

Provisional Intervention: A Preliminary Relational Formalism

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Abstract

This preliminary paper develops a relational formalism for provisional intervention under unresolved and evolving conditions. Intervention is treated as a history-producing transformation: it can alter not only the practical configuration but also later evidence, options, affected positions, and recovery paths. The analysis distinguishes direct footprint from propagated consequence, uses evolving reference courses, and develops protected capacities, minimal sufficient change, reversible probing, modular commitment, preparation before substantive commitment, and bearer-indexed effective reversibility. It then examines ordered intervention sequences, showing why local revisability need not compose into sequence-level reversibility, and develops cumulative reference criteria, capacity-debt histories, revision frontiers, and institutional interruptibility. The resulting framework treats provisionality as an architecture of later revision rather than as a temporary label. It remains deliberately non-scalar and domain-relative: it does not determine substantive goals, acceptable burdens, causal effects, or legitimate authority. Its intended contribution is a structural language for asking whether an intervention that must begin before full resolution still preserves meaningful conditions for later learning, revision, recovery, and decommissioning.

Keywords: provisional intervention; praxis; reversibility; relational systems; adaptive action

Discussion Paper Note

This paper develops a preliminary relational formalism for provisional intervention when relevant knowledge, interpretation, or practical orientation remains incomplete and leaving the system unchanged may itself have consequences. Its analytical object is narrower than decision making under uncertainty in general. The paper asks how an intervention can begin, remain reviewable, and later be revised when intervention itself changes the relational configuration in which subsequent judgment occurs.

The paper treats intervention as history-producing. Once enacted, an intervention may change entities, relations, capacities, expectations, institutional routines, evidential conditions, and the practical options that remain available later. A return to the exact pre-intervention state therefore cannot generally serve as the definition of reversibility. The relevant question is instead whether specified capacities, options, or admissible states remain recoverable through feasible later paths.

This perspective motivates several distinctions developed in the manuscript. Direct intervention footprint is distinguished from propagated relational effect. Practical targets are distinguished from capacities that should remain protected during change. Minimal sufficient intervention is treated as a problem-relative nondominance concept rather than as minimum physical size or minimum expenditure. Information-producing probes are evaluated in relation to prospectively specified discriminations while their observations remain explicitly conditioned by the intervention that generated them.

The paper also distinguishes decomposition from operational modularity. An intervention is not made meaningfully modular merely by naming administrative components. Modularity becomes practically relevant when some functions can be activated, revised, paused, or withdrawn without forcing unnecessary change in others. Preparation is likewise separated from substantive commitment: an actor may preserve the capacity to act later without thereby establishing that the later intervention is warranted.

Reversibility is treated as distributionally indexed. An initiating actor may retain an effective exit path while affected positions face losses or capacity changes that are difficult to recover. The manuscript therefore separates the existence of a recovery path from effective access to that path and tracks bearer-indexed capacity debt where temporary impairment persists across an intervention trajectory.

The analysis then moves from individual interventions to ordered sequences. Local revisability need not compose into sequence-level reversibility. Repeated small interventions can narrow a later revision frontier, normalize earlier burdens into a moving baseline, or create dependencies that make subsequent withdrawal increasingly difficult. Sequence-level analysis therefore preserves both rolling reference courses and longer-run protected criteria.

Institutional architecture becomes relevant when intervention trajectories outlast particular persons or decision episodes. Reviewability alone is not sufficient for provisional praxis if no role possesses effective authority to pause, revise, substitute, or decommission an inherited trajectory. The paper therefore examines institutional memory, interruption authority, affected-position access, dissent preservation, handoff, and decommissioning as conditions through which provisionality may remain practically meaningful.

The formalism is deliberately non-scalar and domain-relative. It does not supply a universal utility function, intervention threshold, justice criterion, causal model, or institutional constitution. The families of protected capacities, admissible burdens, affected positions, and legitimate authorities must be specified and contested within the relevant domain. The mathematical objects used in the paper are primarily structural and reconstructive: they make distinctions and dependencies explicit rather than claiming calibrated prediction.

The paper is analytically downstream from *A Preliminary Framework for Temporal Judgment in Unresolved Inquiry*. That earlier paper studies how an unresolved inquiry can preserve future judgeability, revisability, action windows, review triggers, and institutional continuity. The present paper moves from temporal governance of inquiry to praxis: it asks what happens when action itself changes the system that later inquiry and revision must confront.

The manuscript is offered as a discussion paper and preliminary formal architecture. Its usefulness should ultimately be tested through criticism, domain-specific reconstruction, empirical application, and

comparison with alternative intervention frameworks. The present aim is more modest: to supply a coherent vocabulary for examining whether intervention undertaken before full resolution preserves meaningful conditions for later learning, revision, recovery, and decommissioning.

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This page consolidates the manuscript’s publication status, licence, development disclosure, research-programme relation, and suggested citation.

Status. This discussion-paper preprint records a preliminary relational formalism for provisional intervention. It is released as preprint version 1.0 dated 4 October 2026. The manuscript presents an analytical architecture rather than a calibrated empirical model or domain-independent decision procedure. Its categories, formal representations, and normative interfaces remain open to criticism, empirical application, and subsequent revision.

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Statement on the use of language models. The exploratory discussions and preparation of this paper involved OpenAI’s ChatGPT. ChatGPT supported exploratory dialogue, formal reconstruction, source discovery followed by verification, argumentative criticism, notation and cross-reference checking, structural editing, and drafting in $\text{\LaTeX}$. The author selected the research question, directed and approved the theoretical commitments and epistemic status of the claims, and bears sole responsibility for the manuscript, including its definitions, formal constructions, taxonomy, arguments, conclusions, and errors. Authorship credit remains with the human author.

Research-programme relation. This paper develops the praxis-oriented branch of the author’s contingency and judgment research programme. It is analytically downstream from the paper *A Preliminary Framework for Temporal Judgment in Unresolved Inquiry*, which studies the temporal governance of unresolved inquiry. The present paper instead studies the history-producing structure of intervention itself.

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Table 1: Core notation used across the manuscript

Object	Analytical role
$\mathcal{X}_t$	praxis-relevant, history-bearing relational configuration at time t
α_t	bounded intervention initiated at time t
Ψ^{α_t}	intervention-indexed transition representation
$\mathcal{S}_t^\alpha$	direct intervention footprint
$\mathcal{P}_t^\alpha$	possible propagation envelope relative to a stated dependency relation
π^0	reference course used for later comparison
$\mathcal{G}_t, \mathcal{K}_t$	common target and protected-capacity families used for candidate comparison
$\mathcal{K}_t^\alpha$	intervention-specific protected family, which may augment the common comparison family
$\mathcal{A}_t^{\text{suf}}$	interventions satisfying the stated target and hard-protection conditions
MSI_t	nondominated minimal-sufficient intervention set under the stated burden criteria
$\mathcal{Q}_t^{\text{disc}}$	prospectively specified discrimination criteria for a probe
$\mathcal{M}_t^\alpha$	functional modules of an intervention architecture
$\mathcal{N}_t^\alpha$	represented positions whose capacities are relevant to distributional reversibility
$\alpha_{0:N}$	ordered intervention history through stage N
$\mathcal{V}_t^{\text{rev}}$	currently feasible and admissible revision frontier
$\text{Gov}_t^{\text{prx}}$	institutional architecture supporting review, interruption, handoff, and decommissioning

Table 1 lists only the recurring objects needed across several sections. Section-specific predicates and profiles are defined where introduced. Superscripts and subscripts are semantically significant: for example, $\mathcal{Q}^{\text{cmp}}$ in Section 2 denotes state-comparison criteria, whereas $\mathcal{Q}_t^{\text{disc}}$ in Section 4 denotes distinctions a probe is intended to clarify.

1 Analytical Object of Provisional Intervention

This section specifies the paper’s analytical object: intervention undertaken while relevant judgment remains incomplete and later revision still matters. It separates intervention from decision and action, identifies the conditions that make an intervention provisional, and introduces the relational transition used throughout the paper. The practical problem arises when delaying intervention has consequences while the grounds for irreversible commitment remain unsettled. A simple binary between acting and waiting is therefore insufficient.

1.1 Practical Conditions of Incomplete Judgment

Inquiry and praxis are often presented in a simple sequence: first determine what is true or justified, then act on that determination. Many practical situations do not permit such clean ordering. A public institution may need to protect a vulnerable population before the causal structure of a developing problem is fully understood. A research team may need to alter an experimental or observational environment before all interpretations have stabilized. A diplomatic actor may need to preserve communication channels before the meaning of an emerging signal is clear. An organization may need to reserve resources, establish monitoring capacity, or introduce a limited safeguard while disagreement remains unresolved. In such cases, waiting can itself alter the relational field, consume options, or distribute burdens.

The companion temporal-judgment framework treated this problem primarily from the side of unresolved inquiry: preservation, reversibility, option decay, action windows, review triggers, and institutional continuity were analyzed as temporal conditions of responsible non-closure.[6] The present paper changes the analytical center. Its object is the intervention itself. The question is not merely when an unresolved inquiry should continue or when an action window exists. It is how an intervention can be structured when the actor has reasons to change the present configuration while also retaining reasons to revise, learn, withdraw, escalate, or redistribute the intervention later.

The scope is narrower than a general theory of praxis. Goals, domain-specific evidential thresholds,

and the moral or political permissibility of intervention remain substantive questions for empirical and normative judgment. The formalism instead asks what becomes visible when intervention is represented as a history-producing change to a relational system rather than as an isolated choice.

1.2 Adjacent Literature Boundaries

The problem addressed here is adjacent to several established literatures, but the paper does not treat them as interchangeable. Economic work on irreversibility and option value showed that uncertainty can make irreversible commitment costly and can give waiting or preservation of future choice an identifiable value [1, 5, 3]. The present framework inherits the importance of irreversibility without importing a domain-independent expected-value model: the protected objects here can include heterogeneous capacities, relations, rights, institutional standings, and recovery paths that need not share a common unit.

Adaptive management, robust decision making, planned adaptation, and dynamic adaptive policy pathways likewise treat action as revisable under uncertainty and connect present decisions to later learning or adjustment [10, 7, 8, 4]. Collingridge’s analysis of technological entrenchment is especially close to the paper’s concern that early flexibility can disappear as commitments accumulate [2]. The present paper contributes a different level of analysis: it decomposes the intervention itself into history-bearing transformation, protected capacities, probe design, modular commitment, preparation, bearer-indexed recovery, and sequence-level revisability. These objects can be used with, but are not substitutes for, domain-specific adaptive-planning methods.

The institutional discussion also touches experimentalist governance, where provisional goal setting, local implementation, reporting, peer comparison, and recursive revision are central features [9]. The present paper does not offer a competing general theory of governance. Its narrower concern is whether an intervention trajectory remains practically interruptible and distributionally revisable once material and organizational commitments have formed around it. The literature therefore supplies neighboring problem formulations and established methods; the formalism below is intended to clarify a particular relational architecture of provisional intervention rather than to subsume those traditions.

1.3 Distinct Analytical Roles of Decision, Action, Intervention

The terms *decision*, *action*, and *intervention* are often used interchangeably. The distinctions below are methodological rather than lexical: ordinary language can use the words more loosely, but the paper needs separate objects because their temporal consequences differ.

Definition 1.1 (Decision). A *decision* is a commitment of judgment, selection, authorization, or intention that resolves some practical alternative sufficiently for a course to be chosen, permitted, rejected, or prioritized.

Definition 1.1 does not require immediate execution. A decision can exist as an authorization, plan, or commitment whose implementation is delayed or delegated. It therefore changes the practical architecture even when the external relational configuration has not yet been materially altered.

Definition 1.2 (Action). An *action* is an enacted operation attributable to an agent or organized process that changes, attempts to change, preserves, or deliberately maintains some relevant condition.

Definition 1.2 is broader than the intervention category used below. Observation, communication, preparation, documentation, and deliberate non-escalation can all be actions. Some act mainly on the agent’s own capacities or information environment and do not directly target the relational configuration that constitutes the practical object.

Definition 1.3 (Intervention). An *intervention* is an action or bounded package of actions intentionally directed at altering, preserving, constraining, enabling, or reconfiguring relations, states, capacities, or trajectories within the practical system to which the action is addressed.

Definition 1.3 makes intervention relational. The object need not be a physical entity. An intervention may alter a rule, communication channel, institutional role, resource flow, boundary condition, incentive relation, monitoring arrangement, or permission structure. The relevant unit is therefore the changed configuration of relations and capacities, not merely the motion of an isolated object.

The distinction also clarifies why a decision can be reversible while its intervention is not. An authorization can be withdrawn before execution. Once a consequential intervention has occurred, the system may have incorporated it into expectations, dependencies, records, trust, topology, or resource distribution. Later withdrawal does not erase that history. Conversely, an intervention can sometimes be modified or compensated even when the original decision remains institutionally recorded. The paper therefore avoids treating reversibility as simple cancellation of an earlier choice.

1.4 History-Bearing Relational State

To represent intervention without assuming a universal state space, let

$$\mathcal{X}_t = \langle \mathcal{E}_t, \Lambda_t, \mathcal{C}_t, \mathcal{H}_{\leq t} \rangle \quad (1)$$

be the praxis-relevant relational configuration at time t . Equation (1) uses four primitive components only as a bookkeeping device:

- $\mathcal{E}_t$ denotes the entities, roles, or organized processes presently relevant to the intervention;
- Λ_t denotes typed relations among them, including material, informational, normative, institutional, or strategic relations where relevant;
- $\mathcal{C}_t$ denotes capacities, constraints, permissions, resources, or boundary conditions that shape what can presently occur;
- $\mathcal{H}_{\leq t}$ denotes the historically accumulated changes that remain relevant to the current configuration.

The components are intentionally generic. A domain-specific application may refine them into a graph, field, operator system, dynamical state, institutional schema, or qualitative case description. The present paper requires only enough structure to distinguish a relational configuration before and after intervention and to retain the fact that earlier interventions become part of later history.

Let α_t denote a bounded intervention initiated at time t . Its immediate history-producing transition is represented as

$$\mathcal{X}_{t+}^{\alpha} = \Psi_{t \rightarrow t+}^{\alpha_t}(\mathcal{X}_t). \quad (2)$$

Equation (2) is not a causal law or predictive model. The map Ψ^{α_t} records the analytical claim that the post-intervention configuration should be indexed by the intervention history that helped produce it. In many practical systems, the later configuration cannot responsibly be analyzed as though the intervention had not occurred, even if an actor later withdraws, compensates, or reverses part of its consequences.

A simple but important consequence follows. Later observations may already reflect the intervention. Suppose an actor observes some later data or relational trace $Y_{t'}$ with $t' > t$. The relevant evidential object is more accurately represented as

$$Y_{t'}^{\alpha} = \mathcal{O}_{t'}(\mathcal{X}_{t'}^{\alpha}; \mathcal{H}_{\leq t'}), \quad (3)$$

where $\mathcal{O}_{t'}$ denotes the domain-appropriate observation or recording operation at the later time. Equation (3) is representational rather than predictive: it records that later observations arise from a state already shaped by the intervention history. An intervention may therefore change both the practical situation and the informational conditions under which subsequent judgment is formed.

This coupling is especially important in social and institutional systems. A warning can change behavior; a temporary rule can generate strategic adaptation; a protective resource allocation can alter incentives; public communication can change expectations; and a pilot policy can reshape the population or organization later used to evaluate it. The intervention is thus not merely downstream from knowledge. It can become one of the causes of the evidence through which later knowledge is sought.

1.5 Revision Architecture of Provisionality

The adjective *provisional* should not mean merely short-lived, small-scale, hesitant, or informal. A nominally temporary action can create durable dependencies, while a substantial intervention can sometimes be designed with explicit revision paths. Provisionality is better treated as a relation between present commitment and future revisability.

Let $\mathcal{K}_t^\alpha$ denote a prospectively specified family of capacities, conditions, or relations whose later recoverability or modifiability matters to the intervention. Let $\mathcal{B}_t^\alpha$ denote conditions under which the intervention should be reconsidered, and let Resp_t^α identify the role or process responsible for review, modification, withdrawal, substitution, or escalation. These objects inherit the logic of protected criteria and review triggers from the temporal-judgment framework, but their function here is narrower: they are attached directly to an intervention rather than to unresolved inquiry in general.

Definition 1.4 (Provisional intervention). A *provisional intervention* is an intervention α_t undertaken while one or more practically relevant judgments remain open, for which the intervention architecture explicitly preserves at least one meaningful possibility of later revision and specifies conditions or responsibility for reconsideration.

Definition 1.4 contains four elements:

1. **present practical reason:** there is sufficient reason to alter or preserve some part of the current configuration rather than merely continue unchanged;
2. **residual unresolvedness:** some practically relevant interpretation, prediction, normative judgment, causal account, or preferred response remains unsettled;
3. **revision possibility:** at least one consequential aspect of the intervention remains meaningfully modifiable, withdrawable, substitutable, decommissionable, or recoverable through an admissible later path;
4. **review architecture:** reconsideration is linked to identifiable conditions, evidence, time points, or responsible roles rather than left to unspecified future discretion.

These elements distinguish provisional intervention from rhetorical temporariness. An intervention announced as “temporary” but lacking a feasible revision path, review responsibility, or preserved option is not provisional in the analytical sense developed here merely because its label says so.

