather, it is confirmed through the persistence of irreversible directional structures that survive statistical stabilization and are invalidated under time-reversal operations. Such criteria align with contemporary treatments of irreversibility, where time-reversal asymmetry and sustained probability currents, rather than macroscopic drift, define nonequilibrium behavior (Crooks, 1999; Seifert, 2012).

Accordingly, the aim of this work is not to predict where systems will ultimately evolve, but to clarify when an existing explanatory coordinate remains applicable, and when it must be abandoned in favor of a new structural description.

Section 1 Observation-Structure Mismatch and the Diagnosis of Non-Equilibrium

1.1 Observation-Structure Mismatch

A primary source of failure in complex system analysis does not lie in stochastic noise itself, but in systematic mismatch between observational projections and the system's underlying structural organization. In many long-running systems, trends, fluctuation amplitudes, or performance indicators may remain statistically stationary. However, statistical stability alone is insufficient to establish whether a system continues to operate in a non-equilibrium mode (Seifert, 2012; Maes, 2020).

In this study, non-equilibrium is not identified through growth or decay trends in time series data. Instead, it is diagnosed through the persistence of directional structures that survive statistical stabilization and are invalidated under time-reversal operations. That is, the non-equilibrium character of a system does not depend on whether it exhibits conspicuous macroscopic change, but on whether irreversible process signatures remain embedded in its structure (Crooks, 1999; Gaspard, 2004).

Even when macroscopic distributions appear stationary, as long as these directional features cannot be eliminated through time-symmetric transformations, the system must still be regarded as operating out of equilibrium. This perspective aligns with contemporary approaches in nonequilibrium statistical mechanics, where sustained probability currents, time-asymmetric path measures, and irreversible dynamical activity define non-equilibrium steady states beyond observable drift or variance (Maes & Netočný, 2014; Polettini & Esposito, 2017).

Accordingly, “non-equilibrium” is reframed here from a descriptive or narrative notion into a diagnosable structural condition. A system need not display continuous variation or deviate from a steady distribution in order for its non-equilibrium existence to be confirmed at the structural level. What matters is whether irreversible directional organization persists under the declared observational projection.

1.2 Structural Stress Revelation: High-Coupling Nodes as Diagnostic Signals

Over prolonged irreversible development, a recurring yet frequently misinterpreted phenomenon becomes evident. When a system enters a high-stress regime, perturbations do not distribute uniformly across its components. Instead, they tend to concentrate and manifest at a limited number of locations-specifically, nodes that are simultaneously coupled to multiple structural flows.

This concentration is not determined by individual attributes or subjective choices, but arises as a structural consequence of multi-layer coupled systems under sustained pressure. In such systems, energy, information, and constraints do not propagate along average paths. When residual stress cannot be dissipated globally, the system spontaneously redirects non-assimilable load toward positions that perform multiple coordination functions, turning them into stress convergence sites (Maes, 2020).

Disturbances observed at these nodes should therefore not be interpreted as component-level anomalies. Rather, they constitute early diagnostic signals of internal structural stress-signals that emerge prior to instability becoming visible at the system-wide scale. Behavioral deviation, functional degradation, or reduced stability at these locations serve as empirical readouts of latent structural tension embedded in the system’s coupling architecture .

From this viewpoint, a system does not act as a uniform background exerting equal influence on all elements. It behaves instead as a selective amplification field. Certain structural configurations, information channels, or institutional arrangements function as stress and residual distributors. These distributors need not possess any intentional role; once positioned at the intersection of multiple couplings, they inevitably assume a revelatory function.

Consequently, conventional explanations that attribute such phenomena to individual capacity, intent, or responsibility become structurally displaced. The node in question is not an agent but a measurement point. Its state variation is not causal but indicative. Through these nodes, the system exposes structural tensions that have not yet surfaced at aggregate scales, functioning as channels of system self-reference (Maes & Netočný, 2014).

As a system approaches a transition regime, deformation typically appears first not in its weakest regions, but in those bearing the greatest constraint and throughput. Just as high-symmetry sites in material structures are more prone to fracture, high-coupling nodes in complex systems are predisposed to reveal imbalance at an early stage-a pattern observed across physical, biological, and networked systems (Gaspard, 2004).

In this sense, such state variations are neither boundary conditions nor normative warnings. They are ongoing empirical phenomena-structural “skeletons” naturally exposed through long-term irreversible evolution. The present analysis does not impose additional interpretation upon them, but explicitly incorporates this revelation mechanism as a key indicator in diagnosing non-equilibrium persistence.

