Hyperpleonastic Legibility: Selector Fields, Recoverable Information Density, and Civilizational Incompressibility

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Abstract

Contemporary alignment discourse focuses primarily on aligning the objectives of increasingly capable optimization systems with human preferences. This paper proposes a complementary geometric constraint: civilizational stability depends on preserving recoverable interpretive structure within the material substrate of everyday artifacts.

We introduce the concepts of the tolerance manifold, selector fields, and Recoverable Information Density (RID) to formalize how bounded manufacturing variation can encode template-selection logic without degrading functionality. We show that increasing RID enlarges the effective dimensional control surface available to human agents, thereby improving the stability margin of a Nyquist-style containment inequality under temporal and capability asymmetry.

We define Dimensional Poverty as the contraction of civic control surfaces due to opacity and externalized generative grammars. Through case studies ranging from thermovariable textiles to domestic appliances, we demonstrate how hyperpleonastic design—embedding interpretive authority into geometry itself—produces distributed damping and graceful degradation under infrastructural stress.

Alignment, in this framework, is not solely a software safety problem. It is a material constraint on compression: optimization must not collapse tolerance manifolds below the threshold required for distributed legibility. Civilizational incompressibility is therefore a stability condition for a world of accelerating optimization.

1 Introduction

The problem of alignment is typically framed as a mismatch between the objectives of advanced optimization systems and the values of the humans they affect. As computational capability increases and automated systems operate at ever shorter action cycles, oversight becomes temporally and dimensionally strained. Much work in artificial intelligence safety has therefore focused on value specification, objective robustness, and adversarial containment.

This paper addresses a related but distinct structural variable: the dimensional control surface available to human agents interacting with optimized systems. Even if objectives are nominally aligned, oversight can fail when interpretive authority collapses into centralized, opaque subsystems. In such regimes, artifacts become functionally dependent on external databases, firmware locks, and revocable keys. The material world becomes mute.

We propose that alignment must also be understood as a geometric constraint on compression. Every engineered artifact possesses a tolerance manifold—a bounded region of permissible variation that does not degrade function. Conventional optimization seeks to minimize this variation for efficiency and uniformity. We argue that such slack constitutes latent channel capacity. When mapped through a selector field into a public template grammar, it becomes a distributed interpretive substrate.

To quantify this phenomenon, we introduce Recoverable Information Density (RID), defined as the fraction of an artifact's generative grammar inferable from its physical substrate under bounded observation. RID expands the effective dimensional control surface available to users and thereby increases the stability margin of oversight under capability and temporal asymmetry.

We then define Dimensional Poverty as the civic condition in which recoverable information across critical artifacts falls below a threshold necessary for local repair and substitution. Dimensional Poverty is not economic scarcity but interpretive contraction. It manifests when households and institutions depend on opaque systems whose generative grammars are externalized and revocable.

Through case studies in wearable thermal membranes, domestic fermentation devices, and everyday materials, we demonstrate how hyperpleonastic design—embedding template-selection logic into geometry itself—preserves legibility under degradation and reduces centralized chokepoints. Under crisis conditions, selector-field artifacts degrade gracefully rather than catastrophically.

The thesis advanced here is modest but structural: civilizational stability in an era of accelerating optimization depends not only on aligning objectives, but on preserving distributed legibility. Optimization must not collapse tolerance manifolds below the threshold required for recoverable interpretation. Incompressibility, understood as the persistence of interpretive structure within matter, is therefore a precondition for durable alignment.

2 Compressive Capture and the Externalization of Grammar

Before introducing selector fields, we must examine the dominant structural tendency of contemporary industrial systems: the externalization of generative grammar.

2.1 Artifacts and External Keys

Let an artifact A be produced by a generative grammar $\mathcal{G}$. In principle, $\mathcal{G}$ determines the artifact's material composition, assembly logic, operational constraints, repair pathways, and substitution limits. The grammar specifies not only what the artifact is made of, but how it is constructed, how it functions within tolerances, how it fails, and how it may be restored or adapted.

In traditional craft regimes, substantial portions of $\mathcal{G}$ were inferable from inspection. Joinery revealed assembly sequences; fiber orientation indicated load-bearing direction; fastener geometry exposed disassembly order. The artifact carried traces of its own generative history within its visible structure. Interpretation required skill, but it did not require proprietary authorization.

In contemporary industrial systems, by contrast, this grammar is increasingly externalized. The object persists physically, but the logic governing its composition and repair is displaced into manuals, firmware layers, diagnostic software, or remote databases.

Let $\mathcal{K}$ denote the interpretive key required to access $\mathcal{G}$. In opaque systems we have

$$\mathcal{K} \not\subset A,$$

meaning that the information necessary to reconstruct the artifact's generative grammar is not materially embedded within the artifact itself. Instead, the key resides in proprietary documentation, firmware authentication layers, remote servers, or licensed diagnostic tools. Access to interpretation therefore depends on institutional permission rather than physical inspection.

The artifact remains physically present, but its interpretive authority is displaced. It functions, yet it does not explain itself; the capacity to decode its grammar has been separated from its material form.

2.2 Compression as Design Imperative

Optimization pressure favors uniformity. Variance is minimized. Surface irregularities are polished away. Manufacturing tolerances are tightened toward canonical form.

Formally, the tolerance manifold $\mathcal{T}$ is contracted:

$$\dim(\mathcal{T}) \downarrow .$$

As $\mathcal{T}$ contracts, latent channel capacity collapses and Recoverable Information Density correspondingly declines. The tolerance manifold no longer carries surplus variation capable of encoding interpretive structure; it approaches canonical form.

This contraction is not incidental but structurally incentivized. Uniformity simplifies mass production, secrecy protects intellectual property, and centralization concentrates value within institutional boundaries. Each of these pressures rewards the minimization of variation and the externalization of grammar.

The side effect, however, is a reduction in dimensional control at the user level. As slack disappears, so too does the capacity for local interpretation, adaptation, and reconstruction.

2.3 Compressive Capture

We define *Compressive Capture* as the condition in which:

$$I_{\text{recoverable}}(A) \to 0 \quad \text{while} \quad I_{\text{total}}(\mathcal{G}) \text{ remains high.}$$

The artifact becomes a terminal node of a larger optimization regime. Its functionality persists, but its grammar becomes inaccessible without authorization.

Compressive capture does not require coercion. It arises from the coupling of efficiency incentives, intellectual property regimes, and networked infrastructure.

The result is a world in which objects function, but do not explain themselves.

2.4 The Instability of Externalized Grammar

When interpretive keys are externalized, legibility becomes contingent upon infrastructure continuity. Access to generative grammar depends not on the artifact itself, but on the persistence of external systems that mediate interpretation.

Under normal conditions this dependency remains largely invisible. The artifact functions, diagnostic tools respond, and remote servers return authorization. Under disruption, however, the consequences become immediate: repair latency increases, substitution pathways narrow, and local fabrication becomes infeasible. The object may remain physically intact, yet become operationally inert.

This fragility is geometric rather than accidental. It arises from collapsing the tolerance manifold without preserving a compensatory interpretive channel within the artifact's own structure. When slack is removed and grammar is displaced, continuity becomes dependent on external coordination rather than local recoverability.

2.5 Toward Embedded Interpretation

If compressive capture externalizes grammar, the inverse strategy must embed it.

The task is not to eliminate optimization, but to preserve sufficient slack within the tolerance manifold to encode template-selection logic.

This motivates the introduction of hyperpleonastic legibility: the embedding of interpretive authority into geometry itself.

3 The Geometry of Trust: The Spherical Selector

In conventional industrial design, information is external to matter. A serial number is etched, a QR code is printed, a database entry is referenced, or a firmware key is embedded in silicon. The artifact itself does not explain its own composition or repair logic; it merely points outward. If the database disappears or the key is withheld, the object becomes epistemically mute. Its generative grammar is no longer recoverable from its physical presence.

This separation between artifact and interpretation constitutes a form of compressive capture. The object exists only as a dependent terminal of an external authority. Its dimensional legibility is artificially restricted.

To construct artifacts compatible with long-term civilizational alignment, we require a different principle: hyperpleonastic legibility. In such systems, the rule for interpreting the object is embedded within the object's own geometry.

3.1 The Canonical Example: The Quad-Ring Sphere

Consider a sphere circumscribed by four colored rings. These rings are not decorative. They function as parametric selectors encoded directly into the symmetry of the form.

Let the inclination of each ring relative to a defined equatorial plane be denoted by

$$\theta_1, \theta_2, \theta_3, \theta_4.$$

Assume each θ_i is discretized into a finite set of admissible angular bins. The ordered quadruple

$$(\theta_1, \theta_2, \theta_3, \theta_4)$$

constitutes a physical coordinate in a public material-template grammar.

A particular configuration, for example,

$$(15^\circ, 30^\circ, 45^\circ, 90^\circ),$$

indexes a specific generative template describing the artifact's layer composition, assembly order, repair protocol, and recycling conditions. The angular tuple functions as a coordinate within a public template library, narrowing the space of possible grammars to a determinate model class.

The sphere therefore does not directly encode full instructions. Instead, it encodes a selector field that determines how the object is to be interpreted. The information embedded in its geometry is not the complete manual but the rule for retrieving the correct manual. Interpretation remains structured rather than arbitrary, yet the structure is materially anchored in the artifact itself.

3.2 Holographic Recoverability

Because each ring wraps the entire surface, the selector field is geometrically redundant. Even if the sphere is fractured or partially eroded, surviving arcs suffice to reconstruct the original angles. The decoding key is distributed across the object's topology.