Provisionality is also criterion-relative. An intervention may be reversible with respect to resource allocation but not with respect to reputational effects; revisable for the institution but not for affected individuals; withdrawable in formal law while practically entrenched through infrastructure or expectations. Later sections therefore treat reversibility and burden as indexed to specified capacities and affected relations rather than as a single property of the intervention.

1.6 Inquiry-Producing Intervention

The preceding definitions allow a further distinction between interventions that merely act on the world and interventions that are deliberately structured to improve later judgment. The latter are important but should not be conflated with experiments.

Definition 1.5 (Inquiry-producing intervention). An *inquiry-producing intervention* is a provisional intervention whose design includes the production, preservation, or discrimination of information relevant to later revision, without requiring information production to be the intervention’s primary purpose.

The final clause of Definition 1.5 matters. A protective intervention may primarily aim to reduce exposure or preserve a vulnerable capacity, yet still be designed so that its effects are observable and its assumptions can later be reassessed. A preparatory intervention may reserve resources while also

revealing logistical constraints. A reversible probe may intentionally generate discriminating information, but a provisional safeguard need not be an experiment merely because it creates evidence.

This distinction prevents an epistemic reduction of praxis. People and institutions affected by intervention are not merely sources of data. Protective, legal, ethical, distributive, or political reasons can independently justify constraints on what may be tried, observed, or reversed. Information gain is therefore one possible design objective among several, and it may be subordinated to rights, safety, legitimacy, or burden considerations supplied by the relevant domain.

1.7 A Preliminary Design Profile

The paper does not seek a universal objective function for provisional intervention. A preliminary design profile is nevertheless useful for exposing dimensions that later sections will analyze separately. For intervention α_t , let

$$\Pi_t(\alpha) = \langle \text{Pur}_t^\alpha, \text{Rev}_t^\alpha, \text{Obs}_t^\alpha, \text{Opt}_t^\alpha, \text{Dist}_t^\alpha, \text{Rvw}_t^\alpha \rangle, \quad (4)$$

where the components denote, respectively:

- Pur_t^α : the stated practical purpose, target effect, or protected function;
- Rev_t^α : criterion-relative revisability or recoverability;
- Obs_t^α : observability of intervention-relevant changes;
- Opt_t^α : option preservation or option creation;
- Dist_t^α : distribution of burden, exposure, and irreversibility across affected relations;
- Rvw_t^α : review conditions governing continuation, modification, escalation, or withdrawal.

Equation (4) deliberately does not combine these components into a scalar score. Domains may provide legitimate trade-offs or quantitative measures, but the general framework should not assume that effectiveness, revisability, observability, optionality, distribution, and reviewability share a common unit. A provisional intervention can therefore be analytically superior on one dimension and inferior on another without the formalism pretending to settle the resulting practical judgment.

The profile also clarifies a recurring intuition that will guide the rest of the paper. Under unresolved and evolving conditions, assessment of an intervention need not depend only on whether it produces an immediate desired effect. It may also depend on what kinds of later action, learning, compensation, withdrawal, and redistribution remain possible after the intervention has changed the relational field. This claim is intentionally conditional rather than universal: some emergencies or rights-protecting duties may justify decisive action even when revisability is poor, while some highly reversible interventions may still be substantively unjustified.

1.8 Scope of the Praxis Formalism

The framework is designed for situations in which three conditions overlap: some practically relevant issue remains unresolved; non-intervention or unchanged continuation has consequences; and at least part of the intervention architecture can still be designed. It is less useful where the relevant action is mechanically fixed, where no meaningful revision is possible, or where the primary question is simply whether a fully specified action meets an established rule.

The formal objects are structural and reconstructive. They organize questions that an empirical, legal, ethical, engineering, or institutional analysis may need to answer; they are not empirical laws, calibrated causal estimators, or a universal decision procedure. A symbol such as Ψ^{α_t} marks a history-indexed transformation to be instantiated or reconstructed by domain-appropriate methods. A set such as MSI_t is only as defensible as the target, protection, admissibility, and burden criteria supplied to it.

The paper also does not assume that provisional intervention is always preferable to decisive commitment. Provisionality can become avoidance, distributive burden shifting, institutional temporariness without exit, or strategic ambiguity. Reversible probing can expose others to repeated experimentation. Preparation can entrench a future course before formal authorization. Modular intervention can fragment responsibility. These pathologies are not external exceptions; they are part of the praxis problem and will constrain later sections.

The remainder of the paper develops the consequences of this object. Section 2 examines history-bearing transformation and separates practical recovery from historical erasure; Section 3 then develops protected capacities and minimal sufficient change. Subsequent sections extend the same architecture to probing, modular commitment, preparation, distributional recovery, adaptive sequences, and institutional interruptibility. Together, these analyses specify what can make an intervention genuinely provisional rather than merely temporary.

2 History-Bearing Relational Transformation

Section 1 represented intervention as $\mathcal{X}_t \mapsto \mathcal{X}_{t+}^\alpha$ and treated later observations as arising from an already altered configuration. Four refinements are needed before that representation can support intervention design: separation of direct footprint from propagated consequence, comparison with an evolving reference course, distinction between practical recovery and historical erasure, and representation of revision as a further intervention rather than an inverse operation. These refinements provide the formal basis for the protected-capacity analysis in Section 3.

2.1 Propagation beyond Direct Intervention Footprints

The relational state in Equation (1) contains heterogeneous components: entities or organized processes, typed relations, capacities and constraints, and a history-bearing record. An intervention may address only a small part of that state while nevertheless producing consequences elsewhere. A restriction placed on one resource flow can alter bargaining relations; a temporary safeguard can change expectations; a communication protocol can redistribute informational access; and a local institutional rule can change incentives outside the unit in which the rule is formally enacted. The relevant distinction is therefore not simply between small and large interventions, but between the *direct footprint* of an intervention and the relational region through which effects may propagate.

For bookkeeping, define the contemporaneous component universe

$$\mathcal{U}_t = \mathcal{E}_t \sqcup \Lambda_t \sqcup \mathcal{C}_t, \quad (5)$$

where $\sqcup$ denotes a typed disjoint union. The historical component $\mathcal{H}_{\leq t}$ is excluded from Equation (5) because the history record is updated by the occurrence of intervention itself rather than treated as an ordinary direct target. Let

$$\mathcal{S}_t^\alpha \subseteq \mathcal{U}_t \quad (6)$$

be the *direct footprint* of intervention α_t : the entities, relations, capacities, constraints, permissions, or boundary conditions that the intervention is intentionally designed to modify, preserve, enable, or constrain.

Equation (6) identifies where intervention is applied, not where all consequences will remain. To represent possible propagation without presupposing a universal causal model, let

$$\mathcal{D}_t \subseteq \mathcal{U}_t \times \mathcal{U}_t \quad (7)$$

be a domain-relative *dependency relation*. A pair $(u_i, u_j) \in \mathcal{D}_t$ indicates only that a practically relevant change in u_i may alter, enable, constrain, or otherwise condition u_j under the model or case description being used. Equation (7) can be directed and typed where the domain supports that refinement. It is not assumed to encode complete causal knowledge.

The corresponding propagation envelope is

$$\mathcal{P}_t^\alpha = \text{Reach}_{\mathcal{D}_t}(\mathcal{S}_t^\alpha), \quad (8)$$

where $\text{Reach}_{\mathcal{D}_t}$ denotes the components reachable from the direct footprint through one or more admissible dependency links. Equation (8) is deliberately a possibility envelope rather than a prediction of realized change. A component can lie inside $\mathcal{P}_t^\alpha$ without changing in the realized case, and an incomplete dependency model may omit consequences that later prove important.

This distinction prevents an overly simple reading of intervention size. A narrow direct footprint can have a wide propagation envelope in a tightly coupled system, while an intervention with a formally broad footprint can have limited downstream influence if the addressed components are weakly coupled. The same distinction will later matter for reversibility: withdrawing the direct control need not recover consequences that have propagated through relations, expectations, or capacities beyond the original footprint.

2.2 Intervention-Effect Baselines

A second problem concerns the baseline against which an intervention is evaluated. The pre-intervention configuration $\mathcal{X}_t$ is generally not an adequate counterfactual for the later state $\mathcal{X}_{t'}^\alpha$. The system would often have continued to evolve even if α_t had not been introduced. Comparing a later state directly with the frozen earlier state therefore mixes intervention-related change with background evolution.

Let π^0 denote a specified *reference course* beginning at t . The reference course need not represent literal inactivity. It can represent ordinary continuation, a status-quo policy, an alternative intervention, or another comparison path appropriate to the substantive question. Let π^α denote the course in which α_t is introduced. Their later states are represented as

$$\mathcal{X}_{t'}^0 = \Phi_{t \rightarrow t'}^{\pi^0}(\mathcal{X}_t), \quad (9)$$

$$\mathcal{X}_{t'}^\alpha = \Phi_{t \rightarrow t'}^{\pi^\alpha}(\mathcal{X}_t), \quad t' > t. \quad (10)$$

The course maps in Equations (9)–(10) are again representational. They can be instantiated by empirical models, qualitative process tracing, simulations, institutional descriptions, or other domain-appropriate methods. The formalism does not assume that either later state is known with certainty.

The practical effect attributed to α_t is therefore course-relative. Let $\mathcal{Q}^{\text{cmp}}$ be a family of comparison criteria, each of which maps a pair of later states into a domain-appropriate comparison value. The criterion-relative comparison profile is

$$\mathfrak{E}_{t \rightarrow t'}(\alpha \mid \pi^0; \mathcal{Q}^{\text{cmp}}) = \{ (q, q(\mathcal{X}_{t'}^\alpha, \mathcal{X}_{t'}^0)) \mid q \in \mathcal{Q}^{\text{cmp}} \}. \quad (11)$$

Equation (11) does not require all criteria to share a numerical scale. Some q may be quantitative differences, others ordered categories, logical predicates, or structured qualitative comparisons. The profile merely records that an attributed intervention effect depends on both a reference course and a comparison criterion.

This course-relative formulation has two consequences. First, a favorable change observed after intervention does not by itself establish that the intervention produced the improvement; the relevant comparison is with a defensible alternative course. Second, *non-intervention* is not treated as absence of history. A reference course can itself consume options, redistribute burdens, allow deterioration, create new relations, or generate learning. The praxis problem is therefore not adequately represented by an active intervention on one side and a static world on the other.

The counterfactual later state $\mathcal{X}_{t'}^0$ is usually not directly observable once π^α has been taken. Any empirical use of Equation (11) therefore needs a justified method for estimating, bounding, reconstructing, or qualitatively characterizing the reference course. The formalism exposes this requirement rather than solving the identification problem.

2.3 Criterion-Relative Recovery from Historical Change

The occurrence of intervention also modifies the historical component of the praxis state. Let

$$\eta_t^\alpha = \langle \alpha_t, \mathcal{S}_t^\alpha, \mathcal{X}_t, \mathcal{X}_{t+}^\alpha, \mathcal{R}_t^\alpha \rangle \quad (12)$$

be a minimal intervention inscription. In Equation (12), $\mathcal{R}_t^\alpha$ denotes whatever contemporaneous rationale, authorization, review condition, or provenance record is retained for the intervention. The historical component is updated as

$$\mathcal{H}_{\leq t+}^\alpha = \mathcal{H}_{\leq t} \oplus \eta_t^\alpha. \quad (13)$$

The operator $\oplus$ in Equation (13) denotes historical composition or appendage, not numerical addition. It records the modest claim that the intervention event becomes part of the later system history to the extent that its consequences or records remain relevant.

This construction separates *state recovery* from *historical erasure*. Suppose a later revision $\rho_{t'}$ is introduced after α_t . The later configuration may recover selected practical conditions that resembled the earlier state. Yet the history-bearing component has changed:

$$\mathcal{H}_{\leq t''}^{\alpha, \rho} = \mathcal{H}_{\leq t} \oplus \eta_t^\alpha \oplus \eta_{t'}^\rho \neq \mathcal{H}_{\leq t} \quad (14)$$

for $t'' > t' > t$, except in a representation that deliberately discards the intervening history. Equation (14) is not a metaphysical claim that every intervention leaves an eternally measurable trace. It states how the present analytical framework represents historically relevant intervention: later recovery of selected conditions does not make the intervention unoccur.

A criterion-relative recovery relation makes the distinction more precise. Let $\mathcal{K}$ be a family of comparison criteria relevant to a proposed recovery claim. Define

$$\mathcal{X}_{t''}^{\alpha, \rho} \approx_{\mathcal{K}} \mathcal{X}_t \iff k(\mathcal{X}_{t''}^{\alpha, \rho}, \mathcal{X}_t) = 1 \text{ for every } k \in \mathcal{K}. \quad (15)$$

Equation (15) defines recovery only relative to the selected criteria. It does not imply identity of the two states. One criterion family might concern resource access and legal permissions; another might concern trust, network topology, ecological capacity, institutional precedent, or distribution of burdens. Recovery can hold under one family and fail under another.

The distinction is central to provisional praxis. A claim that an intervention is “reversible” is incomplete until the relevant recovery criteria are identified. The stronger and more heterogeneous the protected criteria, the more demanding the recovery claim becomes. Section 3 specializes this general comparison relation to capacities that an intervention is intended to preserve.

2.4 Revision Paths after Intervention

Historical inscription also changes how revision should be modeled. A later revision is not assumed to be an inverse operator $(\Psi^\alpha)^{-1}$. Such an inverse may not exist, may not be feasible, or may recover only a limited projection of the earlier configuration. The more general representation is a revision path consisting of one or more subsequent interventions.

Let

$$\varrho = (\rho_{t_1}, \rho_{t_2}, \dots, \rho_{t_m}), \quad t < t_1 < \dots < t_m, \quad (16)$$

be a finite revision path initiated after α_t . Equation (16) preserves the order of later revisions rather than treating them as an unordered set. Its resulting state is

$$\mathcal{X}_{t_m+}^{\alpha, \varrho} = \Psi^{\rho_{t_m}} \circ \dots \circ \Psi^{\rho_{t_1}} (\mathcal{X}_{t+}^\alpha). \quad (17)$$

Equation (17) is schematic: each transformation may depend on the contemporaneous state and history, so the notation should not be read as a time-homogeneous operator algebra. Its purpose is to preserve

sequence and path dependence. Different revision paths can lead to states that satisfy different recovery criteria, distribute burdens differently, or consume different future options.

This yields a useful distinction between *withdrawal*, *compensation*, *restoration*, and *redesign*. Withdrawal stops or removes an ongoing intervention. Compensation addresses some burdens or losses produced by it. Restoration attempts to recover selected earlier capacities or relations. Redesign changes the intervention architecture so that the practical objective is pursued through a different configuration. These operations can overlap, but none should be treated automatically as a literal inverse of the original intervention.

The distinction also avoids a common ambiguity in provisionality. An intervention can remain genuinely revisable even when exact restoration is impossible, provided that meaningful revision paths preserve or recover the capacities that matter for the practical problem. Conversely, an intervention can be easy to stop while still being poorly revisable if stopping does not recover the capacities, options, or distributions that the intervention has already changed.

2.5 Reflexive Changes in the Evidential Environment

The post-intervention evidence relation introduced in Equation (3) has a further implication. Interventions can alter the conditions under which their own consequences are observed. A new reporting rule can improve measurement while changing reporting behavior. A temporary safeguard can reduce the incidence of the very event whose underlying rate remains uncertain. A communication intervention can change what participants are willing to disclose. An institutional pilot can attract participants unlike those who would encounter the later permanent arrangement. The evidential environment is therefore potentially reflexive.

To represent this without assuming that every intervention is an experiment, let

$$\mathcal{O}_{t'}^\alpha = \Omega_{t \rightarrow t'}^\alpha(\mathcal{O}_t, \mathcal{X}_{t'}^\alpha) \quad (18)$$

be the later observation regime after intervention. Equation (18) allows the available sensors, reporting practices, access conditions, categories, incentives, or observational relationships to change along with the practical state. Later evidence is then more fully represented as

$$Y_{t'}^\alpha = \mathcal{O}_{t'}^\alpha(\mathcal{X}_{t'}^\alpha; \mathcal{H}_{\leq t'}). \quad (19)$$

Equation (19) should not be read as claiming that observation is always strongly endogenous. It marks a possibility that becomes important whenever the intervention changes access, reporting, incentives, measurement, categories, or behavior relevant to later evaluation.

This reflexivity creates both opportunity and risk. An intervention can improve observability and thereby support later revision. It can also make an intervention appear successful by suppressing adverse indicators, redefining categories, changing who remains observable, or creating dependence on the intervention itself. Inquiry-producing intervention therefore requires more than collecting post-intervention data. It requires attention to how the intervention has altered the conditions under which those data become available and interpretable.

2.6 Protected-Capacity Implications

The formal distinctions developed in this section constrain what a defensible claim of provisionality can mean. The direct footprint $\mathcal{S}_t^\alpha$ does not bound all consequences because changes can propagate through $\mathcal{P}_t^\alpha$. The observed later state must be compared with an evolving reference course rather than with the frozen state at t . State recovery under Equation (15) does not erase the intervention history recorded in Equation (14). Revision proceeds through additional history-producing actions rather than through a guaranteed inverse. Finally, the intervention can alter the evidential environment through which its own consequences are judged.

