MCRP: A Prospective, Claim-Versioned Verification Lifecycle for Computational Research

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Abstract

Computational research is often published as a narrative article accompanied by a repository, an environment description, and selected data or outputs. These materials can support inspection and rerunning, but they do not by themselves identify which execution supports each material claim, what transformations intervene between source data and reported values, which dependencies remain trusted rather than re-examined, or which human judgments were required for acceptance. Agentic tools make this distinction more consequential: an agent can reconstruct environments, execute workflows, compare outputs, and assemble provenance, yet a successful automated run cannot establish scientific validity.

We propose the Minimum Credible Reproducibility Protocol (MCRP), a prospective protocol for constructing and reviewing an immutable Scientific Record Release. MCRP treats material claims, evidence, outputs, executions, workflow definitions, configurations, environments, source artifacts, and declared trust dependencies as versioned review objects. Verification is externally enforced: author-controlled execution may contribute evidence, but conformance requires a verifier operating under a separately recorded authority, and scientific acceptance remains bound to qualified human judgment. Any material change creates a new release identity and requires affected checks and decisions to be re-established. MCRP also separates assurance from resource burden through a multidimensional resource profile and distinguishes full, slice, checkpoint, and witness assessment modes.

This revision decomposes the inherited mechanisms and proposed lifecycle rules, specifies claim-scoped assurance and resource reporting, and formalizes change propagation and conservative carry-forward. A complete worked assurance profile, resource-reporting template and bounded RO-Crate 1.2 transport example make selected rules executable without claiming general interoperability. We withdraw unrecoverable historical test counts and provide a separate itemized rerun of 20 public prototype tests, plus executable revision-semantics counterexamples. These synthetic checks do not establish independent scientific sign-off, real-workflow performance, or improved review outcomes. We give falsifiable comparisons against simpler review packages and present MCRP as a testable policy proposal.

1. Introduction

Scientific review has always depended on more than the visible article. A computational result may inherit assumptions from source data, calibration, preprocessing, numerical libraries, external services, workflow engines, and domain-specific interpretation. Reproducibility initiatives have made many of these dependencies more inspectable. Open review systems expose reviewer–author exchanges; executable research objects package code, data, and environments; provenance standards describe entities, activities, and agents; and independent execution services record whether identified computations can be run (Smith et al. 2018; Rougier et al. 2017; Nüst and Eglen 2021; World Wide Web Consortium 2013; RO-Crate Community 2025; Leo et al. 2024). These practices address different parts of the research record and should not be collapsed into a single undifferentiated badge.

Agentic systems can help assemble and inspect this record. Published systems already demonstrate multi-step planning, specialized retrieval tools, structured observations, citation-linked synthesis, workflow reconstruction, and automated reproducibility assessment (Grabowski et al. 2026; Riehl et al. 2026). The appropriate conclusion is not that agents can replace scientific reviewers. It is that agents can perform bounded, attributable operations inside a review process whose authority, evidence requirements, and failure states are explicit.

The practical problem addressed here is version binding. A repository link can move. A workflow may be repaired during review. A figure may be rerendered from stored values without recomputing the analysis. A provenance graph may be structurally

valid while omitting a manual transformation or mutable service. An author-controlled agent may both produce a result and declare that the result passed. In each case, useful evidence exists, but its scope and authority can be unclear.

MCRP is a prospective protocol intended to make those boundaries inspectable. A research team declares material claims and their evidence paths before a candidate release is accepted. Machine checks and external execution are bound to the exact candidate identity. Qualified humans separately judge whether the data, methods, assumptions, uncertainty treatment, and interpretation warrant the claims. The accepted object is an immutable Scientific Record Release rather than a mutable branch or an unversioned project page. Subsequent changes, dependency drift, or failed re-execution produce explicit new states; they do not silently rewrite the historical record.

This supplement documents a bounded proposal. It defines the review object, the externally enforced lifecycle, assessment modes, resource description, trust boundary, and freshness behavior. It does not claim that claim–evidence graphs are new, that MCRP improves reviewer performance, or that the present reference implementation is scientifically conformant. No comparative study has measured defect detection, claim coverage, reviewer effort, or reviewer agreement under MCRP against simpler review packages; those outcomes remain evaluation targets.