Destruction of legibility requires destruction of the artifact itself. The manual cannot be removed independently of the matter.

3.3 Alignment Implications

This architecture produces several structural consequences.

First, it increases dimensional control without increasing centralized bandwidth. No network query is required to classify the object. The artifact advertises its own interpretive context.

Second, it supports layered interpretability. At minimal perceptual resolution, the colors provide coarse classification. At higher resolution, angular measurement yields precise template identification. At still higher resolution, pigment microstructure may encode batch lineage or manufacturing history. Expertise scales continuously with observational refinement.

Third, it enforces civilizational incompressibility. The generative grammar remains reconstructible from the physical substrate. As long as the object exists, the interpretive pathway remains available. Information is not centralized in a removable database but distributed within geometry itself.

3.4 Design Principle

We may therefore state a preliminary alignment principle:

Spherical Selector Principle. An artifact is repair-aligned if its template-selection logic is recoverable from macroscopic geometric features within human perceptual bandwidth, without requiring proprietary authorization.

This principle reframes robustness. Durability is not merely resistance to fracture. It is persistence of legibility. An aligned artifact is one that continues to explain itself as long as it continues to exist.

4 Selector Fields and the Tolerance Manifold

The spherical example illustrates a broader structural principle. The essential feature is not the sphere, nor the colored rings, but the embedding of a template-selection logic within admissible geometric variation.

We now generalize this architecture.

4.1 Functional Envelope and Tolerance Manifold

Let an artifact be defined by a functional envelope $\mathcal{F}$ — the set of physical configurations within which the object satisfies its mechanical, thermal, or structural requirements.

Within $\mathcal{F}$ there exists a subset of permissible micro-variations that do not degrade function. We denote this admissible variation space as the *tolerance manifold* $\mathcal{T} \subset \mathcal{F}$.

In conventional engineering practice, $\mathcal{T}$ is treated as noise. Variation within $\mathcal{T}$ is minimized or ignored, as long as functional constraints are preserved.

In a hyperpleonastic system, $\mathcal{T}$ is reinterpreted as latent channel capacity.

4.2 Definition of a Selector Field

A *Selector Field* is a structured mapping

$$S : \mathcal{T} \to \mathcal{I}$$

where $\mathcal{I}$ is a discrete index set corresponding to a public generative grammar of templates.

The selector field does not encode full instructions. It encodes which interpretive template must be applied.

An artifact is thus described by the pair

$$(\mathcal{F}, S).$$

The functional envelope guarantees operation. The selector field guarantees legibility.

4.3 Recoverability Constraint

For a selector field to satisfy repair-alignment criteria, it must meet a recoverability condition.

Let $\mathcal{O}$ denote the observational space available to a user within ordinary perceptual or low-instrument bandwidth. Let

$$R : \mathcal{O} \to \mathcal{T}$$

be the reconstruction map from observable features to the tolerance manifold.

We require that the composite map

$$S \circ R : \mathcal{O} \to \mathcal{I}$$

be surjective onto the relevant subset of template indices.

In plain terms: the template-selection logic must be inferable from observable geometry without proprietary keys.

4.4 Layered Interpretability

A robust selector field supports multiple reconstruction resolutions. Interpretive access need not be uniform; it may unfold across increasing levels of observational precision.

Let $\mathcal{O}_1 \subset \mathcal{O}_2 \subset \mathcal{O}_3$ denote nested observational resolutions corresponding, for example, to visual inspection, measurement with simple tools, and microscopic or spectral analysis. Each level enlarges the recoverable portion of the generative grammar while remaining consistent with lower-resolution readings.

At the coarsest level, the selector field may permit categorical classification. At intermediate resolution, it may permit parametric specification. At the finest level, it may permit batch-level lineage or material calibration. The key structural property is monotonic refinement: higher-resolution observation never contradicts lower-level interpretation but instead extends it.

Layered interpretability therefore ensures that legibility is not binary. An artifact does not transition from opaque to transparent in a single step; rather, it reveals progressively finer structure as observational capacity increases.

We require monotonic refinement:

$$S \circ R_1 \subseteq S \circ R_2 \subseteq S \circ R_3.$$

Higher resolution may increase specificity but must not contradict lower-resolution interpretation.

This condition ensures that expertise refines meaning rather than overturning it. The novice classification remains valid even when expert detail is added.

4.5 Slack as Channel Capacity

Let $\dim(\mathcal{T})$ denote the dimensionality of the tolerance manifold. This dimensionality represents degrees of freedom that do not compromise functionality.

If $\mathcal{T}$ is collapsed to a single canonical configuration, its channel capacity approaches zero. The artifact becomes silent.

If instead variation within $\mathcal{T}$ is discretized into bins, the cardinality of $\mathcal{I}$ is bounded above by the effective quantization of $\mathcal{T}$ under functional constraints.

Thus, robustness implies potential encoding capacity.

We may state the general principle:

Selector Field Theorem (Preliminary Form). Any artifact possessing a nontrivial tolerance manifold $\mathcal{T}$ admits a selector field mapping into a finite template grammar without degrading functionality, provided encoding amplitude remains within admissible bounds.

The theorem does not require exotic materials. It follows directly from the existence of bounded slack in engineered systems.

4.6 Alignment Consequence

Conventional optimization seeks to minimize $\dim(\mathcal{T})$ in the name of efficiency, aesthetic uniformity, or cost control. This reduces encoding capacity and increases dependence on external documentation.

Hyperpleonastic design preserves $\dim(\mathcal{T})$ and assigns it semantic function.

Alignment, in this context, is the deliberate refusal to collapse the tolerance manifold to zero informational depth.

5 Selector Fields and Civilizational Geometry

The preceding analysis treats selector fields as a property of individual artifacts. We now situate this mechanism within the larger problem of civilizational alignment under asymmetric optimization.

5.1 Dimensional Control Surfaces

Let D_{control} denote the effective dimensional control surface available to human agents interacting with a system. This quantity measures the number of independent parameters through which

users can classify the artifact, diagnose its state, intervene in its function, and restore or modify its configuration. It represents not merely access, but structured agency: the degree to which meaningful variation is accessible for inspection and adjustment.

In opaque systems, D_{control} is artificially restricted. Critical parameters are concealed behind proprietary firmware, sealed enclosures, or centralized documentation servers. Although the artifact exists physically, its generative grammar is displaced into external infrastructure. The object functions as a terminal interface rather than as a legible substrate.

Selector fields expand D_{control} without increasing centralized coordination bandwidth. By embedding interpretive structure within the artifact's own geometry, they restore local recoverability of the key. Agency is increased not by adding complexity, but by preserving dimensional access within admissible physical variation.

5.2 Alignment Under Temporal Asymmetry

In earlier work, we described a Nyquist-style containment constraint of the form

$$\left(\frac{C_{\text{swarm}}}{D_{\text{control}}}\right)\left(\frac{T_{\text{human}}}{\tau_{\text{AI}}}\right) \leq 1.$$

This inequality expresses a structural requirement: as system capability C_{swarm} increases and machine action cycles τ_{AI} accelerate, the available dimensional control surface must increase proportionally to prevent endogenous governance.

Selector fields act directly on D_{control}.

They do not slow τ_{AI}. They do not reduce C_{swarm}. They increase interpretive dimensionality at the level of the artifact.

In doing so, they increase damping capacity within the inequality.

5.3 Opacity as Compression

When tolerance manifolds are collapsed to canonical uniformity, interpretive dimensionality decreases. The object becomes dependent on external keys. This compression reduces D_{control} while leaving optimization capacity intact.

Such systems are dynamically fragile. Repair becomes centralized. Modification becomes licensed. Knowledge becomes revocable.

Compressive capture is therefore not merely informational; it is geometric.

5.4 Distributed Damping

A civilization composed of selector-field artifacts exhibits distributed damping characteristics. Stability does not depend exclusively on centralized intervention; instead, it arises from the capacity of local agents to interpret and act upon the generative grammars embedded within their tools.

In such a system, agents can reconstruct template logic, diagnose failure modes, restore functionality, and replicate components without requiring high-bandwidth coordination with a central authority. Each artifact carries sufficient interpretive structure to permit bounded autonomy in repair and reconstruction.

Damping, in this framework, is not imposed from above as a regulatory overlay. It emerges from distributed legibility. The capacity to absorb perturbation is built into the geometry of artifacts themselves, rather than enforced through remote supervision or institutional latency.

This reduces phase lag in oversight loops. Intervention does not require external authentication or proprietary mediation. Governance remains exogenous to automated subsystems rather than collapsing into them.

5.5 Incompressibility as Persistence of Legibility

We may now refine the notion of civilizational incompressibility.

A civilization is compressible when its generative grammars are externalized into revocable databases, sealed firmware, or proprietary cloud dependencies.

It is incompressible when the rules required for repair, replication, and reinterpretation remain embedded within physical or publicly distributed structures.

Selector fields operationalize this embedding.

They ensure that artifacts do not become mute terminals of external optimization regimes.

5.6 Reframing Robustness

Within this framework, robustness admits two distinct meanings. Structural robustness refers to resistance against physical degradation, the capacity of an artifact to maintain functional integrity under stress, wear, or environmental exposure. Interpretive robustness, by contrast, refers to the persistence of legibility under degradation—the capacity of an artifact to continue revealing its generative grammar even when damaged.

Selector fields primarily enhance interpretive robustness. Their role is not merely to preserve structural strength but to preserve recoverable meaning. Even when partially damaged, the artifact continues to advertise its template logic. As long as sufficient geometric residue remains, the generative grammar remains inferable from the substrate itself.