These results make the next question more precise. If exact restoration of the earlier world is generally unavailable or analytically unhelpful, what should a provisional intervention attempt to preserve? The answer cannot simply be “the original state.” Section 3 therefore shifts from state identity to *protected capacities*: selected abilities, relations, rights, options, or functions whose preservation can make later revision practically meaningful even when the relational system continues to change.

3 Protected Capacities for Minimal Sufficient Change

The history-bearing account in Section 2 shifts the design problem from restoration of a frozen earlier state to preservation of capacities that make later revision meaningful. Because systems continue to evolve and intervention effects can propagate, minimality cannot be defined by physical size or by closeness to the pre-intervention state. This section instead asks how a candidate can be sufficient for a specified practical purpose while avoiding unnecessary changes, burdens, and commitments relative to that purpose.

The central claim is modest. “Minimal sufficient change” should not be identified with the smallest physical footprint, the lowest expenditure, the weakest formal rule, or the least visible action. A narrow intervention can propagate widely through a tightly coupled relational system, while a somewhat broader preparatory intervention can preserve more important capacities and reduce later lock-in. Minimality is therefore criterion-relative and comparative. It can be stated only after the protected capacities, practical objectives, admissible intervention set, and relevant dimensions of intervention burden have been made explicit.

3.1 Relational Capacities

A capacity is treated here neither as a permanent intrinsic property of an isolated entity nor as a synonym for a favorable state. It is an ability, option, function, standing, or relational possibility that can be realized only under specified conditions. The capacity of an institution to review a decision can depend on records, authority, staffing, and access; the capacity of an individual to exercise an option can depend on resources, legal standing, information, and the behavior of others; the capacity of a communication channel to remain usable can depend on trust, infrastructure, and reciprocal restraint. The relevant bearer is therefore better understood as a bearer-in-configuration.

Let $\mathbf{X}_{[t,T]}^\alpha$ denote the trajectory segment generated after intervention α_t over a relevant horizon $[t, T]$:

$$\mathbf{X}_{[t,T]}^\alpha = \{\mathcal{X}_\tau^\alpha \mid \tau \in [t, T]\}. \quad (20)$$

Equation (20) makes the temporal object explicit rather than evaluating capacity against a single snapshot. A *capacity specification* κ is represented by a domain-appropriate predicate

$$\chi_\kappa(\mathbf{X}_{[t,T]}^\alpha) \in \{0, 1\}, \quad (21)$$

where the predicate states whether the trajectory satisfies the conditions under which the relevant capacity remains meaningfully available over the interval or at the time points specified by the domain. Equation (21) is intentionally general. A capacity may require continuous preservation, recovery by a deadline, availability at a decision point, maintenance above a threshold, or preservation of a legal or relational standing. The predicate can therefore be instantiated differently across domains without forcing all capacities into one numerical scale.

Candidate comparison requires a common basis. Let $\mathcal{K}_t$ be a problem-relative family of protected capacities fixed for the design comparison at time t . A selected intervention may later carry an augmented intervention-specific family $\mathcal{K}_t^\alpha \supseteq \mathcal{K}_t$ when its mechanism creates additional protection requirements, but claims that one candidate is less burdensome than another should use a harmonized comparison family rather than shifting the criteria with the candidate. The protected-capacity profile for the common family is

$$\mathfrak{R}_{t:T}(\alpha; \mathcal{K}_t) = \left\{ \kappa \in \mathcal{K}_t \mid \chi_\kappa(\mathbf{X}_{[t,T]}^\alpha) = 1 \right\}. \quad (22)$$

Equation (22) is set-valued because different capacities may be heterogeneous and non-compensable. Preserving five relatively minor capacities does not automatically compensate for destroying one capacity whose loss the relevant domain treats as critical.

This formulation also permits a distinction between *functional* and *constitutive* capacities. Some capacities can be preserved through substitute arrangements. If one communication route fails, another route may preserve the practical ability to communicate. Other capacities attach to a particular relation or standing whose replacement changes the object being protected. A formal right, a relation of consent, a fiduciary duty, or a historically important institutional role may not be preserved merely because another arrangement produces a similar aggregate function. Capacity specifications must therefore state whether substitution is admissible rather than assuming functional equivalence.

3.2 Separation of Targets from Protected Capacities

A provisional intervention usually aims to change some capacities while preserving others. Treating every capacity as something to be preserved would make intervention impossible; treating only the intended target as relevant would ignore collateral degradation. The design problem therefore requires two families.

Likewise, let $\mathcal{G}_t$ denote the common family of *target conditions* used to compare candidates for the same practical purpose: capacities, functions, protections, or relational changes that an admissible intervention is intended to establish, strengthen, or keep above a required level. Candidate-specific auxiliary aims can be recorded separately, but they should not silently change the common sufficiency test. For each $g \in \mathcal{G}_t$, let

$$\gamma_g(\mathbf{X}_{[t,T]}^\alpha) \in \{0, 1\} \quad (23)$$

state whether the relevant target condition is satisfied over its specified temporal scope. Equation (23) allows target conditions to use their own domain-specific temporal tests. The target-achievement profile is

$$\mathfrak{G}_{t:T}(\alpha; \mathcal{G}_t) = \left\{ g \in \mathcal{G}_t \mid \gamma_g(\mathbf{X}_{[t,T]}^\alpha) = 1 \right\}. \quad (24)$$

The distinction between Equations (22) and (24) is conceptually important. Target conditions answer what the intervention is meant to accomplish. Protected capacities answer what the intervention should avoid unnecessarily disabling while pursuing that accomplishment. The same item can appear in both families when the intervention simultaneously protects and strengthens a capacity, but the roles should not be conflated by default.

A further refinement separates capacities that function as hard constraints from capacities whose temporary degradation can be tolerated only under an explicit recovery architecture. Let

$$\mathcal{K}_t = \mathcal{K}_t^{\text{hard}} \cup \mathcal{K}_t^{\text{rec}}, \quad \mathcal{K}_t^{\text{hard}} \cap \mathcal{K}_t^{\text{rec}} = \emptyset, \quad (25)$$

where $\mathcal{K}_t^{\text{hard}}$ contains capacities that the relevant domain treats as non-negotiable during the intervention horizon, and $\mathcal{K}_t^{\text{rec}}$ contains capacities that may be temporarily impaired only if the impairment is justified, tracked, and linked to a feasible recovery or compensation path.

Equation (25) is not a universal partition. What counts as hard, recoverable, compensable, or substitutable must come from the substantive ethical, legal, technical, or political domain. The formalism merely prevents those judgments from disappearing inside a generic claim that an intervention is “minimal.”

3.3 Recoverability of Capacity Debt

Some practical situations do not permit all protected capacities to remain continuously satisfied. Emergency measures, infrastructure repair, containment, or temporary resource reallocation can impose interim losses even when the intervention remains defensible. A useful representation should make such losses visible rather than treating them as unstructured side effects.

For the recoverable family $\mathcal{K}_t^{\text{rec}}$, define the capacity-debt set at time τ by

$$\mathfrak{D}_\tau^\alpha = \{\kappa \in \mathcal{K}_t^{\text{rec}} \mid \chi_{\kappa,\tau}(\mathcal{X}_\tau^\alpha) = 0\}, \quad (26)$$

where $\chi_{\kappa,\tau}$ is the contemporaneous satisfaction test appropriate to capacity κ . Equation (26) uses the language of “debt” analytically rather than financially. It identifies capacities whose temporary impairment creates a prospective obligation of recovery, compensation, redesign, or explicit reconsideration.

A nonempty debt set is not by itself evidence of wrongful intervention. Its significance depends on at least four questions: who bears the impairment, how severe and durable it is, whether a feasible recovery path exists, and who holds responsibility for monitoring and discharge. A provisional intervention that repeatedly externalizes capacity debt to actors with little power to object can be formally revisable for the decision maker while remaining substantively exploitative for those affected.

Let ϱ_κ be a proposed revision or recovery path for impaired capacity κ , using the revision-path notation of Equation (16). Capacity debt is *recoverably covered* at τ only if an admissible path remains available such that the relevant recovery criterion can still be met within its domain-specified horizon. Schematically,

$$\kappa \in \mathfrak{D}_\tau^\alpha \text{ is covered} \implies \exists \varrho_\kappa \text{ admissible with } \chi_\kappa(\mathbf{X}_{[\tau,T_\kappa]}^{\alpha,\varrho_\kappa}) = 1. \quad (27)$$

The implication in Equation (27) is deliberately one-way. The existence of a formal recovery path does not by itself justify the original impairment. It states only a necessary feature of calling the impairment recoverable within the present analytical vocabulary.

Capacity debt also prevents a misleading use of reversibility. An intervention may be easy for the initiating institution to stop while accumulated capacity debt remains with others. Withdrawal, in that case, is not equivalent to restoration or compensation. The burden of provisionality has simply been distributed asymmetrically.

3.4 Purpose-Relative Sufficiency

Minimality has meaning only after sufficiency has been specified. Let $\mathcal{A}_t$ denote the set of interventions that are feasible and admissible for consideration at time t under whatever legal, technical, ethical, and institutional constraints apply. The unchanged or reference course may be included in $\mathcal{A}_t$ when it is a genuine candidate rather than treated as an empty outside option.

For the common target family $\mathcal{G}_t$ and common protected family $\mathcal{K}_t$ just specified, with $\mathcal{K}_t^{\text{hard}} \subseteq \mathcal{K}_t$, define the sufficient intervention set

$$\mathcal{A}_t^{\text{suf}} = \{\alpha \in \mathcal{A}_t \mid \mathfrak{G}_{t:T}(\alpha; \mathcal{G}_t) = \mathcal{G}_t, \quad \mathcal{K}_t^{\text{hard}} \subseteq \mathfrak{K}_{t:T}(\alpha; \mathcal{K}_t)\}. \quad (28)$$

Equation (28) gives a deliberately demanding binary representation: an intervention enters the sufficient set only if all specified target conditions and all hard protected capacities are satisfied. Domains that permit graded target attainment or probabilistic sufficiency can replace the binary predicates with richer evaluation structures. The present form keeps the logical distinction visible without pretending to supply those domain-specific thresholds.

The sufficient set may be empty. That possibility should remain explicit. If no presently admissible intervention can satisfy the target while preserving the hard capacities, the framework does not manufacture a compromise by averaging them into one score. Possible responses include redesigning the target, enlarging the feasible intervention set, or changing resources and timing. A case may instead require escalation to a different authority or acknowledgment that the desired objective cannot presently be achieved under the accepted constraints.

Sufficiency is also time-indexed. An intervention that is sufficient at t may cease to be sufficient as background conditions change, new relations form, capacities deteriorate, or the reference course improves. Minimal sufficient change is therefore not a once-and-for-all label attached permanently to an intervention type.

3.5 Nondominance Criterion for Minimality

The remaining question is what “minimal” should mean among interventions already judged sufficient. A single scalar such as cost, duration, intensity, or direct footprint is too narrow for the relational problem. Let $\mathcal{Z}_t$ be a family of intervention-burden criteria relevant to the case. Possible members include direct footprint, expected propagation exposure, resource commitment, legal entrenchment, burden on affected actors, irreversibility, institutional dependency, or loss of future options. For each $z \in \mathcal{Z}_t$, let $\preceq_z$ be a domain-appropriate preorder where

$$\beta \preceq_z \alpha \quad (29)$$

means that intervention β is no more demanding than α on criterion z . Equation (29) is criterion-specific; the criteria need not share a common scale.

Define the family-relative comparison relation

$$\beta \preceq_{\mathcal{Z}_t} \alpha \iff \beta \preceq_z \alpha \text{ for every } z \in \mathcal{Z}_t. \quad (30)$$

Equation (30) requires weak improvement across the full stated burden family. Intervention β strictly dominates α within the specified design problem if

$$\beta \prec_{\mathcal{Z}_t} \alpha \iff \beta \preceq_{\mathcal{Z}_t} \alpha \text{ and } \alpha \not\preceq_{\mathcal{Z}_t} \beta. \quad (31)$$

Equation (31) adds strict improvement on at least one represented burden dimension. The set of *minimal sufficient interventions* is then

$$\text{MSI}_t(\mathcal{G}_t, \mathcal{K}_t, \mathcal{A}_t, \mathcal{Z}_t) = \{ \alpha \in \mathcal{A}_t^{\text{suf}} \mid \nexists \beta \in \mathcal{A}_t^{\text{suf}} \text{ with } \beta \prec_{\mathcal{Z}_t} \alpha \}. \quad (32)$$

Equation (32) defines minimality as nondominance rather than smallest magnitude. Several interventions can remain incomparable and jointly occupy the minimal sufficient set. One may preserve more optionality but require more resources; another may have a narrower direct footprint but greater propagation risk. The formalism does not force a universal ranking where the relevant dimensions remain genuinely plural.

This construction also explains why “do the least possible” can be a poor practical rule. A very weak intervention can fail the sufficiency conditions altogether. A small direct footprint can still create a large propagation envelope under Equation (8). An intervention that minimizes present expenditure can consume future options or generate capacity debt elsewhere. Minimal sufficient change is therefore a constrained comparison among interventions that first meet the relevant purpose and protection conditions.

3.6 Relational Scope of Minimality

The term *local* is sometimes used as though local intervention were automatically cautious. Section 2 already showed why that inference is unsafe. The direct footprint $\mathcal{S}_t^\alpha$ and propagation envelope $\mathcal{P}_t^\alpha$ can diverge sharply. A locally applied intervention may reorganize incentives, expectations, access, or dependencies across a much larger relational field.

For this reason, minimality should be assessed at the scale on which the protected capacities can actually be affected. If a capacity depends on relations outside the direct intervention site, those relations belong to the relevant comparison domain even when the intervention is administratively described as local. Conversely, not every remote relation needs to be included merely because some speculative chain of effects can be imagined. The propagation model should remain bounded by domain knowledge, plausible dependencies, and the practical stakes of omission.

This relational account also avoids a different error: preserving every existing relation is not the goal. Some relations are precisely what intervention seeks to change because they generate harm, exclusion, fragility, or incapacity. Protected-capacity analysis therefore asks which abilities, rights, standings, options, or functions matter through change, not which pre-intervention relations should remain untouched for their own sake.

3.7 Reviewability of Minimal Sufficient Change

Because the sufficient set, protected capacities, and burden criteria are all time-indexed, membership in the minimal sufficient set is provisional. Let $t' < T$ be a review time. Updated state information, revised dependency relations, newly available interventions, or changes in the target family can yield

$$\text{MSI}_{t'}(\mathcal{G}_{t'}, \mathcal{K}_{t'}, \mathcal{A}_{t'}, \mathcal{Z}_{t'}) , \quad (33)$$

which need not equal the set defined at t in Equation (32). Equation (33) formalizes a simple but important consequence: an intervention that was minimally sufficient when adopted can later become excessive, insufficient, or dominated by a newly feasible alternative.

Review therefore has two tasks: reassessing the intervention's practical sufficiency and reassessing the grounds for treating it as minimally demanding. Relevant considerations include the continuing appropriateness of the target, preservation of hard capacities, accumulated capacity debt, changes in the propagation envelope or observation regime, and the availability of another admissible intervention that achieves the same purpose with less relational burden. Provisional praxis differs here from merely temporary policy: temporariness expires by time, whereas provisionality remains answerable to changing reasons.

3.8 Limits of the Minimal-Sufficient Formulation

The formalism in this section should not be mistaken for a complete action-selection procedure. First, the target family $\mathcal{G}_t$, protected family $\mathcal{K}_t$, admissible set $\mathcal{A}_t$, and burden criteria $\mathcal{Z}_t$ all contain substantive judgments that the general framework does not derive. Second, capacity predicates can be uncertain, contested, or only partially observable. Third, some interventions change the identities, interests, or institutional categories through which capacities are later assessed. Fourth, power affects whose capacities are recorded as protected, whose burdens count as criteria, and who can redefine sufficiency after intervention begins.

Within this framework, minimal sufficiency is best treated as a discipline of explicit comparison. It asks decision makers to state what the intervention is for, what must remain possible through the intervention, which temporary losses create recovery obligations, which candidate interventions are actually admissible, and on what dimensions one intervention is claimed to be less demanding than another. The result can expose hidden burden shifting even when it cannot determine a unique intervention.

The analysis also prepares the next step. Some interventions are chosen not only to protect a target capacity but also to discriminate among unresolved interpretations. In those cases, observability and information production become part of the design problem itself. Section 4 therefore turns to *reversible probing*: interventions whose practical purpose is combined with a controlled attempt to learn from the altered relational system without treating reversibility or information gain as automatic justification.

4 Reversible Probing for Information-Producing Action

Some interventions are undertaken partly because acting can improve later judgment. Building on the sufficiency and protection criteria of Section 3, this section isolates that epistemic function without treating praxis as experimental methodology. A bounded intervention can expose dependencies, implementation constraints, coordination possibilities, or otherwise latent responses, but the resulting evidence arises from a world already altered by the probe. Information production therefore creates both epistemic opportunity and reflexivity. This problem is adjacent to adaptive management, which can deliberately use management action to learn under uncertainty, while the present analysis does not assume that every probe is controlled or primarily epistemic [10].

