

A Preliminary Framework for Temporal Judgment in Unresolved Inquiry

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Abstract

This preliminary philosophical framework examines inquiry important enough to retain yet insufficiently settled for stable closure, commitment, or release. It models unresolved inquiry as a changing temporal state in which evidence may mature or decay, interpretations may differentiate, options may disappear, institutions may lose memory, and interventions may alter the later evidential environment. The central question is how inquiry can remain judgeable, revisable, responsive, and accountable while both closure and continued non-closure carry consequences. The paper distinguishes delay from accountable deferral and develops future judgeability: the later capacity to reconstruct the evidence, alternatives, confidence, reasons for deferral, and review conditions of an earlier unresolved state. It then analyzes criterion-relative reversibility, the coupled dynamics of information and optionality, action opportunity sets, review-trigger architecture, institutional continuity, and AI-mediated temporal support. The result is a revisable, non-scalar architecture for coordinating epistemic maturity, practical optionality, preservation, and responsibility during periods in which closure remains premature. The framework is intentionally domain-relative and supplies neither a universal stopping rule nor a cross-domain timetable.

Keywords: temporal judgment; unresolved inquiry; accountable deferral; reversibility; future judgeability

Preprint Note

This preliminary preprint is part of an exploratory programme on contingency, judgment, problem formation, incipient change, scholarly practice, and education in the age of artificial intelligence. It develops a preliminary framework for temporal judgment in unresolved inquiry: how inquiry should be organized when a question, interpretation, or possible change deserves continued attention but does not yet warrant stable closure. The framework is philosophical and revisable. It distinguishes conceptual reconstruction from empirical findings and does not propose a universal decision rule for all domains.

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Status. This preliminary preprint develops an exploratory philosophical framework for temporal judgment in unresolved inquiry. Its central categories are analytical and revisable. The manuscript distinguishes inherited empirical or philosophical sources from its own reconstruction and does not claim a universal decision rule across domains.

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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, argumentative criticism, structural editing, and drafting in $\text{\LaTeX}$. External citations used in the manuscript were verified before insertion or inherited from previously verified records in the same research programme. The author selected the research questions, directed and approved the theoretical commitments and epistemic status of the claims, and bears sole responsibility for the manuscript, including its interpretations, arguments, conclusions, and errors. Authorship credit remains with the human author. The verification status and intended use of cited sources are recorded in the accompanying verification ledger.

Notation Guide

The first two sections are primarily conceptual; the recurring formal notation begins in Section 3. Readers can return to this page as a reference when the symbols appear. Table 1 lists only objects used across multiple sections, and each object is defined locally when introduced. Superscripts and subscripts identify the temporal course, commitment, option, or comparison horizon relevant to a particular expression.

Table 1: Recurring notation used across the temporal-judgment framework

Symbol	Role in the framework
$\mathcal{S}_t$	Time-indexed state of an unresolved inquiry.
$\mathcal{R}_t$	Contemporaneous record produced from an earlier inquiry state.
$\mathcal{T}_{t' t}$	Trace from time t that remains available at the later time t' .
$\mathcal{L}_{t'}$	Later methods, background knowledge, or interpretive resources available at t' .
$\mathcal{Q}_t$	Prospectively specified family of questions relevant to later reconstruction.
$\mathfrak{J}_{t \rightarrow t'}$	Set-valued profile of questions that remain responsibly judgeable at the later time.
$\Phi_{t \rightarrow t'}^c$	History-producing transition associated with a provisional commitment c .
$\mathfrak{R}_{t \rightarrow t'}$	Criterion-relative profile of capacities or conditions recoverable through feasible revision paths.
$\mathfrak{D}$	Profile of decision-relevant epistemic discriminations supportable in an inquiry state.
$\mathfrak{O}_{t \rightarrow t'}$	Profile of earlier options that remain meaningfully viable at the later time.
$\mathfrak{P}_{t \rightarrow t'}$	Joint epistemic-option profile pairing $\mathfrak{D}$ and $\mathfrak{O}$.
$\mathcal{W}_V^o$	Times at which option o remains practically viable.
$\mathcal{W}_E^o$	Times at which the specified epistemic conditions for o are satisfied.
$\mathcal{W}_A^o$	Action opportunity set $\mathcal{W}_V^o \cap \mathcal{W}_E^o$.
$\mathcal{B}_t$	Prospectively specified family of review-trigger conditions.
$\mathfrak{B}_{t \rightarrow \tau}$	Set of review triggers recognized as active at time τ .
$\mathcal{A}_t^{\text{inst}}$	Institutional architecture for temporal governance and review.
$\mathfrak{C}_{t \rightarrow t'}$	Functional-continuity profile for prospectively critical institutional functions.
$\mathcal{U}_t$	AI-support units used in the inquiry at time t .
μ_t	Map assigning temporal-governance functions to AI support.
$\Upsilon_{\leq t}$	Longitudinal record of materially relevant AI mediation states up to time t .

Several objects are represented as sets because preservation, reversibility, epistemic discrimination, optionality, and review conditions can involve heterogeneous criteria for which a common scale has not been assumed. This choice keeps the formalism compatible with later domain-specific quantification where such a scale can be justified.

1 Temporal Structure of Unresolved Inquiry

Section 1 defines unresolved inquiry and establishes the temporal problem that motivates the paper. It distinguishes unresolved inquiry from ignorance, indecision, and simple lack of information, then identifies dimensions along which an open inquiry can mature, deteriorate, transform, or lose future judgeability. The argument is philosophical and reconstructive. Dewey's account of inquiry beginning from an indeterminate situation serves as a bounded reference point; the temporal architecture developed here is a preliminary proposal.[3]

1.1 Analytical Object of Unresolved Inquiry

A substantial portion of intellectual and practical work takes place between first recognition and justified closure. A research anomaly may appear important without yet supporting a settled explanation. An archival fragment may deserve preservation before its relation to a larger historical problem is known. A policy concern may justify monitoring before it warrants intervention. A scholar may possess a promising interpretation while recognizing that the relevant evidence, conceptual vocabulary, or comparative cases remain insufficient. In such cases the inquiry is neither empty nor complete. It occupies an intermediate condition in which continued attention is justified while the form of eventual resolution remains open.

Dewey's account of inquiry as the controlled transformation of an indeterminate situation into one whose constituent distinctions and relations become determinate offers a useful starting point for this intermediate domain.[3] The present paper takes a narrower and more explicitly temporal question. Once an indeterminate or problematic situation has become worthy of inquiry, how should the inquiry be organized while decisive closure remains premature? The problem is therefore not only how indeterminacy becomes determinate. It is also how a responsible practice sustains an unresolved state across time without collapsing into premature closure, indefinite postponement, or archival loss.

Definition 1.1 (Unresolved inquiry). An *unresolved inquiry* is a retained inquiry whose object, interpretation, evidential standing, practical significance, or appropriate response remains sufficiently unsettled that closure would exceed the present grounds, while continued attention, preservation, probing, comparison, or preparation remains justified.

Definition 1.1 makes two commitments. First, unresolved inquiry already contains a selective judgment: something has been retained as worthy of continued epistemic or practical treatment. Second, unresolved status is relative to a specified question or commitment. A research programme may be unresolved about a causal mechanism while settled about the existence of an observed regularity. A historian may be unresolved about interpretation while settled about the provenance of a document. An institution may be unresolved about whether to intervene while settled that additional monitoring is warranted. The label therefore describes a relation between the present state of inquiry and the level of closure under consideration; it is not a global description of total ignorance.

The framework does not derive the substantive standards that make retention, closure, intervention, or release justified in a particular domain. It presupposes that such standards are supplied by the relevant evidential, methodological, ethical, legal, or institutional practice and then asks how they are carried through time. Terms such as “sufficiently unsettled,” “justified,” and “warranted” should therefore be read as domain-indexed inputs rather than as conclusions generated by the temporal formalism itself. This scope condition is important throughout the paper: the framework organizes temporal relations among judgments; it does not replace the substantive judgments on which those relations depend.

Several distinct sources of unresolvedness can coexist. The evidential record may be incomplete. Multiple interpretations may remain live. The relevant concepts may not yet be sufficiently differentiated. Important relations may still be changing. The consequences of intervention may be uncertain. A necessary external dependency may not yet have resolved. Or the evidence may be substantial while the normative or practical significance of acting on it remains contested. Treating these different states as one generic category of “uncertainty” can obscure what kind of temporal practice is appropriate. More

observation may help an evidential gap while doing little to resolve a normative disagreement; conceptual clarification may resolve an ambiguity that additional data would merely reproduce.

1.2 Temporal Structure Beyond Chronological Duration

Within the present framework, unresolved inquiry is temporal in a stronger sense than simply requiring elapsed time. Its evidential conditions, interpretive field, action possibilities, costs, and responsibilities can change while the inquiry remains open. Waiting one week does not merely add seven days to an otherwise identical problem. New evidence may appear; existing evidence may decay; actors may adapt; records may disappear; a research instrument may become available; a policy window may close; an initially reversible option may become costly; or the act of monitoring may alter the phenomenon being monitored. The state of the inquiry at a later time can therefore differ qualitatively from its earlier state even when no explicit conclusion has been reached.

Definition 1.2 (Temporal state of inquiry). A *temporal state of inquiry* is the time-indexed configuration of evidential maturity, interpretive plurality, available methods, preservation quality, response reversibility, option structure, review responsibility, and relevant external conditions through which an unresolved inquiry can presently be continued, transformed, escalated, deferred, or released.

Definition 1.2 treats time as constitutive of the inquiry rather than as an external clock. The same nominal question can occupy materially different temporal states. An unresolved hypothesis with intact raw data, several competing explanations, cheap additional tests, and a clear review date differs from the same hypothesis after the raw data have been discarded, the research team has dispersed, and institutional attention has moved elsewhere. Both inquiries may be described as “not yet settled,” yet their future judgeability is very different.

This distinction also helps separate *delay* from *temporal judgment*. Delay describes elapsed time before a later event. Temporal judgment concerns the organization of that interval. The interval may be used to preserve evidence, generate discriminating information, maintain optionality, seek criticism, compare historical cases, prepare a reversible response, or specify conditions for reopening a question. It may also be consumed without such organization. The mere fact that a conclusion was postponed therefore says little about whether the postponement was epistemically responsible.

1.3 Dimensions of an Unresolved Temporal State

Table 2 summarizes several dimensions that can matter while inquiry remains unresolved. The list is illustrative rather than exhaustive. Its purpose is to prevent temporal judgment from being reduced to a single variable such as confidence or elapsed time.

These dimensions are only partially reducible to one another. Stronger evidence can coexist with shrinking practical options. Greater methodological access can arrive after the phenomenon has changed. A well-preserved record can sustain future inquiry even when immediate investigation is impossible. Conversely, abundant new information may have little epistemic value when provenance has been lost or when all information is generated by the same underlying source. A temporal framework therefore needs to track configurations rather than seek a universal scalar of “readiness.”

The configuration is also historically and relationally situated. What counts as a tolerable delay depends partly on the kind of inquiry, the stakes of error, the cost of intervention, the fragility of evidence, and the temporal rhythm of the object. Archaeological interpretation, emergency medicine, diplomatic negotiation, theoretical physics, and constitutional reform do not share one appropriate cadence. The present paper accordingly does not propose a cross-domain timetable. It develops structural questions that can organize domain-specific judgments about time.

Table 2: Illustrative dimensions of an unresolved temporal state

Dimension	Guiding question	Characteristic failure if neglected
Evidential maturity	What observations presently support, discriminate among, or weaken the live accounts?	Closure outruns evidence, or inquiry continues after decisive evidence is already available.
Interpretive plurality	Which serious interpretations remain live, and what would discriminate among them?	One framing becomes dominant through familiarity rather than comparative support.
Preservation quality	Can the original observations, provenance, alternatives, and prior confidence states still be recovered?	Later judgment is reconstructed from memory or from an already stabilized narrative.
Methodological access	What observations, comparisons, experiments, or archival operations remain feasible?	A nominally open question becomes practically uninvestigable.
Response reversibility	Which present actions can be revised without excessive material, institutional, relational, or epistemic cost?	Weak evidence is converted prematurely into difficult-to-reverse commitment.
Option structure	Which opportunities improve, persist, decay, or disappear if commitment is delayed?	Waiting is treated as costless even as relevant action windows close.
Review responsibility	Who or what process is responsible for revisiting the inquiry, and under what trigger?	Deferral becomes abandonment by inertia.
External evolution	How are the phenomenon, environment, institutions, or affected relations changing while inquiry remains open?	The inquiry continues to answer an earlier version of the problem.

1.4 Consequences of Waiting

A central motivation for this paper is that waiting is often described as though it were the absence of a decision. In unresolved inquiry, waiting is itself consequential. A period of non-commitment can protect against overinterpretation, allow new evidence to emerge, preserve alternative explanations, and maintain reversible options. The same interval can also permit records to disappear, opportunity costs to accumulate, affected parties to bear continuing harm, organizational attention to decay, or a tractable problem to become irreversible. Waiting therefore changes the future state from which later judgment will be made.

This point should not be converted into the opposite rule that earlier action is generally superior. Premature action can contaminate evidence, create self-confirming feedback, harden institutions around an untested interpretation, or impose avoidable costs. The relevant question is how different uses of time alter epistemic maturity and practical optionality together. A responsible temporal judgment may recommend observation, probing, preparation, communication, commitment, or deliberate non-intervention depending on that configuration.

The paper will use the term *deferral* for cases in which closure or commitment is intentionally withheld for a reason that remains open to later review. Deferral is therefore narrower than mere delay. Later sections will distinguish forms of deferral, specify conditions for accountable review, and examine when preserving a question is itself a positive scholarly accomplishment. At this stage, the important point is that unresolved inquiry can occupy an organized state in which continued non-closure is justified without being treated as final.

1.5 Trajectories of Unresolved Inquiry

An unresolved inquiry can move through several kinds of trajectory. It may *mature*: evidence and conceptual structure improve until stronger closure becomes warranted. It may *differentiate*: what first

appeared to be one problem separates into several questions with different evidential and temporal requirements. It may *transform*: changes in the world make the original formulation inadequate. It may *decay*: evidence, expertise, or institutional memory deteriorates until future evaluation becomes harder. It may be *displaced*: other questions acquire stronger claims on scarce attention. Or it may be *released*: continued inquiry no longer has sufficient epistemic, normative, or practical justification.

These trajectories illustrate why the present framework does not treat unresolved inquiry as a fixed object waiting passively for more information. The inquiry itself has a history. Decisions made during its unresolved period affect what later evidence can be interpreted, which alternatives remain recoverable, and whether closure will eventually reflect better judgment or merely the exhaustion of alternatives.

This historical structure motivates one of the paper's later concepts: *future judgeability*. A practice can preserve a problem in a way that allows a later observer to reconstruct the original evidence, alternatives, reasons for deferral, and conditions for reconsideration. It can also preserve only a conclusion-shaped residue from which the earlier uncertainty can no longer be recovered. A later section will develop this distinction directly. The present section motivates the more limited claim that temporal organization can affect whether later judgment remains possible and reconstructible.

1.6 Relation to Adjacent Literatures

Several established literatures address narrower parts of the temporal problem considered here. Work on suspended judgment examines the withholding of assent and its relation to inquiry, providing an important epistemological neighbor to the present account of selective non-closure.[5, 6] Research on uncertainty and irreversibility has shown, in environmental and investment settings, why delayed commitment can have option value when information may improve and choices are costly to reverse.[1, 4] Collingridge's analysis of technological control identifies a related temporal tension: information about consequences often becomes available only after intervention has become more difficult.[2] Dynamic adaptive policy pathways likewise develop monitoring, signposts, and adaptive sequences for decision making under deep uncertainty.[7]

Other components have neighboring literatures of their own. Research on organizational memory examines how organizations acquire, retain, and retrieve information.[10] Human-automation research distinguishes types and levels of automation and emphasizes appropriate reliance rather than undifferentiated delegation.[9, 8] These works are not treated here as instances of one pre-existing theory; they operate with different objects, empirical domains, and normative aims.

The contribution claimed by this preliminary paper is therefore integrative and reconstructive rather than priority over each neighboring problem. It asks whether preservation, deferral, reversibility, information gain, option decay, action windows, review triggers, institutional continuity, and AI-mediated support can be represented within a common temporal vocabulary while retaining their differences. The framework does not import domain-specific utility functions, policy objectives, or empirical regularities as universal laws. Where adjacent literatures provide a developed domain-specific method, the present account should be read as complementary scaffolding rather than a substitute for that method.

1.7 Analytical Scope of the Preliminary Framework

The preliminary framework developed in this paper is intentionally plural. It does not identify temporal judgment with Bayesian stopping rules, cost-benefit optimization, organizational delay, prudential patience, or any single cultural vocabulary of timing. Formal decision models can be useful when probabilities, utilities, and options are sufficiently specified, but many unresolved scholarly and practical inquiries involve contested problem definitions, unstable evidence, changing relations, or values that are only partially commensurable. The present analysis therefore begins one level earlier: with the organization of inquiry states in which the conditions for a precise decision model may themselves still be under construction.

The framework also distinguishes epistemic closure from practical commitment. A person can remain uncertain about explanation while responsibly taking a reversible precaution. Conversely, substan-

tial confidence about an empirical relation may coexist with reasons to delay intervention because the normative or institutional conditions for action remain unsettled. Later sections will develop these separations in more detail. They are introduced here because temporal judgment becomes distorted when one threshold is asked to do the work of several distinct judgments.

The paper proceeds from this foundation through forms of deferral, preservation of future judgeability, reversibility in provisional commitment, information gain under option decay, action windows, temporal accountability, institutional architectures of waiting, and AI-mediated temporal judgment. The conclusion then integrates the framework and states its limits. These later analyses retain the distinction introduced here between the temporal state of inquiry and any single decision threshold.

The first section yields a modest proposition: unresolved inquiry is a time-structured epistemic and practical condition whose future quality depends partly on the organization of non-closure. A preliminary theory of temporal judgment therefore needs criteria both for justified closure and for responsible continuation.

2 Forms of Deferral in Ongoing Inquiry

Section 2 develops deliberate deferral as the first major temporal operation. It distinguishes accountable withholding of a specified closure from indecision, avoidance, abandonment, and accidental delay; identifies the layers at which deferral can occur; and specifies a minimal structure for retaining epistemic and practical meaning. The analysis is reconstructive. It extends the temporal state introduced in Section 1 and supplies concepts later used for future judgeability, reversibility, and review.

2.1 Selective Withholding of Closure

An unresolved inquiry need not defer everything at once. A historian can settle the provenance of a document while deferring its political interpretation. A laboratory can establish that an anomaly is reproducible while deferring a causal explanation. An institution can accept that a risk deserves monitoring while deferring public warning or resource mobilization. A scholar can judge that a problem is worth preserving while deferring a decision about whether it belongs within the present research programme. These cases share a temporal structure: some element of closure or commitment is intentionally withheld while other elements remain active.

This selectivity matters because the ordinary language of “waiting” can obscure which judgment is actually being postponed. Inquiry contains several possible closure points: descriptive, interpretive, causal, normative, practical, communicative, and institutional. A person may be ready to close one of these while remaining unresolved about another. Treating the inquiry as simply “decided” or “undecided” therefore loses information about its internal temporal structure.

The notion is broader than doxastic suspension. Contemporary epistemology has analyzed suspended judgment as a distinctive stance and has connected suspension to the activity of inquiry.[5, 6] The present framework retains that epistemic neighbor while extending the object of deferral to interpretation, communication, institutional escalation, and practical commitment. A practice can therefore suspend one judgment while provisionally acting on another layer of the same unresolved inquiry.

Definition 2.1 (Deferral). A *deferral* is the intentional and revisable withholding of a specified closure, commitment, or escalation within an ongoing inquiry, while the inquiry or a defined part of it remains retained for further epistemic or practical treatment.

Definition 2.1 makes three elements explicit. First, the object of deferral should be identifiable: what, exactly, is being withheld? Second, the state remains revisable rather than silently becoming final. Third, the inquiry remains retained in some form. A deferral that leaves no pathway for continued observation, comparison, preservation, review, or release approaches abandonment rather than organized non-closure.

The definition does not imply that every deferral is justified. Deferral can protect inquiry from premature stabilization, but it can also conceal reluctance, shift costs onto others, preserve institutional

Table 3: Illustrative forms of deferral in ongoing inquiry.

Form	What is withheld	Characteristic legitimate use and characteristic risk
Descriptive deferral	Stabilization of what has occurred or what the relevant object is	Useful when observations remain incomplete or provenance is unsettled; risk of treating basic factual uncertainty as if interpretation alone were disputed.
Interpretive deferral	Preference among competing meanings, classifications, or explanatory framings	Useful when several serious accounts remain live; risk of indefinite pluralism after discriminating evidence becomes available.
Causal deferral	Commitment to a mechanism or causal attribution	Useful when regularity is clearer than mechanism; risk of allowing practical necessity to be confused with causal certainty.
Normative deferral	Closure on what ought to be valued, prioritized, permitted, or owed	Useful when relevant interests or standards remain contested; risk of shifting the burdens of delay onto affected parties without acknowledging them.
Practical deferral	Commitment to an intervention, allocation, or operational response	Useful when reversible observation or preparation can improve later choice; risk of losing an action window while describing delay as neutrality.
Communicative deferral	Public or wider dissemination of a provisional judgment	Useful when premature communication could distort evidence or create unnecessary harm; risk of opacity, asymmetric information, or suppression of legitimate concern.
Institutional deferral	Formal adoption, escalation, authorization, or procedural closure	Useful when an organization requires additional review or cross-unit coordination; risk of procedural postponement becoming a mechanism of non-decision.
Programme deferral	Incorporation of a problem into a scholar's or institution's active research portfolio	Useful under scarce attention when preservation can keep the problem available; risk of repeated postponement until the problem disappears from collective memory.

comfort, or allow a problem to decay until meaningful action is impossible. The evaluative question is therefore not whether deferral occurs, but what kind of deferral it is, what it preserves, what it postpones, and what temporal consequences it creates.