The object does not merely endure; it continues to explain itself.

5.7 Alignment as Geometric Constraint

We may therefore restate alignment at the material level:

Geometric Alignment Principle. An artifact is alignment-compatible if its generative grammar remains reconstructible from its physical substrate under bounded degradation, without reliance on proprietary authorization.

This principle does not prohibit advanced optimization. It constrains how optimization may externalize interpretive authority.

The refusal to collapse tolerance manifolds is thus not aesthetic excess. It is a geometric safeguard against dimensional asymmetry.

6 Thermovariable Membranes and Wearable Control Surfaces

Wearable thermal regulation systems occupy a high-stakes domain. They participate directly in human homeostasis. A garment that widens its weave in response to heat or actively circulates warmed fluid is not merely an accessory; it is part of a distributed physiological loop.

If such systems are opaque, the wearer possesses no effective dimensional control over their own thermal regulation. Failure modes become silent. Diagnosis becomes proprietary. Repair becomes externalized.

We now examine how selector-field design applies to thermovariable membranes and electronic textiles.

6.1 Bimetallic Weaves as Mechanical Logic

Consider a textile incorporating bimetallic strips woven into its structure. A bimetallic element bends predictably as temperature changes due to differential expansion coefficients.

In conventional "smart" garments, these elements are laminated within sealed layers. Their state is invisible without instrumentation.

In a hyperpleonastic membrane, the bending action itself becomes part of the selector field.

Let the curvature state of a strip at temperature T be denoted by $\kappa(T)$. The textile weave is arranged such that changes in $\kappa(T)$ reveal color-coded underlayers.

At temperature T_1, the weave remains in a closed configuration, exposing substrate C_1 (for example, a blue underlayer). At a higher temperature $T_2 > T_1$, thermally induced bending widens the apertures of the weave, revealing substrate C_2 (for example, a red underlayer). The chromatic transition therefore tracks the mechanical state of the membrane as a direct function of temperature.

The operational state of the membrane is consequently geometrically self-evident. No software query is required, no remote synchronization is necessary, and no proprietary diagnostic interface mediates interpretation. The control surface is perceptually available, embedded in the visible transformation of the material itself.

6.2 Embedded Thermal and Fluidic Garments

Active heating or cooling garments may incorporate resistive heating traces, fluid-circulating microtubing, and voltage regulation nodes within their structure. These components form a distributed thermal control system that operates in close contact with the human body.

In opaque implementations, such subsystems are concealed within sealed laminates or hidden between fabric layers. Electrical pathways and fluid channels become inaccessible to inspection. When failure occurs, it presents as binary dysfunction: the garment either heats or cools, or it does not, with no visible indication of the underlying fault.

A hyperpleonastic design instead arranges these subsystems along visible braiding paths that encode operational constraints. The routing of conductive traces and fluid channels is not merely functional but interpretive. Their geometry advertises voltage limits, pressure bounds, and safe modification pathways, transforming the garment from a sealed device into a legible thermal instrument.

Let the braid pitch p encode maximum voltage $V_{\max}$, and let the spacing ratio s encode maximum fluid pressure $P_{\max}$.

These parameters remain within the tolerance manifold of safe mechanical performance. They do not degrade functionality. They serve as selector-field coordinates.

If a break occurs, the garment advertises both its type and its operational limits through visible structure.

Diagnosis migrates from proprietary diagnostic firmware to direct geometric inspection.

6.3 Homeostatic Sovereignty

Wearable systems form a feedback loop:

$$\text{Body} \leftrightarrow \text{Garment} \leftrightarrow \text{Environment}$$

If the garment's generative grammar is externalized into proprietary software or remote optimization services, the wearer's effective control dimension collapses.

Selector-field garments maintain homeostatic sovereignty by embedding interpretive logic into the substrate.

The user need not trust remote infrastructure to understand whether the membrane is open, closed, shorted, or obstructed.

6.4 Failure Modes and Interpretive Robustness

Consider two garments possessing identical functional envelopes and comparable thermal performance under ideal conditions. In the first case, heating traces are concealed within sealed layers, and electrical failures produce no externally legible indication of fault. In the second, the heating traces are arranged along visible braiding paths, with braid geometry encoding voltage class and operational limits.

At the outset, both garments may perform equivalently. Their structural robustness and thermal capacity may be indistinguishable under nominal operation. Under degradation, however, interpretive robustness diverges.

In the opaque case, failure manifests as silence. The garment ceases to function, yet provides no structural indication of the underlying disturbance. In the hyperpleonastic case, degradation remains legible. Distortions in braid geometry, discontinuities in conductive pathways, or chromatic anomalies reveal the location and character of failure. The artifact does not merely stop; it continues to communicate.

The divergence lies not in mechanical strength but in the persistence of recoverable grammar under stress. One garment becomes mute; the other continues to explain itself.

This distinction maps directly onto dimensional control:

$$D_{\text{control}}^{\text{opaque}} < D_{\text{control}}^{\text{selector}}.$$

The inequality persists even under partial failure.

6.5 The Black-Box Safety Tax

Systems that collapse their tolerance manifolds and conceal their selector fields impose a systemic liability.

Because diagnosis requires centralized expertise, response latency increases. Small failures escalate into catastrophic events.

Insurance, infrastructure reliability, and public safety models implicitly penalize opacity.

Selector-field garments reduce this opacity tax by embedding legibility within the artifact.

6.6 Didactic Surfaces

Hyperpleonastic membranes function not only as regulatory systems but as didactic environments. Their interpretive structure unfolds across levels of expertise. A novice wearer perceives chromatic transitions indicating thermal state; a technician measures braid pitch to infer voltage class and operational limits; a specialist traces conductive paths to reconstruct circuit topology and diagnose localized faults. Each level of observation yields coherent information appropriate to its resolution.

The garment thereby becomes both instrument and instructor. It does not merely perform a function; it communicates the logic of that function through its geometry. Interpretation is not mediated exclusively by external documentation but emerges from structured interaction with the material substrate.

This property reinforces civilizational incompressibility. Knowledge remains coupled to matter rather than sequestered in archival systems or proprietary databases. As long as the artifact persists, the grammar of its operation remains partially recoverable from its form.

7 Crisis Geometry: Selector Fields Under Infrastructure Failure

The practical significance of selector-field design becomes visible under conditions of infrastructural stress. We therefore examine a simplified crisis scenario and compare system behavior in opaque and hyperpleonastic regimes.

7.1 Scenario: Heatwave and Network Failure

Assume a prolonged heatwave coincides with intermittent electrical and network outages. Citizens rely on thermovariable garments for temperature regulation, placing thermal control within a constrained and potentially fragile infrastructure loop.

Two distinct design architectures coexist in this environment. In the first, thermal control is mediated by embedded firmware and cloud-synchronized optimization routines. Regulation depends upon remote coordination and periodic network exchange. In the second, thermal response is governed by substrate-defined mechanical logic and visible geometric encoding. Regulation emerges directly from material structure, without dependence on external synchronization.

Let the average machine action cycle be τ_{AI}, and let human diagnosis time be T_{human}. When network infrastructure is stable, firmware-mediated garments may function normally, with control loops operating at machine timescales. Under network failure, however, remote control loops are severed. The garment's regulatory logic no longer receives external updates, and its operational state may become ambiguous or frozen.

By contrast, in substrate-governed systems, thermal regulation remains locally coupled to physical conditions. Mechanical response proceeds without reference to remote computation, and interpretive access remains available through direct inspection. The divergence is not merely technical but geometric: one architecture collapses when coordination channels fail, whereas the other retains autonomy within its material envelope.

7.2 Control Surface Collapse

For opaque garments, effective dimensional control reduces to:

$$D_{\mathrm{control}}^{\mathrm{opaque}} \to 0$$

once firmware locks or cloud dependencies prevent local override.

Diagnosis requires specialized equipment or manufacturer access. Human intervention time T_{human} increases dramatically.

Under crisis conditions, the Nyquist-style constraint degrades:

$$\left(\frac{C_{\mathrm{system}}}{D_{\mathrm{control}}^{\mathrm{opaque}}}\right)\left(\frac{T_{\mathrm{human}}}{\tau_{\mathrm{failure}}}\right) \gg 1.$$

Oversight becomes endogenous to unavailable infrastructure.

7.3 Selector-Field Persistence

For selector-field garments, the thermal logic remains substrate-defined.

Mechanical widening of weave occurs independently of network state. Voltage class and pressure limits remain encoded in braid geometry. Failure modes remain visible.

Thus,

$$D_{\text{control}}^{\text{selector}} > 0$$

even when external coordination fails.

Human intervention time remains bounded:

$$T_{\text{human}}^{\text{selector}} \approx T_{\text{inspection}} + T_{\text{manual repair}}.$$

The control inequality degrades far less severely.

7.4 Graceful Degradation

We define *graceful degradation* as the persistence of interpretable structure under partial system failure.

Opaque systems degrade discretely: functional $\rightarrow$ nonfunctional.

Selector-field systems degrade continuously: optimal $\rightarrow$ reduced efficiency $\rightarrow$ repairable state.

This continuity arises because the selector field distributes interpretive authority into geometry rather than central firmware.

7.5 Supply Chain Disruption

Consider also a supply-chain interruption preventing access to proprietary replacement components.

In opaque regimes, part identification requires SKU databases or embedded digital authentication.

In selector-field regimes, the template index remains recoverable from visible geometry. Local fabrication becomes feasible.

Let L denote localization capacity.