The central claim is deliberately limited. A *reversible probe* is not justified merely because it might generate information, nor is an informative intervention automatically an experiment. Within this framework, probing is a design role that an intervention can partly occupy when three conditions are made

explicit: which unresolved distinctions the intervention is intended to illuminate, which capacities and burdens constrain the probe, and how later observations remain linked to the intervention history that helped produce them.

4.1 Practical Role of a Probe

Some unresolved practical questions cannot be clarified adequately through passive observation alone. A proposed communication channel may remain uncertain until limited communication is attempted. A protective protocol may reveal implementation bottlenecks only after a bounded deployment. A temporary allocation rule may expose dependencies invisible in planning documents. A reversible technical or institutional change may show whether a presumed constraint is actually binding. In each case, the action has a practical effect while also changing the informational conditions of the next judgment.

For the present paper, a *probe* is therefore a role played by an intervention, not a separate ontological category of action. An intervention $p_t \in \mathcal{A}_t$ functions as a probe when part of its prospective rationale is to generate observations capable of improving a specified unresolved practical distinction. The same intervention can simultaneously have protective, preparatory, coordinating, or service functions. Calling it a probe does not imply that learning is its only purpose.

This formulation avoids two opposite errors. The first is to treat all action as epistemically equivalent merely because consequences can later be observed. Many interventions produce data without producing information relevant to the unresolved judgment. The second is to treat every information-producing action as an experiment. Controlled experimentation requires additional methodological conditions that the general praxis framework does not assume. The weaker analytical question is whether an intervention produces observations that can responsibly support distinctions relevant to later practical judgment.

4.2 Discrimination among Live Interpretations

Let $\mathcal{I}_t$ denote the family of live interpretations, working explanations, implementation assumptions, or practical hypotheses that remain sufficiently plausible at time t to affect the intervention problem. The framework does not require the members of $\mathcal{I}_t$ to be probabilistic hypotheses or mutually exclusive propositions. In many institutional or social settings they can be partially overlapping accounts of what constraint matters, which relation is fragile, or why an earlier measure failed.

Information gain should be tied to distinctions that matter for later praxis rather than to raw data volume. Let $\mathcal{Q}_t^{\text{disc}}$ be a family of *discrimination criteria*. Each $q \in \mathcal{Q}_t^{\text{disc}}$ specifies a distinction whose resolution would alter some later practical judgment, such as whether escalation is needed, whether a target condition should be revised, whether a constraint is actually binding, whether withdrawal is appropriate, or which implementation mechanism deserves further attention. The family $\mathcal{Q}_t^{\text{disc}}$ is domain supplied. The formalism does not determine which distinctions are worth learning.

Let the probe-conditioned observation trace over $[t, T]$ be

$$\mathbf{Y}_{[t,T]}^p = \{Y_\tau^p \mid \tau \in [t, T]\}, \quad (34)$$

where each Y_τ^p is generated under the post-intervention observation relation of Equation (19). Equation (34) makes the provenance of the observations explicit: the trace is indexed by the probe that helped produce the later relational state and observation regime.

For each discrimination criterion $q \in \mathcal{Q}_t^{\text{disc}}$, let

$$\delta_q(\mathbf{Y}_{[t,T]}^p, \mathcal{H}_{\leq t}) \in \{0, 1\} \quad (35)$$

state whether the probe-conditioned trace and the relevant pre-probe history support the distinction specified by q under the evidential standard of the relevant domain. Equation (35) does not encode a universal evidential threshold. Statistical, causal, qualitative, legal, technical, or institutional standards enter through the substantive application.

The resulting discrimination profile is

$$\Omega_{t:T}(p; \mathcal{Q}_t^{\text{disc}}) = \left\{ q \in \mathcal{Q}_t^{\text{disc}} \mid \delta_q(\mathbf{Y}_{[t,T]}^p, \mathcal{H}_{\leq t}) = 1 \right\}. \quad (36)$$

Equation (36) is set-valued for the same reason that the protected-capacity profile in Equation (22) is set-valued. Distinguishing one practically important issue does not automatically compensate for leaving another unresolved, and several distinctions may be heterogeneous rather than commensurable.

4.3 Intervention-Conditioned Evidence Provenance

A probe can improve observability while simultaneously destroying the conditions needed to interpret what it reveals. For that reason, information-producing action benefits from prospective preservation of the relevant pre-probe trace. Let

$$\mathcal{T}_t^- = \langle \mathcal{X}_t, \mathcal{O}_t, \mathcal{H}_{\leq t}, \mathcal{I}_t, \mathcal{Q}_t^{\text{disc}} \rangle \quad (37)$$

collect the minimal pre-probe objects needed for later reconstruction at the level of abstraction used in this paper. Equation (37) is not a demand to archive every available datum. The relevant record can be much smaller, provided that it preserves the baseline state description, observation regime, live alternatives, and prospective discrimination questions needed to interpret the later trace.

The need for Equation (37) follows from the reflexivity already represented in Equations (18) and (19). A probe can improve reporting, suppress the event being monitored, induce strategic behavior, change participation, create expectations, or alter the categories through which later observations are produced. Post-probe evidence therefore should not be treated as though it had arrived independently of the intervention.

This does not make probe-generated evidence epistemically defective by definition. In some cases the intervention is precisely what makes an otherwise latent dependency observable. The point is one of provenance. Later interpretation should preserve the distinction between observations obtained before the probe, observations generated under the probe, and claims about what might have occurred along a different reference course. The moving-baseline requirement of Equation (11) remains in force. A favorable post-probe observation can be practically informative without by itself identifying the causal effect of the probe.

4.4 Reversibility Conditions for Probing

The adjective *reversible* requires more than small scale or short duration. Section 2 established that exact historical restoration is generally unavailable as a generic requirement. A reversible probe must instead preserve meaningful revision paths relative to the capacities that make later change possible.

Let $\mathcal{K}_t^{p,\text{rev}} \subseteq \mathcal{K}_t^p$ denote the subset of protected capacities whose later recoverability is specifically necessary for the probe to remain practically revisable. Define the probe-revisability condition

$$\text{Rev}_{t:T}(p; \mathcal{K}_t^{p,\text{rev}}) = 1 \quad (38)$$

when there exists at least one admissible revision path ϱ of the form given in Equation (16) such that every $\kappa \in \mathcal{K}_t^{p,\text{rev}}$ satisfies its specified recovery condition by the relevant horizon within $[t, T]$. Equation (38) is deliberately existential and criterion-relative. It does not claim that the probe can be erased, that recovery is costless, or that the existence of a path makes the probe ethically acceptable.

A *reversible probe* in the present framework is then an admissible intervention $p \in \mathcal{A}_t$ satisfying three design conditions:

1. the probe uses a prospectively specified discrimination family, $\mathcal{Q}_t^{\text{disc}}$, rather than an undefined promise to “learn something”;
2. the hard protected capacities specified for the probe remain satisfied under the sufficiency logic of Section 3;

3. the probe-revisability condition in Equation (38) holds for the capacities whose recovery makes later modification meaningful.

These conditions are necessary within the analytical definition, not sufficient for all-things-considered justification. A probe can satisfy them and still be impermissible because of consent, rights, distributive burden, confidentiality, safety, or other domain-specific constraints.

4.5 Epistemic Usefulness without Experimental Overclaim

The discrimination profile in Equation (36) is intentionally weaker than a claim of causal identification. A probe can be useful in at least four ways without supporting a controlled causal estimate. It can reveal whether an implementation dependency exists; show that a coordination assumption is false; expose a previously hidden constraint; or demonstrate that a practical option is infeasible under conditions close enough to the contemplated intervention to matter for later judgment. Such learning can change praxis even when it does not establish a general causal law.

Conversely, a probe can produce abundant observations while adding little discriminating value. If the post-probe trace is compatible with every live interpretation in $\mathcal{I}_t$, or if the observation regime changes in a way that makes the interpretations no longer comparable, data volume can increase without resolving any criterion in $\mathcal{Q}_t^{\text{disc}}$. The distinction between observation and discrimination is therefore central. Information-producing action is valuable because it changes which practically relevant distinctions can be supported, not because it maximizes record production.

This point also limits retrospective rationalization. A successful outcome after a probe does not make every earlier rationale correct. A failed outcome does not automatically identify which interpretation was false. The pre-probe trace in Equation (37) should preserve which distinctions the probe was actually intended to illuminate and what observations were prospectively considered informative. Otherwise later actors can redefine the purpose of the probe after seeing its consequences.

4.6 Coupling of Information Gain with Intervention Burden

A probe can generate information by exerting precisely the influence whose consequences later need to be interpreted. There is therefore no general monotonic relation between informativeness and practical modesty. A weak probe can fail to perturb the system enough to expose a dependency. A stronger probe can be more discriminating while also widening the propagation envelope, increasing capacity debt, changing expectations, or narrowing future options. The design problem is not to maximize information independently of intervention burden.

The formal objects already introduced permit a non-scalar comparison. For a candidate probe p , the discrimination profile in Equation (36) can be considered alongside its protected-capacity profile $\mathcal{R}_{t:T}(p; \mathcal{K}_t^p)$, capacity-debt history $\mathcal{D}_\tau^p$, propagation envelope $\mathcal{P}_t^p$, and the burden criteria used in Equation (30). No universal formula determines the correct trade-off among these objects.

A limited dominance test is nevertheless possible inside a fixed problem representation. Suppose two admissible probes p_1 and p_2 use the same discrimination family, protected-capacity family, horizon, and burden criteria. Define

$$p_1 \succ_t^{\text{probe}} p_2 \tag{39}$$

when

$$\mathcal{Q}_{t:T}(p_2; \mathcal{Q}_t^{\text{disc}}) \subseteq \mathcal{Q}_{t:T}(p_1; \mathcal{Q}_t^{\text{disc}}), \quad p_1 \preceq_{Z_t} p_2,$$

and both probes satisfy the same hard protected-capacity constraints and the probe-revisability condition. Equation (39) means only that p_1 supports at least the represented discriminations of p_2 while being no more demanding on the represented burden criteria. It is a local dominance relation, not a universal ranking. Unrepresented rights, uncertainty about the propagation model, distributional concerns, or differences in the quality of discrimination can still defeat the comparison.

The usefulness of Equation (39) lies mainly in eliminating avoidable trade-offs. Before accepting a highly burdensome probe on the ground that learning requires it, a practitioner can ask whether another

admissible probe yields the same represented discrimination profile with less represented burden. The answer can remain indeterminate; the formalism does not require a unique probe.

4.7 Temporal Control of Repeated Probing

A probe that produces information but has no prospective stopping or review condition can become an ordinary intervention by inertia. Reversibility therefore has a temporal dimension. The relevant question is not only whether an admissible revision path exists at adoption, but whether that path remains viable as the probe continues and the relational system adapts around it.

A practical probe architecture can therefore specify at least three kinds of review condition: a *discrimination condition*, under which enough relevant information has been obtained to reconsider the unresolved question; a *burden condition*, under which capacity debt, propagation, or distributional cost has become too large for continued probing under the original rationale; and a *revisability condition*, under which the recovery paths that made the probe provisional are beginning to close. These conditions need not share a threshold or timing rule.

Repeated probing also produces path dependence. If $p_{t_1}, p_{t_2}, \dots, p_{t_n}$ are introduced sequentially, observations obtained after the later probes arise from a configuration already altered by the earlier ones. The sequence should therefore not be treated as repeated independent tests unless the substantive methodology justifies that interpretation. The adaptive-sequence analysis planned for Section 8 treats this problem directly. The present section only establishes that sequential probes accumulate practical and epistemic history.

4.8 Ethical Boundaries of Probing

Reversible probing should not become a general license to intervene whenever uncertainty is high. First, some domains prohibit or severely restrict intervention for the sake of learning because affected persons or systems bear risks that cannot be justified by epistemic benefit. Second, practical reversibility for the decision maker can coexist with irreversible effects for others. Third, the actors who benefit from improved information may differ from the actors who bear the probe's costs. Fourth, repeated "temporary" probes can normalize surveillance, exceptional authority, resource extraction, or institutional dependence even when each individual step appears formally reversible.

These limits reinforce the distinction between *epistemic usefulness* and *practical justification*. Equation (36) can show that a probe supports relevant distinctions; Equation (38) can show that specified recovery paths remain available; neither establishes that imposing the probe is legitimate. The distributional structure of reversibility will be analyzed explicitly in Section 7.

The present analysis also reveals a design problem that reversible probing alone cannot solve. An intervention can bundle several functions—protection, information generation, preparation, coordination, and commitment—into one package. When those functions have different thresholds, review conditions, or reversibility profiles, bundling can make the whole intervention harder to revise than necessary. Section 5 therefore turns to the modular structure of provisional commitment and asks when separating intervention functions can preserve learning and practical effect while reducing unnecessary coupling.

5 Modular Structure of Provisional Commitment

Provisional interventions often combine protection, information generation, preparation, coordination, authorization, implementation, and longer-term commitment even when those functions have different evidential thresholds, affected positions, temporal windows, and revision costs. Building on the protection and probing analyses above, this section asks when those functions can be separated operationally. Treating them as one indivisible intervention may create coupling that the practical problem itself does not require.

The analytical objective is modest. The section does not claim that interventions should always be decomposed, nor that modularity is intrinsically superior to integrated action. It develops a language for asking whether some intervention functions can be enacted or revised with partial independence while preserving the target and protected-capacity conditions already specified. The relevant contrast is consequently not between “large” and “small” interventions, but between commitments whose components are necessarily coupled and commitments in which at least some coupling can be reduced without losing practical sufficiency.

5.1 Functional Module Architecture

Let $\alpha \in \mathcal{A}_t$ be a candidate intervention. A *functional decomposition* of α is a finite family

$$\mathcal{M}_t^\alpha = \{m_1, m_2, \dots, m_n\}, \quad (40)$$

where each m_i denotes a distinguishable intervention component whose activation, revision, or withdrawal can in principle be considered separately from at least one other component. Equation (40) is not a claim that the components are causally independent. It only identifies candidate units for analyzing dependence.

The same module can serve more than one practical function. Let

$$\phi_t^\alpha : \mathcal{M}_t^\alpha \longrightarrow 2^{\mathcal{F}_t^\alpha} \quad (41)$$

map each module to the subset of intervention functions it serves, where $\mathcal{F}_t^\alpha$ may include, for example, protection, probing, preparation, coordination, authorization, implementation, monitoring, or commitment. Equation (41) is deliberately many-valued: one module may protect and generate information simultaneously, while several modules may jointly realize the same function.

Modularity also requires an explicit account of dependence. Define a directed dependency relation

$$\Lambda_t^{\alpha, \text{dep}} \subseteq \mathcal{M}_t^\alpha \times \mathcal{M}_t^\alpha, \quad (42)$$

where $(m_i, m_j) \in \Lambda_t^{\alpha, \text{dep}}$ means that, under the present design, activating or sustaining m_i depends materially on m_j . The relation can encode technical prerequisites, legal authorization, resource dependencies, safety constraints, informational prerequisites, or constitutive practical relations. The resulting intervention architecture is

$$\mathbf{G}_t^\alpha = \langle \mathcal{M}_t^\alpha, \phi_t^\alpha, \Lambda_t^{\alpha, \text{dep}} \rangle. \quad (43)$$

Equation (42) specifies the dependency relation, while Equation (43) collects the components into one architecture. Decomposition alone does not create modularity. A list of named components can remain completely coupled if the dependency relation forces them to move together.

5.2 Partial Commitment States

A modular architecture becomes practically meaningful only if different subsets of modules can occupy different states through time. Let

$$\mathbf{a}_\tau^\alpha = (a_m(\tau))_{m \in \mathcal{M}_t^\alpha}, \quad a_m(\tau) \in \{0, 1\}, \quad (44)$$

record whether each module is active at time τ . More elaborate applications can replace the binary state with graded, multistage, or probabilistic status variables; the binary representation in Equation (44) is sufficient for the present structural distinctions.

Not every activation vector is admissible. Let

$$\Omega_t^\alpha \subseteq \{0, 1\}^{|\mathcal{M}_t^\alpha|} \quad (45)$$

be the family of activation configurations compatible with the dependency, safety, authorization, and protected-capacity conditions relevant to the intervention. Equation (45) permits partial commitment only where the substantive architecture actually allows it. If a safety component must accompany implementation, a configuration activating implementation alone should simply be absent from Ω_t^α .

This representation distinguishes *partial commitment* from weak commitment. A partial intervention can fully activate one function while leaving another inactive. For example, preparation may be completed while substantive implementation remains unactivated; monitoring may begin while a policy authorization is still withheld; or a protective measure may operate while a learning-oriented probe is terminated. The practical significance lies in functional separation, not in reducing every component's intensity.

5.3 Operational Separability

The central question is whether a module can be revised locally without automatically revising the rest of the architecture. Define module $m_i \in \mathcal{M}_t^\alpha$ to be *operationally separable* at time t when there exist two admissible configurations $\mathbf{a}, \mathbf{a}' \in \Omega_t^\alpha$ such that

$$a_{m_i} \neq a'_{m_i}, \quad a_m = a'_m \quad \text{for every } m \neq m_i, \quad (46)$$

The configurations must also remain compatible with the relevant hard protected capacities. Equation (46) is deliberately stronger than a merely pairwise independence claim: m_i can change while every other represented module is held fixed. It therefore supplies a sufficient diagnostic of local revisability, not a necessary condition for every weaker form of modularity.