2. Established foundations and the remaining design problem

MCRP builds on established review and execution practices rather than replacing them. JOSS uses transparent, issue-based human review supported by automated repository checks (Smith et al. 2018). ReScience C asks independent reviewers to run an implementation and judge reproduction or replication by domain standards (Rougier et al. 2017). CODECHECK records independent execution of identified computations without claiming to investigate or repair the science (Nüst and Eglen 2021). The ACM artifact policy separately labels availability, artifact quality, and result validation (Association for Computing Machinery 2020). These precedents already establish that execution evidence and scientific judgment are related but distinct review products.

Claim and evidence graphs are also established. Micropublications represent machine-readable claims, evidence, methods, attribution, support, challenge, disagreement, and transitive evidence closure (Clark et al. 2014). Nanopublications bind an atomic assertion to separate provenance and publication-information graphs, supporting attribution and persistent publication (Kuhn et al. 2018). EVI goes further by extending PROV with defeasible assertions about results, data, methods, and software; a result can have a supporting directed acyclic graph of computations, software, data, and agents, with support and challenge propagated through that graph (Al Manir et al. 2021). MCRP therefore makes no priority claim for claim nodes, evidence edges, support/challenge semantics, immutable atomic records, or graph-shaped computational justification.

Execution and agent provenance are likewise occupied territory. W3C PROV defines entities, activities, agents, derivation, generation, attribution, association, roles, and delegation (World Wide Web Consortium 2013). RO-Crate and Workflow Run RO-Crate package research objects and workflow-run context, including inputs, outputs, software, versions, status, errors, and responsible human agents (RO-Crate Community 2025; Leo et al. 2024). CWLProv captures content-addressed workflow inputs, outputs, and provenance traces (Khan et al. 2019). PROV-AGENT extends PROV to prompts, responses, decisions, human and peer-agent interactions, MCP tools, and downstream workflow outcomes, with near-real-time capture and evaluation across facilities (Souza et al. 2025). MCRP should profile or export these representations rather than create incompatible substitutes.

The closest execution-level collision is Paper-replication, which treats selected paper claims as replication targets and links generated outputs, execution records, provenance, comparison rules, and report coverage. Its persistent workspace and external validation gates determine completion rather than accepting an agent's assertion. The reported evaluation includes twelve runs and 158 recorded targets (Hans and Bilionis 2026). This already realizes much of the broad claim-to-execution-to-report path and external completion checking that could otherwise be attributed to MCRP.

Traxia is the closest collision for broad agent-native publication and review. It proposes signed agent identities, reasoning traces, claim confidence, immutable contribution logs, tiered peer review, human–agent collaboration, reputation, and contradiction detection; its paper reports architectural foundations and a partial prototype rather than empirical validation (Dogah 2026). MCRP consequently makes no priority claim for agent identity, signatures, immutable contribution records, staged review, or contradiction handling. A signature establishes integrity and signer identity, not scientific adequacy or reviewer independence.

The residual MCRP proposal is narrower: a **prospective, externally enforced, claim-versioned lifecycle**. Before execution, a candidate fixes claim-scoped acceptance predicates and required approver roles. A claim transition may then depend on immutable run evidence and a separately authorized check. Approvals are scoped to a release and affected claims; declared dependency changes invalidate the decisions they can reach. Records should export to established claim, provenance, and research-object standards. This lifecycle is an object for evaluation, not a demonstrated improvement and not a claim that its

constituent graph or review mechanisms are new. Full conformance crosswalks for EVI, Micropublications, Nanopublications, PROV-AGENT, and RO-Crate have not been completed. Section 8.1 now supplies one bounded RO-Crate 1.2 field-preservation example; it does not claim complete conformance or independent interoperability. MCRP also has not been compared directly with Paper-replication or Traxia on prospectively fixed acceptance, mutation-driven invalidation, interruption recovery, independent authorization, false completion, or stale-claim transitions.

2.1 Decomposing the design contribution

The contribution is a lifecycle policy assembled from established mechanisms. Table 1 distinguishes inheritance, adaptation, and decisions made by this proposal. "Proposed" identifies our specified choice, not evidence of first invention; the comparison is not an exhaustive novelty search. A feature absent from the table's description of a neighboring system must not be read as proven absent from that system.