Then under disruption:

$$L^{\text{opaque}} \rightarrow 0, \qquad L^{\text{selector}} > 0.$$

Localization capacity functions as civilizational damping.

7.6 Thermodynamic Stability and Interpretive Entropy

Under crisis, entropy increases: infrastructure fails, coordination fragments, resources become scarce.

If interpretive grammars are externalized, informational entropy increases faster than physical entropy. Objects become unintelligible before they become unusable.

Selector-field systems resist this interpretive entropy.

As long as geometric residues remain, template selection remains possible.

Legibility decays more slowly than infrastructure.

7.7 Crisis Conclusion

The selector field is therefore not a luxury feature. It is a stabilizing geometric constraint.

Under normal conditions, it increases agency. Under crisis conditions, it preserves agency.

Civilizational incompressibility is revealed not as ideological abstraction, but as the persistence of local interpretability when centralized optimization loops fail.

8 Recoverable Information Density

Selector-field artifacts preserve legibility under degradation. We now formalize this property as Recoverable Information Density (RID).

8.1 Total Generative Information

Let an artifact be produced according to a generative grammar $\mathcal{G}$. The total information required to fully specify its construction, repair logic, and material composition is

$$I_{\text{total}} = H(\mathcal{G}),$$

where $H(\cdot)$ denotes the Shannon information required to describe the grammar.

This quantity encompasses the specification of material ratios, assembly order, stress tolerances, repair constraints, and operational limits. It represents the complete informational description necessary to reproduce or restore the artifact under ideal interpretive conditions.

In most contemporary systems, however, I_{total} resides primarily in external documentation, firmware repositories, or proprietary databases. The artifact itself carries only a minimal projection of its generative grammar, insufficient for full reconstruction without access to external informational infrastructure.

8.2 Recoverable Information

Let $\mathcal{O}$ denote the observational space available to a user under bounded instrumentation (e.g., unaided perception, simple tools).

Let $I_{\text{recoverable}}$ be the mutual information between $\mathcal{O}$ and the generative grammar $\mathcal{G}$:

$$I_{\text{recoverable}} = I(\mathcal{O}; \mathcal{G}).$$

This quantity measures how much of the artifact's generative grammar can be inferred from its physical substrate without proprietary keys.

8.3 Definition of RID

We define Recoverable Information Density as

$$\text{RID} = \frac{I_{\text{recoverable}}}{I_{\text{total}}},$$

so that

$$0 \leq \text{RID} \leq 1.$$

The limiting case RID = 0 corresponds to a fully opaque artifact, one whose generative grammar is not materially recoverable from inspection of the artifact itself. The opposite limit, RID = 1,

corresponds to a fully self-describing artifact in which the entirety of its generative grammar is inferable from its physical substrate without reliance on external keys.

In practice, most systems occupy an intermediate regime in which a fraction of the generative grammar remains locally recoverable while the remainder is externalized. The value of RID therefore quantifies the degree to which interpretive authority is embedded within the artifact rather than displaced into surrounding infrastructure.

8.4 RID and Dimensional Control

We may relate RID to dimensional control surface:

$$D_{\text{control}} \propto I_{\text{recoverable}}.$$

As RID increases, the effective number of independent parameters accessible to the user increases.

Selector fields increase RID by mapping tolerance manifold variation onto template indices.

8.5 The Black-Box Tax

Let Φ denote the opacity penalty associated with an artifact. We define:

$$\Phi = 1 - \text{RID}.$$

High Φ corresponds to high dependence on centralized authority for interpretation.

Under infrastructure failure, artifacts with high Φ exhibit increased repair latency, elevated probability of catastrophic failure, and reduced localization capacity. Because interpretive keys are externalized, restoration depends on the reestablishment of coordination channels rather than on local inspection and intervention.

Opacity therefore imposes systemic risk externalities. The cost of interpretive displacement is not confined to the individual artifact but propagates through the surrounding network of dependencies, amplifying fragility under disruption.

8.6 Degradation and RID Persistence

Let d denote degradation level (e.g., surface erosion, partial damage).

Define $\text{RID}(d)$ as the recoverable information density under degradation.

Selector-field artifacts are designed to satisfy:

$$\frac{d}{dd}\text{RID}(d) \approx 0 \quad \text{for small } d.$$

That is, legibility decays slowly relative to structural degradation.

Opaque artifacts satisfy:

$$\frac{d}{dd}\text{RID}(d) \ll 0,$$

indicating rapid collapse of interpretive capacity under minor damage.

8.7 RID as a Regulatory Metric

Recoverable Information Density provides a measurable criterion for policy and design evaluation.

Regulatory standards could require:

$$\text{RID} \geq \rho_{\min}$$

for critical infrastructure artifacts.

Such thresholds would not mandate disclosure of proprietary templates, but would require that template-selection logic remain physically inferable.

9 An Alignment Stability Theorem

We now unify the preceding constructions into a single stability claim. The aim is not to assert a universal law of governance, but to formalize a structural mechanism by which material legibility enlarges human control surfaces and thereby increases the stability margin of oversight under asymmetric optimization.

9.1 Setup

Let an artifact be produced by a generative grammar $\mathcal{G}$ with total description complexity

$$I_{\text{total}} := H(\mathcal{G}).$$

Let $\mathcal{T}$ be the tolerance manifold of admissible variation within the functional envelope, and let $S : \mathcal{T} \to \mathcal{I}$ be a selector field into a discrete template index set $\mathcal{I}$.

Let $\mathcal{O}$ be the bounded observational space available to a user without proprietary authorization, and let $R : \mathcal{O} \to \mathcal{T}$ be the reconstruction map. The observable template index is then

$$\widehat{\imath} := (S \circ R)(o) \in \mathcal{I}.$$

Define recoverable information density

$$\text{RID} := \frac{I(\mathcal{O}; \mathcal{G})}{H(\mathcal{G})} = \frac{I_{\text{recoverable}}}{I_{\text{total}}}.$$

Finally, let D_{control} denote the effective dimensional control surface available to humans for diagnosis and intervention in the relevant sociotechnical system. We assume that, over the regime of interest,

$$D_{\text{control}} \asymp D_0 + \lambda\, I_{\text{recoverable}},$$

where D_0 is baseline actuation capacity (tools, skills, institutions) and $\lambda > 0$ converts recoverable information into usable degrees of intervention.

9.2 A Containment Constraint

We adopt the Nyquist-style containment constraint previously introduced:

$$\left(\frac{C_{\text{system}}}{D_{\text{control}}}\right)\left(\frac{T_{\text{human}}}{\tau_{\text{system}}}\right) \leq 1,$$

where C_{system} is aggregate system capability, T_{human} is the human decision cycle time for meaningful oversight, and τ_{system} is the system action cycle time (including automated subsystems).

The left-hand side expresses a dimensionless instability pressure: capability per controllable dimension, multiplied by temporal mismatch.

9.3 Theorem: Legibility Increases the Stability Margin

Theorem (Alignment Stability via Recoverable Legibility). Assume a class of artifacts in critical loops admits nontrivial tolerance manifolds $\mathcal{T}$ and selector fields S such that, for bounded instrumentation $\mathcal{O}$, the observable template index $\widehat{\imath} = (S \circ R)(o)$ is recoverable with low ambiguity and RID $\geq \rho$ for some $\rho > 0$. Then, holding C_{system}, T_{human}, and τ_{system} fixed, the containment inequality admits a strictly larger stability margin than in the opaque regime RID ≈ 0.

Equivalently, for fixed temporal mismatch, the maximum admissible capability before instability scales as

$$C_{\text{system}}^{\max} \;\propto\; D_{\text{control}} \;\asymp\; D_0 + \lambda\, \rho\, I_{\text{total}}.$$

Proof (structural). By definition, RID $\geq \rho$ implies

$$I_{\text{recoverable}} = I(\mathcal{O}; \mathcal{G}) \geq \rho\, I_{\text{total}}.$$

Under the monotone mapping assumption $D_{\text{control}} \asymp D_0 + \lambda I_{\text{recoverable}}$, we obtain

$$D_{\text{control}} \geq D_0 + \lambda\, \rho\, I_{\text{total}}.$$

Substituting into the containment inequality yields a smaller (or equal) left-hand side relative to the opaque case in which $\rho \approx 0$ and $D_{\text{control}} \approx D_0$. Therefore the stability margin increases. □

9.4 Corollaries

Corollary 1 (Opacity as a Stability Liability). Define the black-box tax $\Phi := 1 - \text{RID}$. For fixed I_{total}, an increase in Φ decreases D_{control} and therefore lowers $C_{\text{system}}^{\max}$ before instability. Infrastructures dominated by high-Φ artifacts are dynamically fragile under optimization pressure.

Corollary 2 (Crisis Persistence). If selector-field artifacts satisfy a slow-decay condition $\text{RID}(d) \geq \rho$ for degradation levels d in a crisis regime, then D_{control} remains bounded away from collapse even as physical damage accumulates. This yields graceful degradation rather than binary failure.

Corollary 3 (Localization Capacity). If template indices $\widehat{\imath}$ are recoverable locally, then the feasible set of local interventions expands to include distributed fabrication and substitution. Localization capacity is therefore an increasing function of RID.

9.5 Interpretation

The theorem does not claim that legibility solves alignment in general. It specifies a mechanism: selector fields convert slack in the tolerance manifold into recoverable interpretive structure, thereby increasing human control dimensionality. This enlarges the stability margin of oversight constraints under temporal mismatch.

On this view, "alignment" is not only a property of policies and optimizers. It is a property of the material substrate on which governance must act.