2.2 Layers of Deferral

A useful way to clarify an unresolved inquiry is to specify the level at which closure remains withheld. Table 3 presents several illustrative forms. The list is non-exhaustive, and multiple forms can coexist in the same inquiry.

The forms in Table 3 are analytically distinct even when they occur together. A public-health body, for example, might retain a practical precaution while deferring causal attribution; a scholar might communicate the existence of an unresolved anomaly while deferring interpretation; an archive might preserve material for future study while deferring programme-level prioritization. The relevant temporal state therefore has a layered structure.

This layered view also prevents one kind of premature totalization. A lack of causal closure does

not automatically require practical inaction, and practical action does not automatically establish causal certainty. Likewise, a decision to communicate uncertainty does not require a settled normative ranking of all possible consequences. Different thresholds can govern different closures.

2.3 Epistemic–Practical Deferral Structure

The distinction between epistemic and practical deferral deserves special attention because the two are frequently conflated. Epistemic deferral withholds a belief-like or interpretive closure: the observer declines to settle what is true, what explains the evidence, or which account should dominate. Practical deferral withholds an intervention, allocation, warning, or commitment. The two can move independently.

A person may maintain epistemic uncertainty while taking a low-cost precaution whose justification does not require a settled explanation. Conversely, a person may possess substantial epistemic confidence while delaying intervention because authority, consent, distributive effects, implementation capacity, or institutional legitimacy remain unsettled. Temporal judgment becomes distorted when a single confidence threshold is treated as sufficient for both epistemic and practical closure.

This distinction also clarifies the role of reversible preparation. Preparation can occupy an intermediate practical state: it changes the option structure without yet committing to the strongest interpretation of the evidence. Reserving analytic capacity, preserving samples, increasing observation frequency, preparing a protocol, or identifying affected stakeholders may be practically consequential while remaining compatible with epistemic restraint. Later sections will analyze the reversibility of such actions in detail. For the present section, the point is narrower: practical temporality has more than two states.

2.4 Epistemic Activity During Deferral

A well-organized deferral will often change what the inquiry does during the period of non-closure. The inquiry can continue through targeted observation, comparison, source checking, replication, archival recovery, criticism, or discriminating tests. Deferral therefore need not mean that the inquiry is frozen. It can be an active interval in which the unresolved state is deliberately made more informative.

The relevant activity should, however, be connected to the reason for deferral. If interpretation is deferred because two mechanisms fit the current evidence, further work should ideally seek observations that discriminate between those mechanisms. If practical commitment is deferred because the action window is uncertain, inquiry should track the variables that determine when the window narrows. If normative closure is deferred because affected interests remain poorly represented, continued inquiry should improve access to those interests rather than merely accumulate more technical data.

This connection between the reason for deferral and the work performed during deferral distinguishes productive non-closure from generic demands for “more information.” Additional information can be abundant while remaining irrelevant to the uncertainty that actually matters. Temporal judgment therefore needs a concept of *discriminating continuation*: continued inquiry should, where feasible, be oriented toward the uncertainty that currently blocks justified closure or commitment.

2.5 Structure of Accountable Deferral

Deferral becomes more robust when its structure is externally reconstructible. The present paper uses the term *accountable deferral* for a deferred state whose reason, object, and conditions of reconsideration are sufficiently explicit that another competent observer can understand why closure was withheld and how the inquiry is expected to proceed.

Definition 2.2 (Accountable deferral). An *accountable deferral* is a deferral for which the practice records, at a level appropriate to the stakes, (i) the closure or commitment being withheld, (ii) the present reason for withholding it, (iii) the state of evidence or interpretation that remains live, (iv) the next relevant epistemic or practical operation, and (v) the responsibility or process through which the deferred state can later be reconsidered, escalated, downgraded, or released.

Definition 2.2 is intentionally preliminary. Later sections will treat preservation quality, review triggers, and temporal accountability in greater detail. Its present function is to distinguish a temporally organized inquiry from an unresolved state maintained only by inertia.

Accountability here does not require exhaustive documentation in every setting. A theoretical note preserved for future scholarship may need less procedural structure than a high-stakes institutional warning. The appropriate granularity depends on the consequences of error, the fragility of the evidence, the number of actors involved, and the difficulty of reconstructing the original state later. The general requirement is proportionality: the more consequential or difficult to recover the deferred state, the stronger the case for explicit temporal structure.

2.6 Boundaries of Deferral

Several neighboring states should remain distinct from accountable deferral.

Indecision describes difficulty choosing among alternatives, but it need not include an organized plan for preserving or improving the inquiry. A person can be indecisive without having identified what evidence would help.

Avoidance occurs when closure or engagement is postponed primarily to escape cognitive, institutional, political, or emotional costs. Avoidance can imitate epistemic humility while functioning as a means of protecting an actor from responsibility.

Abandonment occurs when the inquiry ceases to receive meaningful epistemic or practical treatment. The matter may disappear from attention even though no explicit release judgment has been made.

Strategic postponement can be instrumentally rational without being epistemically oriented. An actor may delay a decision to obtain bargaining leverage, wait for political conditions to change, or transfer responsibility elsewhere. Such postponement can coexist with inquiry, but its temporal rationale is not exhausted by epistemic maturity.

These distinctions are not moral classifications of persons. They describe different structures that can sometimes coexist within the same practice. A formally accountable review process can still be used strategically; an initially responsible deferral can decay into abandonment; indecision can later be converted into a well-structured inquiry. The framework is therefore intended for diagnosis of temporal organization rather than attribution of motive from surface delay alone.

2.7 Partial Closure with Preserved Disagreement

One advantage of layered deferral is that it permits partial closure. An inquiry can stabilize what is sufficiently supported while leaving the remaining disagreements visible. This avoids two opposite errors. The first is global closure, in which one settled component is treated as if it settled the entire inquiry. The second is global suspension, in which unresolved disagreement about one component prevents the practice from using what is already well established.

A useful unresolved state can therefore contain a map of closures and open questions. Provenance may be settled, mechanism unresolved, practical precaution justified, and long-term policy deferred. Such a configuration is more informative than a single label such as “open” or “closed.” It also improves later review because subsequent observers can identify which claim changed and which remained stable.

Preserving disagreement is especially important when the inquiry is distributed across people or institutions. If a majority interpretation becomes the only recorded version, later evidence can appear to have confirmed a consensus that was more conditional than the surviving record suggests. A deferred state can therefore preserve serious alternative interpretations without granting them equal evidential weight. The aim is recoverability of the live structure of disagreement, not indefinite symmetry among all views.

2.8 Temporal Pathologies of Deferral

Deferral can fail through several characteristic temporal pathologies. One is *serial deferral*: each review produces another request for review without materially changing the epistemic state. Another is *threshold drift*: the evidence originally specified as sufficient for reconsideration arrives, but the standard is quietly raised. A third is *responsibility diffusion*: every actor can point to another person or unit as the one expected to reopen the inquiry. A fourth is *option blindness*: the practice monitors evidence while failing to monitor whether opportunities for action are decaying. A fifth is *memory erosion*: the inquiry remains nominally open while the original evidence, alternatives, or reasons for non-closure become unrecoverable.

These pathologies illustrate why, within the present framework, time is not treated as an empty container around inquiry. Delay changes the structure that later judgment inherits. A deferred state can become easier to resolve, harder to resolve, less worth resolving, or impossible to reconstruct. The quality of deferral therefore depends partly on what it does to the next state of inquiry.

A preliminary evaluative criterion can now be stated within the scope of this framework. Other things being equal, a deferral is temporally better organized when it preserves or improves the conditions for later discrimination, judgment, and proportionate response while keeping the costs of non-closure visible. This is neither a sufficient condition for justification nor a ranking rule across domains. Rights, duties, distributive effects, and substantive evidential standards can override or qualify the temporal consideration. The criterion identifies one dimension along which a practice can be evaluated.

The section yields a structural result: deferral is a family of selective, layered, and revisable temporal states. An inquiry may close one question while preserving another, retain serious alternatives without assigning them equal evidential weight, and support provisional action without converting that action into epistemic certainty. This layered account also exposes a further requirement. If deferral is to remain accountable across time, enough of the unresolved state must survive for later reassessment. Section 3 develops that requirement as future judgeability.

3 Preservation of Future Judgeability

Section 3 treats preservation as a condition of later judgment. Its central distinction is between retaining information and preserving a later capacity to judge. A future inquirer can inherit many documents yet lose the provenance, alternatives, temporal order, or reasons for deferral needed to reconstruct the earlier state responsibly. The discussion combines conceptual analysis with a limited structural formalization derived from Sections 1 and 2. The formal objects organize relations among evidence, interpretations, options, and review conditions; they carry no independent ontological claim.

3.1 Future Judgeability

Preservation is often described as though its object were self-evident: retain the data, archive the document, store the minutes, or keep the sample. These practices can be necessary while remaining insufficient. A later observer may recover an item without recovering the structure within which the item was judged. A statement can survive after its speaker, audience, date, revision history, or evidential status has disappeared. A conclusion can remain while the rejected alternatives and reasons for rejecting them are lost. A numerical estimate can be preserved after the model version, input conditions, and confidence qualification have become unrecoverable. In each case, information survives while part of the capacity for later judgment has decayed.

The present framework therefore treats preservation as directed toward *future judgeability*. The term concerns the possibility of later responsible reassessment, not merely physical survival of records and not the guarantee that a future observer will reach a correct answer.

Definition 3.1 (Future judgeability). *Future judgeability* is the later capacity to reconstruct enough of an earlier unresolved inquiry to reassess a specified question, interpretation, decision, or deferral without silently replacing the earlier evidential and temporal situation by information available only in hindsight.

Definition 3.1 contains three restrictions. First, judgeability is question-relative. What needs to be preserved to reassess provenance need not be identical to what needs to be preserved to reassess causal interpretation, normative justification, or a decision to postpone intervention. Second, judgeability is relational. The later observer needs not only surviving items but also enough of their relations to sources, alternatives, reasons, actors, and temporal order to understand what those items could support at the earlier time. Third, judgeability is historical. A later observer may legitimately use later knowledge, but the record should permit a distinction between what was available at the earlier time and what became available afterward.

Future judgeability should also be distinguished from *future answerability*. A later method can sometimes answer a substantive question even when the earlier decision process is no longer reconstructible. Conversely, an excellent record can make an earlier judgment fully inspectable while the substantive question remains unresolved decades later. The first case permits new knowledge without full temporal accountability. The second permits temporal accountability without substantive closure. The framework uses this distinction to reduce the risk that retrospective evaluation rewards or condemns earlier judgments by information that those judgments could not have possessed.

3.2 Formal Status and Minimal Assumptions

The formalism from this point onward is structural rather than predictive. Time indices identify inquiry states and review horizons without assuming continuous time, discrete time, or any particular temporal metric. State components are analytical projections of a relational inquiry and need not be statistically independent or directly observable. Criterion families introduced later in the paper are prospectively specified subsets of what a practice has reason to monitor; they are not presumed exhaustive. Predicates such as “supportable,” “viable,” “admissible,” or “effectively supported” obtain their substantive content from the relevant domain rather than from the notation itself. Finally, maps such as Γ , Σ , and later Φ represent recording, transmission, and historical transition. Unless a domain-specific empirical model is supplied, they should not be read as deterministic laws or calibrated forecasts.

These assumptions limit what can be inferred from the formal relations. The notation can expose inconsistency, missing distinctions, or conditional dominance relative to stated criteria. It cannot independently establish that the criteria are normatively adequate, that future states are known, or that a represented transition is causally correct. The later sections preserve this division between structural representation and substantive warrant.

3.3 Structured Representation of the Earlier State

The temporal-state definition in Section 1 can be restated in a compact form to clarify what preservation acts upon. Let t denote the time at which an unresolved inquiry occupies an earlier state. For the purposes of this section, represent that state as follows.

$$\mathcal{S}_t = \langle \mathcal{E}_t, \mathcal{I}_t, \mathcal{M}_t, \mathcal{V}_t, \mathcal{O}_t, \mathcal{A}_t, \mathcal{X}_t \rangle. \quad (1)$$

In Equation 1, $\mathcal{E}_t$ denotes the evidential configuration available at t , including relevant provenance; $\mathcal{I}_t$ denotes the live interpretive field; $\mathcal{M}_t$ denotes the then-available methods or operations for further inquiry; $\mathcal{V}_t$ denotes the reversibility structure of presently available responses; $\mathcal{O}_t$ denotes the practical option structure; $\mathcal{A}_t$ denotes the allocation of review responsibility and then-specified review conditions; and $\mathcal{X}_t$ denotes relevant external conditions in which the inquiry is situated. These components re-express the dimensions already introduced in Table 2. Preservation quality is not included as a separate component in Equation 1 because the present section analyzes preservation through the recording and transmission of this state.

Equation 1 is not intended to imply that the components are independent. The interpretation of evidence can depend on external conditions; available methods can alter which alternatives remain discriminable; practical options can affect what evidence will still be obtainable; and the allocation of review responsibility can determine whether any of these components are revisited. The tuple is therefore an analytical decomposition of a relational configuration rather than a claim that inquiry consists of separable substances.

A further distinction is required between the earlier state and its record. No archive ordinarily captures $\mathcal{S}_t$ exhaustively. Let Γ_t denote a *recording map*, the practice by which selected aspects of $\mathcal{S}_t$ are rendered into a record $\mathcal{R}_t$. Equation 2 represents this selective capture.

$$\mathcal{R}_t = \Gamma_t(\mathcal{S}_t). \quad (2)$$

The notation in Equation 2 makes selective capture explicit. Γ_t can include written notes, datasets, source copies, version histories, recorded confidence categories, institutional minutes, decision rationales, or other domain-appropriate traces. Different recording practices can therefore generate materially different records from the same broader inquiry state.

The record can then change between t and a later time t' . Let $\Sigma_{t \rightarrow t'}$ denote the processes by which the record is stored, transmitted, migrated, summarized, corrupted, deleted, or institutionally forgotten. Equation 3 represents the trace actually available at t' .

$$\mathcal{T}_{t'|t} = \Sigma_{t \rightarrow t'}(\mathcal{R}_t) = \Sigma_{t \rightarrow t'}(\Gamma_t(\mathcal{S}_t)). \quad (3)$$

Equation 3 separates two failures that are often conflated. Some information was never recorded; other information was recorded but did not survive. Later reconstruction can fail through either path. This distinction matters institutionally because better storage cannot recover an earlier omission, while more comprehensive initial documentation cannot by itself prevent later format obsolescence, inaccessible custody, or organizational memory loss.

A later observer also possesses resources that are not part of the surviving earlier trace. Let $\mathcal{L}_{t'}$ denote the later methods, expertise, comparison cases, concepts, and contextual knowledge available at t' . Later judgment therefore operates on both $\mathcal{T}_{t'|t}$ and $\mathcal{L}_{t'}$. Keeping these objects distinct protects the boundary between contemporaneous evidence and retrospective enrichment.

3.4 Judgeability Profile

A single scalar measure of future judgeability would conceal important differences among questions. An archive can remain excellent for checking provenance while becoming poor for reconstructing alternatives. A later observer can be able to reassess a methodological choice while being unable to recover the practical option structure that existed when the choice was made. The framework therefore uses a set-valued representation.

Let $\mathcal{Q}_t$ denote a specified family of questions that a later review may reasonably need to ask about the unresolved state at t . Examples include whether a source was authentic, which interpretations were live, why one interpretation was provisionally favored, what evidence was missing, which action was deferred, what alternatives remained available, and what trigger was expected to prompt reconsideration. The *judgeability profile* of the earlier state at time t' is represented as follows.

$$\mathfrak{J}_{t \rightarrow t'}(\mathcal{Q}_t) = \{q \in \mathcal{Q}_t \mid q \text{ remains responsibly reassessable at } t' \text{ from } \mathcal{T}_{t'|t} \text{ together with } \mathcal{L}_{t'}\}. \quad (4)$$

Equation 4 does not define “responsibly reassessable” by a universal numerical threshold. Its content is supplied by the question under review and the evidential standards appropriate to the domain. The role of $\mathcal{L}_{t'}$ also requires a non-substitution constraint. Later methods and knowledge may help interpret a surviving trace or answer the substantive question, but they should not be used as substitutes for missing contemporaneous evidence when the question asks what was available, considered, or reasonably

Table 4: Illustrative preservation objects supporting future judgeability

Preservation object	What should remain distinguishable	Characteristic loss
Observation or source trace	The item encountered before later interpretation overwrites its form	Later review inherits only a conclusion-shaped residue
Provenance	Origin, time, custody, instrument, speaker, version, or acquisition pathway	Authenticity and evidential weight become difficult to reassess
Local context	Conditions that made the item meaningful at the time	An item survives after the relations that gave it significance disappear
Interpretive alternatives	Serious live accounts, including unequal evidential weights	Hindsight reconstructs an earlier consensus that did not exist
Confidence and uncertainty	Degree and type of endorsement, doubt, and known limitation	Later outcome is projected backward as earlier certainty
Deferral rationale	The closure withheld and the reason for withholding it	Waiting becomes indistinguishable from inertia or avoidance
Discriminating next steps	Observations, tests, comparisons, or consultations expected to matter	Continued inquiry cannot be evaluated against its own stated purpose
Review responsibility	Person, role, process, date, event, or condition assigned to reconsideration	Nominal deferral decays into abandonment through responsibility diffusion
Negative and failed inquiry	Searches, tests, or alternatives that did not support the favored account	Repeated failure is forgotten and later success appears inevitable
Version lineage	Earlier states, revisions, superseded claims, and reasons for change	Correction is visible but the path of correction becomes unreconstructible

inferable at t . At minimum, reassessment should therefore avoid inventing missing provenance, erasing material disagreement, or attributing later information to the earlier state. The set can differ across domains even when the formal structure is the same.

The set-valued representation yields several useful consequences. Judgeability need not change monotonically with time. It can shrink when records decay, expand when a new method makes an old trace interpretable, or change composition when some questions become answerable while others become unreconstructible. A later increase in substantive knowledge therefore does not imply an increase in the judgeability of the earlier decision. New knowledge can coexist with deteriorating accountability for how the earlier inquiry was handled.

Proposition 3.2 (Temporal non-equivalence of knowledge and judgeability). *Within the present framework, an increase in later substantive knowledge does not by itself establish improved future judgeability of an earlier unresolved state. The latter additionally depends on whether the surviving trace preserves the distinctions needed to reconstruct what was known, unknown, considered, and deferred at the earlier time.*

Proposition 3.2 is a structural consequence of the distinctions adopted by the framework rather than an empirical generalization. It follows from separating $\mathcal{T}_{t'|t}$ from $\mathcal{L}_{t'}$ in Equations 3 and 4. The distinction is nevertheless practically important because retrospective narratives often collapse the two.

3.5 Preservation Objects

The formal representation clarifies why preserving “the evidence” is too narrow. Future judgment can depend on several classes of trace. Table 4 summarizes the main classes proposed here. They are analytical categories rather than a universal archival checklist.

The table extends the preservation logic already present in the programme’s earlier work on prospective calibration. Its distinctive contribution here is temporal: the object to be preserved is not merely a candidate signal or forecast but enough of the unresolved state to permit later reassessment of both inquiry and non-closure.

Several categories deserve emphasis. First, preserving alternatives does not require assigning them equal status. It requires preserving the fact that materially serious alternatives existed and, where possible, the reasons for their relative weighting. Second, negative inquiry matters because failed searches and disconfirming observations constrain what a later narrative can legitimately portray as obvious. Third, the version lineage matters because responsible inquiry changes. A record that displays only the latest view hides whether revisions followed new evidence, conceptual refinement, institutional pressure, or simple forgetting.

3.6 Relational Records

The objects in Table 4 gain epistemic value through relations among them. A source without its provenance is weakened; an interpretation without the evidence that supported it is difficult to reassess; a deferral without its trigger cannot be distinguished from indefinite postponement; a revision without the earlier version cannot support retrospective calibration. Preservation should therefore retain relevant structure rather than merely accumulate isolated items.

One useful representation treats the contemporaneous record as a typed temporal graph. Equation 5 states this representation.

$$\mathcal{G}_t = (V_t, \Lambda_t, \tau_t), \quad (5)$$

where V_t is the set of recorded items, Λ_t is a set of typed relations among those items, and τ_t assigns relevant temporal labels or ordering information to recorded items and relations. The relation types in Λ_t can include domain-appropriate relations such as *derived from*, *supports*, *conflicts with*, *revises*, *deferred because*, *reviewed by*, or *supersedes*. Equation 5 does not require every archive to be implemented as a graph database. It formalizes the simpler proposition that future judgeability depends on relations and sequence as well as stored objects.

This representation also clarifies why information quantity is an inadequate proxy for preservation quality. A large archive can contain many nodes while losing the relations that made them judgeable. Conversely, a smaller but carefully structured record can preserve the provenance, disagreement, temporal order, and decision rationale needed for later review. Preservation quality should therefore not be inferred directly from document count, storage volume, or textual length.