Section 2 Inner and Outer Cycles: The Dual-Cycle Structure of Nonequilibrium Steady States

2.1 Dual Cycles as a Structural Necessity

In long-lived non-equilibrium systems, the distinction between inner and outer cycles is not a metaphorical construct, but a structural consequence jointly imposed by thermodynamic openness and dynamical coupling constraints. Any system capable of sustaining a nonequilibrium steady state must be simultaneously embedded within two interdependent cycles operating at distinct, yet coupled, scales (Prigogine, 1967; Cohen, 2008).

The inner cycle corresponds to local process renewal and dissipative organization, including metabolism, learning, or operational loops within individuals, organizations, or subsystems. The outer cycle corresponds to the larger-scale flow fields in which the system is embedded, such as technological regimes, social environments, resource streams, and energy–information throughput. These cycles are not optional configurations. Together, they constitute the minimal structural requirement for an open system to avoid thermodynamic stagnation and maintain persistent non-equilibrium operation.

From a thermodynamic perspective, the inner cycle functions as the carrier of dissipative structure, while the outer cycle supplies the negentropic flux required to sustain it. A closed inner cycle inevitably accumulates entropy and approaches stasis, whereas an outer cycle that is not absorbed and rectified by internal organization manifests only as stochastic disturbance rather than structured activity. From a dynamical perspective, stable nonequilibrium operation requires structural coupling between inner and outer cycles, enabling both flux transmission and temporal coordination. In the absence of such coupling, no persistent nonequilibrium regime can be maintained (Cohen, 2008).

Within this framework, the relationship between inner and outer cycles does not form a continuous

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spectrum. Instead, it admits only a finite set of discrete dynamical regimes determined by compatibility between flux magnitude, temporal alignment, and structural carrying capacity.

2.2 Three Coupling Regimes

The first regime is meshing. In this state, the update rhythm of the inner cycle falls within a compatibility window relative to variations in the outer flux. Local processes are able to extract usable energy or information from the surrounding flow field and integrate it structurally into their own operation. The system exhibits sustained nonequilibrium existence: throughput persists, structure remains intact, and processes remain closed through internally consistent cycles. This regime corresponds to stable nonequilibrium steady states characterized by persistent probability currents and bounded entropy production (Peng et al., 2020).

The second regime is grinding. Here, the inner cycle operates at a rhythm or orientation misaligned with the outer cycle. Coupling is not fully broken, but flux transfer occurs with elevated friction and dissipation. The system continues to function, yet exhibits increased internal consumption, accumulated stress, and progressive structural fatigue. This regime is not a transient anomaly, but a form of nonequilibrium persistence in which structural capacity is continuously depleted without compensatory restoration. Such states have been identified in driven systems where sustained currents persist while response efficiency deteriorates (Altaner et al., 2012; Maes & Netočný, 2014).

The third regime is idling. In this state, inner and outer cycles become effectively decoupled. The inner cycle may remain highly active, but it no longer accesses the outer flow field in a structurally meaningful way. Conversely, variations in the outer cycle cease to exert regulatory influence on inner processes. Although the system may still appear operational in a statistical sense, its dynamics are no longer externally conditioned, resulting in a gradual loss of adaptability and generative capacity. This regime corresponds to states in which internal activity persists without functional coupling to external driving, leading to effective isolation and eventual stagnation (Cohen, 2008).

These three regimes are not interpretive labels. They arise directly from the relationship between inner and outer cycles with respect to flux magnitude, temporal compatibility, and structural carrying capacity. Under any declared observational projection, a nonequilibrium system must occupy exactly one of these regimes.

2.3 Existence Diagnostics: From State Evaluation to Structural Coherence

Without reconstructing complete system mechanisms, this study introduces a minimal existence diagnostic framework for assessing whether a system continues to operate its nonequilibrium dynamics. The framework does not rely on global state variables or optimality criteria, but on structural-process consistency under conditions of partial observability, consistent with contemporary nonequilibrium statistical approaches (Maes, 2020).

2.3.1 Input Layer (Partial Observation)

Multiple temporal windows, directional measures, and local coupling indicators are used to construct non-uniform sampling structures. Perturbation-response ratios are employed to assess whether processes remain capable of closure under sustained driving. This layer deliberately avoids reliance on single trends or performance indicators, focusing instead on irreversible directional signatures that persist within locally stabilized regimes (Seifert, 2012; Polettini &

Esposito, 2017).