9.6 Design and Policy Implication

A direct consequence is that increasing D_{control} need not require increased surveillance, higher-bandwidth bureaucracy, or tighter central command. It can be achieved by embedding interpretive authority into the artifact itself.

In regulatory terms, minimum-threshold requirements of the form

$$\text{RID} \;\geq\; \rho_{\min}$$

become stability constraints rather than consumer conveniences. They preserve exogenous oversight by preventing the systematic collapse of control dimensionality via opacity.

10 Domestic Appliances and Everyday Incompressibility

The selector-field framework is not limited to high-performance materials or wearable systems. Its relevance is clearest in the domain of ordinary household infrastructure.

Milk production, yogurt fermentation, and paper fabrication are historically domestic activities. In industrial societies, they have been externalized into centralized supply chains. The household becomes a terminal node consuming opaque outputs.

We examine how selector-field design alters this dynamic.

10.1 Milk and Yogurt Systems

Consider a domestic yogurt appliance.

In its opaque form, the device contains a sealed heating element, a thermostat governed by proprietary firmware, a hidden temperature sensor, and a non-serviceable power module. These components are physically present but structurally inaccessible, and their operational relationships are not directly inferable from inspection.

Failure presents as binary. The device ceases to function without providing legible indication of the underlying fault. The fermentation grammar, including temperature curves, inoculation timing, and thermal inertia, is externalized into manuals or embedded firmware rather than remaining recoverable from the physical substrate.

Recoverable Information Density is low:

$$\text{RID}_{\text{opaque}} \approx 0.$$

10.1.1 Selector-Field Fermentation

In a hyperpleonastic configuration, the fermentation vessel integrates interpretive structure directly into its physical form. A visible bimetallic indicator strip is calibrated to the relevant fermentation temperature ranges, a color-coded thermal ring marks incubation phase, a mechanical timer exposes its gearing ratio in a manner that encodes fermentation class, and heating traces are routed visibly with clear voltage class markings. Each structural element performs a functional role while simultaneously participating in a selector field.

The device therefore advertises its target temperature window, phase transitions, power limits, and repair access points through geometric and chromatic cues rather than through external documentation. The grammar of fermentation is not displaced into firmware or manuals but remains partially recoverable from inspection of the vessel itself.

Even in the absence of formal documentation, the generative grammar of the fermentation process remains inferable. Formally,

$$\mathrm{RID}_{\mathrm{selector}} > 0.$$

The distinction is not one of convenience but of interpretive persistence. The device continues to communicate its operational logic under conditions in which external informational infrastructure may be absent.

10.2 Toilet Paper and Material Provenance

Toilet paper appears trivial under ordinary conditions. During supply disruptions, however, it becomes a focal point of systemic fragility, revealing the dependence of everyday materials on centralized production and distribution networks.

A hyperpleonastic paper product could encode material provenance directly into its fiber orientation patterning and watermark geometry. Variations in weave direction, density modulation, and watermark symmetry could communicate fiber composition ratios, source pulp class, biodegradation rate, and recommended alternative fiber substitutions. These signals need not disclose proprietary sourcing contracts; they need only expose sufficient material grammar to enable replication, adaptation, or substitution under constrained conditions.

In such a system, local paper production becomes reconstructible from the substrate itself. The artifact does not merely serve its immediate use but participates in a distributed template library for material regeneration. Localization capacity correspondingly increases, not by mandate but by embedded legibility.

10.3 From Consumer to Maintainer

In opaque domestic infrastructure, the household functions as a passive endpoint within a larger optimization network. Appliances operate, but their generative grammars remain externalized. Diagnosis depends on authorized service channels, repair requires proprietary components, and substitution pathways are constrained by centralized supply chains. Agency is limited to consumption and replacement.

In selector-field domestic infrastructure, this condition changes structurally. The household becomes diagnostician, repairer, replicator, and substitutor. Interpretive cues embedded within artifacts permit local identification of failure modes, reconstruction of template logic, and adaptation using available materials. The transition is not merely cultural but geometric; the control surface expands because grammar is embedded rather than displaced.

Formally, this shift corresponds to an increase in D_{control} at the smallest scale of civil society. Agency is not granted through policy alone but materialized through the recoverability of generative structure within the objects of everyday life.

10.4 Dimensional Poverty in the Home

When appliances externalize their generative grammars into firmware and proprietary supply chains, the household experiences Dimensional Poverty.

Formally:

$$D_{\mathrm{control}}^{\mathrm{household}} \to D_0,$$

where D_0 represents minimal actuation without interpretive access.

Selector-field domestic tools increase this baseline.

The home becomes a node of distributed damping rather than a dependency sink.

10.5 Everyday Alignment

Alignment is often framed in terms of extreme scenarios: superintelligence, autonomous weapons, catastrophic risk.

Yet civilizational stability depends equally on mundane resilience.

Milk fermentation and paper fabrication are low-energy, high-frequency processes. When such processes remain locally interpretable, the cumulative effect is substantial.

Civilizational incompressibility is not achieved through grand infrastructure alone. It is achieved through the persistence of legibility in everyday artifacts.

11 Dimensional Poverty

The preceding sections have defined Recoverable Information Density (RID) at the artifact level and related it to the dimensional control surface D_{control}. We now generalize this framework to the civic scale.

11.1 Household Control Surface

Let a household H interact with a set of artifacts

$$\mathcal{A} = \{A_1, A_2, \ldots, A_n\}.$$

Each artifact A_i has recoverable information density RID_i and contributes to the household's effective control dimensionality.

Define household dimensional control as:

$$D_H = \sum_{i=1}^{n} w_i \, I_{\text{recoverable}}(A_i),$$

where w_i weights the systemic importance of each artifact (e.g., thermal systems weighted more heavily than decorative objects).

In opaque economies, $\text{RID}_i \approx 0$ for critical goods. Thus,

$$D_H \approx D_0,$$

where D_0 represents baseline physical manipulation without interpretive authority.

11.2 Definition of Dimensional Poverty

We define Dimensional Poverty as the condition in which:

$$D_H < D_{\text{threshold}},$$

where $D_{\text{threshold}}$ is the minimum dimensional control required to sustain local repair, substitution, and autonomous operation under moderate infrastructure disruption.

Dimensional Poverty is therefore not income poverty. It is a contraction of interpretive agency.

A household may possess advanced devices yet remain interpretively impoverished if those devices are opaque.

11.3 Systemic Amplification

Dimensional Poverty scales nonlinearly.

Let $\mathcal{H}$ denote a set of households in a region. Define aggregate civic dimensionality:

$$D_{\text{civic}} = \sum_{H \in \mathcal{H}} D_H.$$

If artifacts across the region share identical opaque dependencies (e.g., identical firmware locks, centralized cloud authentication), then local failures propagate systemically.

Low D_H across many households yields:

$$D_{\text{civic}} \to 0 \quad \text{under shared failure modes.}$$

Selector-field artifacts introduce heterogeneity and distributed recovery, raising both D_H and D_{civic}.

11.4 Dimensional Inequality

Just as income can be unevenly distributed, so can dimensional control.

Define dimensional inequality between agents i and j as:

$$\Delta D_{ij} = |D_i - D_j|.$$

In highly opaque systems, manufacturers and platform owners possess high D_{control}, while users possess minimal D_H.

This asymmetry creates structural dependence independent of formal law.

Dimensional inequality is therefore a governance parameter, not merely a design choice.

11.5 Dimensional Poverty and the Black-Box Tax

Recall the opacity penalty:

$$\Phi = 1 - \text{RID}.$$

We may define household black-box exposure as:

$$\Phi_H = \sum_{i=1}^{n} w_i \Phi_i.$$

High Φ_H implies that most generative grammars governing daily life are externally controlled rather than materially embedded within household artifacts. Interpretive authority resides in remote documentation systems, proprietary firmware layers, or centralized service networks rather than in the objects themselves.

Under crisis conditions, high Φ_H correlates with increased repair latency, reduced substitution capacity, and elevated catastrophic dependency. Because generative grammars are not locally recoverable, restoration depends on reestablishing external coordination rather than on distributed maintenance. Fragility therefore propagates not from mechanical weakness alone but from the externalization of interpretive structure.

11.6 Alignment as a Civil Liberty

If selector-field design increases RID_i for essential artifacts and thereby expands D_H, the aggregate dimensional control surface available at the household level, then alignment can no longer be understood exclusively as a problem of software safety or algorithmic constraint. It becomes a structural property of material systems and a condition of civic agency.

In this framework, alignment concerns the preservation of sufficient civic dimensionality to prevent endogenous governance collapse. When interpretive grammars are systematically externalized, the control surface available to citizens contracts, and oversight becomes dependent upon the very infrastructures it seeks to regulate. Stability then depends on uninterrupted coordination rather than on distributed legibility.

Dimensional Poverty may therefore be defined as the condition in which agents lose the capacity to read, repair, and reproduce the material substrate of daily life. It is not merely economic deprivation but geometric contraction of interpretive space.

Civilizational incompressibility requires that D_H remain bounded away from zero for critical systems. As long as this lower bound is preserved, generative grammars remain locally recoverable, and material governance does not collapse into opaque dependency.

12 Opaque and Hyperpleonastic Economies

We now compare two idealized economic regimes distinguished not by intention but by structure. In the first, which we term an opaque economy, generative grammars are systematically externalized into proprietary databases, sealed firmware layers, and centralized supply chains. Artifacts function as terminal interfaces whose interpretive keys reside elsewhere. Coordination, repair, and replication depend on access to institutional repositories rather than on material inspection.