The history-bearing character of the record is especially important. Later annotations should not silently overwrite earlier entries. If an interpretation changes at t_1 , the record should, where feasible, preserve both the earlier state and the later revision with their temporal relation. Otherwise, a dynamic inquiry is flattened into a single endpoint. The resulting archive may accurately state the present view while becoming unreliable evidence about how the view developed.

Claim 3.3 (Order-sensitive preservation). When later interpretation can compress, reclassify, or overwrite an earlier observation, preservation performed only after interpretive stabilization may not be equivalent to preservation performed while the earlier state remains recoverable. Future judgeability can therefore depend on the order in which observation, interpretation, recording, and revision occur.

Claim 3.3 does not imply that every first impression deserves permanent retention. It identifies a source of path dependence. Once an observation has been absorbed into a stable narrative, the earlier alternatives, uncertainties, and contextual relations may be difficult or impossible to reconstruct from memory. This is one reason prospective records have a different epistemic function from retrospective memoir.

3.7 Selective Compression

Perfect preservation is neither feasible nor desirable. Inquiry generates redundant notes, intermediate files, low-value observations, sensitive information, routine communications, and material whose long-term retention can impose privacy, security, financial, or cognitive costs. A temporal framework therefore needs a concept of selective compression rather than an ideal of total capture.

The appropriate target is not maximal information retention but retention of distinctions that remain relevant to foreseeable later judgment. A record can summarize repeated observations if the summary preserves the information needed to reassess the question for which the observations matter. A long deliberation can be compressed if the record still preserves the principal alternatives, decisive reasons, unresolved objections, and temporal conditions of the decision. Conversely, a short conclusion can be inadequate when it deletes precisely those distinctions.

Definition 3.4 (Judgeability-preserving compression). A *judgeability-preserving compression* is a reduction of the contemporaneous record that removes material judged non-essential for a specified family of foreseeable later questions while retaining the distinctions, provenance, relational structure, and temporal boundaries needed to reassess those questions responsibly.

Definition 3.4 is intentionally relative to a family of questions rather than absolute. An archive optimized for reproducibility may preserve details that an archive optimized for institutional accountability would omit, and vice versa. The difficulty is that future questions are not fully known at the time of preservation. Excessively narrow compression can therefore damage generativity: material that appears peripheral to the present problem may later support a new problem formulation, comparison, or method.

This creates a tension between *targeted preservation* and *generative preservation*. Targeted preservation protects the traces needed for presently foreseeable review. Generative preservation retains some additional raw, anomalous, marginal, or weakly interpreted material because future problem spaces can differ from present ones. The latter directly continues the insight developed in the preceding papers: a scholarly community inherits not only conclusions but also a historically filtered field of what earlier observers chose to retain.

A defensible preservation practice therefore need not seek a universal optimum. It can instead ask whether compression is reversible enough, whether raw material remains recoverable where later reinterpretation is plausible, whether provenance survives summary, and whether the record makes its own omissions visible. Recording that a class of material was discarded can itself improve later judgeability compared with leaving the later observer unaware that selection occurred.

3.8 Preservation Windows

Some traces remain recoverable for long periods; others are ephemeral. Spoken exchanges fade from memory, web pages change, software versions disappear, biological samples degrade, actors leave institutions, informal rationales become inaccessible, and local contexts are reorganized by later events. Preservation therefore has its own temporal windows.

Definition 3.5 (Preservation window). A *preservation window* is an interval during which a judgment-relevant trace, relation, or contextual condition can still be captured with materially greater reliability or lower reconstruction cost than would ordinarily be possible after the interval closes.

Definition 3.5 distinguishes a preservation window from the action windows examined later in the paper. The former concerns the opportunity to secure material for future judgment; the latter concerns opportunities to intervene, commit, communicate, or otherwise alter the practical situation. The windows can overlap without coinciding. A laboratory may have only hours to preserve a sample but months to decide how strongly to interpret it. An institution may have a long documentary window but a short opportunity for low-cost intervention.

Preservation windows create an asymmetry in temporal judgment. Closure can often be postponed while recording cannot. An observer can defer interpretation yet still need to preserve the observation now. Similarly, practical intervention can remain premature while preparation to preserve evidence is already justified. This asymmetry provides one of the strongest reasons why “wait” should not be treated as a unitary instruction.

The asymmetry also suggests distinguishing losses by their practical substitutability. Missing secondary commentary may later be replaced by comparable analysis. Lost contemporaneous provenance

may be non-substitutable. A vanished dataset may sometimes be regenerated; an unrecorded negotiation context may not. The relevant distinction is not simply between preserved and lost information but among *recoverable*, *substitutable*, and *non-substitutable* losses. Within a proportional preservation design, traces whose loss would remove a unique pathway to later reassessment provide a comparatively strong reason for early preservation.

3.9 Proportional Preservation

Preservation duties should be proportional rather than maximal. Several variables can strengthen the case for richer preservation: high consequences of later error, fragility of the evidence, rarity of the event, difficulty of replication, substantial disagreement, long expected deferral, high turnover among responsible actors, or a strong possibility that later methods will reinterpret the material. These variables do not produce a mechanical formula. They identify reasons why a more reconstructible record may be warranted.

Other variables can limit preservation. Sensitive personal information, security risks, legal restrictions, duties of confidentiality, storage burden, or the danger of converting ordinary activity into pervasive surveillance can make retention itself harmful. An ethically responsible archive can therefore require access controls, minimization, aggregation, time-limited retention, or deliberate destruction. The preservation of future judgeability is one value within a wider practical and normative configuration, not a permission to retain everything indefinitely.

This limit is particularly important because the language of accountability can otherwise expand into retrospective omniscience. A practice should not be judged as defective merely because it failed to preserve every fact that later became relevant. Future relevance is partly contingent. The more defensible question is whether the preservation practice was reasonable given what could have been anticipated at the time, the stakes, the fragility of the material, and the costs or rights affected by retention.

A proportional standard also preserves the distinction between scholarly and institutional settings. A private theoretical notebook can support future judgeability through dated versions and retained alternatives without the procedural machinery appropriate to a public agency. A high-stakes institutional deferral may require stronger provenance controls, explicit custody, assigned review responsibility, and auditable version history. The framework specifies dimensions of adequacy while leaving their implementation domain-sensitive.

3.10 Dynamic Preservation

Preservation should make revision possible, not make the earlier state authoritative merely because it was recorded. A well-preserved mistake remains a mistake. An alternative preserved for historical reconstruction need not continue to receive equal attention after contrary evidence accumulates. The record functions as epistemic memory, not as a veto on learning.

This point avoids a second pathology: *archival inertia*. An institution can become so committed to preserving the record of an unresolved question that it repeatedly reproduces obsolete categories, actors, or hypotheses. Future judgeability requires historical fidelity to earlier states, but present judgment also requires permission to reclassify, supersede, or release them. Versioned preservation is therefore preferable to static preservation because it can retain the path of change without forcing inquiry to remain at an earlier stage.

The same reasoning applies to release. Some inquiries cease to justify continued retention because the question has been resolved, displaced, ethically restricted, or rendered irrelevant by external change. A mature preservation architecture should record why release occurred when that reason matters for accountability, then permit appropriate closure or destruction. Preservation and release are thus not opposites. Both are temporal judgments about what later inquiry should inherit.

Future judgeability is one candidate condition for accountable deferral: a later observer should inherit enough structure to reassess the earlier state rather than merely inherit its surviving conclusion. Preservation alone does not determine how an inquiry should act while remaining open. Provisional

commitment introduces the distinct temporal question of whether present action preserves feasible paths of later revision.

4 Reversibility of Provisional Commitment

Section 4 shifts from later judgment to later revision. Its object is *provisional commitment*: actions, preparations, communications, allocations, or institutional arrangements that matter in the present while remaining explicitly open to withdrawal, redirection, limitation, or replacement as the inquiry changes. The section clarifies reversibility in a history-bearing setting, separates declared provisionality from actual revisability, and develops a structural representation that preserves heterogeneous revision criteria rather than collapsing them into a single score.

The section extends the reversible-response architecture developed for incipient change in the preceding paper of this programme. The present analysis has a broader object. An inquiry can require provisional commitment because evidence is incomplete, because interpretations remain plural, because normative implications remain unsettled, because an external dependency has not resolved, or because the practical cost of waiting is increasing. Reversibility therefore belongs to the general temporal structure of unresolved inquiry rather than only to weak-signal response.

Economic and environmental analyses of irreversibility provide a nearby but narrower precedent for treating delayed commitment as potentially valuable when learning can occur before a difficult-to-reverse choice.[1, 4] The present framework does not generalize their optimization models beyond their domains. It instead uses reversibility as a criterion-relative structural property that can concern evidence, relations, institutional capacities, rights, or options whose values need not be commensurable.

4.1 Temporal Operations of Provisional Commitment

Unresolved inquiry does not imply practical immobility. An inquiry may preserve samples, reserve resources, begin a bounded pilot, communicate a qualified concern, suspend one procedure, commission a test, create temporary capacity, or adopt an interim rule while a stronger conclusion remains unwarranted. These actions modify the inquiry’s environment and its later option structure. Their epistemic significance depends partly on whether they are treated as evidence of a settled conclusion or as revisable responses to an unsettled state.

Definition 4.1 (Provisional commitment). A *provisional commitment* is a presently consequential action, preparation, communication, allocation, or institutional arrangement adopted while a relevant inquiry remains unresolved, where the scope of the commitment and the conditions under which it can be revised, redirected, withdrawn, or superseded remain part of the temporal organization of the inquiry.

Definition 4.1 makes provisionality a property of temporal organization rather than a verbal disclaimer. Calling a measure “temporary,” “pilot,” or “interim” does not by itself make the measure revisable. A nominally temporary action can create durable legal expectations, sunk costs, reputational commitments, altered relationships, or technical dependencies. Conversely, a materially significant preparation can remain highly revisable if it preserves alternative uses, has an explicit exit procedure, and leaves the later option structure comparatively open.

The inquiry-state representation introduced in Equation 1 can be used to describe the effect of a commitment. Let c denote a feasible commitment selected at time t from the practical possibilities represented within $\mathcal{O}_t$. Let t^+ denote a later point at which the effects relevant to the present analysis have begun to enter the inquiry state. The commitment induces a state transition represented by Equation 6.

$$\mathcal{S}_{t^+}^c = \Phi_{t \rightarrow t^+}^c(\mathcal{S}_t). \quad (6)$$

In Equation 6, $\Phi_{t \rightarrow t^+}^c$ denotes the history-producing transition associated with undertaking c in the earlier state $\mathcal{S}_t$. The superscript on $\mathcal{S}_{t^+}^c$ records that the later state is conditioned by that commitment.

The transition can change evidence, interpretations, available methods, response reversibility, options, review responsibilities, and external conditions. It may also change relations among these components. A public communication can alter the external environment and thereby alter what later evidence means; a pilot can generate data while also changing participant behavior; a temporary allocation can preserve technical capacity while creating organizational expectations that make later withdrawal more difficult.

Equation 6 is deliberately broader than an action-outcome model. It represents a commitment as part of the evolving inquiry itself. The same act can therefore have epistemic, practical, relational, and institutional consequences at once.

4.2 Historical Non-Invertibility

In many history-bearing inquiries, literal return to the earlier state is unavailable or analytically unhelpful. Time passes, actors learn, records accumulate, opportunities change, and the commitment itself becomes part of the history later observers must interpret. Even when a physical action is undone, the effects of having acted can remain. A public warning can be retracted while the fact of the warning remains socially consequential. A temporary policy can expire while expectations formed under it persist. A research intervention can stop while the pre-intervention baseline is no longer fully observable.

For this reason, the present framework does not define reversibility as the existence of an exact inverse to $\Phi_{t \rightarrow t^+}^c$. Such an inverse would require the later practice to erase the history generated by the commitment, which is often neither possible nor desirable. Reversibility is instead treated as a relation between a commitment, a later horizon, and a specified family of capacities or conditions that the inquiry has reason to preserve or recover.

Claim 4.2 (Historical non-invertibility). Within a history-bearing unresolved inquiry, practical reversibility ordinarily concerns the recovery or preservation of specified capacities, options, relations, or admissible states through later revision. It should not be presumed to require restoration of an identical pre-commitment state.

Claim 4.2 preserves an important distinction between *reversal* and *erasure*. A decision can be responsibly reversed even when its history remains visible. Indeed, the preservation argument of Section 3 suggests that some traces of the earlier commitment should remain visible precisely so that later observers can reconstruct what occurred and why it changed.

The claim also prevents an excessively permissive use of the word “reversible.” If a commitment can be formally cancelled while its principal practical consequences remain, cancellation is a weak proxy for reversibility. The relevant question is which features of the later state remain recoverable and at what cost, not whether an administrative label can be removed.

4.3 Revision-Reachable States

A structural account of reversibility therefore begins with feasible paths of revision. After commitment c has produced the later state $\mathcal{S}_{t^+}^c$, some withdrawals, compensations, redirections, reallocations, disclosures, or institutional changes may remain feasible. Others may be prohibited, unaffordable, ethically unacceptable, or physically impossible. Let $\mathcal{P}_{t^+ \rightsquigarrow t'}(c)$ denote the set of admissible revision paths available between t^+ and a later review horizon t' . Admissibility is domain-sensitive and can incorporate material, legal, ethical, institutional, and role-based constraints.

Each path $p \in \mathcal{P}_{t^+ \rightsquigarrow t'}(c)$ induces a later state. The set of states reachable through admissible revision is represented by Equation 7.

$$\text{Reach}_{t'}^{\text{rev}}(c \mid \mathcal{S}_t) = \{ \Phi_{t^+ \rightarrow t'}^p(\mathcal{S}_{t^+}^c) \mid p \in \mathcal{P}_{t^+ \rightsquigarrow t'}(c) \}. \quad (7)$$

Equation 7 makes reversibility a reachability question. The set can contract as time passes. A refund can cease to be available, a temporary appointment can become institutionally entrenched, a confidential disclosure can spread beyond recall, a technical migration can make the earlier system costly to restore,

or relationships can adapt to the provisional arrangement. Reversibility is therefore itself temporally variable.

The representation also permits partial reversal. A later state need not reproduce $\mathcal{S}_t$ to count as a successful revision. A pilot can end while the knowledge produced by it remains. A contingency fund can be redirected rather than returned to its exact prior use. A provisional interpretation can be superseded while the earlier version remains in the record. What matters is whether the capacities or conditions relevant to the inquiry's reason for provisionality remain recoverable.

4.4 A Set-Valued Reversibility Profile

The multidimensional character of reversibility creates the same difficulty that Section 3 encountered for future judgeability. A single scalar can hide differences that are practically decisive. A commitment may be materially reversible while informationally irreversible. It may be institutionally easy to revoke while relationally costly to undo. It may preserve resources while destroying the evidential baseline needed to evaluate whether the commitment was justified.

Let $\mathcal{K}_t$ denote a specified family of *revision criteria* relevant to commitment c . A criterion $\kappa \in \mathcal{K}_t$ is a predicate on later inquiry states specifying a capacity or condition that should remain recoverable or acceptable. Examples include whether an alternative practical option remains feasible, whether an authority allocation can be restored, whether a protected relation remains within an acceptable range, whether a pre-commitment evidential baseline remains reconstructible, or whether a temporary resource can be redirected without disproportionate loss.

The reversibility profile at horizon t' is represented by Equation 8.

$$\mathfrak{R}_{t \rightarrow t'}(c; \mathcal{K}_t) = \{\kappa \in \mathcal{K}_t \mid \exists \mathcal{S} \in \text{Reach}_{t'}^{\text{rev}}(c \mid \mathcal{S}_t) \text{ such that } \kappa(\mathcal{S}) = 1\}. \quad (8)$$

Equation 8 is set-valued for the same reason as the judgeability profile in Equation 4. It identifies which specified dimensions remain recoverable through some admissible revision path. It does not assert that every recoverable dimension can be recovered simultaneously, and it does not convert heterogeneous consequences into one commensurable quantity.

This qualification is important. Suppose one revision path restores a technical system but sacrifices a newly formed cooperative relation, while another preserves the relation but makes technical restoration infeasible. Each criterion can appear individually in the profile even though no single later state satisfies both. A stronger notion is therefore needed for commitments whose legitimacy depends on preserving several conditions together.

Let $\mathcal{K}_t^* \subseteq \mathcal{K}_t$ denote the subset of criteria that the practice treats as jointly protected. Joint recoverability is represented by Equation 9.

$$\exists \mathcal{S} \in \text{Reach}_{t'}^{\text{rev}}(c \mid \mathcal{S}_t) \quad \text{such that} \quad \kappa(\mathcal{S}) = 1 \quad \text{for each} \quad \kappa \in \mathcal{K}_t^*. \quad (9)$$

Equation 9 expresses the minimum formal condition used here for *joint* reversibility relative to the protected criteria. The condition remains local to the specified horizon and constraints. A path judged admissible in one institutional setting may be unavailable in another, and a criterion that matters in one inquiry may be irrelevant in another.

Definition 4.3 (Operational reversibility). A provisional commitment is *operationally reversible* relative to a protected criterion family $\mathcal{K}_t^*$ and review horizon t' when at least one admissible revision path leads to a later state satisfying the protected criteria jointly.

Definition 4.3 deliberately isolates practical revisability from future judgeability. Operational reversibility is a reachability property relative to specified criteria; it does not by itself establish that the commitment was well documented, justified, or accountable. A practice that can reverse an action while losing the record of what the action changed may recover practical options while damaging epistemic

Table 5: Illustrative dimensions of reversibility in provisional commitment

Dimension	Protected question	Characteristic lock-in
Material and resource	Can committed resources, infrastructure, or capacity be withdrawn, repurposed, or redirected?	Sunk costs or specialized assets make continuation cheaper than reconsideration.
Institutional and authority	Can temporary rules, delegated powers, roles, or procedures be revised without extraordinary disruption?	Interim governance becomes the default architecture through inertia or vested responsibility.
Relational	Can trust, role expectations, cooperation, or bargaining positions remain compatible with later revision?	The provisional act reorganizes relationships that cannot be restored by formal cancellation.
Informational and communicative	Can disclosure, signaling, categorization, or public communication be limited, corrected, or contextualized?	Information spreads or labels persist after the originating claim is withdrawn.
Epistemic	Can the pre-commitment evidence, uncertainty, and baseline remain reconstructible after intervention?	Action changes the phenomenon or deletes the comparison needed for later evaluation.
Option-structural	Do materially relevant future alternatives remain reachable after the commitment?	The provisional path narrows the later choice set before the inquiry has matured.
Rights and distribution	Can burdens, benefits, permissions, or protections created by the measure be revised without leaving unaddressed harm?	Temporary asymmetries create durable reliance, exclusion, or uncompensated loss.

accountability. Conversely, a perfectly documented action can remain practically irreversible. An *accountably provisional* practice may therefore need both operational reversibility, where reversibility is relevant, and sufficient preservation for later assessment, without reducing either capacity to the other.

4.5 Dimensions and Protected Criteria

The criteria in $\mathcal{K}_t$ should be supplied by, and remain criticizable within, the commitments and vulnerabilities of the actual inquiry. Table 5 lists several recurrent dimensions. The table develops the multidimensional logic introduced earlier in the programme while generalizing it beyond incipient change.

Table 5 illustrates why the framework treats the magnitude of a commitment and its reversibility as distinct dimensions. A low-cost communication can be informationally durable. A substantial investment in modular capacity can preserve multiple future pathways. An action can be administratively reversible while remaining distributively difficult to unwind because some actors have borne costs or formed legitimate reliance during the provisional period.

The dimensions can also interact. Institutional lock-in can increase material lock-in by directing future budgets toward the temporary arrangement. Public communication can alter relationships and thereby change the evidence subsequently observed. A resource commitment can create a constituency whose continued support changes the politics of later review. Reversibility is therefore partly relational among dimensions, not merely a checklist of independent properties.

Claim 4.4 (Dimensionwise and joint reversibility). Recoverability of several criteria considered separately does not by itself establish that those criteria are jointly recoverable through one admissible revision path. Temporal judgment should therefore distinguish dimensionwise reversibility from the combinations of conditions that are intended to remain recoverable together.

Claim 4.4 is a direct consequence of the distinction between Equations 8 and 9. It becomes practically important when revision requires trade-offs among capacities that the original inquiry hoped to preserve

simultaneously.

4.6 Provisionality Gaps and Commitment Coupling

A recurrent failure of provisional action is the *provisionality gap*: the declared temporary status of a commitment exceeds its actual capacity for later revision. The gap can arise because exit conditions were never specified, because dependencies accumulated unnoticed, because affected actors formed legitimate expectations, because information escaped containment, or because a nominal pilot became the infrastructure on which subsequent work depended.

The problem is frequently produced by *commitment coupling*. An apparently narrow action can become coupled to other arrangements that were not included in the original description of the commitment. A temporary software platform can reshape data formats and staff skills. A preliminary classification can migrate into reporting templates and eligibility rules. A bounded research intervention can alter the relationships through which later observations are collected. Once these couplings emerge, revision of the initial commitment can require revision of a larger relational structure.

This observation has two implications. First, reversibility should be assessed over the history generated by the commitment rather than only over its initial design. A commitment that was highly revisable at t can become difficult to revise at t' because later practices have attached themselves to it. Second, a practice can improve reversibility by monitoring dependency formation during the provisional period. The relevant question is not only whether an exit exists today, but also whether current actions are constructing the conditions under which that exit will cease to be viable.

A related phenomenon is *asymmetric lock-in*. Some consequences are much easier to create than to remove. Public disclosure, reputational attribution, institutional precedent, and certain forms of technical integration have this structure. Temporal judgment should therefore be particularly cautious when a provisional action crosses a boundary after which later revision can change policy without recovering the earlier practical field.