2.3.2 Intermediate Layer (Structural Correspondence)

Structural continuity, path dependence, and cycle nesting are examined within non-uniform mapping spaces. By comparing observed throughput against structural capacity boundaries, this layer evaluates whether the existing structure can still sustain the intensity of the observed processes. Mechanistic equivalence is not assumed; only structural compatibility is required. This approach aligns with cycle-based descriptions of nonequilibrium steady states, where structure is defined by admissible flux loops rather than microscopic detail (Altaner et al., 2012; Peng et al., 2020).

2.3.3 Output Layer (Existence Determination)

The output is not a prediction of future evolution, but an existence determination of the present condition: whether structure remains matched, has entered a critical stress interval, or has undergone structure–process decoupling. Results are expressed as interval states rather than point-valued labels, indicating whether the current explanatory coordinate remains valid.

Through this diagnostic, nonequilibrium existence is no longer assessed by performance or outcome. It is confirmed solely by whether inner and outer cycles remain within a viable meshing interval. This shift establishes a unified structural basis for subsequent cross-system comparison and for the design-oriented considerations developed in later sections.

Section 3 Pathology Localization: Diagnosis, Not Judgment

In non-equilibrium systems, coupling failure does not occur uniformly across space or scale. Structural degradation rarely manifests as immediate global collapse. Instead, it emerges first in localized regions, appearing as persistent mismatches between sustained throughput and available structural capacity. Identifying these early manifestations is essential for understanding systemic fragility and constitutes a necessary precondition for determining whether an existing explanatory framework remains valid.

In this study, pathology does not refer to component malfunction, anomalous behavior, or functional breakdown at the level of individual elements. Rather, it denotes regions in which the system's structural carrying capacity becomes persistently misaligned with the throughput required to sustain ongoing processes. Such regions are not primarily induced by external shocks; they arise endogenously through prolonged irreversible operation, when cumulative adjustments fail to keep pace with sustained driving forces (Cohen, 2008).

3.1 Structural Signatures of Pathological Localization

The emergence of pathological sites exhibits distinct structural characteristics, which can be summarized along three dimensions.

First, persistent throughput without corresponding structural adaptation.

Under effective structure-process coupling, sustained flow induces structural reorganization or expansion, preserving compatibility over time. When throughput persists while structure remains rigid, excess energy or information ceases to contribute to structural renewal and instead accumulates as internal stress. Systems in this condition may continue to display statistical stability, yet they have already lost the capacity for further adaptive reconfiguration. Similar phenomena have been identified in nonequilibrium steady states where probability currents persist while response efficiency deteriorates (Altaner et al., 2012).

Second, premature exhaustion of buffering intervals.

Non-equilibrium systems rely on finite tolerance bands to absorb fluctuations and perturbations. When these buffers are repeatedly saturated under routine variation, structural slack effectively collapses toward a critical threshold. At this stage, minor disturbances can trigger disproportionate process imbalance, signaling a progressive loss of resilience to uncertainty. Early-warning studies of critical transitions consistently show that such local saturation precedes global regime shifts (Scheffer et al., 2009).

Third, temporal misalignment across hierarchical layers.

Structural effectiveness depends not only on capacity, but also on whether response rhythms remain compatible with driving processes. When structural adjustment lags significantly behind flux variation, or conversely proceeds faster than the stabilization requirements of the process itself, coupling integrity degrades even if individual layers remain internally coherent. Multiscale analyses of nonequilibrium systems demonstrate that such temporal desynchronization often concentrates stress at specific coupling interfaces rather than distributing it uniformly (Kuehn, 2011; Maes & Netočný, 2014).

3.2 Pathology as Structural Outcome, Not Anomaly

It is crucial to emphasize that these pathological sites are neither anomalies nor externally imposed disruptions. They are natural outcomes of sustained mismatch among structural capacity, generative surplus, and process-level constraints under long-term irreversible operation. For this reason, pathology localization does not constitute a verdict of failure, but a positional diagnosis indicating where coupling viability begins to erode.

From this perspective, system failure is reinterpreted as a spatially and temporally bounded structural phenomenon, rather than a violation of thresholds in isolated variables or performance metrics. The significance of pathological sites lies not in announcing imminent collapse, but in signaling that, at these locations, existing structural descriptions are no longer sufficient. Continuing to apply the same explanatory coordinate inevitably introduces systematic misinterpretation and masks the onset of irreversible degradation (Cohen, 2008).