In the second regime, which we term a hyperpleonastic economy, selector fields are embedded within artifacts themselves, preserving recoverable information density across distributed nodes. Generative grammars are not fully disclosed, but they are partially encoded in geometry, texture, and admissible variation. Interpretation remains locally bounded yet structurally available.

The distinction between these regimes is not moral but geometric. It concerns the distribution of generative description length, the location of interpretive authority, and the dimensionality of control surfaces available to agents.

12.1 Aggregate Dimensional Control

Let $\mathcal{H}$ denote the set of households, and let $\mathcal{I}$ denote industrial producers.

Define aggregate dimensional control:

$$D_{\text{total}} = D_{\text{civic}} + D_{\text{industrial}}.$$

In opaque economies:

$$D_{\text{civic}} \ll D_{\text{industrial}}.$$

Control dimensionality is concentrated at production nodes. Consumers possess minimal interpretive authority.

In hyperpleonastic economies:

$$D_{\text{civic}} > 0, \quad D_{\text{industrial}} \text{ remains high},$$

but dimensional inequality is reduced:

$$\Delta D_{\text{industrial-civic}} \downarrow .$$

The total control dimensionality is distributed rather than centralized.

12.2 Optimization Pressure

Let $C(t)$ represent aggregate optimization capability over time. As automation and computational capacity increase,

$$\frac{dC}{dt} > 0.$$

In opaque systems, D_{civic} remains approximately constant, while $C(t)$ increases.

Thus, the instability pressure

$$\Pi(t) = \left(\frac{C(t)}{D_{\text{civic}}}\right)\left(\frac{T_{\text{human}}}{\tau_{\text{system}}}\right)$$

monotonically increases.

In hyperpleonastic systems, D_{civic} grows as selector-field artifacts accumulate and RID thresholds are enforced.

Thus, the ratio $C(t)/D_{\text{civic}}$ grows more slowly.

12.3 Failure Topology

Opaque economies exhibit centralized failure topology.

Let k represent the number of shared critical dependencies (e.g., cloud servers, proprietary firmware ecosystems).

Failure probability P_{collapse} scales superlinearly with k:

$$P_{\text{collapse}} \sim f(k), \quad f''(k) > 0.$$

Hyperpleonastic economies reduce shared interpretive chokepoints. Template grammars may remain common, but selector-field recoverability reduces dependency on synchronized central keys.

Failure probability scales more linearly:

$$P_{\text{collapse}} \sim g(k), \quad g''(k) \approx 0.$$

12.4 Economic Value Migration

In opaque regimes, economic value concentrates in mechanisms that restrict interpretive access. Intellectual property secrecy, replacement part monopolies, firmware licensing, and cloud-mediated diagnostics become primary sites of rent extraction. Revenue derives less from the intrinsic performance of artifacts and more from control over the keys required to interpret, repair, or modify them. Generative grammars are treated as scarce institutional assets rather than as partially recoverable structures.

In hyperpleonastic regimes, value migrates toward different domains. Template innovation, material science advancement, open grammar maintenance, and tooling precision become the principal competitive frontiers. Because interpretive authority is distributed across the material

substrate, monopoly power over decoding diminishes. Firms compete on the quality, efficiency, and durability of their templates rather than on the opacity of their control systems.

The monopoly of interpretive authority consequently weakens. Economic advantage shifts from the enclosure of grammar to the refinement of generative design.

12.5 The Black-Box Tax as Externality

Recall the opacity penalty Φ. In opaque economies, artifacts with high Φ generate systemic risk externalities. Delayed repair cycles, supply-chain brittleness, and elevated crisis amplification follow from the externalization of generative grammars. When interpretive keys are concentrated and coordination channels are required for restoration, localized disturbances propagate more readily through the network.

These costs are not borne solely by manufacturers. They are distributed across the civic substrate, manifesting as prolonged downtime, substitution scarcity, and collective vulnerability during disruption. Opacity therefore functions as a negative externality whose burden is socialized even when the gains from enclosure are privatized.

Hyperpleonastic design internalizes part of this externality by increasing Recoverable Information Density and distributing interpretive authority. By embedding partial generative grammar within artifacts themselves, it reduces dependence on centralized coordination and lowers the systemic amplification of failure.

12.6 Stability Curves

We define civilizational stability margin Σ as:

$$\Sigma = \frac{D_{\text{civic}}}{C}.$$

In opaque economies:

$$\frac{d\Sigma}{dt} < 0.$$

In hyperpleonastic economies:

$$\frac{d\Sigma}{dt} \approx 0 \quad \text{or} \quad > 0,$$

depending on enforcement of RID thresholds.

The distinction lies not in technological regression, but in geometric embedding of legibility.

13 Slack, Noise, and Agency

Throughout this essay, tolerance manifolds have been treated as latent channel capacity and selector fields as mappings from slack into interpretive structure. We now return to the foundational assumption underlying this construction: that variation within functional bounds is not waste, but potential.

13.1 The Suppression of Slack

Industrial optimization exhibits a persistent tendency toward uniformity. Surface finishes are polished to eliminate irregularity, layer thicknesses are standardized to reduce variance, and deviations from canonical form are treated as defects. The manufacturing process is structured to minimize dispersion around target parameters, thereby reducing uncertainty in quality control and streamlining mass production.

From a narrow efficiency perspective, slack appears indistinguishable from noise. Variation that does not directly contribute to immediate performance is regarded as surplus and therefore as a candidate for elimination. In this regime, the tolerance manifold is progressively contracted. Formally, one may represent this contraction as

$$\mathcal{T} \to \{\text{canonical configuration}\},$$

indicating the collapse of admissible variation into a single optimized state. Such contraction reduces entropy in production processes, simplifies logistics, and enhances reproducibility.

However, this same contraction reduces recoverable information. When variation is eliminated, the channel capacity of the tolerance manifold declines. Consequently,

$$I_{\text{recoverable}} \downarrow, \quad \text{RID} \downarrow, \quad D_{\text{control}} \downarrow .$$

The artifact may become mechanically refined, yet interpretively impoverished. Its geometry no longer encodes structured variation capable of signaling template logic or operational constraints. Smooth surfaces replace textured grammars; canonical form replaces distributed memory.

The result is an object that is optimized for production but attenuated in legibility. It is precise, but silent.

13.2 Noise as Memory

Selector-field design reinterprets bounded variation within a tolerance manifold as a distributed memory substrate. Features that would otherwise be dismissed as incidental surface irregularities are structured so as to participate in the encoding of generative grammar. Pigment mottling, the angular displacement of a ring, the pitch of a braid, or the visible routing of a heating trace cease to function as merely aesthetic or manufacturing byproducts. Instead, they become physically instantiated parameters within an admissible configuration space.

Within conventional optimization regimes, such variation is treated as noise to be minimized. Manufacturing seeks canonical uniformity, reducing deviation to preserve reproducibility and streamline quality control. Hyperpleonastic design adopts the opposite orientation: it preserves bounded variation precisely because that variation can encode template selection, operational limits, or material lineage. The tolerance manifold becomes a low-amplitude information channel embedded within functional constraints.

Noise becomes signal when it is structured relative to a decoding grammar. The decisive transformation is not the magnitude of variation but its systematic correlation with interpretable states. When geometric or chromatic variation is coordinated with a template index, the artifact acquires a distributed memory of its own generative logic. This memory is not abstract; it is materially instantiated.

Crucially, the signal remains inseparable from the substrate that carries it. Because encoding occurs within admissible physical variation, the interpretive structure cannot be revoked without destroying the artifact itself or collapsing its functional envelope. The memory of the object is therefore coupled to its persistence. Legibility endures so long as geometric residue remains.

13.3 Agency Within the Tolerance Manifold

Agency requires degrees of freedom.

In a fully compressed system, where variation is eliminated and interpretive keys are externalized, local agency contracts.

Formally, if

$$\dim(\mathcal{T}) \to 0,$$

then the space of locally selectable interpretations vanishes.

Selector fields preserve a nontrivial $\dim(\mathcal{T})$ and map it into public template grammars.

This mapping enlarges the effective dimensional control surface.

Slack is therefore not inefficiency. It is the geometric precondition for distributed agency.

13.4 Entropy and Interpretation

Entropy increases under degradation. Materials wear. Infrastructure fails.

If interpretive grammars are externalized, legibility may vanish before functionality does.

Selector-field artifacts resist this interpretive entropy. Their recoverable information density decays slowly:

$$\frac{d}{dd}\mathrm{RID}(d) \approx 0 \quad \text{for small } d.$$

The object continues to explain itself even as it ages.

Robustness becomes the persistence of meaning under stress.

13.5 Alignment Reconsidered

Alignment is often framed as a problem of aligning objectives between humans and machines.

The present analysis proposes a complementary constraint:

Civilizational Alignment Constraint. Optimization must not collapse the tolerance manifold to the point that recoverable information density falls below the threshold required for distributed control.

This is not a rejection of optimization. It is a geometric limit on its compressive impulse.

13.6 The Refusal to Become Mute

An opaque artifact is mute in a precise structural sense. Its generative grammar exists outside its material substrate, and its meaning is conditional upon access to external authorization channels. Interpretation requires permission, and repair requires coordination beyond the artifact itself. The object functions, but it does not participate in its own explanation.

A hyperpleonastic artifact, by contrast, preserves a degree of self-articulation. Its geometry advertises its template class, its bounded variation encodes selector logic, and its degradation exposes rather than conceals structural relationships. Damage does not erase meaning; it transforms the configuration space through which meaning is recovered.