Mechanism	Established source or practice	Status in MCRP	Specific policy commitment evaluated here
Claim–evidence graph with support and challenge	Micropublications and EVI (Clark et al. 2014; Al Manir et al. 2021)	Adopted	Material claims name scoped acceptance predicates and required decisions; the graph alone is not the contribution.
Entity, execution, attribution, and derivation records	PROV-O (World Wide Web Consortium 2013)	Adopted	Bind each decision to the exact claim and release under review.
Packaged research objects and run context	RO-Crate and Workflow Run RO-Crate (RO-Crate Community 2025; Leo et al. 2024)	Adopted representation target	Preserve claim scope and decision state across exports; general and independent-consumer compatibility remains unimplemented; Section 8.1 supplies a bounded self-round-trip example.
Content identities and version-specific archival records	CWLProv, Nanopublications, and archive versioning (Khan et al. 2019; Kuhn et al. 2018; Zenodo, n.d.)	Adopted	A material edit creates a successor; historical acceptance is immutable.
Independent execution and external completion checking	CODECHECK and Paper-replication (Nüst and Eglen 2021; Hans and Bilionis 2026)	Adapted	Fix claim-level predicates prospectively and require a recorded authorization boundary for verification.
Execution distinct from scientific judgment	CODECHECK and artifact-review practice (Nüst and Eglen 2021; Association for Computing Machinery 2020)	Adopted distinction	Machine outcomes cannot populate the qualified human disposition field.
Dependency-triggered reconsideration	Graph propagation and versioned provenance are established; EVI supplies defeasible evidence relations (Al Manir et al. 2021)	Adapted into lifecycle rules	Mark reachable decisions pending; permit carry-forward only after an unchanged-claim mapping and separately authorized scope-delta disposition.
Assurance together with bounded assessment coverage	Artifact policies motivate separate review products (Association for Computing Machinery 2020)	Proposed profile and assignment rules	Report claim-specific predicates, currentness, mode, and coverage before any aggregate label.
Resource envelope separate from assurance	Established compute, storage, access, and labor accounting	Proposed composite disclosure profile	Report workload-specific measured or estimated burdens without treating expense as evidence strength.

The incremental research question is consequently whether this combination of prospective predicates, exact-version authority, and conservative change handling improves review decisions relative to equally informative simpler packages. A positive result would establish usefulness of the tested policy, not novelty of its constituent graph, signature, archive, or review mechanisms.

3. Operational vocabulary

MCRP separates five properties that are often described with the single word "reproducible." **Rerenderability** means regenerating a presentation from saved derived values. **Computational repeatability** means rerunning the declared workflow with the same identified inputs and materially equivalent setup. **Computational reproducibility** requires a non-author to reconstruct and execute the identified workflow under reviewer control. **Independent replication** tests the scientific proposition with a materially independent implementation, dataset, measurement, or experimental realization. **Scientific validity** is the qualified judgment that a claim is warranted under its stated scope, assumptions, uncertainties, and domain standards. This vocabulary follows distinctions used by artifact-review and reproduction communities while making the weak rerendering case explicit (Association for Computing Machinery 2020; Rougier et al. 2017).

No one property implies all stronger properties. Bitwise-identical figures may be rerendered from unsupported values. A reproducible computation may implement a biased method. An independent replication may disagree for reasons that require further scientific interpretation. MCRP records orthogonal outcomes such as `schema-valid`, `artifacts-resolved`, `workflow-executed`, `outputs-match`, `claim-covered`, `human-methods-approved`, and `fresh-as-of`. It does not reduce these outcomes to a universal green check.

4. The Scientific Record Release

The unit of review is an immutable **Scientific Record Release** (SRR). An SRR resolves to a claim manifest; artifact and provenance manifests; source, workflow, configuration, and environment descriptions; acceptance tests; trust and access declarations; execution and review records; licenses; resource descriptions; and an archival identity. The candidate may change during review, but acceptance binds to one exact digest and release identifier. A later material change creates a successor SRR.

Each material scientific claim receives a stable identifier within the release. A material claim is one whose removal or revision would change a principal result, interpretation, abstract, conclusion, or safety statement. Its record states the exact text and scope, claim type, supporting or contradicting evidence, claim-bearing values or artifact fragments, producing executions, comparison criteria, uncertainty model, assumptions, limitations, and required reviewer roles. Evidence relations are typed—for example, `supports`, `calibrates`, `bounds`, `contradicts`, or `contextualizes`—so a contextual citation cannot silently become derivational support.