4.7 Reversibility Windows

Reversibility can have a temporal window just as preservation does. A commitment may be easy to redirect shortly after adoption and much harder to redirect after resources, expectations, contracts, or technical dependencies accumulate. The relevant window is not necessarily defined by a calendar date. It can close when a relation stabilizes, when a third party relies on the arrangement, when a disclosure propagates, when a migration passes a compatibility boundary, or when the cost of restoring alternatives rises beyond what the role can responsibly bear.

Definition 4.5 (Reversibility window). A *reversibility window* is an interval during which the protected criterion family of a provisional commitment remains jointly recoverable through at least one admissible revision path at a cost and level of disruption that the relevant practice can still responsibly accept.

Definition 4.5 introduces an important temporal asymmetry. The inquiry can remain epistemically unresolved after the reversibility window begins to close. In such a case, simply waiting for stronger evidence can function as an implicit commitment because non-action allows the option structure to harden around the existing provisional arrangement. This does not imply that early reversal is always preferable. It implies that the decay of revisability belongs among the conditions monitored during deferral.

Reversibility windows can also differ across dimensions. A material allocation may remain recoverable for months while a public disclosure becomes effectively irreversible within minutes. A temporary institutional rule may be formally revocable for years while relational expectations become difficult to reset much earlier. The protected criterion family should therefore record which dimension is likely to close first when that difference affects the timing of review.

This insight prepares a later part of the paper. Section 3 developed the possibility that preservation windows can close before interpretive closure is justified. The present section adds that reversibility windows can also close while the inquiry remains unresolved. Temporal judgment therefore needs to

consider several potentially different clocks rather than assume that the evidential clock governs the entire inquiry.

4.8 Information-Generating Commitment and Reflexivity

A provisional commitment can generate information. A bounded pilot can reveal implementation constraints; a reversible preparation can expose dependencies; a limited communication can reveal whether coordination is possible; a small intervention can sometimes discriminate among competing interpretations. The informational value of such action should, however, be separated from the claim that the action leaves the inquiry untouched.

Commitment c changes the state through Equation 6. Subsequent observations are therefore observations of a history in which c occurred. The action can deter, amplify, redirect, conceal, or constitute part of the phenomenon later treated as evidence. This reflexivity is especially important in social, institutional, legal, and communicative settings, but the underlying issue is broader: intervention can change the conditions under which later evidence is produced.

The preservation architecture of Section 3 becomes essential here. Before a probe or provisional commitment, the practice should preserve enough of the pre-commitment state to distinguish later change from retrospective reconstruction. Where feasible, it should also record which effects were expected under the live interpretations, which observations would count against the preferred account, and which mechanisms could make the intervention alter the evidence itself. This does not turn an uncontrolled intervention into an experiment. It makes the epistemic consequences of acting more reconstructible.

A useful design principle follows. A provisional commitment is epistemically stronger when it generates discriminating information while preserving both a recoverable pre-commitment trace and a viable route for later revision. These conditions can conflict. A highly informative intervention can be difficult to reverse, while a highly reversible preparation can generate little information. Section 5 will treat this trade-off more directly through the joint evolution of information gain and option decay.

4.9 Exit Architecture and Temporal Responsibility

Operational revisability in an institutional setting usually requires more than abstract possibility. Some role or process must be able to recognize that revision is due under the relevant criteria and have authority to initiate it. Resources may need to remain available for withdrawal or redirection. A review may need to occur before a reversibility window closes. The commitment therefore benefits from an *exit architecture*: a prospective specification of how provisionality can be made operational.

Table 6 identifies several elements that can make a provisional commitment more reconstructible and revisable. The appropriate granularity remains proportional to the stakes.

The review boundary in Table 6 is intentionally stated at a high level. Section 7 will examine review triggers and temporal accountability in detail. The present point is narrower: a commitment is less meaningfully provisional when there is no viable process through which its provisional status can later have practical effect.

Exit architecture also clarifies responsibility for non-reversal. If the original conditions for revision are met and no authorized actor reviews the commitment, continued operation should not automatically be interpreted as renewed endorsement. It may reflect institutional inertia or responsibility diffusion. Conversely, repeated review can legitimately reaffirm a provisional arrangement when the reasons for retaining it remain visible. The temporal record should therefore distinguish continuation by review from continuation by default.

4.10 Limits of Reversibility

Reversibility is a valuable temporal resource, yet it should not become a universal preference. Some situations require durable commitment for reasons of trust, rights, coordination, safety, or institutional

Table 6: Elements of a revisable provisional commitment record

Element	Question recorded prospectively	Temporal function
Scope of commitment	What is being done now, and which stronger commitments remain withheld?	Prevents a bounded response from being retrospectively treated as full closure.
Epistemic status	Which claims remain unresolved despite the action?	Preserves separation between practical response and epistemic certainty.
Protected criteria	Which capacities, relations, options, or rights should remain recoverable?	Makes reversibility assessable relative to explicit objects.
Revision pathways	What withdrawals, redirections, compensations, or replacements remain feasible?	Converts provisionality from a label into an operational possibility.
Review boundary	What event, date, threshold, or change in conditions should force reconsideration?	Reduces drift beyond the period for which the provisional design remains defensible.
Responsibility	Who can initiate review, revision, escalation, or release?	Limits responsibility diffusion.
Intervention trace	What should be preserved about the pre-commitment state and the effects of acting?	Supports later judgeability and reflexive evaluation.

stability. Repeatedly reversible arrangements can impose costs on actors who need dependable expectations. A commitment designed for easy withdrawal can also transfer risk to those with less control over the timing of revision. The framework therefore treats reversibility as one dimension of responsible temporal organization rather than as an overriding good.

There are also domains in which attempts to preserve reversibility can themselves create harm. Continuous contingency planning can weaken commitments that require mutual reliance. Extensive monitoring of exit conditions can produce surveillance burdens. Maintaining parallel infrastructures can consume resources that would be better used elsewhere. A temporary arrangement can become unjust if actors bear prolonged uncertainty solely so that a decision maker can retain optionality.

These limits reinforce the need for protected criteria that include relational, rights-based, and distributional considerations. Reversibility for one actor can be irreversibility for another. A firm can retain the option to cancel a provisional contract while a worker cannot recover the opportunity forgone by relying on it. An institution can reverse a classification while an affected person continues to bear reputational or administrative consequences. Temporal judgment should therefore ask whose options are being preserved, whose are being consumed, and whether the distribution of revisability is itself defensible.

Reversibility makes present action compatible with continuing inquiry only while relevant revision paths remain feasible. Yet both waiting and acting also change the informational and practical field: epistemic discrimination may improve while meaningful options contract. That coupled change is the object of Section 5.

5 Coupled Dynamics of Information and Optionality

Sections 3 and 4 developed the capacities to preserve later judgeability and to revise present commitments. Section 5 examines their interaction when epistemic and practical conditions change at different rates. Continued inquiry can improve the evidential basis for judgment while options become less viable, more costly, less reversible, or unavailable; preparation or provisional action can preserve options while changing the evidential field. A limited set-valued formalization represents these coupled dynamics without assuming a common scalar measure for information and optionality.

The analysis extends a distinction already implicit in the earlier papers of this programme. Additional information has value for unresolved inquiry when it improves a relevant capacity to discriminate, calibrate, reconstruct, or challenge live accounts. Additional time has practical value when it preserves or creates meaningful courses of action. Neither follows automatically from accumulation. A larger archive can add little discriminating power, and a larger nominal menu of actions can conceal that the actions capable of addressing the problem have become ineffective or normatively inadmissible. Temporal judgment therefore concerns the relation between changing epistemic capacities and changing practical possibility.

The tension has a clear family resemblance to the value-of-waiting logic in work on uncertainty and irreversibility.[1, 4] The present analysis differs in two respects that matter for the rest of the paper: information is represented through decision-relevant discriminations rather than a single expected-value quantity, and options can carry legal, relational, distributive, or epistemic conditions that are not presumed to share a common metric.

5.1 Divergent Temporal Trajectories

The temporal state in Definition 1.2 already permits evidential maturity and option structure to move independently. The independence is practically important because an unresolved inquiry can improve in one dimension while deteriorating in another. A later observation can discriminate between two live interpretations after the cheapest intervention window has closed. A delay can preserve neutrality while allowing a fragile sample to degrade. A temporary preparation can preserve access to a later response while contributing little to interpretation. A bounded pilot can improve knowledge while creating dependencies that narrow subsequent revision.

The central difficulty is therefore not simply that information arrives late. The temporal course through which information is acquired can itself change the option structure. Likewise, the course through which options are preserved can alter what later evidence means. Waiting, observation, probing, preparation, communication, and commitment are history-producing operations. Their consequences belong to the inquiry state rather than occurring outside it.

The present section uses *option decay* as a broad term for loss in the practical viability of an option that mattered to the earlier inquiry. Decay can occur through deadline closure, material deterioration, resource exhaustion, institutional entrenchment, reliance, altered relationships, legal change, strategic response by other actors, or loss of the background conditions under which the option would have been effective. The term does not imply that every option deteriorates with time. Some options persist, some improve, and new options can emerge. Its analytical role is to make visible the cases in which epistemic maturation and practical viability diverge.

Definition 5.1 (Option decay). *Option decay* is a temporally produced reduction in the viability of an option that belonged to an earlier inquiry state, where viability is assessed relative to the feasibility, effectiveness, admissibility, timing, reversibility, or other conditions that made the option practically meaningful in that inquiry.

Definition 5.1 treats options as relational and history-bearing. An option is not merely an action name. Its availability depends on resources, authority, external conditions, other actors, relevant rights, and the effects the action can still produce. The same nominal action can therefore remain linguistically available while ceasing to be a meaningful practical option.

5.2 Decision-Relevant Epistemic Gain

A temporal analysis also requires a more precise account of information gain. The amount of information accumulated is a poor proxy for epistemic improvement. Ten additional observations that reproduce the same source dependence can add less to an unresolved inquiry than one observation that distinguishes between two previously live explanations. A new document can increase volume while decreasing clarity

if its provenance is uncertain. A later method can reopen an inquiry by making a previously inaccessible distinction observable.

The framework therefore represents epistemic gain through *discrimination criteria*. Let $\mathcal{D}_t$ denote a finite or otherwise specified family of epistemic criteria derived from the unresolved questions that matter at time t . Each $\delta \in \mathcal{D}_t$ is a predicate on an inquiry state. The statement $\delta(\mathcal{S}) = 1$ means that, within state $\mathcal{S}$, the available evidence, methods, provenance, and interpretive structure support the particular discrimination represented by δ at the level required for the present inquiry. Examples include discriminating between two causal accounts, establishing whether a source is independent, determining whether an observed change exceeds a relevant baseline, or deciding whether a claimed mechanism survives a specified criticism.

For a reference family $\mathcal{D}_t$, the discrimination profile of a state $\mathcal{S}$ is defined in Equation 10.

$$\mathfrak{D}(\mathcal{S}; \mathcal{D}_t) = \{\delta \in \mathcal{D}_t \mid \delta(\mathcal{S}) = 1\}. \quad (10)$$

Equation 10 is intentionally set-valued. It records which specified distinctions are presently supportable without treating heterogeneous epistemic achievements as commensurable units. It also allows information loss. A discrimination supported at t can cease to be supportable later if a baseline disappears, provenance is lost, the phenomenon changes, or an intervention destroys the comparison on which the earlier distinction depended.

To compare alternative ways of carrying the inquiry forward, let π denote a *temporal course* between t and a later horizon t' . A temporal course can contain waiting, observation, preservation, probing, preparation, communication, commitment, or combinations of these operations. The transition notation introduced in Equation 6 is extended here by allowing the superscript to denote the whole course π . The later state generated by that course is represented by Equation 11.

$$\mathcal{S}_{t'}^\pi = \Phi_{t \rightarrow t'}^\pi(\mathcal{S}_t). \quad (11)$$

Equation 11 generalizes the earlier commitment transition. A single commitment c is one possible course, while a course can also consist primarily of observation or preparation. The notation does not presume deterministic evolution. It records the realized or analytically specified history associated with π ; uncertainty about future transitions can be represented by considering several possible later states or scenarios rather than by treating Φ as a known physical law.

Relative to the earlier profile, the newly acquired discrimination set under course π is represented by Equation 12.

$$\mathfrak{G}_{t \rightarrow t'}(\pi; \mathcal{D}_t) = \mathfrak{D}(\mathcal{S}_{t'}^\pi; \mathcal{D}_t) \setminus \mathfrak{D}(\mathcal{S}_t; \mathcal{D}_t). \quad (12)$$

Equation 12 defines gain relative to distinctions already specified at t . It does not imply that inquiry merely fills a fixed list. Contingent encounters can generate new questions, concepts, or candidate explanations, as developed in the preceding papers of this programme. When the question family itself changes, the appropriate response is to enlarge or revise $\mathcal{D}_t$ and record that conceptual change rather than force a false comparison within an obsolete reference set. The formalism is therefore local to a bounded comparative problem and remains compatible with generative problem formation.

5.3 Viable Option Profiles

The option component $\mathcal{O}_t$ of Equation 1 denotes the practical option structure recognized at the earlier time. A raw set of option labels is insufficient for temporal comparison because an option can remain nominally present after the conditions that made it meaningful have deteriorated. The present framework therefore associates each earlier option $o \in \mathcal{O}_t$ with a specified family $\mathcal{C}_t^{o,*}$ of jointly required viability criteria. Depending on the inquiry, these can include resource sufficiency, legal or institutional authority, expected effectiveness, temporal access, acceptable reversibility, compatibility with protected rights,

or other conditions whose failure would make the option materially different from the one originally contemplated.

An earlier option remains viable at t' under temporal course π when its jointly required criteria remain satisfied in the later state. The viable-option profile is represented by Equation 13.

$$\mathfrak{O}_{t \rightarrow t'}(\pi; \mathcal{O}_t) = \{o \in \mathcal{O}_t \mid \chi(\mathcal{S}_{t'}^\pi) = 1 \text{ for each } \chi \in \mathcal{C}_t^{o,*}\}. \quad (13)$$

Equation 13 reuses the joint-criterion logic of Equation 9. It differs in object. Reversibility asks whether a commitment can later reach a state satisfying protected revision criteria. The viable-option profile asks which options identified at the earlier state remain meaningfully exercisable after a temporal course has unfolded. An option can therefore remain viable even when no commitment has yet been made, and a previously exercised commitment can be reversible even after some other options have decayed.

The options lost relative to the earlier inquiry are the members of $\mathcal{O}_t$ that are absent from the later viable-option profile in Equation 13. This loss is useful for diagnosis but should not be interpreted as a complete measure of practical deterioration. Losing one highly consequential option can matter more than losing several marginal ones. Likewise, an option can weaken before crossing the threshold encoded by $\mathcal{C}_t^{o,*}$. Where such gradations matter, the viability criteria should be decomposed more finely rather than replaced by a universal scalar score.

The profile is also intentionally asymmetric with respect to new opportunities. A course can create options that did not exist at t . New methods, alliances, resources, legal authorizations, or technical capacities can expand the later practical field. Such emergence is represented within the later component $\mathcal{O}_{t'}^\pi$ of $\mathcal{S}_{t'}^\pi$. The inherited-option profile in Equation 13 asks a narrower historical question: which options that mattered earlier survived the passage of time? A complete later review should examine both survival and generation.

5.4 Joint Epistemic-Option Profiles

The two profiles can now be examined together. For a temporal course π and review horizon t' , define its epistemic-option profile as the ordered pair in Equation 14.

$$\mathfrak{P}_{t \rightarrow t'}(\pi) = \langle \mathfrak{D}(\mathcal{S}_{t'}^\pi; \mathcal{D}_t), \mathfrak{O}_{t \rightarrow t'}(\pi; \mathcal{O}_t) \rangle. \quad (14)$$

Equation 14 does not aggregate knowledge and optionality. It places them side by side so that temporal courses can be compared by inclusion where such comparison is warranted. Let π_1 and π_2 be two courses evaluated at the same horizon using the same reference families $\mathcal{D}_t$ and $\mathcal{O}_t$. Course π_1 temporally dominates π_2 relative to those families when it supports at least the same discrimination criteria and preserves at least the same viable options, with one inclusion strict. The relation is stated in Equation 15.

$$\pi_1 \succ_{t'} \pi_2 \iff \begin{aligned} \mathfrak{D}(\mathcal{S}_{t'}^{\pi_1}; \mathcal{D}_t) &\supseteq \mathfrak{D}(\mathcal{S}_{t'}^{\pi_2}; \mathcal{D}_t), \\ \mathfrak{O}_{t \rightarrow t'}(\pi_1; \mathcal{O}_t) &\supseteq \mathfrak{O}_{t \rightarrow t'}(\pi_2; \mathcal{O}_t), \end{aligned} \quad (15)$$

with at least one of the two inclusions strict.

Equation 15 yields a deliberately partial dominance relation over courses evaluated with the same reference families and horizon. Many important temporal choices remain incomparable. One course can preserve more options while producing less discrimination; another can generate stronger evidence while closing a fragile response window. The framework does not convert such cases into an artificial ranking. Their comparison requires additional domain-specific judgments concerning stakes, rights, error costs, urgency, distribution, and the relevance of the distinctions being gained.

This dominance relation provides a limited diagnostic result. Some delays can be weakly dominated before a difficult trade-off arises. If one admissible course preserves every represented option preserved by another while also supporting more represented discriminations, the latter course is dominated relative to the specified horizon and reference families. Choosing the dominated course may still be defensible

Table 7: Illustrative effects of temporal practices on epistemic discrimination and option viability

Temporal practice	Potential epistemic effect	Potential option effect
Passive waiting	Allows exogenous evidence or dependencies to mature without direct intervention.	Can preserve neutrality, but can also consume deadlines, resources, access, or bargaining positions without compensating gain.
Targeted observation	Adds evidence while minimizing intervention in the phenomenon where feasible.	Often preserves more options than direct action, though observation costs and access windows can still alter the practical field.
Discriminating probe	Seeks evidence specifically capable of separating live interpretations.	Can preserve or consume options depending on invasiveness, disclosure, resource use, and reflexive effects.
Reversible preparation	Generates readiness information and reveals dependencies before full commitment.	Can preserve response capacity, although preparation can itself create expectations, sunk costs, or path dependence.
Qualified communication	Tests coordination, elicits criticism, or surfaces missing information.	Can create cooperative options while closing confidentiality, reputational, or bargaining options.
Provisional commitment	Generates implementation evidence under real conditions.	Can preserve a threatened opportunity while narrowing later alternatives through coupling and reliance.

for reasons that the formal comparison does not represent, such as unmodeled rights, burdens, coordination effects, or uncertainty about the transition itself. Passive waiting that produces no represented epistemic gain while allowing represented options to decay can therefore be distinguished from deferral that improves the represented future inquiry state, but the comparison remains conditional on the adequacy of the prior relational analysis.

5.5 Temporal Profiles of Waiting, Probing, and Preparation

Different temporal practices tend to affect the two profiles through different mechanisms. Table 7 provides an analytical comparison. The entries are tendencies rather than empirical laws; the actual effect depends on the inquiry and environment.

Table 7 clarifies why “wait” and “act” are too coarse as categories. A practice can intervene epistemically while remaining practically conservative, or it can prepare practically while withholding stronger epistemic closure. This layered organization was already implicit in the taxonomy of deferral in Section 2. The present section adds that the layers can be evaluated by how they change the two temporal profiles.

A particularly important class of operations attempts to *decouple* information gain from option decay. A low-cost observation protocol can improve discrimination without materially changing the action field. Reserving a resource can preserve an option while a separate inquiry continues. A small reversible probe can generate evidence without crossing the threshold of a larger commitment. Decoupling is rarely complete, because preservation, probing, and preparation themselves consume resources and can alter expectations. It is nevertheless a useful design objective: before accepting a direct trade-off between knowledge and optionality, the inquiry can search for operations that change the coupling between them.

This observation creates a bridge to generative problem solving. The temporal task is not limited to choosing among a fixed menu of waiting and acting. An inquiry can sometimes *generate a better temporal course* by redesigning the observation, partitioning the commitment, preserving a baseline,

modularizing an intervention, or creating an exit architecture. Such redesign changes the space of trajectories available to the inquiry. In this sense, temporal judgment can be generative rather than merely allocative.

5.6 Waiting Horizons and the Cost of Additional Discrimination

The comparison between epistemic gain and option decay is horizon-dependent. A course that looks attractive at $t + 1$ may be dominated by another at $t + 3$, while a course that preserves options for months may fail if the decisive evidence arrives only after those options have become ineffective. Temporal judgment therefore benefits from attention to the sequence of profiles rather than to a single end point.

Let $t < t_1 < t_2 < \dots < t_n$ denote review horizons relevant to the inquiry. For a temporal course π , the sequence $\mathfrak{P}_{t \rightarrow t_1}(\pi), \dots, \mathfrak{P}_{t \rightarrow t_n}(\pi)$ records how epistemic discrimination and inherited option viability evolve together. The representation is descriptive rather than predictive unless the transitions are empirically estimated. Its purpose is to expose temporal asymmetries that a single review date can conceal.

Several recurrent patterns follow. In an *epistemically productive interval*, discrimination expands while the protected option field remains comparatively stable. In an *exchange interval*, additional discrimination is purchased through loss of some earlier options. In a *drift interval*, little decision-relevant discrimination is gained while options continue to decay. In a *regenerative interval*, preparation, institutional change, or new technology can create or restore options even while the substantive inquiry remains unresolved. These patterns are analytical descriptions rather than universal phases.