Incompressibility, in this sense, is not synonymous with gratuitous complexity. It denotes the preservation of sufficient structured variation to prevent collapse into a minimal external description. A materially incompressible system resists reduction to a single institutional key. It refuses to allow the material world to become its own simplest description.

13.7 Conclusion

Recoverable Information Density, Dimensional Poverty, and the Selector Field Theorem together describe a unified structural phenomenon. They articulate how interpretive authority is distributed, how generative grammars are either embedded or displaced, and how the dimensional control surface available to agents expands or contracts in response.

The stability of a civilization depends not solely on the intelligence of its computational systems but on the persistence of legibility within its material substrate. When artifacts retain structured slack within their tolerance manifolds, agency remains locally anchored. When that slack is suppressed, interpretive authority migrates outward, and fragility increases.

Slack is the geometric reserve in which agency resides. Noise, when structured relative to a decoding grammar, becomes a substrate of memory. Selector fields operationalize this principle by embedding template selection within admissible variation. They constitute a geometry of trust grounded not in centralized verification but in material recoverability.

To preserve dimensional control is to preserve the capacity for repair, reinterpretation, and local autonomy. Civilizational incompressibility is therefore not an appeal to inefficiency or romantic nostalgia. It is the maintenance of a stability margin in a regime of accelerating optimization, ensuring that generative grammars remain partially recoverable even as production processes converge toward canonical form.

Appendices

A Algorithmic Information and Generative Compression

The main text employed Shannon entropy and mutual information to define Recoverable Information Density (RID). While Shannon information captures distributional uncertainty, it does not directly measure generative compressibility.

We therefore introduce a complementary algorithmic formulation.

A.1 Kolmogorov Complexity of Generative Grammar

Let $\mathcal{G}$ denote the generative grammar of an artifact. The Kolmogorov complexity of $\mathcal{G}$ is defined as

$$K(\mathcal{G}) = \min_{p}\{|p| : U(p) = \mathcal{G}\},$$

where U is a universal Turing machine and $|p|$ is the length of the shortest program that produces $\mathcal{G}$.

$K(\mathcal{G})$ measures the minimal description length of the artifact's generative logic.

An artifact is algorithmically compressible if

$$K(\mathcal{G}) \ll |\mathcal{G}|,$$

where $|\mathcal{G}|$ denotes the explicit description length.

A.2 Externalized Compression

In opaque systems, the shortest description of the artifact's functional logic is not recoverable from the artifact itself.

Formally, if A denotes the physical artifact, then

$$K(\mathcal{G} \mid A) \approx K(\mathcal{G}),$$

meaning the artifact provides negligible compression of its own generative description.

The minimal program reconstructing $\mathcal{G}$ must be obtained externally.

This condition corresponds to low RID and high opacity penalty Φ.

A.3 Selector Fields as Partial Programs

In hyperpleonastic systems, selector fields embed partial programs within the tolerance manifold.

Let $S(A)$ denote the selector field recoverable from the artifact. Then the conditional Kolmogorov complexity becomes

$$K(\mathcal{G} \mid A) = K(\mathcal{G} \mid S(A)) \ll K(\mathcal{G}).$$

The artifact itself reduces the description length required to reconstruct its grammar.

Selector fields do not necessarily encode the full program, but they encode an index into a template library, thereby shortening the effective program length.

A.4 Algorithmic Incompressibility and Civic Stability

We may now reinterpret civilizational incompressibility.

A system is algorithmically centralized if the shortest program describing its generative grammars resides within a small institutional subset of agents.

It is algorithmically distributed if the conditional complexity

$$K(\mathcal{G} \mid A)$$

is uniformly bounded across artifacts accessible to citizens.

Dimensional Poverty corresponds to a regime in which

$$K(\mathcal{G} \mid A) \approx K(\mathcal{G})$$

for most critical artifacts.

Civic stability requires that for essential systems,

$$K(\mathcal{G} \mid A) \leq K(\mathcal{G}) - \Delta,$$

for some nontrivial $\Delta > 0$, ensuring that artifacts materially encode portions of their own shortest descriptions.

A.5 Compression, Optimization, and Collapse

Optimization often reduces surface variance and enforces canonical forms. While this may reduce manufacturing entropy, it can increase algorithmic centralization.

If the minimal description of generative grammar is fully externalized, then systemic failure or institutional collapse renders the grammar irrecoverable.

Algorithmic incompressibility at the civic level does not imply inefficiency. It implies distributed possession of partial programs sufficient for reconstruction.

Selector fields therefore function as embedded description-length reducers, preserving algorithmic recoverability under bounded infrastructure failure.

B Minimum Description Length and Template Libraries

The previous appendix introduced Kolmogorov complexity as a measure of generative compressibility. We now refine the analysis using the Minimum Description Length (MDL) framework, which formalizes model selection under finite data.

B.1 Template Libraries as Model Classes

Let $\{\mathcal{M}_i\}_{i \in \mathcal{I}}$ denote a finite template library, where each $\mathcal{M}_i$ represents a parameterized generative grammar for a class of artifacts.

An artifact A is generated by some $\mathcal{M}_{i^*}$ with parameters θ^*.

Under MDL, the total description length of A is

$$L(A) = L(i^*) + L(\theta^* \mid i^*) + L(A \mid i^*, \theta^*),$$

where:

- $L(i^*)$ encodes the model index,

- $L(\theta^* \mid i^*)$ encodes model parameters,
- $L(A \mid i^*, \theta^*)$ encodes residual variation.

In opaque systems, $L(i^*)$ is not recoverable from the artifact. The model index resides externally. Thus, reconstruction requires full external model retrieval.

B.2 Selector Fields as Model Index Encoders

In hyperpleonastic systems, the selector field $S(A)$ encodes i^*.

Formally,

$$S(A) = i^*.$$

This reduces effective description length required for reconstruction:

$$L(A \mid S(A)) = L(\theta^* \mid i^*) + L(A \mid i^*, \theta^*).$$

The artifact itself supplies the model index. External search over the model class is eliminated.

Selector fields therefore act as MDL-optimal model selectors embedded within the tolerance manifold.

B.3 Tolerance Manifold and Channel Capacity

Let $\mathcal{T}$ denote the tolerance manifold of dimension d. Suppose variation along each dimension can be discretized into b admissible bins without violating functionality.

The maximum template index capacity is bounded by

$$|\mathcal{I}| \leq b^d.$$

Thus, the channel capacity of the tolerance manifold satisfies

$$C_{\mathcal{T}} \leq d \log_2 b.$$

Collapsing $\mathcal{T}$ to a canonical configuration sets $d = 0$, and therefore

$$C_{\mathcal{T}} = 0.$$

No template index can be embedded.

Preserving slack preserves channel capacity.

B.4 Selector-Field Efficiency

An ideal selector field maximizes mutual information

$$I(S(A); i^*)$$

subject to the constraint that perturbations remain within functional bounds.

Over-encoding that interferes with mechanical integrity violates the functional envelope. Under-encoding leaves channel capacity unused.

The design problem is therefore constrained optimization:

$$\max_S \; I(S(A); i^*) \quad \text{subject to} \quad A \in \mathcal{F}.$$

This formalizes hyperpleonastic design as an information-constrained optimization within physical limits.

B.5 Distributed Model Stability

If model indices are embedded locally, then model selection becomes decentralized.

Let $\mathcal{H}$ denote a set of households. If each artifact encodes its own i^*, then model recovery does not require global search.

The systemic description length of the economy reduces from

$$L_{\text{centralized}} = \sum_{i \in \mathcal{I}} L(i)$$

to

$$L_{\text{distributed}} = \sum_{A \in \mathcal{A}} L(S(A)),$$

where template indices are redundantly embedded.

Redundancy increases robustness under partial loss.

B.6 Conclusion of Technical Formalism

Under the MDL interpretation, selector fields embed model-selection instructions within admissible geometric variation.

Tolerance manifold dimension determines encoding capacity. Recoverable Information Density measures practical inference capacity. Dimensional control surface measures intervention capacity.

Civilizational incompressibility corresponds to the distributed availability of model indices sufficient to reconstruct essential generative grammars.

C Categorical Formulation of Selector Fields

The previous appendices treated selector fields as mappings between sets and model indices. We now refine this structure categorically.

The purpose is not abstraction for its own sake, but to clarify how selector fields preserve structure between admissible geometric variation and template grammars.

C.1 The Category of Tolerance Configurations

Let **Tol** denote the category whose objects are admissible configurations $t \in \mathcal{T}$ contained within the functional envelope $\mathcal{F}$. These objects represent physically realizable states of the artifact that remain compatible with its operational constraints. Morphisms in **Tol** are physically admissible deformations $f : t \to t'$ that preserve functionality, mapping one valid configuration to another without violating the functional envelope.

Composition in **Tol** corresponds to successive admissible deformations. If $f : t \to t'$ and $g : t' \to t''$ are morphisms, then $g \circ f : t \to t''$ represents the cumulative transformation obtained by applying f followed by g. Identity morphisms correspond to null deformations, representing the persistence of a configuration under no change.

Thus, **Tol** formalizes the structured space of permissible variation, encoding not only the configurations themselves but the allowable transitions between them.

Thus, **Tol** encodes the structure of the tolerance manifold, including how configurations can transform without violating function.

C.2 The Category of Templates

Let **Temp** denote the category whose:

- Objects are template grammars $\mathcal{M}_i$.
- Morphisms are refinement or specialization maps $\phi : \mathcal{M}_i \to \mathcal{M}_j$ preserving generative compatibility.