The review graph must be traversable in both directions. A reviewer can move from a claim to evidence, outputs, execution, workflow, configuration, environment, and source inputs. A dependency update or failed artifact can be traced forward to every output and claim reachable through declared propagating dependencies. Omitted dependencies may remain undetected. Derivation edges must be acyclic, although citation and interpretation links may form cycles when their types are explicit.

Artifacts are classified as raw, intermediate, derived, or presentation objects relative to a declared custody boundary. "Raw" does not mean metaphysically original; it means earliest available within the record. If the workflow begins with provider-calibrated data, that boundary and provider process remain declared trust leaves. Each included object has a content digest, schema or media type, role, size, acquisition or creation time, custodian, access status, and resolver. For an external or restricted object that cannot be hashed directly, the release records the strongest available version identity and the resulting loss of inspectability.

This graph is not asserted to be a new data structure. Its role in MCRP is normative: material claims block acceptance when required paths, identities, tests, or human dispositions are missing. The sufficiency and usability of the proposed required fields have not been evaluated across scientific domains; multi-domain trials are required before treating the present field set as a credible common profile.

5. An externally enforced lifecycle

MCRP's central position is that verification authority must be distinct from author-controlled production. Separation need not imply a particular institution or service. It means that the verifier's identity, policy, execution boundary, permissions, and result are recorded independently of the process that produced the candidate claim.

5.1 Candidate construction

Authors assemble a candidate SRR and declare its claim scope. Author-run tests, logs, and attestations are admissible evidence, but they remain author evidence. The candidate includes expected results and tolerances fixed before the verifier's run, meaningful scientific invariants, and negative or adversarial controls. Silent repairs are prohibited: if a reviewer or agent modifies code, configuration, data, or environment, the patch is preserved and the candidate receives a new identity.

5.2 Admission and machine checks

An external gate resolves the candidate digest and validates schemas, unique identities, graph reachability, artifact digests, observable undeclared inputs and outputs within a named instrumented boundary, acceptance criteria, and freshness policy. Dependencies outside that boundary—including uninstrumented services, manual transformations, and silent upstream processes—remain trust leaves or omissions rather than machine-detectable facts. The gate must fail closed when a required object cannot be resolved. A structurally valid record can still fail later scientific review; admission only establishes that the declared review object is inspectable enough to proceed.

5.3 Reviewer-controlled execution

Where the assessment mode permits execution, a non-author verifier reconstructs the declared environment and runs the claim-bearing workflow or its explicitly bounded surrogate. The execution record captures inputs, source and configuration identities, runtime and dependency state, compute context, external services, timestamps, logs, outputs, and comparison results. Agent assistance is allowed for installation, inventory, execution, comparison, and discrepancy reporting, but every action that changes the candidate is attributable and reviewable.

Operational independence profiles

Independence has at least three distinct coordinates: **decision control**, **execution custody**, and **scientific failure modes**. A different account, session, model, or signature establishes none of these by itself. The following are candidate implementable profiles, not validated governance arrangements.

Every profile must record: (i) candidate producers and controlling principals; (ii) the separately accountable verifier and authorization source; (iii) who can change acceptance policy and who controls the verification environment and result record; (iv) disclosed financial, supervisory, collaboration, and reciprocal-review relationships; and (v) a conflict disposition under a policy fixed before review. The author cannot unilaterally replace a refusal or failure with a passing verifier record. Changing the candidate requires a new digest and attributable patch.

Setting	Feasible candidate arrangement	Minimum observable evidence	Remaining limitation
Small collaboration	A researcher outside the candidate's author group accepts a bounded review; one competent person may perform both execution and scientific review as separately recorded acts.	That reviewer independently retrieves the identified candidate, controls the verification run or declared witness inspection, records conflicts, and issues their own dated result.	A personal relationship or reciprocal favor may still bias judgment; separate control does not demonstrate independent scientific errors. If nobody meets the policy, report author evidence and pending external review.
Community service	A service-appointed maintainer or reviewer operates a separately administered runner and disposition record.	Assignment and conflict decisions, versioned service policy, runner custody, actual execution evidence, and independent result publication are inspectable. Authors cannot write the service result or choose only a favorable result from the declared batch.	Service governance, funding pressure, shared dependencies, and attempts outside the recorded batch remain possible failure sources.
Institution	A review unit delegates a named assessor under documented separation from the producing project's approval chain.	The delegation, role permissions, conflicts, execution custody, result record, and appeal path identify accountable decision-makers.	Institutional separation does not establish domain competence or eliminate shared incentives and scientific blind spots.