The drift interval is particularly important for accountable deferral. Once continued waiting ceases to improve the distinctions that block justified closure while materially relevant options are being consumed, the rationale for deferral has changed. The appropriate response need not be immediate full commitment. It may be to redesign the inquiry, increase observation, preserve a threatened option, adopt a bounded provisional measure, or release a line of inquiry that no longer warrants its opportunity cost. Within this framework, a potential temporal failure arises when the earlier justification for waiting is carried forward after the structure that supported it has materially changed and no new justification is supplied.

5.7 Non-Monotonic Information and Endogenous Option Change

Neither side of the temporal profile should be assumed monotonic. Information can deteriorate as well as improve. Sources can disappear, measurement regimes can change, memory can become reconstructed, and intervention can destroy the baseline needed for later comparison. An inquiry can therefore move to a later state with more data but fewer responsibly supportable discriminations. Equation 10 permits this because membership can be lost as well as gained.

Options can likewise regenerate. A later coalition can make an intervention feasible that was impossible earlier. A new method can reduce implementation cost. Additional preparation can turn a previously irreversible response into a modular one. A legal or institutional change can reopen authority. This possibility is another reason to use the term option decay locally rather than assume a universal law of shrinking choice.

The interaction can also be endogenous. A probe can create the evidence that justifies a larger intervention while simultaneously creating stakeholder reliance that makes withdrawal harder. A communication can reveal new information because other actors respond to it, yet the response itself changes the strategic environment. A preparation can keep an option open because resources are reserved, but the reservation can prevent those resources from supporting alternative inquiries. Temporal judgment therefore needs to preserve the causal history of its own epistemic operations. Otherwise later information can be treated as though it arrived independently of the course that helped produce it.

This endogeneity links directly to future judgeability. The record should distinguish observations obtained under substantially different temporal courses and preserve enough information to reconstruct which actions changed the conditions of observation. It also links to reversibility. A course that pro-

duces excellent information at the price of destroying the baseline or foreclosing every response except continuation can be epistemically informative while temporally brittle.

5.8 Protected Options, Distribution, and the Limits of Temporal Optimization

The language of option preservation can become misleading if it treats the decision maker’s optionality as the only relevant practical good. An institution can preserve its own ability to postpone while imposing prolonged uncertainty on affected persons. A researcher can retain several methodological choices while consuming a participant’s limited time. A negotiating actor can preserve bargaining flexibility by transferring risk to a counterparty whose alternatives are shrinking. Use of the option profile therefore depends on a prior judgment about whose options and which relations deserve protection.

This distributive concern cannot be repaired by simply adding more options to $\mathcal{O}_t$. Some constraints have a different normative status. Rights, duties, prohibitions, or thresholds of unacceptable harm can limit which temporal courses count as admissible even when those courses would preserve substantial optionality or generate valuable evidence. The criteria $\mathcal{C}_t^{O,*}$ can encode some of these restrictions at the level of individual options, while the admissibility of an entire temporal course may require additional domain-specific constraints.

The same caution applies to information gain. Information about affected actors is not automatically worth acquiring through any available means. Surveillance, coercive experimentation, confidentiality breaches, or exploitative uncertainty can generate discrimination while violating constraints that make the course unacceptable. The formalism therefore supports comparison among admissible courses; it does not make epistemic gain a license to override independent ethical or legal limits.

A further limitation concerns commensuration. Once two courses are incomparable under Equation 15, the framework does not supply a universal formula for deciding how much option decay should be accepted for a given epistemic gain. Such a formula would require substantive judgments about the importance of particular distinctions, the value and distribution of particular options, the costs of error, and the consequences of delay. The present paper treats those judgments as domain-dependent inputs to temporal reasoning rather than as quantities derivable from the abstract framework alone.

The joint epistemic-option profile makes visible the possibility that information and optionality move in different directions. A particular response becomes temporally exercisable only when its practical viability overlaps with the epistemic conditions specified for its use. Section 6 formalizes that overlap.

6 Action Windows in Changing Situations

Section 6 develops a timing consequence of the epistemic–option divergence analyzed in Section 5. An option can remain nominally available after it has become ineffective, inadmissible, or insufficiently supported; it can also become practically available before the inquiry satisfies the epistemic conditions prospectively specified for its exercise. The resulting temporal object is an *action opportunity set*: the times at which a specified response is both practically viable and epistemically supportable relative to stated criteria. Connected components of this set constitute action windows.

The analysis remains local and criterion-relative. It does not assume that every domain has a single optimal time to act, that action windows are known in advance, or that the same timing rule applies to observation, preparation, communication, provisional commitment, and irreversible intervention. Its purpose is narrower: to make explicit the temporal overlap required for responsible exercise of a particular option and to show how that overlap can narrow, fragment, reopen, or disappear as the inquiry and its surrounding situation evolve.

Adaptive-planning methods have developed related ideas through pathways, signposts, and adaptation tipping points under deep uncertainty.[7] The present notion of an action opportunity set is not offered as a replacement for those domain-specific methods. It isolates a more general structural condition: a contemplated response is temporally available only where its practical viability and the epistemic standard specified for that response overlap.

6.1 Two Temporal Conditions of Exercisable Action

The viable-option profile in Equation 13 associates each earlier option $o \in \mathcal{O}_t$ with a family $\mathcal{C}_t^{o,*}$ of jointly required practical viability criteria. Those criteria answer one question: does the option still exist in a sufficiently meaningful practical form? They do not by themselves answer whether the inquiry has reached a state in which exercising that option is responsibly supportable.

A second criterion family is therefore required. Let $\mathcal{D}_t^{o,*} \subseteq \mathcal{D}_t$ denote the decision-relevant epistemic criteria that the inquiry specifies as prerequisites for responsible exercise of option o . The family need not contain every unresolved question. A temporary protective measure can be justified without causal closure, while a high-impact irreversible intervention can require much stronger discrimination. The content of $\mathcal{D}_t^{o,*}$ is consequently domain-specific and action-specific.

For a temporal course π and a time $\tau \geq t$, define the practical viability condition for o by Equation 16.

$$V_o^\pi(\tau) = 1 \iff \chi(\mathcal{S}_\tau^\pi) = 1 \text{ for each } \chi \in \mathcal{C}_t^{o,*}. \quad (16)$$

Likewise, define the epistemic support condition by Equation 17.

$$E_o^\pi(\tau) = 1 \iff \delta(\mathcal{S}_\tau^\pi) = 1 \text{ for each } \delta \in \mathcal{D}_t^{o,*}. \quad (17)$$

Equations 16 and 17 derive action timing from the two profiles already introduced in Section 5. $V_o^\pi(\tau)$ asks whether the option remains meaningfully exercisable. $E_o^\pi(\tau)$ asks whether the inquiry supports the distinctions required for exercising it responsibly. Neither is a universal threshold. Both depend on explicit criterion families whose adequacy remains open to substantive criticism.

The distinction yields two preliminary temporal sets over a review horizon $[t, T]$. Equation 18 defines the *viability set* of o under course π .

$$\mathcal{W}_V^o(\pi; t, T) = \{\tau \in [t, T] \mid V_o^\pi(\tau) = 1\}, \quad (18)$$

Equation 19 defines the corresponding *epistemic-readiness set*.

$$\mathcal{W}_E^o(\pi; t, T) = \{\tau \in [t, T] \mid E_o^\pi(\tau) = 1\}. \quad (19)$$

These sets should not be interpreted as independently observed clocks. They are two analytical projections of the same evolving inquiry state. An evidential operation can alter practical viability, and a practical preparation can alter what evidence later means. Their separation is nevertheless useful because the most consequential timing failures often arise when they cease to overlap.

Definition 6.1 (Action opportunity set). For an option o , temporal course π , and review horizon $[t, T]$, the *action opportunity set* is the set of times at which o is both practically viable and epistemically supportable. Equation 20 gives this intersection.

$$\mathcal{W}_A^o(\pi; t, T) = \mathcal{W}_V^o(\pi; t, T) \cap \mathcal{W}_E^o(\pi; t, T). \quad (20)$$

Definition 6.1 does not imply that action is mandatory whenever $\tau \in \mathcal{W}_A^o$. Membership establishes only a criterion-relative opportunity: the option remains meaningful under the represented viability conditions and the specified epistemic conditions are satisfied. Other options can be preferable, rights or duties can prohibit the option, and unrepresented uncertainty or prudential reasons can favor further inquiry. The set therefore marks one represented conjunction relevant to responsible exercisability, not a sufficient decision rule.

Because the construction is anchored to $\mathcal{O}_t$, it directly tracks options recognized at the reference time. If a genuinely new option o^+ emerges at a later time $s > t$, the framework should be re-based at s : the then-current inquiry state supplies a new option family and corresponding viability and epistemic criteria. This re-basing rule prevents newly generated possibilities from being forced into an inherited option set that did not contain them.

6.2 Fragmented Action Windows

Ordinary language suggests that a window opens once and later closes. Changing situations are often less orderly. Legal authority can lapse and later be restored. A resource can become unavailable and later be replenished. A method can temporarily support a discrimination before a baseline changes. A coalition can dissolve and later reform under different conditions. An action can therefore move into and out of responsible exercisability more than once.

For this reason, Equation 20 defines a set rather than assuming a connected interval. When time is represented continuously and $\mathcal{W}_A^o(\pi; t, T)$ contains several connected components, each component can be treated as an individual action window. When the inquiry uses discrete review times, a window can instead be represented by a maximal consecutive block of times at which the joint condition remains satisfied. This convention prevents the language of a single closing deadline from concealing reopening or fragmentation.

The distinction also separates an *exogenous deadline* from an *endogenous action window*. A filing date, treaty deadline, scheduled launch, or physical expiration can contribute to $\mathcal{C}_t^{o,*}$, but the action window can narrow earlier because effectiveness, authority, reversibility, cooperation, or evidential relevance has deteriorated. Conversely, a formal deadline can remain unchanged while new preparation or authorization reopens a practical route that had previously appeared closed.

A useful consequence is that deadline information may be insufficient for temporal judgment. The additional questions are which conditions keep the option meaningfully exercisable, which conditions make its exercise epistemically supportable, and how those conditions are changing. Calendar information can answer only part of that inquiry; the remainder requires continuing relational analysis.

6.3 Prematurity, Timeliness, and Missed Windows

The two-set construction allows three recurrent timing configurations to be distinguished without presupposing that earlier or later action is generally preferable.

First, there can be a period of *practical availability without epistemic readiness*. Equation 21 represents this region.

$$\tau \in \mathcal{W}_V^o(\pi; t, T) \setminus \mathcal{W}_E^o(\pi; t, T). \quad (21)$$

During such a period, the option remains available, but the inquiry does not yet support the distinctions specified in $\mathcal{D}_t^{o,*}$. Exercising the option can therefore be premature relative to the stated epistemic requirements. Prematurity is criterion-relative rather than chronological. An action taken “early” in calendar time is not premature if its required support conditions are already satisfied.

Second, there can be a period in which practical viability and epistemic readiness overlap. This is precisely $\mathcal{W}_A^o$. Such an interval can be called a *timely action region* for that option, with the qualification that the framework has not yet selected among all available options.

Third, epistemic readiness can arrive after practical viability has disappeared. Equation 22 represents such times.

$$\tau \in \mathcal{W}_E^o(\pi; t, T) \setminus \mathcal{W}_V^o(\pi; t, T), \quad (22)$$

the inquiry can support the distinctions that would have informed o , yet o is no longer meaningfully exercisable. This is a *missed-window configuration*. It does not prove that earlier exercise of o would have been justified, because the epistemic conditions may genuinely have been absent then. The configuration records an absence of temporal overlap between the represented evidence requirements and the represented conditions of practical viability. Whether that absence reflects avoidable temporal design, unavoidable external timing, or a defensible refusal to lower substantive standards requires additional counterfactual and domain-specific analysis.

This distinction matters because retrospective narratives can misdescribe such cases. Once later evidence is strong, it can appear obvious that action should have occurred earlier. Equation 22 makes

clear that this inference does not follow from the later outcome alone; the required evidence may not have been available during the earlier viability period. Conversely, an institution can invoke earlier uncertainty to excuse delay even when a less demanding provisional option had different epistemic requirements and may have remained responsibly exercisable. Temporal accountability therefore benefits from reconstructing the action-specific criterion families and the evidence then available, not only the final outcome.

Claim 6.2 (Window mismatch). An unresolved inquiry can possess a practically meaningful option and later acquire adequate epistemic support for that option while never possessing a non-empty action opportunity set for it. This occurs when the option’s viability and epistemic-readiness sets fail to overlap.

Claim 6.2 is a direct consequence of Equation 20. Its practical importance is that some timing problems are not resolved merely by the instruction to wait longer or act sooner. If the two sets do not overlap under the current temporal course, one possible response is to examine whether the course can be redesigned; another is to recognize that no responsible overlap is available under the present constraints.

6.4 Window Engineering through Preparation and Probing

The possibility of window mismatch gives a more precise role to the generative temporal practices identified in Section 5. Observation, preservation, preparation, modularization, reversible probing, and resource reservation can alter either side of Equation 20. A better observation design can cause the epistemic-readiness set to begin earlier. Preparation can extend practical viability. Modularization can weaken the criteria required for a smaller provisional action without weakening those required for a larger commitment. Preservation can prevent an epistemic window from closing through loss of baseline or provenance.

This suggests the concept of *window engineering*. The term denotes deliberate alteration of the inquiry process intended to create, preserve, widen, or reconnect temporal overlap between epistemic support and practical viability; it does not imply control over time or the external world. Definition 6.3 states the concept formally.

Definition 6.3 (Window engineering). *Window engineering* is the prospective redesign of observation, preservation, preparation, commitment structure, or review practice intended to alter the action opportunity set of one or more options without misrepresenting the epistemic or normative conditions required for their exercise.

The final clause is important. An institution does not genuinely widen an action window by lowering an evidential standard merely because waiting has become inconvenient. Nor does it preserve a window by treating rights constraints as optional. Window engineering acts on the temporal course, not on the truth conditions or normative restrictions that make action responsible.

Suppose two feasible temporal courses π_1 and π_2 are compared for the same option and horizon. Equation 23 states a sufficient set-inclusion relation for a larger represented action opportunity set.

$$\mathcal{W}_A^o(\pi_1; t, T) \supset \mathcal{W}_A^o(\pi_2; t, T), \quad (23)$$

then π_1 provides a strictly larger action opportunity set for o relative to the specified criteria. Equation 23 is useful diagnostically, but it is not a complete temporal ordering. The course with the larger window can impose greater costs, reduce judgeability, burden other actors, or close the windows of other important options. Window expansion for one response is therefore not automatically an improvement of the whole inquiry.

This limitation reinforces the relational character of temporal judgment. Reserving a scarce resource can preserve one option while preventing another. Public communication can create the coordination needed for one action while eliminating a confidential route. A pilot can open an implementation window while closing a neutral-observation window. The inquiry should therefore examine a family of action opportunity sets rather than optimize one in isolation.

6.5 Staged Responses and Asymmetric Windows

Many unresolved inquiries do not face one undifferentiated act-or-wait decision. They possess related responses with different epistemic burdens, practical effects, and degrees of reversibility. Observation can require little commitment. Preparation can preserve a later option without asserting a final interpretation. A reversible probe can require more support than passive observation but less than irreversible intervention. Public communication can have a narrow relational window even when material intervention remains possible later.

Let $\mathcal{O}_t^\dagger \subseteq \mathcal{O}_t$ denote a specified family of related responses relevant to the same unresolved problem. Each $o \in \mathcal{O}_t^\dagger$ retains its own criterion families $\mathcal{C}_t^{o,*}$ and $\mathcal{D}_t^{o,*}$ and therefore its own action opportunity set. The resulting family is represented by Equation 24.

$$\mathbb{W}_A(\pi; t, T) = \left\{ \mathcal{W}_A^o(\pi; t, T) \mid o \in \mathcal{O}_t^\dagger \right\}. \quad (24)$$

The family representation avoids assuming that all responses lie on a single commitment scale. It nevertheless permits structured comparison when the substantive inquiry supplies such relations. A reversible preparation can have an earlier and wider window than a public commitment. A protective intervention can have a narrow early window even when a final causal attribution should remain deferred. A communication window can close through loss of trust while a technical intervention window remains open. These asymmetries explain why responsible temporal practice can require staged responses rather than synchronized closure across all dimensions.

The point is not to multiply actions unnecessarily. Every additional intervention can alter the evidential field and create dependencies. The point is that unresolvedness in one layer need not suspend every other layer. Section 2 already distinguished descriptive, interpretive, causal, normative, practical, communicative, institutional, and programme deferral. The present formalism shows how those layers can also possess different action windows.

6.6 Path Dependence after Action

An action window should not be imagined as a fixed opening in an external schedule through which an actor simply passes. Exercising an option changes the subsequent inquiry state. It can therefore alter the future windows of the same option, of alternative options, and of later review.

Let π denote the course followed until time τ , and let o be exercised at $\tau \in \mathcal{W}_A^o(\pi; t, T)$. Denote the resulting concatenated course by $\pi \oplus_\tau o$. Equation 25 represents the state at a later time $s > \tau$.

$$\mathcal{S}_s^{\pi \oplus_\tau o} = \Phi_{\tau \rightarrow s}^{\pi \oplus_\tau o}(\mathcal{S}_\tau^\pi). \quad (25)$$

Equation 25 extends the history-producing logic of Equations 6 and 11. After o is exercised, later action opportunity sets should be evaluated on the changed history rather than on the counterfactual course in which o was never taken.

This path dependence produces several possibilities. Exercising one option can close competing windows through resource consumption or commitment. It can open new windows by generating information, coordination, or capacity. It can preserve a threatened window by stabilizing material conditions. It can also destroy a neutral baseline and thereby close an epistemic window even while expanding practical control. Temporal judgment therefore concerns sequences of window transformations, not isolated choices at independent dates.

The point also clarifies the relation to reversibility. An action can be inside its action window and still be difficult to reverse later. Conversely, a highly reversible action can be outside its action window because it lacks sufficient epistemic support or would no longer achieve its intended function. Action-window analysis and reversibility analysis answer different questions. The former asks when an option is responsibly exercisable; the latter asks what specified capacities remain recoverable after it has been exercised.

6.7 Prospective Windows, Uncertainty, and Silent Closure

The formal sets above can be reconstructed retrospectively from a realized history, but practical judgment occurs prospectively. At time t , future states S_t^π are ordinarily uncertain. A responsible actor therefore does not know the future action opportunity set with certainty. The framework should not disguise this uncertainty by treating Equations 18–20 as forecasts.

Prospective use requires conditional or scenario-based reasoning. The inquiry can ask which viability criteria appear fragile, which epistemic discriminations are expected to mature, what events would alter either assessment, and how sensitive the overlap is to plausible trajectories. Where quantitative models are justified, probabilities or hazard estimates can be added at the domain level. The present framework does not supply those probabilities. Its role is to specify which quantities or conditions would need to be estimated and preserved if such models are used within this architecture.

This prospective perspective makes *silent closure* especially important. An action window can close without a conspicuous deadline event. Trust can erode gradually. A biological sample can become less informative. An institutional coalition can drift apart. A temporary authorization can remain formally valid while operational capacity disappears. Reversibility can decay below an acceptable level without any formal announcement. If the inquiry reviews only on fixed calendar dates, it can discover closure only after the relevant option has vanished.

A mature temporal practice therefore needs indicators tied to the conditions that constitute the window. If a criterion in $\mathcal{C}_t^{o,*}$ is approaching failure, that change can itself justify review even when no new substantive evidence has arrived. Likewise, the acquisition of a decisive discrimination in $\mathcal{D}_t^{o,*}$ can justify review even when the practical situation appears stable. These observations prepare the next section's analysis of review triggers.

6.8 Limits of Action-Window Reasoning

Action-window language can become misleading if it encourages temporal optimization detached from substantive ethics. Some duties are immediate and do not wait for a favorable window. Some actions remain prohibited even when they are feasible and epistemically well supported. Some affected parties can reasonably reject being kept in prolonged uncertainty merely because an institution wishes to preserve a larger opportunity set. The criterion families therefore do not replace normative judgment; they make its temporal conditions explicit.

Nor should every shrinking window create urgency. Scarcity can be strategically manufactured. Actors can attempt to force decisions by imposing artificial deadlines or by framing reversible choices as once-only opportunities. A claimed window should therefore be examined for how its closure conditions were produced, who controls them, and whether the urgency is endogenous to the phenomenon or strategically constructed by participants.

There is also a risk of excessive anticipatory monitoring. Constantly estimating every possible closing window can consume attention, encourage defensive behavior, and produce institutional hypervigilance. The framework is intended for inquiries whose unresolvedness is sufficiently consequential to warrant temporal organization. It is not an argument that every possibility should be monitored continuously.

Finally, the action opportunity set remains criterion-relative and path-relative. An omitted criterion can make a window appear wider than it responsibly is. A mistaken forecast can misidentify its opening or closure. A later reconstruction can overstate how foreseeable a closing condition was. These limits reinforce the importance of future judgeability: records should preserve not only which window was believed to exist, but also why, on what evidence, with what uncertainty, and under which assumptions.

Action opportunities can change between scheduled reviews and may close without an explicit deadline. Temporal governance consequently needs conditions for reopening or intensifying reconsideration when evidence, options, reversibility, preservation quality, or external circumstances change. Section 7 develops those conditions as review triggers while keeping them distinct from belief, communication, and action thresholds.