The definition is intentionally demanding. Administrative labels do not establish separability. If withdrawing a learning module necessarily disables the protective module, or if activating implementation automatically activates a long-term data-retention commitment, then those components remain coupled under the current architecture even if separate teams administer them.

Separability is also time-indexed. Background evolution, accumulated capacity debt, institutional dependence, sunk infrastructure, or changed expectations can shrink Ω_t^α over time. Modules that were independently revisable at adoption can become effectively inseparable later. Modular design should therefore be evaluated through the intervention trajectory rather than solely from the initial organizational diagram.

5.4 Forced Co-Commitment Burden

Operational separability makes it possible to identify a common form of overcommitment. For a module m_i , define its *forced co-commitment set*

$$\mathcal{L}_t^\alpha(m_i) = \{m_j \in \mathcal{M}_t^\alpha \setminus \{m_i\} \mid a_{m_i} = 1 \Rightarrow a_{m_j} = 1 \text{ for every } \mathbf{a} \in \Omega_t^\alpha\}. \quad (47)$$

Equation (47) records which other modules must be activated whenever m_i is activated under the represented architecture. A nonempty set is not automatically a defect. Some co-commitments are constitutive or protective. The diagnostic question is whether each forced relation is substantively necessary.

This yields a criterion-relative notion of *coupling burden*. Suppose a desired function can be realized only by activating module m_i , while $\mathcal{L}_t^\alpha(m_i)$ also activates functions whose threshold has not yet been met or whose burdens are not required for the immediate purpose. The resulting intervention may commit the system beyond what the present justification supports. Coupling burden therefore concerns the practical consequences of forced linkage, not the mere number of dependencies.

A useful design test is counterfactual but local: could the target function remain sufficient and the hard protected capacities remain satisfied under an admissible redesign in which one or more non-constitutive elements of $\mathcal{L}_t^\alpha(m_i)$ are no longer forced? If so, the original bundling contains potentially reducible coupling. The framework does not determine whether redesign is worth its own cost; it identifies the dependency that should be justified rather than assumed.

5.5 Modular Revision Paths

Section 2 represented revision as a further history-producing transformation rather than as inversion of the past. In a modular architecture, revision can be localized. Let

$$\varrho_{\tau \rightarrow T}^{m_i} = (\mathbf{a}_\tau^\alpha, \mathbf{a}_{\tau_1}^\alpha, \dots, \mathbf{a}_T^\alpha) \quad (48)$$

be an admissible path through module configurations in which changes are directed primarily at module m_i while the path remains inside Ω_t^α and respects the relevant recovery conditions. Equation (48) permits revision to occur through staged deactivation, substitution, compensation, or redesign rather than a single switch.

A module is *revision-local* relative to a protected family $\mathcal{K}_t^{\text{rev}}$ if at least one admissible path of the form in Equation (48) can alter its status while preserving or recovering the specified capacities without requiring revision of every other active module. Revision locality is weaker than full independence. It allows dependencies to remain while asking whether revision can be contained to a bounded portion of the architecture.

This distinction matters because provisionality can otherwise be illusory. An intervention may be described as revisable because one component can formally be withdrawn, yet withdrawal may require abandoning protective infrastructure, renegotiating unrelated commitments, or disabling information systems that later action still needs. Module-level analysis exposes whether the claimed revision path is genuinely local or whether the intervention is effectively atomic.

5.6 Threshold Separation through Temporal Staging

Modularity also creates the possibility of different activation times. Let τ_m^{on} and τ_m^{off} denote the activation and deactivation times of module m when those times are defined. Functions with different evidential or practical thresholds need not therefore enter the intervention simultaneously.

This is particularly important under unresolved conditions. Preparation may be justified before implementation; reversible protection may be justified before causal interpretation is settled; monitoring may continue after a probe ends; or coordination infrastructure may be retained after a specific substantive commitment is withdrawn. Modular staging can preserve this threshold separation without pretending that every function is justified by the strongest or weakest threshold in the package.

Staging can also fail. Early modules can create sunk costs, expectations, organizational constituencies, or technical dependencies that make later substantive commitment more likely even when the formal activation decision remains open. Preparation can therefore produce *commitment pressure*. The presence of separate modules does not by itself protect later discretion. A serious modular design must examine how early modules alter the future admissible configuration set $\Omega_{t'}^\alpha$.

5.7 Limits of Modularity

Modularity has costs and boundaries. First, some intervention functions are constitutively integrated. Separating them can destroy the mechanism that makes the intervention effective. Second, interfaces among modules can introduce coordination failures, duplicated responsibility, latency, or new safety hazards. Third, modular arrangements can obscure cumulative burden by presenting each component as individually modest while their combined history produces substantial transformation. Fourth, strategic actors can exploit modularity by advancing a contested intervention incrementally until reversal becomes politically or practically difficult. Fifth, excessive decomposition can make accountability ambiguous if no actor remains responsible for the behavior of the whole configuration.

These limits show why maximal modularity is not the objective. The relevant question is whether the degree and location of coupling are justified by the practical function, protected capacities, and revision architecture. Some dependencies should be strengthened rather than weakened, especially when safety, rights protection, provenance, or accountability require components to remain linked.

The section also leaves a further distinction unresolved. A module can be prepared without being substantively activated. Resources can be reserved, interfaces built, permissions sought, personnel trained, or monitoring established before the intervention whose future execution those preparations support. Such acts change the relational configuration and can themselves create commitment pressure, yet they are analytically different from substantive implementation. Section 6 therefore examines preparatory action before substantive commitment and asks when preparation preserves future options rather than silently deciding among them.

6 Preparatory Action before Substantive Commitment

Preparation can occur before substantive implementation. It can reserve resources, establish monitoring, train personnel, obtain permissions, build interfaces, preserve access, or coordinate roles so that a later intervention remains practically possible. Such action may be valuable under unresolved conditions because substantive commitment can remain unjustified even while delay threatens the capacity to respond.

Preparation is nevertheless history-producing. It can preserve future options while also consuming alternatives, creating sunk costs, altering expectations, or making one later course progressively easier to adopt than its competitors. The section therefore distinguishes preparedness from substantive warrant and develops criteria for evaluating whether preparation preserves later discretion rather than quietly deciding the later intervention in advance. This concern is compatible with work on planned adaptation in regulation, where revision mechanisms are designed in advance rather than added only after rules become obsolete [8].

6.1 Relative Practical Role of Preparation

Preparation is not an ontologically separate kind of action. The same operation can be preparatory in one practical architecture and substantive in another. Training personnel may prepare a later emergency response; creating a permanent enforcement unit may already constitute a substantive institutional transformation. Reserving a resource may merely preserve response capacity in one setting while materially depriving another use in a resource-constrained setting. The category is therefore relative to a specified family of later interventions and to the target conditions those interventions would themselves instantiate.

Let

$$\mathcal{A}_t^{\text{sub}} \subseteq \mathcal{A}_t \quad (49)$$

be a prospectively specified family of later substantive interventions whose future availability matters at time t . Equation (49) does not imply that every member is presently justified, desirable, or even likely to be selected. The family identifies courses whose later executability should remain visible while judgment is unresolved.

Let $\sigma_t \in \mathcal{A}_t$ denote an action initiated at time t . Relative to $\mathcal{A}_t^{\text{sub}}$, σ_t functions as a *preparatory action* when its primary prospective role is to alter enabling conditions for one or more members of $\mathcal{A}_t^{\text{sub}}$ without itself constituting the substantive activation whose later warrant remains open. The qualification “primary prospective role” is important. Preparation can have immediate protective or organizational effects, and the boundary between preparation and implementation can be contested. The framework therefore treats preparatory status as a claim that should be justified by the intervention architecture, not as a label that immunizes an action from substantive scrutiny.

Because σ_t is an action, its history-producing effect remains represented by the same transition architecture introduced earlier:

$$\mathcal{X}_{t+}^{\sigma} = \Psi_{t \rightarrow t+}^{\sigma_t}(\mathcal{X}_t). \quad (50)$$

Equation (50) prevents a common analytical mistake: treating preparation as though nothing consequential has yet happened. A reserve, training programme, data system, contractual option, or coordination structure can already modify capacities, relations, expectations, and subsequent path dependence even before substantive implementation begins.

6.2 Independent Substantive Warrant

The central distinction is between being able to act later and having sufficient reason to act later. To keep those objects separate, let

$$\varepsilon_{\alpha,\tau}(\mathcal{X}_\tau) \in \{0, 1\} \quad (51)$$

be a domain-relative predicate indicating whether the enabling conditions needed to execute substantive intervention $\alpha \in \mathcal{A}_t^{\text{sub}}$ are sufficiently available at time τ . Depending on the domain, these conditions can include personnel, resources, permissions, interfaces, access, communication channels, logistical readiness, or other practical capacities. Equation (51) deliberately excludes the substantive evidential, ethical, legal, or political warrant for choosing α . Those judgments remain separate.

The resulting preparedness profile after σ is

$$\mathfrak{E}_{t \rightarrow \tau}(\sigma; \mathcal{A}_t^{\text{sub}}) = \{\alpha \in \mathcal{A}_t^{\text{sub}} \mid \varepsilon_{\alpha,\tau}(\mathcal{X}_\tau^\sigma) = 1\}. \quad (52)$$

Equation (52) records which prospectively relevant substantive interventions remain practically executable under the represented enabling criteria. Membership does not imply that the intervention should be used. A well-designed preparation can therefore increase preparedness while leaving the substantive decision unresolved.

This separation supports a useful practical architecture. A lower threshold may justify preserving logistical or organizational capacity, while a higher threshold governs substantive implementation. Such threshold separation can reduce the false choice between immediate commitment and unprepared waiting. It also creates a responsibility to prevent the lower preparation threshold from silently migrating into the higher implementation threshold.

6.3 Reference-Course Option Preservation

Preparation is often described as preserving options, but that description is relational and criterion-dependent. The relevant comparison is not with a frozen pre-preparation state. Section 2 established that interventions should be compared against an evolving reference course. Let π^0 again denote the relevant course without the preparation under examination, and let π^σ denote the course in which σ_t occurs.

For a later time τ , define the practically available substantive-family profiles

$$\mathcal{V}_\tau^0 = \{\alpha \in \mathcal{A}_t^{\text{sub}} \mid \alpha \text{ remains feasible and admissible on } \pi^0\}, \quad (53)$$

$$\mathcal{V}_\tau^\sigma = \{\alpha \in \mathcal{A}_t^{\text{sub}} \mid \alpha \text{ remains feasible and admissible on } \pi^\sigma\}. \quad (54)$$

Equation (53) is intentionally broader than preparedness. An intervention can be technically prepared yet become legally unavailable, ethically impermissible, institutionally unauthorized, or practically ineffective. Conversely, an option can remain available without being highly prepared.

Relative to the reference course, preparation can therefore have both enabling and foreclosing effects:

$$\mathcal{V}_\tau^+(\sigma) = \mathcal{V}_\tau^\sigma \setminus \mathcal{V}_\tau^0, \quad (55)$$

$$\mathcal{V}_\tau^-(\sigma) = \mathcal{V}_\tau^0 \setminus \mathcal{V}_\tau^\sigma. \quad (56)$$

Equation (55) makes visible a feature hidden by the phrase “keeping options open.” The same preparation can preserve one future intervention while foreclosing another. Resource reservation can protect the capacity for rapid deployment while reducing resources available to a competing strategy; a specialized technical architecture can accelerate one intervention while making later substitution costly; an early agreement with one partner can preserve coordination while narrowing alternative partnerships.

Accordingly, *option-preserving preparation* should always be indexed to a prospectively specified protected option family $\mathcal{O}_t^{\text{prep}} \subseteq \mathcal{A}_t^{\text{sub}}$. A preparation is option-preserving relative to that family and horizon when the relevant members remain available under π^σ and the hard protected capacities identified

in Section 3 remain satisfied. This formulation does not claim neutrality among all imaginable futures. It requires the paper or practitioner to state which future options are intended to remain genuinely open.

The family $\mathcal{A}_t^{\text{sub}}$ contains substantive options recognized at the reference time. If a genuinely new option emerges later, the analysis should be re-based on $\mathcal{A}_\tau^{\text{sub}}$. It should not retrospectively count that new option as one preserved or foreclosed by the earlier preparation. This keeps the option-preservation claim prospective and avoids crediting an earlier design with possibilities that were not yet represented.

6.4 Mobilization Latency in Preparation

One practical benefit of preparation is often temporal rather than substantive: it reduces the delay between a later justified decision and effective implementation. Let

$$\ell_\tau(\alpha \mid \mathcal{X}_\tau) \geq 0 \quad (57)$$

represent the domain-appropriate mobilization latency for substantive intervention α from state $\mathcal{X}_\tau$. Equation (57) need not be measured in clock time alone; in qualitative applications it can represent an ordered estimate of delay due to authorization, resource assembly, coordination, training, or technical setup.

Preparation σ is latency-reducing for α at τ when

$$\ell_\tau(\alpha \mid \mathcal{X}_\tau^\sigma) < \ell_\tau(\alpha \mid \mathcal{X}_\tau^0), \quad (58)$$

relative to the chosen reference course. Equation (58) captures one reason preparation can be justified before substantive action: the later action window may be too short to build all enabling capacities after the substantive threshold is crossed.

Latency reduction is nevertheless not a warrant for implementation. A prepared intervention can remain unjustified, unnecessary, or prohibited. The distinction matters because organizations often infer commitment from readiness: once personnel are mobilized, resources reserved, or infrastructure built, non-use can be framed as waste. In the present framework, the value of preparedness is precisely that it can preserve the capacity to act later without predetermining whether later action should occur.

6.5 Preparatory Commitment Pressure

Section 5 introduced commitment pressure as a possible consequence of temporal staging. Preparation makes that mechanism more explicit. Even if $\mathcal{V}_\tau^\sigma$ preserves several later options, the practical architecture can become biased toward one of them through sunk costs, organizational specialization, public expectations, contractual dependencies, political ownership, or technical compatibility.

This bias should not be represented as though it were a deterministic transition from preparation to implementation. A more modest diagnostic is to ask whether preparation changes the relative burden of later revision among members of $\mathcal{A}_t^{\text{sub}}$. If abandoning prepared intervention α later requires dismantling specialized infrastructure, compensating affected parties, renegotiating agreements, or writing off substantial commitments while an alternative remains comparatively costly to establish, then the future choice architecture has changed even though formal authorization remains open.

Three forms of preparatory pressure are analytically useful:

- *resource pressure*: reserves can create opportunity costs and sunk-cost salience;
- *relational pressure*: partners, affected actors, or institutions form expectations and dependencies around the prepared course;
- *architectural pressure*: technical or organizational interfaces become increasingly specialized to one downstream intervention.

These forms can occur separately or together. None proves that later substantive choice is illegitimate. They indicate that claims of preserved discretion should be evaluated against the changed relational architecture rather than against formal decision rights alone.

6.6 Lifecycle Governance of Preparation

Preparatory arrangements can persist after the conditions that justified them have weakened. Standby infrastructure may become normalized; temporary reserves may become routine allocations; provisional coordination bodies may acquire permanent constituencies; monitoring systems may continue collecting data after their original purpose has expired. Preparation therefore needs its own review and exit architecture rather than borrowing review conditions only from the downstream substantive intervention.

Let $\mathcal{B}_t^\sigma$ denote the review-trigger family attached to the preparation, and let Resp_t^σ identify the role or process responsible for reviewing continuation, redesign, release, or decommissioning. These objects parallel the intervention-specific architecture introduced in Section 1. Useful review questions include whether the threatened option remains relevant, whether the preparation still reduces meaningful latency, whether preserved capacity has become disproportionate to its burden, whether the preparation is foreclosing alternatives, and whether decommissioning would itself create capacity debt or new dependencies.

Decommissioning is also history-producing. Releasing a reserved resource, dismantling infrastructure, terminating a standby contract, or dissolving a coordination body does not restore the earlier relational state automatically. Expectations, learning, records, competencies, or dependencies created during the preparatory period can persist. The history-bearing logic of Section 2 therefore applies equally to preparation and to its termination.

6.7 Distributional Limits of Preparation

Preparation can look cautious from the perspective of the decision maker while already imposing substantive burdens elsewhere. Resource reservation can withhold capacity from other users. Training and standby requirements consume labor. Data infrastructure can create privacy or surveillance exposure. Maintaining a rapid-response capability can shift risk, authority, or attention toward some groups and away from others. A formally unactivated substantive intervention may therefore coexist with real distributional consequences.

For that reason, the distinction between preparation and implementation cannot function as a normative exemption. Preparatory action remains subject to the hard protected capacities of Section 3, the propagation analysis of Section 2, and the burden comparison used throughout the paper. Where preparation itself materially affects rights, standing, access, or irreversible conditions, those effects require substantive justification at the time they occur.

The section yields a narrower conclusion. Preparation can be a valuable form of provisional praxis when it preserves the ability to respond later while keeping substantive warrant genuinely open. Its quality depends not simply on how much readiness it creates, but on which options it preserves or forecloses, how it changes mobilization latency, what commitment pressures it generates, which capacities it burdens, and whether the preparatory architecture itself remains reviewable and decommissionable. The next section develops a related asymmetry that has appeared repeatedly in this paper: an intervention may be revisable for the initiating actor while imposing consequences that are difficult or impossible for other affected actors to reverse. Section 7 therefore examines the distributional structure of reversibility.