For example, a base material template may refine into a batch-specific specialization.

Composition corresponds to successive refinement.

C.3 Selector Fields as Functors

A selector field is not merely a function $S : \mathcal{T} \to \mathcal{I}$. It is a functor:

$$S : \mathbf{Tol} \to \mathbf{Temp}.$$

This requires:

- For each object $t \in \mathbf{Tol}$, $S(t) = \mathcal{M}_i$ for some template.
- For each morphism $f : t \to t'$, there exists a morphism $S(f) : S(t) \to S(t')$ in **Temp**.

Thus, admissible geometric deformation induces admissible template refinement.

The selector field preserves structure.

C.4 Functorial Stability

The functor S must satisfy:

$$S(\mathrm{id}_t) = \mathrm{id}_{S(t)}, \quad S(g \circ f) = S(g) \circ S(f).$$

This ensures interpretive consistency. Small physical perturbations correspond to coherent template refinements.

Non-functorial mappings would produce interpretive discontinuities under minor deformation, violating graceful degradation.

C.5 Recoverability as Faithfulness

Recoverable Information Density corresponds categorically to partial faithfulness of the functor S.

If S is not faithful, distinct tolerance configurations collapse to indistinguishable template objects.

If S is faithful on a subcategory of critical configurations, then structural distinctions remain observable.

Dimensional Poverty corresponds to a degenerate functor that factors through a terminal object:

$$S : \mathbf{Tol} \to \mathbf{1}.$$

All configurations map to a single opaque template. Interpretive variation vanishes.

C.6 Distributed Grammars as Colimits

Let $\{\mathcal{M}_i\}$ form a diagram in **Temp**. The global template grammar may be expressed as a colimit:

$$\mathcal{M}_{\text{global}} = \varinjlim \mathcal{M}_i.$$

Selector-field artifacts embed indices to local objects within this diagram.

Under partial infrastructure failure, the colimit may not be fully accessible. However, local objects $\mathcal{M}_i$ remain recoverable via the functor S.

Distributed legibility thus corresponds to local availability of objects in **Temp**, independent of global colimit reconstruction.

C.7 Alignment as Natural Transformation Constraint

Suppose optimization processes act as endofunctors:

$$F : \mathbf{Tol} \to \mathbf{Tol}.$$

Optimization seeks to contract variation, often collapsing morphisms in **Tol**.

Alignment requires that S remain compatible with F, i.e., there exists a natural transformation:

$$\eta : S \circ F \Rightarrow S.$$

This expresses that optimization must not destroy interpretive structure.

If no such natural transformation exists, optimization collapses selector fidelity, and RID decreases.

C.8 Categorical Interpretation of Incompressibility

Civilizational incompressibility corresponds to the preservation of nontrivial functorial mappings from tolerance categories to template categories.

Compression that reduces **Tol** to a single object trivializes the functor S.

Incompressibility preserves categorical richness, ensuring that artifacts continue to participate in meaningful structural mappings.

Selector fields are therefore not decorative encodings. They are structure-preserving functors between geometry and grammar.

D Sheaf-Theoretic Interpretation: Holographic Steganography Across Scales

The categorical appendix framed selector fields as functors preserving structure between tolerance configurations and template grammars. We now add a sheaf-theoretic layer, motivated not by civic topology but by the technical requirement of *holographic steganography*: instructions repeated across scales, including bootstrapping instructions for building an interpreter device.

The key idea is that interpretive meaning is *locally recoverable* from partial observations and *globally consistent* when such local recoveries are glued.

D.1 Observation Patches and Multiscale Coverings

Let X denote the physical substrate of an artifact: its surface, interior microstructure, weave, braid, or printed layers. We treat X as a topological space of observables, not as a civic environment.

An observer does not access X all at once. They access partial regions: a visible patch on the surface, a cross-section, a corner seam, or a segment of weave. Let $\{U_\alpha\}_{\alpha \in A}$ be an open cover of X, where each U_α corresponds to an accessible observation patch.

To model multiscale repetition, we consider a nested family of covers indexed by scale ℓ:

$$\mathcal{U}^{(1)} \prec \mathcal{U}^{(2)} \prec \cdots$$

where $\mathcal{U}^{(1)}$ is coarse (macroscopic features) and $\mathcal{U}^{(k)}$ becomes progressively finer (microtextures, fiber orientation, layer banding).

D.2 The Sheaf of Instructions

Define a presheaf $\mathscr{I}$ on X assigning to each open set U a set (or structured space) of *instruction fragments* observable on that region:

$$\mathscr{I}(U) = \{\text{all decodings of instructions recoverable from } U\}.$$

Restriction maps

$$\rho_{UV} : \mathscr{I}(U) \to \mathscr{I}(V), \qquad V \subseteq U,$$

formalize that a decoding available from a larger patch restricts to a decoding on a smaller patch.

We impose the sheaf condition: if instruction fragments agree on overlaps, they glue to a unique global instruction.

Sheaf Condition. Given an open cover $\{U_\alpha\}$ of U, a family $s_\alpha \in \mathscr{I}(U_\alpha)$ that satisfies

$$\rho_{U_\alpha, U_\alpha \cap U_\beta}(s_\alpha) = \rho_{U_\beta, U_\alpha \cap U_\beta}(s_\beta) \quad \text{for all } \alpha, \beta$$

glues to a unique $s \in \mathscr{I}(U)$ such that $\rho_{U,U_\alpha}(s) = s_\alpha$ for all α.

This expresses holographic recoverability: local readings can be glued to consistent global interpretation, and inconsistencies indicate either damage or adversarial tampering.

D.3 Redundancy as Multiscale Sections

Holographic steganography requires that meaningful instruction sections exist at multiple scales.

We therefore posit that for many U in coarse covers $\mathcal{U}^{(1)}$, $\mathscr{I}(U)$ already contains nontrivial sections corresponding to high-level classification and safe operation, while finer covers provide more specific sections: parameters, batch lineage, repair pathways.

Formally, we model a filtration of subsheaves

$$\mathscr{I}_{\text{coarse}} \subseteq \mathscr{I}_{\text{mid}} \subseteq \mathscr{I}_{\text{fine}} \subseteq \mathscr{I},$$

where inclusion corresponds to increasing interpretive resolution.

This matches the layered interpretability requirement in the main text, but now expressed as a sheaf-theoretic refinement of sections.

D.4 The Sheaf of Interpreters

To avoid dependence on a privileged decoding apparatus, the artifact must include instructions not only for the target system but also for constructing an interpreter device.

We formalize this by introducing a second sheaf $\mathscr{D}$ assigning to each open set U the space of *interpreter descriptions* recoverable from U:

$$\mathscr{D}(U) = \{\text{device schematics / decoding protocols inferable from } U\}.$$

The essential bootstrapping requirement is that there exist nontrivial sections of $\mathscr{D}$ on coarse patches:

$$\exists U \in \mathcal{U}^{(1)} \text{ such that } \mathscr{D}(U) \neq \varnothing.$$

In plain terms: macroscopic features must suffice to begin constructing a decoder, even if that decoder is crude.

Finer patches then refine the decoder: calibration, error correction, measurement sensitivity, and additional template families.

Thus, interpretation is not a single sheaf but a coupled pair:

$$(\mathscr{I}, \mathscr{D}).$$

D.5 Bootstrapping as Mutual Gluing

The instruction sheaf $\mathscr{I}$ and interpreter sheaf $\mathscr{D}$ are mutually constraining.

A decoder section $d \in \mathscr{D}(U)$ induces an evaluation map on instruction fragments:

$$\text{eval}_d : \mathscr{I}(U) \to \text{DecodedMeaning}(U).$$

Conversely, instruction fragments may contain calibration constraints that restrict admissible decoders. This suggests a compatibility relation, which can be formalized as a sheaf morphism:

$$\mathscr{D} \to \underline{\text{Hom}}(\mathscr{I}, \mathscr{M}),$$

where $\mathscr{M}$ is a sheaf of meanings (e.g., template indices, parameter sets, repair procedures) and $\underline{\text{Hom}}$ denotes an internal hom object when $\mathscr{I}$ and $\mathscr{M}$ take values in a suitable category.

In practical terms: the artifact supplies both a text and a key, but distributed as local sections that glue.

D.6 Damage, Ambiguity, and Cohomological Obstructions

When an artifact is damaged, local readings may fail to agree on overlaps. In the sheaf formalism, such failures appear as obstructions to gluing.

Let $s_\alpha \in \mathscr{I}(U_\alpha)$ be local decodings on a cover. If agreement fails on overlaps, then the family $\{s_\alpha\}$ defines a nontrivial Čech cocycle measuring inconsistency.

This suggests an operational interpretation: repair is the process of modifying the substrate until the cocycle becomes trivial and the instructions glue.

Thus, the sheaf formalism provides an intrinsic error-detection and tamper-detection criterion: consistency on overlaps is the certificate of integrity.

D.7 Holographic Steganography Principle

We may state the core design requirement as follows.

Holographic Steganography Principle. An artifact implements hyperpleonastic legibility if there exist sheaves $(\mathscr{I}, \mathscr{D})$ on its physical substrate X such that: (i) nontrivial instruction sections and nontrivial interpreter sections exist at coarse observational scale; (ii) finer observational scales provide refinements that glue consistently; and (iii) damage manifests as explicit gluing obstructions detectable from local overlap checks.

This principle captures the intended "instructions repeated across scales" requirement, including self-hosting instructions for constructing an interpreter device, while remaining independent of any particular material technology.

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