7 Review-Trigger Architecture for Temporal Accountability

Section 7 converts changing preservation, reversibility, option, and action-window conditions into a problem of review architecture. It specifies when a deferred inquiry becomes eligible for reconsideration and how responsibility for that reconsideration can remain traceable across time. The analysis distinguishes scheduled review from condition-sensitive review, derives trigger families from the state and window structures already introduced, and clarifies the limited epistemic status of trigger activation.

7.1 Scheduled and Condition-Sensitive Review

A scheduled review date is a useful temporal backstop. It can prevent an inquiry from disappearing merely because no conspicuous event occurs. It can also allocate attention in environments where continuous monitoring would be costly or disruptive. Yet a fixed schedule is not, by itself, responsive to the temporal structure developed in Sections 3–6. A relevant condition can change materially between scheduled reviews. A preservation opportunity can become fragile, a reversible arrangement can begin to harden, a practical option can approach loss, or a previously unavailable discrimination can become supportable.

The converse problem also occurs. Repeated calendar review can consume attention even when no judgment-relevant condition has changed. Such review can become ritualistic: the inquiry is reopened because the date arrived, then deferred again without a clearer account of what would make the next review different. Calendar review and condition-sensitive review therefore solve different problems. The former limits institutional forgetting; the latter responds to material change.

The present framework accordingly treats a mature review architecture as potentially *hybrid*. Scheduled review supplies a failsafe against unrecognized change, monitoring failure, and poorly specified triggers. Condition-sensitive review allows reconsideration before the next scheduled date when some specified feature of the inquiry materially changes. Neither form should automatically replace the other.

7.2 Trigger Families Derived from the Inquiry State

The earlier inquiry state in Equation 1 already includes $\mathcal{A}_t$, the allocation of review responsibility and the review conditions specified at time t . The present section makes one part of that component explicit. Let $\mathcal{B}_t$ denote a family of prospective *review-trigger predicates* contained within, or attached to, the review architecture at t . Each $\beta \in \mathcal{B}_t$ evaluates whether a specified condition for reconsideration has been met at a later time τ along temporal course π .

Equation 26 represents a trigger predicate for present purposes.

$$\beta(\tau, \mathcal{S}_\tau^\pi) \in \{0, 1\}, \quad \beta \in \mathcal{B}_t, \quad (26)$$

where the meaning of the value 1 is only that the condition specified by β is satisfied. The predicate can be anchored to the baseline state $\mathcal{S}_t$, to an expected trajectory recorded at t , to an external deadline, or to a later versioned baseline if the trigger architecture has itself been revised. Equation 26 is therefore bookkeeping notation for prospectively stated review conditions rather than a claim that every trigger can be measured mechanically.

Equation 27 collects the triggers active at τ .

$$\mathfrak{B}_{t \rightarrow \tau}(\pi; \mathcal{B}_t) = \{\beta \in \mathcal{B}_t \mid \beta(\tau, \mathcal{S}_\tau^\pi) = 1\}. \quad (27)$$

Equation 27 is deliberately set-valued. Different triggers can concern different temporal dimensions and need not be commensurable. The activation of a provenance-preservation trigger, an option-loss trigger, and a legal review date should not be collapsed into one universal urgency score merely because all three can justify reconsideration.

Table 8 illustrates how trigger families can be constructed from objects already introduced in the paper. The examples are illustrative rather than exhaustive.

Table 8: Illustrative review-trigger families derived from earlier sections

Trigger family	Change that can justify review	Earlier structure to which it relates
Epistemic	A previously unsupported discrimination becomes supportable; a central item loses provenance; serious contrary evidence appears.	$\mathfrak{D}$ and $\mathfrak{G}$ from Section 5.
Option structure	A meaningful option is lost, newly created, or materially altered; a required viability condition becomes fragile.	$\mathfrak{D}$ and $\mathcal{C}_t^{o,*}$ from Sections 5 and 6.
Action-window	Practical viability and epistemic readiness begin to overlap, cease to overlap, or are expected to separate before the next scheduled review.	$\mathcal{W}_V^o$, $\mathcal{W}_E^o$, and $\mathcal{W}_A^o$ from Section 6.
Reversibility	A protected revision criterion becomes difficult to recover jointly, or dependencies begin to narrow an exit path.	$\mathfrak{R}$ and the reversibility-window analysis of Section 4.
Preservation	A judgment-relevant trace approaches a preservation boundary, custody changes, or record integrity deteriorates.	$\mathcal{R}_t$, $\mathcal{T}_{t' t}$, and preservation windows from Section 3.
External-state	The phenomenon, affected relations, legal environment, institutional setting, or other relevant external conditions change materially.	$\mathcal{X}_t$ and the temporal course Φ^π introduced earlier.
Responsibility	The responsible role changes, authority becomes unclear, a handoff fails, or the monitoring process itself becomes unreliable.	$\mathcal{A}_t$ from Equation 1.
Scheduled backstop	A prospectively specified date or interval is reached even if no other trigger has been recognized.	Calendar or procedural condition inside $\mathcal{B}_t$.

This table also reveals an important distinction between *first-order* and *second-order* triggers. First-order triggers concern the inquiry’s evidence, interpretations, options, or external object. Second-order triggers concern the temporal architecture itself: the sensor fails, the archive becomes inaccessible, the responsible analyst leaves, the review authority changes, or the trigger family is no longer appropriate to the transformed problem. A temporal framework that monitors only its object can therefore fail because the capacity to notice relevant change has itself deteriorated.

7.3 Epistemic Status of Trigger Activation

A review trigger should not be confused with the judgment that a hypothesis is true, a policy is warranted, or an intervention should be executed. Its narrower function is to indicate that the justification for continuing the present temporal disposition should be reconsidered. The possible outcomes of that reconsideration remain plural. Review can reaffirm deferral, intensify observation, preserve additional traces, redesign a provisional commitment, communicate a qualified update, escalate action, downgrade attention, or release the inquiry.

This distinction continues an important result of the preceding papers in this programme. In the analysis of incipient change, sensitivity to a weak signal was separated from confidence in a strong interpretation and from the response threshold for consequential action. The present paper generalizes that separation. A practice can rationally adopt a relatively sensitive threshold for *review* while retaining more demanding thresholds for *closure* or *irreversible commitment*. Review can therefore be early without making the substantive judgment early.

Definition 7.1 (Review trigger). A *review trigger* is a prospectively specified condition whose activation makes the continued adequacy of an existing deferral, provisional commitment, monitoring arrangement, or release assumption an appropriate object of reconsideration, without by itself determining the outcome of that reconsideration.

Definition 7.1 prevents two opposite errors. The first is *trigger inflation*: treating every activated trigger as proof that strong action is justified. The second is *trigger trivialization*: recording trigger conditions while allowing their activation to have no procedural effect. A trigger architecture is meaningful only when activation can actually reopen the relevant question.

For a specified architecture, Equation 28 defines a review-activation indicator.

$$\text{Rev}_{t \rightarrow \tau}(\pi; \mathcal{B}_t) = \begin{cases} 1, & \mathfrak{B}_{t \rightarrow \tau}(\pi; \mathcal{B}_t) \neq \emptyset, \\ 0, & \mathfrak{B}_{t \rightarrow \tau}(\pi; \mathcal{B}_t) = \emptyset. \end{cases} \quad (28)$$

Equation 28 says only that, under the architecture presently in force, at least one review condition has activated. Domain-specific governance can legitimately distinguish informational triggers, advisory triggers, mandatory review triggers, or emergency escalation triggers. Those institutional force rules are not encoded by Equation 28; they belong to the implementation of $\mathcal{A}_t$.

7.4 Single, Cumulative, and Compound Triggers

Not every relevant change is well represented by a single threshold crossing. Some events are individually sufficient to justify review: loss of legal authority, corruption of a critical dataset, a decisive replication result, or the imminent closure of a non-substitutable preservation window. Other situations become review-worthy only through accumulation. Several weak but concordant observations can matter jointly even when none should trigger reconsideration alone. Still other conditions are conjunctive: review becomes appropriate only when two or more changes occur together.

The set-valued representation in Equation 27 allows these architectures without reducing them to one scalar. A compound trigger can itself be defined as a predicate whose activation depends on several underlying conditions. A cumulative trigger can be versioned to record how a sequence of observations changes its activation state. The framework does not require a universal aggregation rule because the evidential and practical meaning of accumulation differs across domains.

The distinction is particularly important for threshold drift. Suppose a trigger was prospectively specified as the conjunction of conditions a and b . If both later occur, quietly adding condition c changes the review architecture after the fact. Such revision can sometimes be justified by new understanding, but it should be recorded as a revision rather than presented as though the original trigger had never activated. Otherwise, a supposedly accountable deferral can reproduce the threshold-drift pathology identified in Section 2.

The reverse problem is *stale triggering*. A trigger family can become inappropriate because the inquiry itself has changed. A measure that once tracked risk can lose validity; an option can disappear entirely; an external dependency can make an old deadline irrelevant; a new problem formulation can render the old criterion family incomplete. Temporal accountability is strengthened when the trigger architecture itself remains reviewable. A revised $\mathcal{B}_t$ should preserve enough version history to show which triggers governed which period and why the change occurred.

7.5 Response Time and Temporal Accountability

A trigger architecture becomes practically meaningful only if responsibility survives long enough to respond to activation. Yet response need not mean immediate substantive closure. It is useful to distinguish at least three moments: trigger activation, acknowledgment that reconsideration is due, and substantive review of the temporal disposition.

For an activated trigger β , let τ_β denote its first *recognized* activation time within the relevant monitoring architecture. This time can differ from the time at which the underlying condition first became true

when observation is intermittent, delayed, or fallible; the distinction should be retained when it matters for accountability. Let τ_β^{ack} denote the time at which the responsible process acknowledges the activation, and let τ_β^{rev} denote the time at which the specified review is completed or formally reclassified. Equation 29 defines the corresponding lags.

$$\ell_\beta^{\text{ack}} = \tau_\beta^{\text{ack}} - \tau_\beta, \quad \ell_\beta^{\text{rev}} = \tau_\beta^{\text{rev}} - \tau_\beta. \quad (29)$$

Equation 29 does not imply that shorter is always better. A careful review can require time, consultation, additional preservation, or conflict-of-interest controls. The relevant question is whether the lag remains defensible relative to the trigger’s meaning and the temporal windows at risk. An acknowledgment that arrives after a preservation window has closed, or a substantive review completed after the relevant action opportunity has disappeared, can be procedurally real yet temporally ineffective.

This leads to a narrower definition of temporal accountability.

Definition 7.2 (Temporal accountability). *Temporal accountability* is the capacity to reconstruct, for a specified unresolved inquiry or provisional commitment, which review architecture was prospectively in force, which relevant triggers were recognized as activated, who or what process held responsibility for reconsideration, how the activation was acknowledged and reviewed, what temporal disposition followed, and how the next review conditions were revised or retained.

Definition 7.2 extends future judgeability rather than replacing it. Section 3 asked whether later observers can reconstruct the earlier evidential and practical state. Temporal accountability adds whether they can reconstruct the *temporal governance* of that state: not merely what was known, but how the practice decided when to look again.

The definition is intentionally procedural and historical. Compliance with a prospectively specified trigger architecture does not prove that the underlying judgment was correct, ethically adequate, or substantively justified. A badly designed trigger can be followed perfectly. Conversely, departure from an earlier trigger can sometimes be warranted by a genuine transformation of the problem. Temporal accountability makes these differences inspectable; it does not eliminate the need for substantive judgment.

7.6 Responsibility Continuity and Handoff

Review responsibility can decay even when the trigger architecture remains formally intact. Individuals leave, teams reorganize, projects end, institutional mandates shift, or an inquiry crosses organizational boundaries. If $\mathcal{A}_t$ identifies only a person rather than a role, succession rule, or custody process, the inquiry can become temporally orphaned despite having explicit review conditions.

Where an inquiry depends on continuing review across personnel or organizational change, the architecture benefits from *responsibility continuity*. This does not require one actor to own the inquiry indefinitely. It requires a reconstructible chain through which the duty or authority to reconsider the inquiry can move without silently disappearing. A handoff should preserve, at a level proportionate to the stakes, the present temporal state, active or pending triggers, the status of preservation and reversibility windows, unresolved alternatives, and the conditions governing the next review.

This continuity can be thought of as a special case of judgeability-preserving transmission. The object transmitted is not only evidence but also the capacity to know that review is due. A new team that inherits an archive while remaining unaware that an option-loss trigger activated shortly before handoff does not inherit the same inquiry state in a practically adequate sense.

Responsibility continuity also places a limit on automated monitoring. A system can detect or flag trigger conditions while leaving no actor authorized to interpret them, no resource available for review, or no process for escalating disagreement. Such a system produces alerts without temporal accountability. Section 9 will return to this problem in the context of AI-mediated inquiry.

7.7 Trigger Pathologies

Several characteristic failures follow from the preceding analysis.

Calendar ritualism occurs when review is performed because a date arrives while the inquiry has no articulated account of which changes would matter before or after that date. *Trigger blindness* occurs when a materially important temporal dimension has no corresponding monitoring or review condition. *Trigger saturation* occurs when too many low-value conditions activate review, consuming attention and producing alert fatigue. *Orphan triggering* occurs when a trigger activates but no actor or process retains effective responsibility. *Review theatre* occurs when the procedural event of review takes place but the relevant alternatives are not genuinely reopened. *Trigger gaming* occurs when actors manipulate measurements, baselines, classifications, or reporting times so that a condition formally fails to activate. *Trigger ossification* occurs when an obsolete trigger architecture is preserved after the inquiry has materially changed.

These pathologies illustrate why sensitivity alone is insufficient to characterize a defensible trigger architecture. An architecture that activates on every fluctuation can make review impossible to sustain; one that activates only after irreversible loss can be temporally useless. Trigger design should therefore be proportionate to stakes, observability, expected rates of change, monitoring costs, and the temporal asymmetry of error. A missed trigger can be serious where a non-substitutable window can close rapidly. A false or low-value trigger can be costly where review interrupts fragile work, exposes sensitive information, or repeatedly destabilizes commitments that require continuity.

No universal sensitivity-specificity balance follows from these considerations. The appropriate architecture depends on what a trigger does. A low-cost internal review can reasonably activate more readily than a public alarm or coercive intervention. This repeats the section's central distinction: a review threshold should not be treated as the same object as a belief threshold, communication threshold, or action threshold.

7.8 Retrospective Evaluation and Foreseeability

Temporal accountability can become unfair if later observers evaluate earlier actors as though all later developments were foreseeable. A trigger architecture should therefore be assessed partly from the standpoint of what could reasonably have been specified, monitored, and interpreted at the time. An unanticipated phenomenon can reveal that the earlier trigger family was incomplete without proving negligence. Later learning should improve the architecture, but it should not be projected backward as though the earlier practice possessed it already.

The opposite error is also possible. Invoking unpredictability can become a way of avoiding responsibility for ignored warning conditions that were in fact visible and prospectively recognized. The record should therefore preserve not only whether a trigger eventually activated but also how its relevance, uncertainty, and observability were understood at the earlier time. This is another reason the trigger family and its revisions belong within the history-bearing record rather than only in retrospective narrative.

A useful retrospective question is consequently not, "Did the institution predict what happened?" It is, "Given the inquiry state then available, did it preserve and respond to the temporal conditions that it had reason to treat as review-relevant, and did it revise those conditions when the problem materially changed?" This question remains demanding while avoiding hindsight certainty.

7.9 Limits of Trigger-Based Accountability

Review triggers can improve temporal organization, but they can also encourage a false image of governance by rule. Important changes can be qualitatively novel and therefore absent from the trigger family. Judgment is still required to recognize that the existing architecture no longer fits the situation. A practice should retain some capacity for discretionary reopening when an unanticipated event materially transforms the inquiry.

Nor should every unresolved inquiry receive formal trigger machinery. In low-stakes scholarly exploration, a dated note, retained alternatives, and a deliberate future checkpoint can provide adequate temporal organization. More elaborate architectures are justified when consequences, fragility, duration, institutional turnover, or asymmetry of error make silent drift more costly.

Trigger systems can also become instruments of surveillance or managerial control. Continuous measurement undertaken solely to maintain review readiness can impose privacy, labor, autonomy, or security costs. As in the preservation and reversibility analyses, temporal accountability is one value within a larger normative configuration. The desire to know when to review does not itself justify unlimited monitoring.

Finally, the existence of a trigger architecture can create false reassurance. A well-documented procedure cannot compensate for lack of authority, resources, expertise, or institutional willingness to act on review. Those conditions move the analysis beyond the design of individual triggers toward the organizational structures that sustain waiting, memory, escalation, disagreement, and handoff over longer periods.

A trigger architecture has practical force only while memory, custody, authority, and responsibility remain connected strongly enough to support review. Section 8 extends temporal accountability from individual review episodes to the institutional arrangements that can carry unresolved inquiry across turnover, handoff, and long periods of non-closure.

8 Institutional Architectures of Waiting

Section 8 shifts the unit of analysis from a review episode to the institutional arrangements that carry unresolved inquiry across time. An inquiry can outlast the person who noticed it, the project that recorded it, the team that reviewed it, or the arrangement that initially had authority to act. The section identifies functions through which memory, responsibility, disagreement, escalation, redundancy, and handoff can remain coupled when duration, stakes, fragility, or distributed authority exceed what individual memory or informal commitment can reliably sustain. The analysis is functional rather than a general argument for organizational expansion.

The institutional analysis has an obvious neighbor in organizational-memory research, which has long examined how organizations acquire, retain, and retrieve information.[10] The present section narrows that broad concern to the temporal governance of unresolved inquiry: whether records, responsibility, disagreement, escalation capacity, and review obligations remain connected strongly enough for later reconsideration to be meaningful.

8.1 Institutional Duration Beyond Individual Memory

Institutional waiting is easy to misdescribe as an organization doing nothing. In the present framework, the relevant object is more demanding. An institution can preserve an unresolved inquiry, maintain the conditions under which it can be reconsidered, keep fragile options from disappearing, and refrain from stronger commitment while the grounds remain incomplete. Such waiting can involve substantial activity: maintaining interpretable records, monitorable triggers, continuity of responsibility, protected disagreement where warranted, and access to authority when the inquiry crosses an escalation threshold.

The institutional problem therefore begins where individual temporal judgment becomes insufficient. A researcher can remember why an anomaly was retained; a successor may inherit only the file. A committee can agree that a question should be revisited in six months; after reorganization, no unit may regard that promise as its responsibility. A monitoring process can continue to produce signals after the office authorized to interpret them has disappeared. A minority interpretation can be recorded in minutes while becoming practically unrecoverable because later reviewers inherit only the consensus summary. In each case, formal persistence of an inquiry coexists with deterioration of the capacities needed to judge it.

This is why institutional continuity should not be identified with personnel continuity. Keeping the same people can preserve tacit memory while still allowing records, review authority, or option structures to decay. Personnel turnover can coexist with strong continuity when a handoff transmits the inquiry state, the live alternatives, the review architecture, and the authority relations needed for later reconsideration. The relevant question is therefore which *functions* survive and remain connected, not whether the names attached to the inquiry remain unchanged.

Definition 8.1 (Institutional architecture of waiting). An *institutional architecture of waiting* is a history-bearing arrangement of roles, records, review conditions, authority relations, and transfer practices that keeps an unresolved inquiry judgeable, reviewable, and capable of proportionate response across intervals longer than reliable individual continuity.

Definition 8.1 does not imply that every unresolved inquiry requires a formal institution. The definition identifies an architecture when the functions are distributed or stabilized beyond an individual's immediate memory and discretion. A laboratory notebook with an explicit successor protocol can instantiate a modest architecture; a regulatory monitoring programme can require a much more elaborate one.

8.2 Expanding the Review-Responsibility Component

Equation 1 represented the earlier inquiry state with a review-responsibility component $\mathcal{A}_t$. Section 7 made the trigger family $\mathcal{B}_t$ explicit within that component. Institutional analysis requires a further expansion of the same object rather than a parallel formal system.

For an institutionally supported inquiry, let the review-responsibility component be represented in the form stated in Equation 30.

$$\mathcal{A}_t^{\text{inst}} = \langle \mathcal{P}_t, \mathcal{F}_t, \omega_t, \Lambda_t^A, \mathcal{B}_t \rangle. \quad (30)$$

In Equation 30, $\mathcal{P}_t$ is the set of institutionally relevant roles or role-bearing processes at time t ; $\mathcal{F}_t$ is the family of temporal-governance functions that the inquiry presently requires; ω_t assigns those functions to one or more roles; Λ_t^A contains typed relations among the roles, such as succession, consultation, independent review, escalation, appeal, or backup responsibility; and $\mathcal{B}_t$ is the review-trigger family introduced in Section 7. The superscript in $\mathcal{A}_t^{\text{inst}}$ marks an institutional refinement of $\mathcal{A}_t$, not a new component of the inquiry state.

Equation 31 writes the assignment map from Equation 30 explicitly.

$$\omega_t : \mathcal{F}_t \longrightarrow 2^{\mathcal{P}_t}, \quad (31)$$

where $\omega_t(f)$ identifies the role or roles assigned to function f . Equation 31 allows both singular responsibility and deliberate redundancy. It does not imply that every role has equal authority or that assigning more roles is automatically better.

The function family $\mathcal{F}_t$ is domain-relative. It can include record custody, preservation monitoring, trigger monitoring, substantive review, maintenance of dissenting alternatives, escalation, authorization of provisional measures, communication, and succession or handoff. The family should remain proportionate to the inquiry. Its analytical purpose is to make visible a common failure of institutional waiting: the presence of an institution can conceal the absence of one function that the unresolved inquiry actually needs.