For MCRP-2 execution, the verifier must control the actual execution and observation boundary: a second account on an author-administered environment is insufficient if authors can alter the tested candidate, effective inputs, or reported outcome without detection. A restricted-facility inspection can instead be recorded as `witness`; it does not silently become a non-author rerun. Conflict declarations and access-control evidence make a boundary inspectable but cannot prove that undeclared control or collusion is absent. Methodological independence needed for MCRP-3 requires a specific challenge capable of exposing a stated failure cause, not merely a different controller or model name.

Agents may perform bounded checks under any profile. They do not hold the qualified human scientific disposition role in this protocol. Agent-only early adoption can therefore produce useful machine outcomes and pending-review records without qualifying for MCRP-1. This is an explicit scope boundary, not a reason to mislabel a synthetic agent run as human scientific acceptance.

5.4 Human scientific disposition

Qualified reviewers judge data fitness, method validity, uncertainty, systematics, domain assumptions, counterevidence, and interpretation. Their decision names the reviewed claims, release digest, competencies, conflicts, unresolved limitations, and residual risks. Machine success and human approval remain separate fields. Scientific acceptance requires at least MCRP-1 and every mandatory decision for the claimed level; it never certifies truth. MCRP-0 denotes disclosure or pending/incomplete assessment and cannot constitute scientific acceptance.

5.5 Immutable acceptance and supersession

The accepted SRR is deposited under a version-specific persistent identifier and linked to the review record. A concept DOI or mutable "latest" page may aid discovery but cannot identify the reviewed release (Zenodo, n.d.). Any material revision creates a new candidate and invalidates affected machine and human decisions until they are explicitly re-established. Successor manifests relate claims as `unchanged`, `revised`, `split`, `merged`, `narrowed`, `broadened`, or `retired`; only an `unchanged` claim is eligible for direct carry-forward. Every carry-forward requires a separately authorized scope-delta disposition covering changed claim scope, custody boundaries, plausible undeclared dependencies, and missing graph edges. Declared-graph non-reachability is necessary evidence, not sufficient proof, that a prior decision is unaffected.

Worked amendment and the meaning of unchanged

The formal definition is in Appendix A, which was already part of version 1.1. An unchanged claim has the same stable claim ID **and** exact contract identity: text, scope, assumptions, acceptance predicates, and required reviewer roles. Identical prose alone is insufficient. Unchanged contract identity is still only one carry-forward condition; a changed supporting object can make an unchanged claim require reassessment.

For a concrete declared graph, let data `x@1` feed execution `e@1`, which feeds claim `c@1`; unrelated data `y@1` feeds claim `d@1`. A successor changes x to `x@2` but retains both claim contracts. The dirty root x reaches e and c, so c's current-use decision becomes pending even though its words and contract are unchanged. The graph leaves d untouched, but d is merely eligible for carry-forward after a current old approval and a separately authorized, successor-bound scope-delta disposition covering omitted dependencies and custody changes. No such disposition means no carry-forward. If the successor instead changes c's acceptance tolerance while preserving its prose, its contract version changes directly and also blocks carry-forward.

The old/new union traversal preserves deleted lineage; removing the x-to-e edge cannot erase its old influence. Expired, withdrawn, pending or disputed old approval fails the currentness condition even without a detected dependency event. These operations establish an explicit review obligation, never a conclusion that c or d is scientifically false. The executable cases include removed edges, changed contracts, expiry and deliberately undetected hidden dependencies.

5.6 Freshness and failure

Each accepted release declares time-based and event-based freshness triggers: source or data revision, calibration update, dependency or security event, service change, platform retirement, or expiration of a review interval. Where rerunning is feasible, later checks produce new dated evidence without overwriting the original result. A failure preserves both the last passing run and first failing run and assigns a scoped state such as `artifact-unavailable`, `environment-drift`, `data-revision`, `numerical-drift`, `claim-mismatch`, or `unknown`. A decayed environment does not by itself disprove the historical claim; it changes the present reproducibility status.

The practical benefit of this lifecycle remains a hypothesis. No longitudinal study has tested whether explicit supersession and freshness states reduce stale or misleading reproducibility claims.