7 Distributional Structure of Reversibility

This section examines an asymmetry that has appeared throughout the paper but has not yet been made explicit. An intervention can remain revisable for the actor who initiates, authorizes, or administers it while leaving other affected actors with losses, burdens, or altered capacities that are difficult to recover. A policy can be withdrawn while trust remains damaged; a technical deployment can be decommissioned while data already disclosed cannot be recalled; a temporary resource reallocation can end while another user has already lost a time-sensitive opportunity; a reversible organizational pilot can be easy for management to terminate while participants bear durable disruption. A system-level statement that an intervention is “reversible” is therefore incomplete unless the relevant bearers, recovery criteria, and access to revision are specified.

The section develops a distributionally explicit account of reversibility. It does not derive a universal theory of justice or compensation. Its narrower purpose is analytical: to make visible whose capacities are expected to recover, which revision paths are actually available to them, where irreversibility is concentrated, and which burdens remain after the initiating actor regains practical discretion.

7.1 Bearer-Indexed Recovery Criteria

The protected-capacity analysis in Section 3 treated capacities as abilities or functions realized by a bearer-in-configuration. Distributional analysis requires the bearer index to remain visible. Let

$$\mathcal{N}_t^\alpha = \{n \mid n \text{ is a represented position relevant to the reversibility analysis of } \alpha\}. \quad (59)$$

be the represented position family for intervention α . The elements of Equation (59) need not be isolated individuals. Depending on the domain, n can index a person, group, institution, community, ecological bearer, or another relational position for which the analysis can meaningfully specify capacities and consequences. The family can therefore contain both burden-bearing positions and initiating or controlling positions when their recovery conditions are compared.

Let $\mathcal{N}_t^{\text{init}} \subseteq \mathcal{N}_t^\alpha$ denote initiating, authorizing, or administratively controlling positions included in the representation, and let $\mathcal{N}_t^{\text{aff}} \subseteq \mathcal{N}_t^\alpha$ denote positions whose capacities may bear intervention-related change or burden. The subsets can overlap. Their purpose is analytical typing rather than a claim that all positions have the same ontology, standing, or normative status.

The represented family should be prospective where possible, especially for $\mathcal{N}_t^{\text{aff}}$. If burden-bearing positions are identified only after harm becomes visible, distributional analysis risks reproducing the intervention designer's original field of attention rather than testing it. Prospectivity does not require complete foresight. New positions can emerge as propagation becomes visible, in which case $\mathcal{N}_t^\alpha$ and the relevant subsets should be revised and the intervention architecture re-evaluated.

For each $n \in \mathcal{N}_t^\alpha$, let

$$\emptyset \neq \mathcal{K}_{t,n}^{\alpha,\text{rev}} \subseteq \mathcal{K}_t^\alpha \quad (60)$$

be a nonempty subset of protected capacities whose recovery is relevant whenever reversibility is claimed for that position. Equation (60) specializes the criterion-relative recovery logic of Equation (15). Different positions need not have identical criteria. One position may require restoration of resource access, another the recovery of legal authority, another the restoration of a technical capability, and another a relation such as confidentiality or participation that may not be reconstructible once altered.

This indexing prevents a misleading aggregation. An intervention can preserve most represented capacities in the system while concentrating a non-recoverable loss on one position. Conversely, a visible system-level disruption can coexist with strong recovery paths for every position whose protected capacities were prospectively identified. Distributional structure concerns the location and recoverability of change, not merely its total magnitude.

7.2 Effective Access to Recovery

A feasible recovery path is not necessarily available to the position whose capacities are affected. A later revision may exist technically but depend on an authority that the affected party cannot petition, a compensation process it cannot access, a resource it cannot afford, information it does not possess, or an institutional actor with no enforceable obligation to act. Reversibility therefore has at least two analytically distinct components: the existence of a suitable recovery path and effective access to that path.

For an admissible revision path ϱ of the form introduced in Equation (16), define the position-relative recovery profile

$$\mathfrak{R}_{t:T}^{n,\alpha,\varrho} = \{\kappa \in \mathcal{K}_{t,n}^{\alpha,\text{rev}} \mid \kappa \text{ satisfies its specified recovery condition under } \varrho \text{ by horizon } T\}. \quad (61)$$

Equation (61) remains set-valued because different capacities can recover under different conditions and at different rates. Full represented recovery for n along ϱ holds when

$$\mathfrak{R}_{t:T}^{n,\alpha,\varrho} = \mathcal{K}_{t,n}^{\alpha,\text{rev}}. \quad (62)$$

Equation (62) is criterion-relative. It does not imply restoration of the complete earlier relational state or erasure of the intervention history.

Let

$$\text{Acc}_{t:T}(n, \varrho) \in \{0, 1\} \quad (63)$$

indicate whether position n has an effective route to obtain, invoke, claim, or be reliably protected by revision path ϱ within the relevant horizon. Equation (63) uses a binary indicator only to expose the structural distinction; domain applications can replace it with a graded or typed access representation. It does not require personal control over the path. Effective access can be supplied by an enforceable institutional obligation, automatic safeguard, fiduciary responsibility, legal remedy, or another mechanism that makes the recovery path practically available rather than merely conceivable.

The resulting position-relative effective reversibility condition is

$$\text{EffRev}_{t:T}(n; \alpha) = 1 \iff \exists \varrho \text{ admissible such that } \mathfrak{R}_{t:T}^{n,\alpha,\varrho} = \mathcal{K}_{t,n}^{\alpha,\text{rev}} \text{ and } \text{Acc}_{t:T}(n, \varrho) = 1. \quad (64)$$

Equation (64) deliberately combines recovery feasibility with access. An abstract restoration mechanism that the affected position cannot realistically obtain should not support the same practical reversibility claim as a path that is both feasible and effectively available.

This condition remains analytically modest. It says nothing by itself about whether the intervention was justified, whether the recovery burden is proportional, or whether the affected position consented to the original change. It only specifies when a represented reversibility claim is supported for that position under the selected capacity family and horizon.

7.3 A Distributional Reversibility Profile

The actor-relative conditions can be assembled without collapsing them into a scalar score. Define

$$\mathfrak{R}_{t:T}^{\text{dist}}(\alpha) = \{n \in \mathcal{N}_t^\alpha \mid \text{EffRev}_{t:T}(n; \alpha) = 1\}. \quad (65)$$

Equation (65) records the represented positions for which effective reversibility is available under the stated criteria. Its complement within $\mathcal{N}_t^\alpha$ identifies positions for which the claim fails under at least one represented requirement. The profile should not be interpreted as a percentage measure of how reversible the intervention is. A single excluded position can be practically or normatively decisive in some domains, while other domains may distinguish among degrees or types of non-recoverability.

The comparison can be sharpened by isolating burden-bearing positions outside the initiating subset:

$$\mathcal{J}_{t:T}^\alpha = \{n \in \mathcal{N}_t^{\text{aff}} \setminus \mathcal{N}_t^{\text{init}} \mid \text{EffRev}_{t:T}(n; \alpha) = 0 \text{ and } \exists i \in \mathcal{N}_t^{\text{init}} : \text{EffRev}_{t:T}(i; \alpha) = 1\}. \quad (66)$$

Equation (66) identifies an *asymmetric irreversibility exposure*: at least one initiating position can recover its represented capacities while an affected non-initiating position cannot. A nonempty $\mathcal{J}_{t:T}^\alpha$ does not by itself establish injustice. Some asymmetries can be unavoidable or justified under domain-specific standards. The diagnostic value is that a claim of “reversible intervention” can no longer rely solely on the initiator’s exit path while leaving the asymmetry unreported.

This distinction is especially important for provisional praxis. The initiator often controls the intervention boundary: it can stop a pilot, cancel a programme, withdraw a device, release a reserve, or terminate a contract. The affected position may instead bear consequences that have already propagated beyond that boundary. Withdrawal by the initiator and recovery by the affected party are therefore different practical events.

7.4 Distributional Capacity Debt

The capacity-debt set in Equation (26) records recoverable capacities that are temporarily impaired. For a selected intervention whose protected family has been augmented beyond the common comparison family, let $\mathcal{K}_t^{\alpha, \text{rec}}$ denote the recoverable part of that intervention-specific family under the same classification logic used in Equation (25). For position n , define the recoverable part of its reversibility criteria by

$$\mathcal{K}_{t,n}^{\alpha, \text{rec}} = \mathcal{K}_{t,n}^{\alpha, \text{rev}} \cap \mathcal{K}_t^{\alpha, \text{rec}}. \quad (67)$$

Equation (67) inherits the hard/recoverable partition from Equation (25); it does not create a new substantive classification. For distributional analysis, the bearer should remain attached to each recoverable impairment. Define

$$\mathfrak{D}_\tau^{\alpha, \text{dist}} = \{(n, \kappa) \mid n \in \mathcal{N}_t^\alpha, \kappa \in \mathcal{K}_{t,n}^{\alpha, \text{rec}}, \chi_{\kappa, \tau}(\mathcal{X}_\tau^\alpha) = 0\}. \quad (68)$$

Equation (68) refines the earlier debt representation by preserving who bears each impaired capacity. Two interventions can therefore produce capacity-debt sets of similar cardinality while having very different distributional structures. One may spread modest recoverable burdens widely; another may concentrate severe or repeated burdens on the same position.

The distributional form also exposes debt transfer. A revision that restores the initiator's capacity can discharge one pair (i, κ_i) while creating or leaving unresolved another pair (n, κ_n) . Recovery should therefore not be inferred from a decline in aggregate burden unless the bearer-indexed debt has also been examined. The same caution applies to substitution. Restoring system performance through a different bearer or relation may be operationally successful while leaving the original position's capacity debt unresolved.

Repeated temporary impairment deserves special attention. A capacity can be formally recovered after each intervention yet spend a large proportion of the relevant horizon in a degraded state. The set in Equation (68) can therefore be tracked through time rather than inspected only at the terminal horizon. This observation will matter in Section 8, where sequences of individually revisable interventions can accumulate into a trajectory that is distributionally difficult to reverse.

7.5 Recovery Modes for Relational Standing

Section 2 distinguished withdrawal, compensation, restoration, and redesign. Distributional analysis sharpens their non-equivalence. Compensation can address a burden without restoring the affected capacity. Functional substitution can recreate an output without restoring the relation, status, or opportunity through which the original capacity was realized. Withdrawal can end an ongoing intervention without recovering what has already been lost. Restoration of one capacity can coexist with durable change in another.

This matters when the protected object includes standing rather than only function. If an intervention changes who has authority, access, privacy, recognition, participation, or control over a resource, a later substitute may reproduce practical output while leaving the earlier relational position altered. The framework therefore should not treat compensation or functional replacement as automatic satisfaction of the recovery criteria in Equation (60). Whether substitution counts as recovery is a domain-specific judgment that must be stated rather than smuggled into the term “reversible.”

The same point applies to consent and authorization. Prospective consent can be highly relevant to justification, but it does not make an irreversible consequence reversible. Conversely, lack of individual control over a recovery path does not imply lack of effective access when an enforceable protective architecture reliably secures the relevant capacities. Reversibility, legitimacy, consent, compensation, and control remain related but distinct analytical dimensions.

7.6 Distributionally Explicit Reversibility Claims

The preceding distinctions support a narrower standard for how reversibility claims should be stated.

Definition 7.1 (Distributionally explicit reversibility). A reversibility claim for intervention α over horizon $[t, T]$ is *distributionally explicit* when it identifies, to the extent reasonably representable at the time: (i) the affected-position family $\mathcal{N}_t^\alpha$; (ii) the position-relative recovery criteria $\mathcal{K}_{t,n}^{\alpha, \text{rev}}$; (iii) at least one admissible recovery or revision path for each position for which reversibility is claimed; (iv) the mechanism of effective access to that path; and (v) any known residual burdens or capacities not expected to be recovered within the horizon.

Definition 7.1 is a reporting and analytical standard, not a complete theory of permissible intervention. It can be satisfied by an intervention that is still unjustified, and it can be impossible to satisfy fully when affected positions or propagation channels are unknown. Its purpose is to prevent the adjective “reversible” from referring only to the convenience of the actor with authority to stop the intervention.

The definition also makes uncertainty visible. If the intervention designer cannot yet identify who bears a propagated consequence, that uncertainty should remain part of the reversibility claim. A provisional design can respond by limiting propagation, strengthening monitoring, preserving contingency resources, or narrowing the intervention until the distributional architecture becomes better understood. The formalism does not determine which response is required; it exposes the missing object of judgment.

7.7 Limits of Distributional Reversibility

Distributional analysis has several limits. First, the affected-position family can be incomplete, especially where consequences emerge slowly or through long relational chains. Second, the same intervention can alter the identities, roles, or boundaries of the affected positions themselves, making a fixed bearer index inadequate. Third, recovery criteria can be contested: different actors can reasonably disagree about whether compensation, substitution, or restoration is sufficient. Fourth, some losses are not meaningfully commensurable, so a common burden scale may be inappropriate. Fifth, effective access can deteriorate even when a recovery path still exists formally, for example when institutions lose capacity, legal standing changes, or resources become scarce.

These limitations reinforce the paper’s non-scalar orientation. Distributional reversibility is not a single score to be maximized. It is a structured claim about who can recover what, through which path, with what access, over which horizon, and with which residual changes still present.

The analysis also identifies the next problem. Provisional interventions rarely occur only once. Protection, probing, preparation, and modular commitments can be repeated and revised as the situation changes. A sequence in which every individual step appears locally reversible can nevertheless accumulate capacity debt, alter the affected-position family, narrow later revision paths, or normalize burdens on the same actors. Section 8 therefore turns from the reversibility of a single intervention to adaptive sequences of intervention and asks how path dependence should be represented across successive acts.

8 Adaptive Sequences of Intervention

Practical intervention often unfolds as an ordered sequence rather than an isolated act: protection can be extended, a probe can motivate another probe, preparation can enable implementation, and revision can create conditions for further intervention. This section therefore treats the sequence itself as the analytical object. Its central problem is compositional: local provisionality need not survive aggregation. Individually limited or locally revisable steps can accumulate history, capacity debt, coupling, and distributional asymmetry until later revision becomes substantially harder than any one step suggested. Adaptive-planning and robust-decision traditions likewise emphasize staged action and future adjustment under deep uncertainty [7, 4]; the narrower question here is whether revisability survives when interventions become an ordered history.

8.1 Ordered Intervention Histories

Let

$$\alpha_{0:N} = ((t_1, \alpha_1), (t_2, \alpha_2), \dots, (t_N, \alpha_N)), \quad t_0 < t_1 < \dots < t_N, \quad (69)$$

be a finite ordered sequence of N interventions beginning from a reference time t_0 . Equation (69) records both intervention identity and order. The order matters because each later act is applied to a configuration whose relations, capacities, option structure, observation regime, and history may already have been changed by earlier acts.

For each stage k , let

$$\mathcal{X}_{t_k^+}^\alpha = \Psi_{t_k \rightarrow t_k^+}^{\alpha_k}(\mathcal{X}_{t_k}^\alpha) \quad (70)$$

denote the immediate post-intervention state conditional on the realized sequence history through stage k . Equation (70) reuses the history-producing transformation introduced in Section 1; the superscript α indicates that the current state is path-dependent rather than generated by α_k in isolation.

The associated historical component contains the ordered intervention inscriptions,

$$\mathcal{H}_{\leq t_k}^\alpha = \mathcal{H}_{\leq t_0} \oplus \eta_{t_1}^{\alpha_1} \oplus \dots \oplus \eta_{t_k}^{\alpha_k}, \quad (71)$$

subject to whatever additional non-intervention events the domain records between stages. Equation (71) makes explicit that adaptation does not replace the earlier history. A later correction can alter present conditions while leaving the earlier intervention sequence relevant to expectations, institutional precedent, distributional burden, or future interpretation.

The sequence representation is intentionally finite and discrete. Continuous control, stochastic policies, or densely repeated interventions would require a richer formalism. The present representation is sufficient for the conceptual point that provisionality must be evaluated across ordered intervention histories rather than only act by act.

8.2 Baseline Drift under Rolling Reference Courses

Section 2 replaced the frozen pre-intervention baseline with an evolving reference course. A sequence creates a further difficulty. After several interventions have occurred, the relevant counterfactual for the next step is usually no longer the original no-intervention course from t_0 . It is a course conditional on the realized history up to the current stage.

Let π_k^0 denote a stage- k reference course beginning from the actual pre-intervention state $\mathcal{X}_{t_k}^\alpha$ but omitting, replacing, or otherwise varying the candidate intervention α_k according to the substantive comparison being made. The local comparison is therefore between

$$\Phi_{t_k \rightarrow t'}^{\pi_k^\alpha}(\mathcal{X}_{t_k}^\alpha) \quad \text{and} \quad \Phi_{t_k \rightarrow t'}^{\pi_k^0}(\mathcal{X}_{t_k}^\alpha), \quad t' > t_k. \quad (72)$$

Equation (72) provides a rolling baseline that is conditional on what has already happened. It reduces the error of comparing each later adjustment with a world that ceased to be a plausible reference after the first intervention.