Table 9 gives an illustrative decomposition. The table should be read as a diagnostic vocabulary rather than a universal organizational template.

The decomposition in Table 9 also clarifies why institutional memory is not equivalent to document retention. Memory adequate for temporal judgment includes the relations between records and responsibilities. A preserved record with no identifiable custodian or review path can be historically informative while being institutionally inert.

Table 9: Illustrative functions in an institutional architecture of waiting

Function	Temporal role	Characteristic failure if unsupported
Record custody	Preserve accessible, versioned, and provenance-bearing traces of the inquiry.	Records survive physically but become inaccessible, uninterpretable, or detached from review responsibility.
Trigger monitoring	Maintain awareness of scheduled and condition-sensitive review conditions.	Relevant change occurs without reaching any actor capable of reopening the inquiry.
Substantive review	Reconsider evidence, alternatives, and temporal disposition when review becomes due.	Alerts accumulate while the underlying inquiry is never genuinely reopened.
Dissent preservation	Keep materially relevant alternatives, objections, and minority interpretations reconstructible.	Apparent consensus grows through archival loss rather than improved discrimination.
Escalation	Move the inquiry to a role with adequate competence, authority, resources, or independence when local review is insufficient.	A trigger is recognized but remains trapped at a level unable to respond.
Succession and handoff	Transfer records, pending triggers, authority, and unresolved alternatives across personnel or organizational change.	The inquiry is inherited as a file without its temporal obligations.

8.3 Functional Continuity

To state this point more precisely, let $\mathcal{F}_t^* \subseteq \mathcal{F}_t$ denote the functions prospectively treated as critical for carrying the unresolved inquiry beyond time t . At a later time t' , the framework counts a function as institutionally supported only when its role assignment remains effective and the records, authority, and relational paths specified for exercising it remain available. Equation 32 introduces an indicator for this condition.

$$\text{Sup}_{t'}(f; \mathcal{A}_{t'}^{\text{inst}}, \mathcal{S}_{t'}^{\pi}, \mathcal{T}_{t'|t}) \in \{0, 1\} \quad (32)$$

indicate whether function f is effectively supported at t' , using the institutional architecture then in force, the current inquiry state $\mathcal{S}_{t'}^{\pi}$, and the surviving trace $\mathcal{T}_{t'|t}$ from Section 3. The current state matters because functions can depend on resources, methods, authority, or external conditions that did not exist at t ; the surviving trace matters because continuity also requires enough historical connection to the earlier inquiry. Equation 32 is intentionally abstract. In one domain, effective support may require an authorized office and a versioned case record; in another, it may require access to physical samples, specialist expertise, and an independent review pathway.

The resulting continuity profile is stated in Equation 33.

$$\mathfrak{C}_{t \rightarrow t'}(\mathcal{F}_t^*) = \{f \in \mathcal{F}_t^* \mid \text{Sup}_{t'}(f; \mathcal{A}_{t'}^{\text{inst}}, \mathcal{S}_{t'}^{\pi}, \mathcal{T}_{t'|t}) = 1\}. \quad (33)$$

Equation 33 remains set-valued for the same reason that the judgeability, reversibility, and trigger profiles earlier in the paper are set-valued. Custody, review authority, dissent preservation, and escalation are heterogeneous functions. A single continuity score can conceal the loss of one non-substitutable function behind strength in several others.

Proposition 8.2 (Personnel continuity and functional continuity are non-equivalent). *Within the present framework, persistence of the same personnel is neither sufficient nor necessary for continuity of an institutional waiting architecture. Functional continuity depends on whether the critical functions represented in $\mathfrak{C}_{t \rightarrow t'}(\mathcal{F}_t^*)$ remain effectively supported and connected to the surviving inquiry trace.*

Proposition 8.2 is a structural consequence of how continuity is defined in Equations 30–33, rather than an empirical claim about every organization. The same team can lose access to records, authority, or effective escalation. A successor team can preserve continuity when the relevant functions and their history-bearing relations are transferred. The proposition therefore resists two common assumptions: that organizational continuity follows automatically from stable staffing, and that turnover necessarily destroys temporal accountability.

Functional continuity is also history-dependent within the present representation. The critical family $\mathcal{F}_t^*$ may change when the inquiry changes. A new legal constraint can create a review function that was previously unnecessary; a terminated intervention can eliminate a monitoring function; a cross-institutional transfer can require an independent appeal path. Version history is therefore needed for the function family just as it is needed for the trigger family. Retrospective review should be able to distinguish a function that was omitted from the beginning from one that became necessary only after the inquiry transformed.

Functional continuity is a condition of institutional persistence, not a sufficient condition of institutional legitimacy or good judgment. An institution can preserve every represented function while using poor substantive criteria, excluding affected perspectives, or maintaining an inquiry that ought to be closed. The continuity profile therefore answers the narrower question of whether prospectively specified temporal-governance capacities survive; the adequacy of those capacities remains open to normative, legal, empirical, and political evaluation.

8.4 Redundancy with Explicit Responsibility

Institutional architectures often use redundancy to resist failure. More than one person may receive an alert; records may exist in more than one repository; a review can have a primary and backup chair; an escalation path can have an alternate route if the ordinary authority is unavailable. Such redundancy can protect against absence, turnover, technical failure, and local blind spots.

Redundancy also creates a characteristic danger. When a function is assigned to many roles without a rule for primary responsibility, acknowledgment, or transfer, each role can reasonably infer that another will act. The resulting architecture is formally populated while practically orphaned. Redundancy therefore contributes to resilience only when duplicated capacity remains coupled to explicit responsibility.

The assignment map ω_t makes this issue visible. A large set $\omega_t(f)$ does not establish that function f is well governed. The architecture also needs a way to determine who acknowledges activation, who has authority to convene review, what happens when the primary role is unavailable, and how unresolved disagreement among responsible roles is escalated. These questions are better represented through the typed relations in Λ_t^A than through a numerical redundancy count.

This point is especially important for automated alerting systems. Copying an alert to many recipients can increase nominal coverage while reducing practical ownership. Section 7 described orphan triggering as activation without effective responsibility. Institutional redundancy should therefore be designed to reduce orphaning without producing responsibility diffusion.

8.5 Preserving Disagreement Through Time

An unresolved inquiry can deteriorate through premature institutional consensus even when its records remain intact. Organizations summarize, standardize, and compress information in order to coordinate action. Those operations can be necessary, yet they can also remove precisely the alternatives that later evidence would make valuable. A minority interpretation may survive as a sentence in an appendix while losing its evidential basis, its conditions of plausibility, and the circumstances under which it should be reconsidered.

Preserving disagreement does not require preserving every objection indefinitely. The principle is narrower: when an alternative remains materially relevant to future discrimination, the architecture should preserve enough of its evidential and argumentative relation to the inquiry that later review can

recover why it remained live. This is a direct institutional extension of judgeability-preserving compression from Section 3.

The relational record $\mathcal{G}_t$ from Equation 5 is useful here. A dissenting interpretation should, where proportionate, remain linked to the evidence it explains, the evidence that challenges it, the version of the dominant interpretation with which it disagrees, and any trigger that would make renewed comparison especially important. Such structure permits later review to distinguish a rejected alternative from a forgotten one.

Institutional dissent also requires relational protection. A review body can preserve dissent on paper while making it professionally costly to maintain, impossible to escalate, or inaccessible to later reviewers. The relations in Λ_t^A can therefore include an independent review or appeal path where stakes justify one. This is not an argument that every disagreement deserves institutional symmetry. It is an argument that the architecture should avoid converting organizational hierarchy into an unrecorded epistemic filter.

There is also a temporal reason to preserve some disagreement. A weak interpretation at t can become stronger after new evidence arrives at t' . If the interpretation and its supporting relations have been erased, the later institution may have to reconstruct the possibility from scratch. Preserved disagreement can therefore function as an option on future interpretation, much as preserved practical reversibility functions as an option on future action.

8.6 Escalation, Authority, and Institutional Reach

Review becomes practically meaningful only when an institution can connect recognition to an actor with adequate competence, authority, resources, or independence. Trigger monitoring and substantive review can be located at one organizational level while consequential action belongs to another. An inquiry can therefore be well monitored and still fail temporally because escalation is slow, ambiguous, politically blocked, or directed to a body that lacks the relevant mandate.

The typed relations Λ_t^A should consequently distinguish several forms of institutional relation that are often collapsed into the phrase “responsible for.” A role can be responsible for observing without being authorized to decide. Another can be authorized to convene review without controlling resources. A third can approve a temporary measure without possessing authority for final closure. Separating these relations helps preserve the distinction, developed throughout this paper, among observation, review, communication, provisional commitment, and stronger action.

Escalation also has a temporal structure. An escalation route can be formally available while becoming practically unusable if its response time exceeds the remaining preservation, reversibility, or action window. The adequacy of an institutional path therefore depends partly on whether its expected operation fits the temporal geometry of the inquiry. A procedure designed for quarterly deliberation can be suitable for a slowly evolving archival question and unsuitable for a rapidly closing safety window.

A useful institutional diagnosis is consequently to ask whether the architecture contains an *escalation mismatch*: a condition in which the inquiry can be recognized and reviewed locally, while the path to a role capable of effective response is slower, narrower, or more fragile than the relevant opportunity set. This diagnosis extends the window-mismatch analysis of Section 6 from actions to organizational reach.

Cross-boundary inquiries make this issue especially visible. Evidence can be held by one institution, affected persons can be located in another jurisdiction, review authority can belong to a third body, and action capacity can depend on a fourth. In such settings, no single institution may possess the entire temporal architecture. The relevant object is the relation among institutions. Handoff, escalation, and record interoperability then become part of temporal judgment rather than merely administrative details.

8.7 Governance-State Handoff

A handoff is often treated as transfer of information. For unresolved inquiry, that description is incomplete. The successor needs enough of the governance state to know what remains unresolved, what has already been tried, which alternatives remain live, which triggers are active or pending, which windows are fragile, and what authority the successor actually possesses.

A minimally adequate handoff therefore carries several linked objects: the surviving inquiry trace $\mathcal{T}_{t'|t}$; the current review-trigger family and activation status; the critical function family and its new assignments; the next scheduled or condition-sensitive review conditions; unresolved disagreements; and any known preservation, reversibility, or action-window constraints. Transferring only the evidential file can preserve historical information while losing the temporal obligations attached to it.

This suggests a distinction between *record continuity* and *governance continuity*. Record continuity concerns whether the relevant trace survives. Governance continuity concerns whether a successor can act on that trace within an architecture that makes review, escalation, and further preservation possible. Both are needed for long-duration accountable waiting.

Handoff also creates a characteristic compression problem. A successor cannot usually absorb every detail possessed by the previous team. The objective is therefore not exhaustive transfer. It is judgeability-preserving and governance-preserving compression: enough structure should survive for the successor to reconstruct the unresolved questions, the live alternatives, the reasons for the present temporal disposition, and the conditions that would warrant changing it. This directly connects institutional handoff to the compression analysis of Section 3.

Handoff quality can also be asymmetric. Technical records may transfer well while tacit understanding of local relations disappears; formal authority may transfer while trust with affected communities does not; a successor may gain analytical expertise while losing access to historical witnesses. These losses should remain visible rather than being hidden by the administrative fact that a file changed custody successfully.

8.8 Institutional Memory, Access, and Selective Forgetting

Long-duration inquiry creates pressure toward accumulation. If future judgeability matters, institutions can be tempted to retain every record, every message, and every monitoring stream indefinitely. The preservation analysis in Section 3 already rejected maximal archiving as a general principle. Institutional memory requires the same restraint.

Some information should expire, be aggregated, be access-restricted, or be deleted because privacy, confidentiality, security, legal requirements, labor conditions, or the interests of affected persons outweigh marginal gains in future reviewability. A mature architecture therefore includes rules for selective forgetting as well as preservation. The relevant standard is whether the remaining structure continues to support the questions and temporal obligations that the institution has reason to retain.

Access control is part of this structure. A record that is preserved but available to everyone can create harms; a record available to nobody can become functionally equivalent to loss. Institutions may therefore need differentiated access, audit trails, custodial separation, or time-limited permissions. These mechanisms affect future judgeability because they shape who can reconstruct the inquiry and under what conditions.

Selective forgetting can also protect inquiry from institutional overreach. A review architecture that justifies indefinite collection because some future trigger might become relevant can turn temporal accountability into permanent surveillance. The proportionality constraints developed in Sections 3 and 7 therefore apply at institutional scale. Memory is an epistemic resource whose acquisition and retention can carry independent normative costs.

8.9 Institutional Failure Modes

The preceding analysis supports a more differentiated taxonomy of institutional failure. *Archive without owner* describes preserved records with no role responsible for future review. *Owner without authority* describes responsibility assigned to a role unable to obtain information, convene review, or escalate action. *Redundancy illusion* occurs when multiple nominal assignees create the appearance of resilience while responsibility is diffused. *Consensus lock-in* occurs when alternatives disappear through organizational compression before the evidence discriminates among them.

Other failures concern temporal reach and continuity. *Escalation bottleneck* occurs when local recognition cannot reach an adequately authorized role within the relevant temporal window. *Handoff amnesia* occurs when records transfer while pending triggers, rationale, dissent, or temporal obligations are lost. *Committee drift* occurs when repeated institutional review changes participants and language while losing a stable account of the unresolved object. *Perpetual review* occurs when an architecture can reopen an inquiry indefinitely but lacks conditions for release, closure, or transfer to a lower-intensity state.

These failure modes illustrate how institutionalization can both preserve and degrade temporal judgment. Formal roles can stabilize memory and authority; they can also encourage responsibility to be inferred from procedure rather than demonstrated in practice. More review bodies can widen perspective; they can also lengthen response paths beyond useful windows. More records can preserve history; they can also obscure the decision-relevant trace. The quality of an architecture therefore depends on the relations among its functions, not simply on the number of controls it contains.

An additional pathology is *institutionalized non-closure*: the organization becomes better at maintaining the inquiry than at revising its temporal disposition. Each review reproduces the conditions for another review, and the existence of an architecture becomes evidence for continued waiting. Accountable waiting therefore needs release conditions as well as preservation conditions. An inquiry can be responsibly closed, downgraded, archived, transferred, or terminated when continued institutional attention no longer has sufficient epistemic, normative, or practical justification.

8.10 Proportional Architecture and Institutional Limits

Institutional formalization should remain proportionate to the inquiry. Formalization has costs: administrative burden, delay, professional defensiveness, disclosure risk, reduced local discretion, and the possibility that procedural compliance substitutes for judgment. A modest scholarly inquiry can be well served by a versioned note, named custodian, clear review condition, and successor instruction. A high-stakes, rapidly evolving, multi-jurisdictional inquiry can require distributed monitoring, independent review, explicit escalation paths, and redundant custody.

The appropriate architecture therefore depends on duration, stakes, expected turnover, fragility of evidence, speed of external change, asymmetry of error, reversibility of action, and the distribution of affected interests. These considerations do not yield a universal formula for institutional design. They identify reasons for increasing or decreasing architectural support.

Institutional design also has limits. Some inquiries lack a proper institutional owner. Others cross domains whose standards cannot be fully harmonized. Authority can remain politically contested. Critical evidence can disappear despite excellent custody. A later generation can reinterpret the problem in terms that the original architecture could not anticipate. The present framework treats institutional architecture as a means of preserving conditions for judgment, not as a mechanism that guarantees correct judgment.

A final limitation concerns power. The institution that controls the record, trigger family, review agenda, and escalation pathway can shape which uncertainties remain visible and which become administratively silent. Preserving disagreement and independent review can mitigate this problem without eliminating it. Temporal accountability should therefore include attention to who can define the architecture, who can contest it, and whose costs of waiting are represented in its design.

Computational systems increasingly participate in retrieval, monitoring, summarization, comparison, and alerting within institutional temporal governance. These functions can strengthen continuity while introducing new provenance, migration, and authority problems. Section 9 examines AI mediation as a support layer within the institutional architecture while retaining accountable authority in the responsibility-bearing roles already defined.

9 AI-Mediated Temporal Judgment

Section 9 examines computational mediation within the temporal architecture developed so far. AI systems can summarize long records, monitor changing environments, compare versions, flag review con-

ditions, retrieve earlier alternatives, generate temporal scenarios, and support handoff across personnel changes. These functions affect temporal as well as informational conditions: they can change the latency of recognition, the accessibility of earlier inquiry states, and the continuity of institutional attention.

Computational mediation also introduces distinctive failure modes. Machine-generated summaries can flatten disagreement; repeated outputs can resemble independent corroboration; automated monitoring can saturate review capacity; model changes can alter longitudinal signals; and continuous machine operation can conceal discontinuity in accountable responsibility. The section places these possibilities inside the existing framework by examining computational support, provenance, compression, alerting, temporal acceleration, model change, and authority. AI is treated as a support layer within temporal governance, not as a separate source of institutional accountability.

This support/authority distinction is compatible with established human–automation work that separates kinds and levels of automation and emphasizes appropriate reliance on imperfect automated systems.[9, 8] The present section does not attempt a general theory of automation or trust. It asks the narrower temporal question of how computational mediation changes preservation, monitoring, review, handoff, and the reconstructibility of those operations over time.

9.1 AI Temporal Support Functions

Section 8 represented institutional temporal governance through the architecture $\mathcal{A}_t^{\text{inst}}$ in Equation 30. AI mediation can be added to that architecture without redefining the underlying functions or transferring responsibility to a machine process.

Let $\mathcal{U}_t$ denote the set of AI-support units, meaning systems or AI-dependent computational processes currently used in the inquiry. This notation is intentionally distinct from $\mathcal{M}_t$ in Equation 1, which denotes methods or operations available for further inquiry. The set can include language models, classifiers, retrieval systems, anomaly detectors, forecasting models, summarization pipelines, or compound workflows in which several systems are connected. Let μ_t assign temporal-governance functions to the AI systems that support them. The support map is stated in Equation 34.

$$\mu_t : \mathcal{F}_t \longrightarrow 2^{\mathcal{U}_t}. \quad (34)$$

Equation 34 is intentionally parallel to the institutional role assignment ω_t in Equation 31, while the two maps have different meanings. The map ω_t records responsibility-bearing institutional roles. The map μ_t records computational support. A function can therefore have machine support, human or institutional responsibility, both, or neither.

AI-mediated temporal architecture can then be represented as the refinement stated in Equation 35.

$$\mathcal{A}_t^{\text{AI}} = \langle \mathcal{A}_t^{\text{inst}}, \mathcal{U}_t, \mu_t, \Upsilon_{\leq t} \rangle. \quad (35)$$

In Equation 35, $\Upsilon_{\leq t}$ is a longitudinal mediation record that identifies materially relevant computational conditions across the history of AI support up to time t . Depending on the system, it can include model or service version, prompt or instruction template, retrieval configuration, data or index version, tool access, threshold settings, timestamp, and other parameters whose alteration could materially change the output. The architecture does not require every low-level technical parameter to be archived. It requires enough of the mediation state to determine what kind of transformation produced a judgment-relevant output and whether later outputs were produced under materially different conditions.

Definition 9.1 (AI-mediated temporal judgment). *AI-mediated temporal judgment* is a temporal inquiry practice in which AI systems materially support preservation, monitoring, comparison, trigger detection, scenario generation, review, or handoff while the evidential status, version history, and institutional responsibility for those operations remain distinguishable.

Definition 9.1 treats AI as part of a historical relation among records, criteria, people, institutions, and changing situations. It does not require a claim about whether an AI system possesses judgment in

Table 10: Illustrative AI-supported functions in temporal inquiry

Function	Possible temporal contribution	Characteristic risk
Record retrieval	Recover prior observations, alternatives, reasons, and versions across a large archive.	Retrieval ranking makes some preserved material practically invisible despite physical retention.
Compression and summarization	Reduce review burden while preserving salient structure for handoff or recurrent review.	Disagreement, uncertainty, provenance, or temporal order is flattened into a stable narrative.
Continuous monitoring	Maintain attention during intervals too long or data-rich for unaided observation.	Alert saturation, silent blind spots, or criterion changes create false reassurance.
Trigger assistance	Flag possible activation of conditions in $\mathcal{B}_t$.	A machine flag is mistaken for a substantive conclusion or action threshold.
Version comparison	Detect changes in evidence, claims, options, models, or institutional state.	Changes in the comparison system itself are mistaken for changes in the monitored object.
Scenario generation	Explore possible option decay, window closure, or consequences of provisional courses.	Plausible generated trajectories acquire forecast-like authority without calibration.
Handoff support	Assemble unresolved alternatives, pending triggers, fragile windows, and next-review obligations.	A coherent summary creates apparent continuity while governance responsibility has actually broken.

a general philosophical sense. The analytical question is narrower: what temporal-governance function does a computational process perform, what transformations does it introduce, and where does accountable authority remain located?

Proposition 9.2 (Support-accountability non-equivalence). *Within the present framework, the existence of machine support for a temporal-governance function does not by itself establish that the function has an accountable institutional bearer. For a function $f \in \mathcal{F}_t$, $\mu_t(f) \neq \emptyset$ and $\omega_t(f) \neq \emptyset$ express analytically different conditions.*

Proposition 9.2 follows directly from the separation of μ_t and ω_t . An automated monitor can operate continuously while no role is assigned to acknowledge or review its alerts. A model can produce a polished handoff summary while no successor has authority to reopen the inquiry. Conversely, a responsible role can exist without using AI. Machine continuity therefore does not, within this architecture, substitute for responsibility continuity.