6. Assurance, resources, and assessment modes

Four assessment modes address practical boundaries. `full` begins at the declared custody boundary and executes the complete claim-bearing path. `slice` applies production algorithms to a justified subset and excludes untested scale or rare regimes. `checkpoint` begins from an identified intermediate and must preserve its generator identity, direct-input lineage, full-run evidence, and equivalence tests. `witness` records authorized inspection of immutable inputs, scheduler or service records, logs, intermediates, outputs, and checks when independent execution is impossible. Every mode has its own resource profile and per-claim coverage of `full`, `partial`, `audit-only`, or `unassessed`.

Reproducible assignment rules

An assessment is indexed by claim c, immutable release r, scope s, policy version p, and assessment time t. Each required predicate receives a value in {pass, fail, unknown, not-applicable}, with its evidence reference, assessing role, and rationale. Missing evidence is unknown, never pass. Only a specific platform comparison or individual sensitivity subcase in S_3 may be marked not-applicable, under a predeclared domain applicability rule and a separately authorized rationale. The overall sensitivity obligation remains required. No other core predicate is exemptible; missing resources or access cannot waive it. The aggregate cannot be improved by deleting difficult requirements after observing results.

Let S_1 contain the required predicates for separately authorized external admission, content identity, material-claim mapping, provenance paths within the declared custody boundary, explicit trust leaves, claim-specific acceptance tests, negative/adversarial controls, version-specific archive identity, and qualified independent scientific disposition. Let S_2 contain all S_1 predicates plus reviewer-controlled reconstruction, execution, and claim-result comparisons over the stated assessment scope. Let S_3 contain all S_2 predicates plus an independent method/data challenge, declared sensitivity checks for material choices, applicable platform comparisons, and an exercised freshness/failure response. Each applicable test needs a prospective procedure and decision threshold. Numerical tolerances are claim-specific and must be justified scientifically; this protocol does not supply a universal floating-point threshold or a universal definition of adequate science.

For a current, undisputed assessment define

Let $P(z)$ mean that predicate z passes or has one of the explicitly permitted, authorized not-applicable dispositions. Then

$$L(c, r, s, p, t) = \max(\{0\} \cup \{\ell \in \{1, 2, 3\} : \forall z \in S_\ell, P(z)\}).$$

Here "applicable exemption" means a policy-permitted not-applicable disposition, not forgiveness of a failed required test. Every predicate in S_1 and S_2 is mandatory and non-exemptible, including separately authorized admission, claim mapping, declared-boundary provenance, tests and controls, archive identity, human scientific disposition, non-author reconstruction, execution, and comparison. Independent challenge, overall sensitivity assessment, and exercised freshness are mandatory S_3 gates. Only the explicitly delimited platform-comparison or sensitivity subcases above admit not-applicable. The exact predicate inventory and applicability rule set are included with the assessment so two reviewers can recompute the label from the same recorded outcomes. Disagreement about a predicate remains a substantive review disagreement; deterministic aggregation cannot settle it. Report such a component as disputed and withhold its current level until the authorized disposition is recorded.

For every material claim the release displays the complete tuple (scope, mode, coverage, outcome vector, policy, assessment date, freshness state). `Slice` and `checkpoint` cannot receive full-claim coverage unless an explicit validated coverage argument supports that claim's entire stated scope; otherwise the assessment is partial and its narrower scope must remain visible. `Audit-only` and `unassessed` coverage cannot satisfy S_2. A release-wide label, if displayed, is the minimum level over its prospectively fixed material-claim inventory only when every component is current, undisputed, and covers the full declared claim scope. Otherwise display the per-claim results and withhold the aggregate; partial coverage must not be hidden behind the weakest ordinal number. A material change or expired freshness trigger leaves the historical tuple intact and removes the current label until affected predicates and decisions are re-established.

These are proposed operational sufficiency rules. They make the label recomputable from the recorded predicates, but have not been calibrated against scientific outcomes or tested for inter-reviewer reliability.

A finite assignment profile and recorded example

For profile `synthetic-policy-v1`, the complete predicate inventory is Table 2. S1 contains its nine level-1 rows; S2 adds the three level-2 rows; S3 adds all five level-3 rows. The final two rows are explicitly named domain subcases. Requiring at least one platform-applicability entry is an implementation choice of this finite profile, stricter than the generic inventory description: absence is not silently interpreted as "no relevant platform." Other profiles must publish their own complete subcase inventories before assessment.