3.3 Methodological Role of Pathology Localization

Accordingly, the primary function of pathology localization is to establish a clear boundary for subsequent analysis: distinguishing regions that remain interpretable within the current coupling framework from those that already require alternative structural descriptions or operational logics. This boundary marks the necessary transition point from explaining system behavior to evaluating how non-equilibrium existence may continue under altered coupling conditions.

Pathology localization therefore serves not as a normative judgment, but as a structural diagnostic interface. It preserves analytical rigor by preventing the extrapolation of obsolete explanatory coordinates beyond their domain of validity, and it provides the minimal condition for any subsequent design-oriented or intervention-oriented consideration.

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Section 4 Inference by Probes: When the Field Is Not Directly Measurable

In most non-equilibrium systems, the forces that ultimately shape system behavior do not appear as directly measurable variables. Cognitive load underlying neural activity, institutional and technological fields shaping social dynamics, or distributed pressure landscapes within organizations operate as fields that cannot be isolated, sampled at a single point, or directly observed.

The non-measurability of such fields, however, does not imply that the system is analytically inaccessible. On the contrary, precisely because field effects are continuous and system-wide, they necessarily leave structured traces in the systems they act upon. The premise of inverse measurement is therefore simple: when the field itself cannot be measured, one measures the stress responses it induces in coupled structures and processes. In this sense, measurement does not occur on the field, but at the interfaces where coupling takes place.

4.1 Layers as Probes in Coupled Systems

In multi-layered systems, each structural layer simultaneously fulfills two roles. It acts as the carrier of downstream processes while also serving as a response surface to upstream field influence. Neural dynamics bear cognitive demand; cognitive organization manifests as behavioral choice; behavioral patterns embed within social interaction; and social organization, in turn, constitutes broader technological and institutional environments. No layer is terminal. Each operates as a probe for the field acting upon the layer above it.

Inverse measurement does not attempt to penetrate these layers to reconstruct the field in its entirety. Instead, it exploits the structured relationships between layers, reading field effects indirectly through their projected consequences. States acquire analytical relevance not because individual elements are the object of interest, but because certain locations occupy junctions where multiple structural flows converge. Changes at these junctions inherently encode information about higher-order fields.

This logic is consistent with classical notions of observability in large-scale systems, where unobservable driving forces can nevertheless be inferred through structured responses at coupled interfaces.

4.2 Readouts as Signals, Not Anomalies

Within this framework, pain, fatigue, internal friction, and noise are not treated as anomalies or error terms. They represent the most immediate and least suppressible forms of readout when local structures are subjected to sustained structure-process mismatch. When throughput exceeds structural capacity, when generative surplus is continuously depleted, or when process closure is delayed or disrupted, these conditions will first become visible at nodes most directly coupled to the field.

Such readouts are frequently misinterpreted because conventional analysis equates stability with low variance and minimal noise. In non-equilibrium systems, however, noise is not always interference; in many cases, it is the signal itself. As long as structure can effectively absorb throughput, readouts may appear smooth. When structural compatibility erodes, readouts manifest as wear, stress, or discomfort-long before global failure becomes visible.

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From the perspective of inverse measurement, these manifestations do not indicate that the system has ceased functioning. Rather, they indicate that the system is still operating-still attempting to maintain coupling under increasing strain. The critical concern is not the presence of readouts, but situations in which readouts persist and accumulate without inducing corresponding structural adjustment. At that point, the explanatory coordinate itself begins to fail.

4.3 Scope and Limits of Inverse Measurement

Accordingly, the aim of inverse measurement is neither to identify culpable agents nor to isolate abnormal points for correction. Its purpose is to assess whether observed readouts can still be interpreted as coherent responses within the current structural description. When such interpretation is no longer possible, the problem lies not in the magnitude of the readouts, but in the continued application of an observational framework that no longer matches the system's coupling conditions.

In this sense, the principle that "everything functions as a probe" is not rhetorical but methodological. Under conditions where fields cannot be directly measured, all perceptible state variations constitute the system's only interface for revealing its internal coupling configuration. Inverse measurement does not eliminate uncertainty; it establishes a location from which uncertainty can be continuously and meaningfully read.