Table 10 summarizes several temporal functions for which AI can provide support. The table is diagnostic rather than prescriptive. The same system can occupy several rows, and each function can be performed without AI.

The table also illustrates why the architecture, rather than the model alone, is the relevant unit of analysis here. A highly capable model embedded in a weak temporal architecture can accelerate compression, trigger saturation, or responsibility diffusion. A more limited system embedded in a strong architecture can still contribute substantially by reducing search costs, preserving version relations, or maintaining a disciplined alert channel.

9.2 Versioned Mediation and Provenance

Within this framework, accountable AI-mediated temporal judgment benefits from provenance for two different historical objects. The first is the underlying inquiry trace: observations, documents, alternatives, actions, and institutional events. The second is the computational mediation through which some of those traces become ranked, summarized, classified, or compared. Preserving only the machine output can therefore be insufficient even when the output is accurate at the time it is produced.

For a support unit u used at time τ , let $\vartheta_\tau(u)$ denote the materially relevant mediation state of that unit at that time. The longitudinal record in Equation 35 can then be represented as in Equation 36.

$$\Upsilon_{\leq t} = \{ (u, \tau, \vartheta_\tau(u)) \mid \tau \leq t, u \in \mathcal{U}_\tau, \vartheta_\tau(u) \text{ is materially relevant to later interpretation} \}. \quad (36)$$

Equation 36 does not imply that the internal mechanism of a proprietary system must be fully inspectable before its output can be used. It identifies a weaker requirement for temporal accountability: later review should be able, where materially relevant, to distinguish outputs produced by different model versions, retrieval corpora, prompts, thresholds, or tool configurations. Without such distinctions, a longitudinal record can combine machine outputs whose semantics or operating characteristics changed silently.

This problem is especially important for repeated monitoring. Suppose an institution asks the same nominal question each week while the underlying model, retrieval index, or classification threshold changes. Similar labels across time can create an appearance of measurement continuity; different labels can create an appearance of environmental change. Neither inference is secure when the mediation state is unrecorded. Longitudinal comparison therefore benefits from version-aware interpretation and, where stakes justify it, overlap periods or recalibration when the computational support layer changes materially.

The same principle applies to generated rationales. A model can produce a later explanation that reconstructs why an earlier alert might have mattered. Such an explanation belongs to the later epistemic resources $\mathcal{L}_{t'}$ unless it was actually available at the earlier time. It should not silently become part of the contemporaneous record $\mathcal{R}_t$. This distinction preserves the separation between earlier trace and later knowledge developed in Section 3.

A second provenance problem arises from correlated machine mediation. Repeated outputs from the same model family, shared retrieval corpus, or recursively generated synthetic material can appear to provide independent confirmation while inheriting a common source. The temporal dimension can make this especially misleading. A similar conclusion generated on ten review dates may look like accumulating evidence even when each output primarily reprocesses the same underlying material. Repetition through time therefore does not by itself establish evidential independence.

Prospective records should consequently distinguish at least three categories where they materially affect review: new external observations, newly retrieved but previously existing material, and newly generated machine interpretations. This distinction allows an institution to recognize genuine information gain separately from repeated computational restatement.

9.3 AI-Mediated Compression and Future Judgeability

Section 3 introduced judgeability-preserving compression because complete retention is neither feasible nor desirable. AI can make such compression much more powerful. Long deliberations can be summarized, similar documents clustered, changes highlighted, and unresolved alternatives extracted automatically. These operations can enlarge practical access to a large archive. They can also create a new risk: the derived summary becomes easier to retrieve than its sources and gradually functions as the institution's effective memory.

To make this distinction explicit, let $\mathcal{Z}$ be any candidate trace presented to a later reviewer. A trace-relative version of the judgeability profile is stated in Equation 37.

$$\mathfrak{J}_{t \rightarrow t'}(\mathcal{Q}_t \mid \mathcal{Z}) = \{ q \in \mathcal{Q}_t \mid q \text{ remains responsibly reassessable at } t' \text{ from } \mathcal{Z} \text{ together with } \mathcal{L}_{t'} \}. \quad (37)$$

Equation 37 refines rather than replaces Equation 4. The earlier definition is recovered when $\mathcal{Z} = \mathcal{T}_{t'|t}$. The refined notation is useful when comparing a surviving source trace with an AI-produced summary, index, or transformed representation.

Let an AI system m produce a derived trace $\hat{\mathcal{T}}_{t'|t}^m$ from the surviving trace under a recorded mediation state. For a specified family of later questions $\mathcal{Q}_t^* \subseteq \mathcal{Q}_t$, replacement of the source trace by the derived trace is judgeability-preserving only when the equality in Equation 38 holds.

$$\mathfrak{J}_{t \rightarrow t'}(\mathcal{Q}_t^* | \hat{\mathcal{T}}_{t'|t}^m) = \mathfrak{J}_{t \rightarrow t'}(\mathcal{Q}_t^* | \mathcal{T}_{t'|t}). \quad (38)$$

Equation 38 expresses a demanding condition because it concerns *replacement*. AI summaries used as interfaces need not satisfy it when the source trace remains available and the summary preserves links that permit retrieval of the underlying material. This distinction between *interface compression* and *replacement compression* is important. Interface compression can be aggressively selective when omissions remain visible and reversible through source access. Replacement compression carries a stronger burden because discarded distinctions may become unrecoverable.

Claim 9.3 (Accessibility and preservation are non-equivalent). AI-mediated summarization or retrieval can improve practical access to an archive while decreasing future judgeability if the derived representation becomes a substitute for source traces whose provenance, disagreement, or temporal structure it does not preserve.

Claim 9.3 identifies a temporal form of summary lock-in. An institution can become progressively more efficient at retrieving a compressed narrative while losing the capacity to inspect how that narrative was produced. The result can look like improved institutional memory because answers arrive faster and more consistently. From the perspective of future judgeability, however, the memory can have narrowed.

A robust AI-assisted archive therefore benefits from source-linked summaries, explicit versioning, visible uncertainty, and the preservation of material alternatives where later reassessment is plausible. It can also preserve records of selection itself: which documents were excluded from a summary, which retrieval query was used, which model version produced a synthesis, and whether a later revision superseded rather than overwrote an earlier one. These requirements should remain proportional. A routine low-stakes summary does not require forensic reconstruction of every token; a high-stakes institutional deferral can justify much stronger traceability.

9.4 Machine Alerting and Review Triggers

AI can also support the trigger family $\mathcal{B}_t$ introduced in Section 7. Some trigger conditions can be evaluated directly from structured data. Others involve open-ended text, anomaly detection, distributed evidence, or changing contextual relations for which machine assistance can expand monitoring capacity. The central distinction is that a machine alert and a review-trigger determination occupy different epistemic statuses.

For a system $m \in \mathcal{M}_t$, define its machine-alert profile at time τ as stated in Equation 39.

$$\hat{\mathfrak{B}}_{t \rightarrow \tau}^m(\mathcal{B}_t) = \{\beta \in \mathcal{B}_t \mid m \text{ flags } \beta \text{ for review at } \tau\}. \quad (39)$$

Equation 39 is deliberately marked with a hat. It is an AI-produced candidate profile. It should not be identified automatically with the active-trigger profile $\mathfrak{B}_{t \rightarrow \tau}$ defined in Section 7. The distinction permits sensitive machine monitoring while preserving the conceptual boundary between alert generation and accountable review.

A useful architecture can therefore employ different thresholds at different stages. A machine system may use a relatively sensitive alert criterion because the cost of internal review is low. The responsible review process can then apply the domain's evidential and institutional standards before concluding that a trigger condition is active. Communication or intervention can require still stronger conditions. This layered arrangement continues the paper's earlier distinction among review, belief, communication, and action thresholds.

AI mediation can nevertheless change the cost structure of triggers. When candidate alerts become cheap, institutions can generate more of them than human reviewers can assess. Trigger saturation then

becomes an architectural rather than merely technical failure. A highly sensitive detector that produces an unreviewable volume of alerts can reduce temporal responsiveness by increasing acknowledgment and substantive-review lags. The relevant performance measure is therefore end-to-end preservation of review capacity, not model sensitivity in isolation.

Machine alerting can also produce *automation orphaning*. An alert is generated and stored, yet no responsibility-bearing role acknowledges it because institutional actors assume the system or another team is handling escalation. Proposition 9.2 explains why this failure persists even when the technical monitoring pipeline operates exactly as designed.

A second risk is criterion drift. A trigger can appear formally unchanged while the system used to operationalize it evolves. A language model may classify a category differently after an update; a retrieval system may index new sources; an anomaly detector may be recalibrated. Where such changes can alter trigger frequency or meaning, the relevant mediation state $\vartheta_\tau(u)$ becomes part of the trigger's version history. Temporal accountability is strengthened when later review can reconstruct both the nominal criterion and the computational transformation through which the criterion was evaluated.

9.5 Temporal Acceleration, Horizon Distortion, and Scenario Generation

AI systems can accelerate several stages of temporal inquiry. They can reduce search time, maintain continuous observation, compare versions rapidly, and prepare recurrent review packets with little marginal effort. Acceleration can enlarge an action window when faster analysis allows epistemic readiness to arise before practical viability disappears. It can also reduce the cost of maintaining low-intensity attention to an unresolved problem.

Temporal acceleration has limits. Faster production of candidate interpretations can move attention toward what is quickly machine-processable and away from slow-forming evidence, tacit knowledge, difficult field observation, or relationships whose significance becomes visible only across longer historical intervals. The result can be *horizon distortion*: the temporal architecture becomes highly responsive to fast, legible change while becoming less capable of retaining slow, ambiguous, or weakly digitized processes.

This problem is related to the distinction between information generation and information recognition. A model can rapidly generate hypotheses about how an option window might close, but the existence of a generated scenario does not establish that the corresponding transition is likely. Scenario generation belongs to the construction of possible temporal courses π unless empirical calibration supports stronger predictive interpretation.

AI-assisted comparison of temporal courses can nevertheless be valuable. A system can enumerate plausible consequences of waiting, identify which options depend on fragile conditions, search for historical analogues, or reveal that several proposed actions share a common irreversible commitment. Such outputs can enrich the families $\mathcal{D}_t$, $\mathcal{O}_t$, $\mathcal{C}_t^{o,*}$, or $\mathcal{B}_t$ used in earlier sections. Their status should remain explicit: generated alternatives expand the field of judgment; they do not acquire evidential weight merely through fluency or quantity.

The same distinction matters for simulated action windows. A model may estimate when a legal, technical, or organizational opportunity will close. Unless the estimate is grounded in a calibrated domain model or externally supported constraints, it should be treated as a scenario or heuristic rather than a measured window. Temporal judgment can use such scenarios to identify what information would matter, what preparations are reversible, or what trigger should be monitored without converting speculative timing into false precision.

A further temporal risk arises from repeated machine-generated forecasting. Earlier forecasts can alter later attention, resource allocation, public communication, or data collection. Those interventions change the environment from which later evidence is drawn. AI-mediated temporal judgment is therefore potentially reflexive. A monitoring system can participate in producing the pattern it later appears to confirm, especially when many actors respond to similar recommendations. Prospective records should preserve enough of this intervention history to distinguish external development from feedback generated

by the monitoring architecture itself.

9.6 Model Change and Long-Horizon Continuity

Institutional waiting can outlast the useful life of any particular AI system. Models are retired, services change, retrieval indices are rebuilt, interfaces disappear, and access conditions shift. For long-horizon temporal judgment, dependence on the continued availability of one opaque computational service creates a continuity risk that should be made explicit and, where proportionate, reduced.

The relevant continuity object is the temporal-governance function, consistent with Proposition 8.2. A new system can functionally replace an earlier system for the purposes of this framework when the required temporal-governance function remains supported and the transition preserves enough provenance to interpret material longitudinal differences. Conversely, retention of the same nominal product or vendor does not establish continuity when its internal behavior changes materially.

For a critical AI-supported function $f \in \mathcal{F}_t^*$, a handoff across systems should therefore preserve at least the functional specification, relevant source traces, output lineage, trigger or classification criteria, known limitations, and the relation between the old and new mediation states. Where direct comparison matters, an overlap period can be useful: both systems operate on a bounded common sample so that differences can be inspected before the older process disappears. This is an architectural option rather than a universal requirement.

Where continuity would otherwise depend on a particular computational service, an explicit exit or migration path can materially strengthen the architecture. A temporal architecture that can function only while a specific model provider, proprietary memory store, or inaccessible embedding index remains available contains a hidden option-decay problem of its own. Exportable records, stable identifiers, source retention, and documented transformations can preserve the possibility of migration. The same logic that Section 4 applied to provisional commitments therefore applies to computational infrastructure: a useful AI integration can still be poorly designed when its removal destroys the institution's capacity to reconstruct or continue the inquiry.

This point is especially important for conversational systems. A long conversation can feel like persistent institutional memory because the interface can retrieve prior content and produce coherent continuity. That practical experience should be distinguished from an archive whose retention, versioning, access control, and export conditions are known. High-stakes temporal inquiry benefits when judgment-relevant records are externalized into an auditable record system rather than relying solely on the apparent memory of a conversational interface.

9.7 Authority, Distribution, and Temporal Pathologies

Temporal judgment mediated by AI remains subject to the normative constraints developed throughout the paper. Faster review, broader monitoring, and stronger memory can benefit some actors while increasing surveillance, documentation burden, information asymmetry, or institutional power over others. An architecture that preserves the decision maker's optionality through continuous monitoring can simultaneously reduce the privacy or autonomy of the people being monitored. Computational capacity therefore does not remove the proportionality constraints on preservation and review.

Authority requires similar care. An institution may permissibly delegate routine classification, summarization, or alerting to automated systems while retaining responsibility for the criteria, escalation rules, and consequences. More consequential delegations require stronger attention to contestability and review. A person affected by an AI-supported temporal disposition may need to know that a machine-supported process materially shaped delay, escalation, communication, or release, especially when that mediation changes access to rights, resources, or institutional remedies. The appropriate disclosure requirement is domain-specific, but accountability becomes weaker when consequential mediation cannot be reconstructed or contested.

Several recurring pathologies can now be stated. *Summary lock-in* occurs when a generated synthesis becomes the practical archive and its source disagreements disappear from routine view. *Synthetic conti-*

nuity occurs when uninterrupted machine output creates an appearance of institutional continuity despite broken responsibility, custody, or authority. *Alert saturation* occurs when automated sensitivity exceeds the institution's capacity for meaningful review. *Automation orphaning* occurs when machine outputs have no effective responsibility bearer. *Version drift* occurs when changing computational mediation alters the meaning of longitudinal comparisons without an adequate record.

A second group concerns evidential and temporal interpretation. *Correlated corroboration* occurs when repeated or multiple machine outputs are treated as independent support despite shared sources or model lineage. *Horizon narrowing* occurs when fast, machine-readable processes dominate slower or less digitized temporal evidence. *Scenario reification* occurs when generated possibilities acquire forecast-like status without sufficient calibration. *Reflexive confirmation* occurs when AI-supported monitoring changes behavior or data collection in ways that later appear to confirm the original machine-supported interpretation.

These pathologies call for differentiated safeguards. Some are easier to mitigate through computational design; others require institutional safeguards, independent review, source preservation, or narrower deployment. Evaluation remains functional and relational: AI mediation should be assessed by whether it preserves or improves the conditions for future judgment, timely review, revisability, and accountable action relative to the inquiry's stakes and constraints.

A particularly useful design principle follows from the distinction between support and authority. Within some domains, AI support may be assigned more broadly to reversible intermediate operations than to irreversible or rights-affecting closure, because the acceptable error and review architecture can differ across those stages. Candidate generation, document clustering, source-linked summarization, and low-cost internal alerting can tolerate a different error profile from public accusation, coercive intervention, permanent record alteration, or termination of an inquiry. The architecture can therefore assign machine mediation asymmetrically across the temporal course rather than accept or reject automation as a whole.

AI mediation adds a final reflexive layer to the analysis: the systems that support temporal judgment can themselves become history-bearing objects of preservation, comparison, migration, and review. The conclusion integrates these components and states the limits of the preliminary proposal.

10 Conclusion

This paper developed a preliminary framework for temporal judgment in inquiries that remain unresolved while the conditions of later judgment and action continue to change. Its central object is the organization of non-closure: how evidence, interpretations, records, options, responsibilities, and external conditions evolve during periods in which stable closure remains premature.

10.1 Integrated Architecture

The analysis begins with accountable deferral. Deferral can withhold a specified form of closure while observation, preservation, preparation, communication, or provisional action continues elsewhere in the inquiry. Epistemic, practical, communicative, and institutional thresholds can therefore occupy different temporal states.

Future judgeability adds a preservation requirement. Later observers may know more about eventual outcomes while knowing less about what was available, considered, or reasonably inferable earlier. Responsible reassessment depends on the survival of relevant traces, relations, alternatives, provenance, and temporal order. Preservation remains selective and proportional because privacy, rights, security, cost, and unforeseeable future relevance constrain what can reasonably be retained.

Provisional commitment adds the problem of later revision. In a history-bearing inquiry, acting changes the state from which revision occurs. Reversibility is therefore represented as feasible recovery of prospectively protected capacities, relations, options, or admissible conditions through revision

paths. Practical reversibility and historical reconstructibility remain separate capacities: an action can be materially easy to revise yet poorly documented, or thoroughly documented yet difficult to undo.

The framework then tracks the coupled dynamics of epistemic discrimination and practical optionality. Continued inquiry can improve discrimination while meaningful options contract; preparation or provisional action can preserve options while changing the evidential field. Action opportunity is defined more narrowly by the overlap between practical viability and the epistemic conditions specified for a response. A missed opportunity consequently does not establish that earlier action was warranted. In some cases, the relevant readiness and viability sets never overlap.

Review-trigger architecture and institutional continuity govern this changing temporal state. A trigger makes reconsideration due without settling the substantive answer. Institutional continuity is functional rather than personal: memory, custody, authority, dissent, escalation, and handoff must remain connected well enough for review to have practical effect. AI can support many of these functions, while accountable authority remains with responsibility-bearing institutional roles. Computational versions, transformations, summaries, and alerts can themselves become historically relevant objects of provenance and review.

10.2 Non-Scalar Coordination

Several central objects remain set-valued because they can involve heterogeneous criteria without a defensible common scale. Future judgeability, reversibility, epistemic discrimination, viable options, active triggers, and functional continuity are therefore represented as profiles rather than collapsed into a universal score for readiness, urgency, or temporal responsibility.

This formal choice leaves room for stronger quantitative methods where a domain supplies justified probabilities, utilities, thresholds, or transition models. The present framework operates at a more preliminary level when objects, criteria, values, or authorities remain partly specified, contested, changing, or institutionally distributed. Its role is to expose relevant temporal structure before a more specialized model is selected.

The resulting comparisons are local and criterion-relative. One temporal course may dominate another relative to a stated option family, discrimination family, and horizon while remaining inferior on a right, duty, value, or consequence outside that representation. An action window can be open under one evidential standard and closed under another. Functional continuity can persist while substantive judgment remains poor. The formalism is informative only when these scope conditions remain visible.

10.3 Analytical Scope and Limits

The framework supplies no substantive standard for truth, evidential sufficiency, ethical permissibility, legal authority, distributive justice, or acceptable risk. Such standards enter from the relevant domain. Temporal judgment organizes relations among those judgments through time; it does not replace them.

The proposal also remains limited in several respects. Most formal objects are reconstructive rather than empirically calibrated, so the paper does not estimate the prevalence or causal importance of particular temporal pathologies. Preservation, recurrent review, redundancy, monitoring, and provenance can impose material costs and can themselves create surveillance, bureaucracy, or delay. Strategic environments can include actors who manipulate signals, deadlines, records, or trigger conditions. Collective inquiries can contain disputes over who has authority to define the question, criterion family, or protected option set. AI-mediated inquiry adds technical and institutional dependencies whose governance exceeds the present architecture.

The strongest claims of the paper are therefore structural distinctions internal to the representation, such as the separation between practical reversibility and record preservation, or between review activation and substantive closure. Claims about what a particular institution should preserve, when it should act, or which architecture is proportionate remain conditional on domain-specific evidence and normative standards.

10.4 Research Programme

Several lines of further work follow from these limits. Empirical reconstruction could compare inquiries that matured, decayed, or lost action opportunities and test whether the proposed distinctions improve explanation. Domain-specific studies could operationalize preservation windows, revision criteria, trigger families, and handoff requirements in areas such as science, public administration, safety, diplomacy, or technology governance. Formal work could examine when the set-valued relations admit principled partial orders, sensitivity analyses, or domain-specific optimization without erasing non-commensurable constraints.

Institutional research could study the interaction of temporal accountability with organizational memory, turnover, distributed authority, and strategic behavior. Educational research could examine how researchers and decision makers learn to recognize when a question should be preserved, probed, provisionally acted upon, or released. AI-focused research could assess whether computational support improves long-horizon judgeability and responsiveness in practice, and under what arrangements for provenance, contestability, migration, and human responsibility.

10.5 Programme Continuity

Within the wider contingency-and-judgment programme, this paper addresses the interval after significance has been recognized but before stable closure is warranted. Earlier papers examined problem formation and judgment under partial manifestation. The present framework adds the temporal governance of the unresolved interval: preservation of later judgeability, revisable commitment, changing optionality, action opportunities, review, institutional continuity, and computational mediation.

A later synthesis can integrate these stages into a broader practical epistemology of contingency. The more limited conclusion established here is that unresolved inquiry has a temporal architecture whose quality depends partly on what is preserved, what remains revisable, what is allowed to expire, when reconsideration occurs, and whether later observers can reconstruct the reasons for those temporal choices.

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