Rolling comparison, however, creates the opposite risk: *baseline drift*. Earlier burdens or losses can become normalized because they are already embedded in $\mathcal{X}_{t_k}^\alpha$ and therefore disappear from the local comparison at stage k . A sequence can consequently look locally modest at every stage while the cumulative trajectory has moved far from the capacities, relations, or distributions protected at t_0 .

A defensible adaptive architecture therefore benefits from dual reference. Local decisions can use the rolling reference course in Equation (72), while sequence-level review retains at least one earlier protected reference family. Let

$$\mathcal{K}_{0:N}^{\text{seq}} \supseteq \mathcal{K}_{t_0}^{\text{hard}} \quad (73)$$

be the sequence-level protected criteria retained for cumulative review, possibly augmented as new affected positions or capacities become visible. Equation (73) does not require preservation of the initial

state. It preserves selected criteria against which cumulative change remains judgeable even after the operational baseline has been updated.

Adaptive intervention can also change who enters the represented position family. New burden-bearing or controlling positions can enter the propagation envelope, organizational roles can split or merge, and earlier positions can lose standing or exit the system. Define

$$\mathcal{N}_{0:N}^\alpha = \bigcup_{k=1}^N \mathcal{N}_{t_k}^{\alpha_k} \quad (74)$$

as the accumulated represented position family across the sequence. Equation (74) is a bookkeeping device, not a claim that position identity is stable. Where roles or identities transform, the mapping among positions across stages must be supplied by the domain analysis rather than inferred from the union itself.

8.3 Composition of Local Revisability

The distinction between local and sequence-level reversibility is central. Suppose each intervention α_k has a locally admissible recovery or revision path relative to the state and criteria visible at t_k . It does not follow that the full sequence admits a later path that recovers all capacities that matter across the sequence.

For each represented position $n \in \mathcal{N}_{0:N}^\alpha$, let

$$\mathcal{I}_n = \{k \in \{1, \dots, N\} \mid n \in \mathcal{N}_{t_k}^{\alpha_k}\} \quad (75)$$

be the stages at which that position is represented in the intervention analysis. Equation (75) prevents a local reversibility premise from being imposed at stages where the position was not part of the represented intervention field. Let $\mathcal{K}_{0:N,n}^{\text{seq}} \subseteq \mathcal{K}_{0:N}^{\text{seq}}$ denote the sequence-level protected criteria relevant to the position. Define sequence-level effective reversibility over horizon $[t_0, T]$ by

$$\text{SeqEffRev}_{t_0:T}(n; \alpha_{0:N}) = 1 \quad (76)$$

when there exists at least one admissible post-sequence revision path that (i) satisfies $\mathcal{K}_{0:N,n}^{\text{seq}}$ and (ii) is effectively accessible to position n in the sense developed in Section 7. Equation (76) is therefore stronger than asking whether the last intervention can be stopped or whether every step once had a local recovery path. It remains a criterion-relative terminal claim: even when it equals one, earlier burdens, lost opportunities, or repeated capacity impairment can remain historically significant. Sequence-level effective reversibility should therefore be read together with the cumulative debt history introduced below rather than as a statement that the sequence left no residual harm.

Let $T_k > t_k$ denote the stage-specific horizon used for the local reversibility claim about α_k . In general, the following implication need not hold:

$$[\text{EffRev}_{t_k:T_k}(n; \alpha_k) = 1 \text{ for every } k \in \mathcal{I}_n] \not\Rightarrow \text{SeqEffRev}_{t_0:T}(n; \alpha_{0:N}) = 1. \quad (77)$$

Equation (77) states a structural non-implication rather than an empirical regularity. Local recovery paths can depend on conditions later interventions remove; capacities can be repeatedly impaired; burdens can shift across positions; or individually recoverable changes can interact so that no single later path satisfies the cumulative protected criteria together.

This non-composition is one reason provisional praxis should not be evaluated only through the adjective attached to each step. A sequence of “temporary,” “pilot,” “limited,” or “reversible” interventions can become globally difficult to revise through accumulation even when none of its steps was initially designed as permanent.

8.4 Recurrent Capacity-Debt Histories

Section 7 attached capacity debt to the positions that bear it. Adaptive sequences require the additional possibility that debt can recur across stages. At stage k , let $\mathfrak{D}_{t_k}^{\alpha, \text{dist}}$ denote the bearer-indexed debt set obtained by applying Equation (68) to the current sequence state and the protected-capacity families then in force. Define the sequence debt history

$$\mathbb{D}_{0:N}^{\alpha} = \left\{ (k, n, \kappa) \mid (n, \kappa) \in \mathfrak{D}_{t_k}^{\alpha, \text{dist}} \right\}. \quad (78)$$

Equation (78) preserves stage, bearer, and capacity rather than reducing repeated impairment to an aggregate score. The same pair (n, κ) can therefore appear at several stages even if the capacity is nominally restored between them.

Repeated appearance matters because terminal recovery can hide temporal burden. A capacity may be restored by T while having remained unavailable through several periods in which its absence affected participation, opportunity, income, privacy, authority, or another practically relevant function. Sequence-level review should therefore consider both terminal debt and the history represented in $\mathbb{D}_{0:N}^{\alpha}$.

The same logic applies to concentration. A sequence can repeatedly assign modest burdens to the same position while each intervention remains below whatever local threshold would have attracted strong scrutiny. No universal accumulation rule follows from the formalism, but preserving the bearer-indexed history makes cumulative concentration available for substantive judgment rather than allowing it to disappear through stagewise resetting.

8.5 Evolving Revision Frontiers

At each stage, the sequence also leaves a changing set of future interventions and revision paths. Reusing the option-availability logic from Section 6, let

$$\mathcal{V}_{t_k}^{\text{rev}} \subseteq \mathcal{A}_{t_k} \cup \{\emptyset\} \quad (79)$$

be the intervention and revision options that remain feasible and admissible for managing the current trajectory while respecting the relevant hard capacities, with $\emptyset$ denoting a null continuation in which no new intervention is introduced at that stage. Equation (79) is a *revision frontier*: it records what can still be done from the present configuration, not what would have been possible earlier.

A shrinking $\mathcal{V}_{t_k}^{\text{rev}}$ can indicate increasing lock-in, but shrinkage is not automatically undesirable. Some options should disappear once they become unsafe, unlawful, ineffective, or inconsistent with newly recognized obligations. The diagnostic question is whether option loss reflects justified updating or whether the sequence has unintentionally consumed revision paths that the provisional design was supposed to preserve.

This distinction also clarifies why adaptation is not synonymous with flexibility. A system can change frequently while its admissible revision frontier narrows. Conversely, a sequence can preserve substantial revision capacity even while individual interventions become more specialized, provided alternative paths remain feasible and effectively accessible.

8.6 Stagewise Adaptive Updating

The term “adaptive” can conceal a further risk. If each observation of unresolved difficulty automatically motivates another intervention, the sequence can become a ratchet. Adaptation should therefore involve revision of the intervention architecture, not merely escalation of intervention intensity.

At stage k , let

$$\mathcal{A}_{t_k}^{\text{adm}} \subseteq \mathcal{A}_{t_k} \cup \{\emptyset\} \quad (80)$$

be the contemporaneously admissible candidate family after considering the updated evidence, protected capacities, distributional reversibility, and available revision paths. Equation (80) can contain continuation, modification, substitution, pause, withdrawal, decommissioning, or the null continuation $\emptyset$. Adap-

tation is therefore not represented as a rule that maps new information to “more action.” It is a repeated re-opening of the practical choice set under a changed history-bearing configuration.

A stagewise review can then ask at least four questions. First, does the next proposed intervention remain sufficient for a stated practical purpose rather than merely continue an inherited programme? Second, do the hard protected capacities and bearer-indexed recovery conditions remain satisfied? Third, has the sequence accumulated debt or coupling that changes the justification of another step? Fourth, has the revision frontier narrowed enough that preserving future discretion itself becomes a practical reason to pause, redesign, or decommission?

These questions do not generate a universal stopping rule. They define objects that a domain-specific stopping rule or judgment should inspect. In some settings continued intervention can be necessary because the reference course is itself deteriorating. In others, the appropriate adaptive response can be to reduce intervention rather than intensify it.

8.7 Sequence-Level Pathologies

Several characteristic pathologies become visible only at sequence level. *Incremental lock-in* occurs when each step modestly reduces future revision capacity until the remaining frontier is narrow. *Baseline normalization* occurs when earlier burdens disappear from current comparison because they have become part of the rolling reference state. *Recurrent burden concentration* occurs when the same position repeatedly carries nominally temporary capacity debt. *Probe ratcheting* occurs when inconclusive or intervention-conditioned evidence repeatedly motivates additional probes without a clear stopping architecture. *Preparatory entrenchment* occurs when readiness investments progressively make one substantive path easier to adopt and alternatives harder to sustain. *Adaptive drift* occurs when the original practical purpose is gradually replaced by continuation of the intervention process itself.

The sequence formalism also has limits. It does not by itself identify causal contribution among interacting interventions, especially when background conditions evolve simultaneously. It does not supply a common metric for comparing cumulative burden across heterogeneous capacities or positions. It cannot guarantee that the affected-position family is complete. It also does not solve the normative problem of deciding when path dependence is acceptable; many valuable institutions and commitments are intentionally path-forming. The framework only separates intended commitment from unexamined lock-in and preserves enough history for that distinction to remain discussable.

The analysis points toward an institutional problem. Adaptive sequences require memory across stages, responsibility for cumulative rather than merely local effects, authority to pause or redesign an inherited trajectory, and mechanisms for preserving dissent about whether adaptation has become entrenchment. These functions can exceed the capacity of any single decision maker or intervention team. Section 9 therefore turns to the institutional conditions under which provisional praxis can remain reviewable across time, personnel change, and distributed authority.

9 Institutional Conditions for Provisional Praxis

Section 8 showed why locally provisional steps can form a trajectory that is difficult to revise. The remaining problem is partly institutional: intervention histories can outlast their initiators, distribute authority across organizations, accumulate dependencies, and make continuation easier than reconsideration. Provisionality therefore depends not only on intervention design but also on whether institutions preserve cumulative memory, reopen practical choice, authorize interruption, maintain affected-position access, and retain decommissioning capacity.

This section therefore examines the institutional conditions of provisional praxis. It builds on the institutional analysis of unresolved inquiry in the preceding temporal-judgment paper [6], but the present object is different. Institutional waiting asks whether an unresolved inquiry remains judgeable and reviewable. Institutional praxis asks whether a history-bearing intervention trajectory remains *interruptible*, *revisable*, and *decommissionable* after material, organizational, and relational commitments have

already formed around it. The analysis remains functional rather than organizationally prescriptive. It does not imply that every provisional intervention requires a formal committee, independent agency, or elaborate bureaucracy. Recursive review and revision are also central to experimentalist-governance architectures [9]; the present section isolates the additional praxis requirement that review remain coupled to executable interruption, substitution, or decommissioning capacity.

9.1 Sequence-Level Praxis Governance

The intervention sequence in Equation (69) can create obligations that exceed the temporal reach of its original decision makers. Records must remain interpretable; cumulative burdens must remain visible; someone must be able to ask whether the practical purpose still holds; and, crucially, some role or process must possess effective authority to pause, revise, or decommission the trajectory. An institution can satisfy the first three conditions while failing the fourth. It may remember perfectly that an intervention was provisional while lacking any role capable of interrupting it.

This distinction motivates the following definition.

Definition 9.1 (Institutional architecture of provisional praxis). Such an architecture is a history-bearing arrangement of roles, authority relations, review functions, and transfer practices that couples preserved records to practical governance capacity. It keeps an intervention trajectory cumulatively reviewable and interruptible across changes in time, personnel, organizational structure, and distributed authority.

Definition 9.1 does not require that every intervention remain easy to reverse. Some interventions are intentionally path-forming, and some later revisions become costly for reasons that cannot be eliminated. The narrower requirement is that institutional continuation should not silently substitute for substantive re-justification. A trajectory counts as institutionally provisional only to the extent that the architecture still contains practicable routes for reconsideration and, where warranted, non-continuation.

The distinction is especially important because continuation often has an institutional advantage over interruption. Budgets, contracts, technical infrastructure, routines, reporting formats, professional roles, and stakeholder expectations can all be organized around the current trajectory. Once those structures exist, “do what is already being done” can require less coordination than pause or redesign even when continuation was never intended to become the default. Provisionality therefore has an institutional dimension: the practical burden of reopening the trajectory should not become so asymmetric that formal review survives while real revision becomes unreachable.

9.2 Functional Role Architecture

To expose this structure without prescribing a particular organization chart, let

$$\mathcal{F}_t^{\text{prx}} = \{f_1, \dots, f_m\} \quad (81)$$

be the family of institutional functions prospectively regarded as relevant to the provisional intervention trajectory at time t . Equation (81) is domain-relative. Depending on duration and stakes, it can include sequence-memory custody, stagewise substantive review, monitoring of cumulative capacity debt, preservation of dissent, representation of affected positions, pause authority, revision authority, decommissioning, escalation, and handoff.

Let $\mathcal{W}_t^{\text{role}}$ denote the institutionally relevant role family. The function assignment map is

$$\omega_t^{\text{prx}} : \mathcal{F}_t^{\text{prx}} \longrightarrow 2^{\mathcal{W}_t^{\text{role}}}. \quad (82)$$

Equation (82) allows one function to have several assigned roles and one role to carry several functions. It does not imply that more assignees are better. Redundancy can increase resilience, but it can also diffuse responsibility if no role is expected to act when a revision condition becomes salient.

The relevant roles also stand in typed relations. Let

$$\Lambda_t^{\text{prx}} \subseteq \mathcal{W}_t^{\text{role}} \times \mathcal{W}_t^{\text{role}} \times \text{Type}_t^{\text{inst}} \quad (83)$$

Table 2: Illustrative functions in an institutional architecture of provisional praxis

Function	Praxis role	Characteristic failure if unsupported
Sequence-memory custody	Preserve the ordered intervention history, cumulative criteria, recurrent burdens, and revision rationales.	Each stage appears locally reasonable because earlier costs and alternatives disappear from view.
Stagewise substantive review	Re-open the practical purpose and admissible action family at defined or condition-sensitive points.	Continuation is reviewed procedurally without reconsidering whether the intervention remains needed.
Interruption authority	Permit pause, revision, substitution, or decommissioning when continued action is no longer justified.	The institution can diagnose lock-in but has no practical route to stop it.
Affected-position access	Keep routes through which materially affected positions can supply information, contest burden descriptions, or invoke applicable safeguards.	Distributional reversibility is assessed only from the initiating institution's perspective.
Dissent preservation	Retain materially relevant alternative interpretations of the trajectory and its cumulative effects.	Apparent consensus grows through organizational attrition rather than improved discrimination.
Handoff and succession	Transfer memory, authority, pending review conditions, and unresolved burdens across personnel or organizational change.	A successor inherits the programme but not the reasons it was provisional.
Decommissioning	Maintain practicable routes for ending infrastructure, obligations, or organizational arrangements created by the intervention.	Temporary arrangements become durable because exit itself was never institutionally designed.

collect institutionally relevant relations, where $\text{Type}_t^{\text{inst}}$ is a domain-specified family of relation types such as succession, consultation, appeal, authorization, escalation, independent review, information access, or backup responsibility. Equation (83) keeps the architecture relational. A role is not institutionally adequate merely because its title appears in a procedure; its practical significance depends on what information, authority, and recourse it can access through the surrounding relations.

The resulting institutional architecture is represented by

$$\text{Gov}_t^{\text{prx}} = \langle \mathcal{W}_t^{\text{role}}, \mathcal{F}_t^{\text{prx}}, \omega_t^{\text{prx}}, \Lambda_t^{\text{prx}} \rangle. \quad (84)$$

Equation (84) is intentionally modest. It says nothing by itself about whether the institution is legitimate, competent, democratic, efficient, or ethically adequate. It only makes visible the functional and authority structure through which provisional praxis is supposed to remain governable.

Table 2 gives an illustrative decomposition. The functions are not universal and need not be housed in separate offices.

The table also clarifies why ordinary record retention is insufficient. A complete archive can coexist with an institution that has no pause authority, no route for an affected position to challenge a recovery claim, and no process capable of decommissioning the structures created by the intervention. Institutional provisionality therefore concerns the coupling of memory with authority and revision capacity, not memory alone.

9.3 Effective Interruption Authority

The most distinctive praxis problem is not whether an intervention can be discussed again but whether discussion can alter the trajectory. It is therefore useful to distinguish nominal authority from *effective authority*. Let

$$\mathcal{Y}_t^{\text{gov}} = \{\text{continue, pause, revise, substitute, decommission, escalate}\} \quad (85)$$

be an illustrative family of governance acts relevant to the intervention sequence. Equation (85) is not an exhaustive menu; a domain can refine or replace these acts.

For role $p \in \mathcal{W}_t^{\text{role}}$ and governance act $u \in \mathcal{Y}_t^{\text{gov}}$, let

$$\text{EffAuth}_t(p, u \mid \alpha_{0:k}) \in \{0, 1\} \quad (86)$$

indicate whether p has an effective institutional route to perform or validly initiate u for the current intervention trajectory. Equation (86) is stronger than formal jurisdiction on paper. Effective authority can fail when a nominally authorized role lacks access to the relevant records, resources, procedural standing, implementation capacity, or escalation path needed to make its decision consequential.