Section 5 Re-coupling and Emergent Resilience: When the Order of Design Is Rewritten

In the preceding analysis, coupling has not been treated as a normative stance or a strategic preference, but as an unavoidable condition of non-equilibrium existence (Prigogine, 1967; Cohen, 2008). Once systems are shown to operate persistently within multi-layered couplings-and once it is acknowledged that no observation or intervention can occur from a position outside these couplings-the foundational assumptions of design itself are fundamentally altered.

Conventional design impulses often rely on an implicit premise: that systems are external objects whose deficiencies can be corrected through expansion, efficiency optimization, or functional augmentation. Under conditions of sustained throughput and finite structural capacity, however, this premise no longer holds (Youn et al., 2011). Expansion ceases to be synonymous with improvement, and detachment no longer guarantees safety.

From a coupling perspective, there is no genuine "exit" from the system. Any attempt at withdrawal that is not accompanied by the formation of a new embedding structure will inevitably re-enter the coupling network in another form. Re-coupling is therefore not a remedial response to failure, but a structural inevitability under sustained pressure (Gunderson & Holling, 2002). The relevant distinction lies not between coupling and escape, but between re-embedding through uncontrolled collapse and re-embedding within a still-reversible window.

This recognition alters the temporal position of design. Design no longer follows failure, nor does it primarily aim at maximizing performance metrics. Instead, it shifts toward identifying and preserving reversible intervals-periods in which compatibility between structural capacity and throughput has not yet been exhausted. Within such intervals, the primary function of design is no

longer to impose form, but to avoid further compression of the remaining compatibility space.
Accordingly, the notion of resilience undergoes a corresponding transformation. Emergent resilience is not expressed through higher load tolerance or faster response rates, but through the distribution of risk, the deliberate slowing of feedback, and the suppression of single-point amplification. Distributed architectures, slow-feedback mechanisms, and non-performance-driven regulation do not arise from normative preference; they emerge as structural consequences of operating under high coupling conditions.
Within this framework, the role of design is no longer to guide systems toward predefined target states, but to prevent premature crossing of irreversible thresholds. When structural stress has already entered a high-pressure regime, interventions oriented toward further expansion or optimization tend to accelerate concentration of mismatch rather than alleviate systemic risk.
The rewriting of the design order does not imply the abandonment of design. It signals a repositioning of design from a dominant control variable to a modulator of structural conditions. Design ceases to determine what a system ought to become, and instead determines whether the system retains any capacity for self-adjustment.
In this sense, Design in Accord with e does not propose a new design methodology, but establishes a more fundamental operational constraint: once coupling and dissipation are acknowledged as irreducible, design can only occur within intervals where minimal dissipation and reversibility still persist. When this interval collapses, design activity degenerates into post-hoc repair.
Section 5 therefore offers no actionable prescriptions. It delineates a boundary condition for subsequent work in design and operation: design remains meaningful only so long as structure-observation strain remains below critical limits and the explanatory coordinate remains viable. Beyond that point, the continuation of design demands reflection rather than execution.

Section 6 Conclusion

This work has examined long-running non-equilibrium systems under the premise that sustained existence, rather than optimal performance or asymptotic state, constitutes the primary object of analysis. By treating observation as an embedded projection and non-equilibrium as a structurally diagnosable condition, we have shifted attention away from state variables, performance metrics, and equilibrium references toward the persistence of irreversible directional organization under finite structural capacity.
Across Sections 1-5, a unified framework was developed in which analytical failure arises from observation-structure mismatch, sustained non-equilibrium operation requires viable coupling between inner and outer cycles, and structural degradation manifests first through localized pathologies at high-coupling nodes. When driving fields are not directly measurable, inverse measurement through stress readouts at coupled interfaces provides the only available access to system-wide pressures. Within this framework, resilience is not identified with increased tolerance or accelerated response, but with the preservation of reversible coupling intervals under sustained throughput.
Importantly, this work does not propose predictive models, optimization strategies, or design prescriptions. Its contribution lies in delineating the conditions under which an explanatory coordinate remains valid and identifying the structural thresholds beyond which continued explanation, comparison, or design loses coherence. Design, accordingly, is repositioned from a

control mechanism to a bounded structural modulator whose relevance is strictly limited by remaining reversibility.

By establishing a minimal, domain-independent criterion for diagnosing non-equilibrium existence and its erosion, this framework provides a common structural basis for cross-system analysis without collapsing distinct domains into a single model. Its role is not to determine how systems ought to be governed, optimized, or repaired, but to clarify when such interventions remain meaningful-and when the appropriate response is not further action, but the revision or abandonment of the explanatory frame itself.

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