Define the institutionally reachable governance family by

$$\mathcal{Y}_t^{\text{eff}}(\alpha_{0:k}) = \{u \in \mathcal{Y}_t^{\text{gov}} \mid \exists p \in \mathcal{W}_t^{\text{role}} : \text{EffAuth}_t(p, u \mid \alpha_{0:k}) = 1\}. \quad (87)$$

Equation (87) makes an institutional asymmetry visible. Continuation may remain reachable through ordinary operations. Pause, revision, or decommissioning may instead depend on approval paths too slow for the relevant window.

This motivates a narrow notion of institutional interruptibility. Let

$$\text{Int}_t(\alpha_{0:k}) = 1 \quad (88)$$

when

$$\mathcal{Y}_t^{\text{eff}}(\alpha_{0:k}) \cap \{\text{pause, revise, substitute, decommission}\} \neq \emptyset. \quad (89)$$

Equations (88)–(89) do not imply that interruption is substantively justified. They indicate only that at least one meaningful non-continuation pathway remains institutionally actionable. An institution can therefore be formally committed to periodic review while being effectively non-interruptible if every review outcome other than continuation lacks an executable path. The governance-act family must also be specified at sufficient granularity: a merely cosmetic “revision” should not satisfy the condition when the practical trajectory remains unchanged in every dimension relevant to the review.

This distinction also prevents an easy misunderstanding of “independence.” An independent review body with no authority, no binding escalation route, and no access to implementation can supply epistemic criticism without supplying practical interruptibility. Conversely, a highly empowered executive role can provide interruption capacity while lacking independence. The two properties answer different institutional questions and should not be treated as substitutes.

9.4 Institutional Presumption of Continuation

A provisional intervention can become self-perpetuating when continuation requires less justification than interruption. The problem need not involve bad faith. Once a programme is running, its current state becomes the operational baseline, staff acquire routines, budgets are allocated, and monitoring reports are designed around its continued existence. Non-continuation can then appear as a new action requiring special proof, while continuation is treated as absence of action.

The sequence formalism suggests a different framing. At each stage, continuation is one member of the contemporaneous admissible family represented in Equation (80); it is not the null state of history. Continuing an intervention can preserve, intensify, or redistribute its effects and can further narrow the revision frontier. The institution should therefore be able to ask whether continuation remains supported by the present practical purpose, protected capacities, distributional conditions, and cumulative history rather than infer its legitimacy from mere persistence.

This does not mean that every stage requires a de novo authorization process. Requiring one at every stage can impose disproportionate administrative burden and can destabilize beneficial long-term practices. The narrower point is that the architecture should specify when continuation receives ordinary presumption, when cumulative change makes re-justification appropriate, and who can invoke that reconsideration. Trigger conditions can include substantial narrowing of $\mathcal{V}_{t_k}^{\text{rev}}$, repeated appearance of

the same bearer-capacity pair in $\mathbb{D}_{0:k}^\alpha$, emergence of a newly affected position, failure of an anticipated recovery path, or material divergence from the original practical purpose.

The same logic applies to institutional metrics. A programme can meet the indicators it was designed to report while drifting from the reason those indicators originally mattered. Stagewise review benefits from retaining the practical purpose and protected criteria alongside performance measures so that metric success does not become an automatic argument for continuation.

9.5 Cumulative Sequence Memory

Institutional review of a long trajectory requires more than the latest state. For any stage k , the prefix notation $\mathcal{K}_{0:k}^{\text{seq}}$, $\mathbb{D}_{0:k}^\alpha$, and $\mathcal{N}_{0:k}^\alpha$ applies the constructions of Section 8 to the realized prefix $\alpha_{0:k}$ rather than introducing new cumulative objects. To keep those prefix objects and the distributional architecture of Section 7 jointly accessible, define the sequence ledger

$$\text{Ledger}_{t_k}^{\text{seq}} = \langle \mathcal{H}_{\leq t_k}^\alpha, \mathcal{K}_{0:k}^{\text{seq}}, \mathbb{D}_{0:k}^\alpha, \mathcal{N}_{0:k}^\alpha, \mathcal{V}_{t_k}^{\text{rev}}, \text{Gov}_{t_k}^{\text{prx}} \rangle. \quad (90)$$

Equation (90) is not a demand for one literal database or file. It names the linked information needed to reconstruct the intervention history, the cumulative protected reference, recurrent capacity debt, the represented position family, the current revision frontier, and the institutional architecture through which further revision can occur.

The ledger should also preserve contemporaneous rationales at a level proportionate to the stakes. Later reviewers otherwise face a familiar hindsight problem: they can see that an earlier intervention produced a burden or that an option later became unavailable, but not what alternatives, constraints, expectations, or unresolved judgments were present when the earlier stage was chosen. Preserving rationale does not immunize the earlier decision from criticism. It makes the criticism historically better specified.

A cumulative ledger also resists *handoff reset*. When a new team, administration, contractor, or institutional unit takes responsibility, the present state can appear to be its starting point. If the earlier sequence history and debt structure are not carried forward, the successor can reasonably assess only local conditions while inadvertently normalizing inherited burdens. Governance continuity therefore requires enough transmission for the new role to inherit not merely the current intervention but its unfinished provisional obligations.

The ledger has obvious proportionality and privacy limits. Preserving every communication, personal datum, or operational detail indefinitely can create surveillance, security, confidentiality, and administrative harms. The same judgeability-preserving compression principle developed for unresolved inquiry applies here: retain enough structure to reconstruct cumulative effects, alternatives, responsibilities, and revision conditions without treating maximal retention as an intrinsic good [6].

9.6 Affected-Position Access Architecture

Adaptive intervention creates a special risk of dissent attrition. An objection raised at stage 1 can disappear from the operational record by stage 5 even when the evidence never clearly resolved it. Staff turnover, summary reports, changing terminology, or repeated majority decisions can transform a contested trajectory into an apparently settled one. Preserving dissent does not mean granting every objection permanent veto. It means keeping materially relevant alternatives reconstructible until there is a reason to retire them.

Affected-position access raises a related but distinct issue. Section 7 showed that effective reversibility depends partly on whether the position bearing the affected capacity can obtain or invoke a recovery path. Institutional praxis should therefore preserve, where substantively appropriate, routes through which affected positions can correct descriptions of burden, provide information unavailable to the initiating institution, contest claims of recovery, or activate applicable review and remedy mechanisms.

Three institutional capacities should remain separate. *Voice* concerns the ability to supply relevant information or objections. *Standing* concerns whether the institution recognizes a position as entitled to

invoke some review or safeguard. *Authority* concerns power to decide or validly initiate a governance act. Affected positions can have voice without standing, standing without final authority, or some delegated authority without controlling the entire intervention. The present framework does not determine which allocation is normatively correct. It makes those allocations explicit because distributional reversibility is difficult to assess when the party defining “recovery” is always the party that initiated the change.

Dissent preservation should also be bounded. Requiring institutions to retain and repeatedly reconsider every abandoned interpretation can produce paralysis and strategic obstruction. A proportionate architecture can record why a dissenting view was retired, what evidence would warrant reopening it, and whether any affected position retains a legitimate route to challenge the closure. The goal is not permanent disagreement but resistance to unexplained disappearance of relevant disagreement.

9.7 Governance-State Succession

Personnel and organizational transitions can break provisionality even when the intervention itself remains unchanged. A successor can inherit operational responsibility without inheriting authority to pause; a new contractor can receive technical infrastructure without the cumulative burden record; an agency reorganization can preserve a programme while scattering review functions across several units. Handoff should therefore transfer a governance state rather than only an operational task.

For the present paper, an adequate handoff includes, proportionately, access to the sequence ledger in Equation (90), current function assignments from Equation (82), relevant authority relations from Equation (83), pending review conditions, and any known fragility in the revision frontier. The handoff need not reproduce every tacit understanding of the predecessor. It should preserve enough of the history and authority structure for the successor to know what remains provisional and what would make non-continuation actionable.

Decommissioning deserves separate attention because it is often institutionally underdesigned. A temporary intervention can generate data stores, dedicated staff, contracts, physical infrastructure, public expectations, technical dependencies, or legal instruments that survive the practical purpose that originally justified them. If no role is responsible for dismantling or repurposing those structures, “ending the intervention” can mean only stopping its most visible activity while the architecture it created remains in place.

Decommissioning is itself an intervention and can create new burdens. Terminating a support system can harm users who came to depend on it; deleting records can improve privacy while reducing future accountability; dissolving a team can save resources while destroying expertise needed for recovery. The institutional requirement is therefore not an automatic preference for dismantling but the capacity to evaluate and carry out proportionate decommissioning when the sequence-level judgment supports it.

9.8 Institutional Pathologies of Provisional Praxis

The preceding analysis supports several characteristic institutional pathologies. *Continuation by default* occurs when ordinary operations can extend the trajectory while every non-continuation act faces exceptional procedural barriers. *Review without interruption authority* occurs when institutions can diagnose problems but cannot translate review into pause, revision, substitution, or decommissioning. *Local-accountability truncation* occurs when each office is responsible for its own stage while no role owns cumulative effects across the sequence.

Other failures concern memory and distribution. *Handoff reset* occurs when a successor inherits the present intervention while earlier burdens and provisional obligations disappear from the operative baseline. *Dissent attrition* occurs when repeated summaries erase unresolved alternatives without an explicit closure rationale. *Affected-position exclusion* occurs when the architecture evaluates reversibility or recovery without a credible route for the positions bearing the relevant capacities to correct or contest that evaluation. *Decommissioning orphanhood* occurs when no role possesses both responsibility and effective authority to dismantle structures whose original justification has expired.

Institutionalization can also produce the opposite problem: excessive proceduralization. Too many review layers can delay necessary protective action, diffuse responsibility, or make every minor adjustment administratively costly. A trajectory can remain technically interruptible yet practically rigid because initiating any revision requires burdens disproportionate to the intervention itself. The architecture should therefore remain proportionate to duration, stakes, expected turnover, propagation risk, distributional asymmetry, and the difficulty of recovering lost capacities.

9.9 Power Constraints on Institutional Provisionality

Institutional architecture does not neutralize power. The institution that defines the protected-capacity family, controls the sequence ledger, determines who counts as affected, sets review conditions, and allocates interruption authority can shape which consequences remain visible and which trajectories appear admissible. The formalism cannot resolve those substantive political and normative questions. It can, however, prevent them from disappearing behind an undifferentiated statement that an intervention is “institutionally reviewed.”

This limitation is especially relevant when the intervention crosses organizational or jurisdictional boundaries. One actor can hold the data, another the budget, another the legal authority, and another the burden. No single institution may possess all functions in $\mathcal{F}_t^{\text{prx}}$. In such cases the architecture is inter-institutional rather than organizationally self-contained, and effective interruptibility can depend on relations among bodies that do not share the same mandate or incentives.

The section also does not establish a universal presumption for decentralization, independent review, participatory governance, or centralized authority. Each can be appropriate in some domains and dangerous in others. The narrower contribution is to identify institutional properties that matter whenever an intervention is described as provisional across a sequence: cumulative memory, effective interruption authority, continuity of review, distributionally informed access, preserved dissent where still relevant, and practical capacity for revision or decommissioning.

These conditions complete the paper’s movement from a single history-producing intervention to an institutionally governed praxis trajectory. Section 10 synthesizes the resulting framework while keeping its limits explicit: the formalism supplies a language for structuring provisional intervention, not a domain-independent rule for what should be done.

10 Conclusion

This paper has developed a preliminary relational formalism for intervention undertaken while relevant judgment remains unresolved, the surrounding configuration continues to change, and later revision still matters. The objective has been structural rather than prescriptive: to identify features that become salient once intervention is treated as a history-producing transformation rather than as a detachable choice.

10.1 Analytical Synthesis

The analysis began by separating decision, action, and intervention. Intervention changes a relational configuration and enters the history against which later observations, options, burdens, and recovery paths are assessed. Literal rollback is therefore an unreliable model of revisability. What may remain recoverable is a specified family of capacities, relations, options, or functions through an admissible later path.

That premise supports the paper’s account of *minimal sufficient change*. Sufficiency is evaluated first against a common practical target and hard protected capacities; minimality is then represented through nondominance over the stated burden criteria. The result need not be unique. Several interventions can remain incomparable when resource use, propagation exposure, reversibility, distributional burden, or option loss cannot legitimately be collapsed into one scale.

The same architecture constrains information-producing intervention. A reversible probe may improve discrimination among live interpretations, yet its evidence remains conditioned by the intervention that generated it. Probe design therefore joins epistemic aims to protected capacities, admissible revision paths, provenance, and stopping conditions. Modularity and preparation extend this logic to intervention architecture: decomposition matters only where components are operationally separable, and preparation can preserve later executability without supplying substantive warrant for the intervention it prepares.

Distributional analysis makes reversibility bearer-sensitive. A recovery path available to an initiating or controlling position may remain inaccessible to a burden-bearing position. Withdrawal, restoration, compensation, and substitution accordingly remain distinct. Across sequences, local reversibility may also fail to compose: individually revisable interventions can narrow later revision frontiers, normalize altered baselines, accumulate capacity debt, and eliminate earlier recovery paths. Rolling reference courses therefore need cumulative reference objects that preserve earlier criteria and burdens from baseline drift.

Section 9 adds the institutional condition of *interruptibility*. Review alone is insufficient where no role can effectively pause, revise, substitute, or decommission an intervention trajectory. Institutional provisionality thus depends on reachable governance acts, continuity of responsibility, affected-position access, cumulative memory, and decommissioning capacity.

Taken together, these results support a demanding but limited conception of provisional intervention. Provisionality is better represented as an architecture of later revision than as a temporary label or weak initial commitment. Its relational, temporal, distributional, sequential, and institutional dimensions are connected, but no single dimension guarantees the others.

10.2 Boundary with Temporal Judgment

The paper extends rather than replaces the earlier temporal-judgment framework [6]. Temporal judgment asks how unresolved inquiry can remain judgeable, revisable, and accountable while information and practical options change. The present paper moves downstream: once intervention changes the configuration under inquiry, it can also alter later evidence, option structure, affected positions, recovery paths, and institutional trajectories.

The distinction is therefore one of analytical object. Temporal governance can preserve the conditions for later judgment without yet specifying how an intervention should be architected once action begins. P1 contributes that intervention-side structure through history-bearing transformation, protected capacities, probing, modularity, preparation, bearer-indexed recovery, sequence-level path dependence, and institutional interruption.

10.3 Scope and Limits of the Formalism

Several limits should remain explicit. The framework does not derive substantive targets, protected capacities, acceptable burdens, affected positions, recovery standards, or legitimate authority. These are domain-dependent and may require empirical, ethical, legal, political, professional, or participatory judgment. Making their relations explicit cannot settle their legitimacy.

The formal objects are also reconstructive rather than calibrated causal models. Transition operators, reference courses, propagation envelopes, and sequence objects organize dependencies; empirical applications still require domain-appropriate methods for causal identification, prediction, and counterfactual assessment.

Revisability is not an overriding value. Some commitments should become difficult to reverse, some options should close, and delay can itself be harmful. Nor does formal explicitness guarantee normative completeness: the selection of capacities, burden criteria, affected positions, histories, and institutional functions can reproduce existing power. Computational tractability imposes another limit because realistic option families, propagation relations, and revision paths may be too large or uncertain for exhaustive representation.

Finally, the paper has not established that applying these concepts improves outcomes. Its present contribution is analytical: to distinguish structures often compressed into labels such as *temporary*, *re-*

versible, adaptive, experimental, or cautious. Whether particular implementations improve safety, legitimacy, learning, resilience, or decision quality remains an empirical question.

10.4 Subsequent Questions

The framework suggests several bounded research problems. Empirical reconstruction can test whether distinctions among local reversibility, sequence-level revisability, capacity debt, option preservation, and institutional interruptibility are descriptively useful in actual intervention histories. Domain-specific studies can operationalize protected capacities and recovery access without assuming that one criterion set transfers across public policy, organizational change, technological governance, humanitarian action, infrastructure, or other fields.

A second problem concerns sequence dynamics: when do revision frontiers contract, reopen, or bifurcate, and under what conditions can locally revisable steps produce global lock-in? A third concerns distribution and power: which principles should govern burden, standing, compensation, consent, and interruption authority when recovery is unevenly accessible? A fourth concerns institutions: which governance arrangements preserve meaningful interruption capacity without producing review theatre, disproportionate procedure, or paralysis?

These questions are research directions rather than a publication queue. Further formal development is warranted only where an independent problem requires it.

10.5 Closing Thesis

The paper's central claim is modest. Under unresolved and evolving conditions, provisional praxis can be structured not only around immediate purposes but also around the future conditions of revision. Relevant conditions include protected capacities, bounded propagation, interpretable evidence provenance, modular revision where feasible, option-conscious preparation, distributionally explicit recovery, sequence-level memory, and institutional interruptibility.

These properties cannot establish that an intervention is correct. Their narrower value is to make visible how a nominally provisional intervention may become effectively irreversible through coupling, cumulative burden, path dependence, inaccessible recovery, or institutional inertia. Provisional intervention, in this sense, is action undertaken while preserving enough practical structure for later judgment and revision to remain meaningful.

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