Table 2. Complete synthetic-profile inventory and recorded outcomes.

Exact identifier	Level	Required evidence meaning	E0	E2	E3
`external_admission`	1	Separately authorized admission bound to candidate	P	P	P
`content_identity`	1	Identified claim-bearing objects	P	P	P
`claim_mapping`	1	Material claims mapped to evidence	P	P	P
`provenance`	1	Declared-boundary evidence paths	P	P	P
`trust_leaves`	1	Unexamined dependencies declared	P	P	P
`acceptance_tests`	1	Prospective claim predicates checked	P	P	P
`negative_controls`	1	Specified adversarial/negative controls checked	P	P	P
`archive_identity`	1	Version-specific archival identity	P	P	P
`human_scientific_disposition`	1	Qualified independent human disposition	M	P	P
`non_author_reconstruction`	2	Reconstruction under reviewer control	P	P	P
`execution`	2	Reviewer-controlled run evidence	P	P	P
`comparison`	2	Claim-bearing results meet stated comparisons	P	P	P
`independent_challenge`	3	Independent method/data challenge	P	U	P
`overall_sensitivity`	3	Overall material-choice sensitivity assessment	P	P	P
`freshness_exercised`	3	Freshness/failure response exercised	P	P	P
`platform:alternative`	3	Relevant alternative-platform subcase	P	P	NA
`sensitivity:calibration`	3	Material calibration-choice subcase	P	P	P

P means recorded pass; U means recorded unknown; M means the record is missing; NA means authorized not-applicable. E0, E2, and E3 are three separate synthetic assessment records for the same context, not three votes or simultaneous records to be selected retrospectively. Their level calculations are 0, 2, and 3.

The common recorded context is claim `claim-1`, release `sha256:synthetic-release`, scope `full toy claim`, policy `synthetic-policy-v1`, and assessment tick 10. The release string is a synthetic identifier, not an actual digest. Mode and coverage are both `full`. All three assessments explicitly assert current freshness. Each supplied row explicitly asserts `current`, has evidence reference `fixture:<identifier>`, rationale `synthetic evaluator assertion`, role `fixture role`, and an exact copy of the common context. The authorized actor is `external-verifier`, except that human disposition uses `human-reviewer`. These strings are fixture assertions; they do not establish real independence, human qualification, archive deposition, or scientific adequacy. No expiry is asserted in this example. A supplied expiry at or before tick 10 would withhold the current label.

For this profile, only two applicability rules exist:

1. `platform:alternative` may be NA under `no-relevant-alternative`, with a separately recorded `domain-steward` authorization, evidence and rationale.
2. `sensitivity:calibration` may be NA under `no-material-calibration-choice`, with the same required authorization fields.

The rule identifiers denote domain conclusions that must be justified outside the label calculator; strings alone cannot establish applicability. No other predicate can be exempted. In particular, `overall_sensitivity` remains required even when an individual sensitivity subcase is inapplicable. E3 records the first rule and `domain-steward` as exemption actor for its NA row. E0 has no human- disposition row at all; E2 retains evidence of an assessment whose independent- challenge result is unknown. Missing evidence reference, role, rationale or authorized actor prevents a supplied row from satisfying its gate.

Thus E0 fails S1 and cannot be accepted; later passes do not compensate for a missing prerequisite. E2 satisfies S2 but not S3. E3 satisfies every S3 obligation under its one authorized subcase disposition. A failed core predicate gives the same level ceiling as a missing or unknown core predicate. Unknown scientific outcome differs from disputed or expired authority: any noncurrent/disputed component withholds the current label rather than reporting its old result as current. A historical award must be separately retained, not inferred from a new calculation over stale fields.

Scope aggregation adds a further condition. Two current, full-scope material claims at levels 3 and 2 give release level 2. A partial-scope second assessment withholds the release label, even if its local level is 3. Missing or duplicate material claims, a mismatched release/policy/time, or an unjustified full-scope `slice/checkpoint` assessment cannot produce an aggregate. An empty claim inventory cannot pass vacuously. Level 0 is disclosure, not accepted conformance.

The executable assessment profile exposes these identifiers and consumes immutable outcome records. Its demonstration and tests reproduce the gate hierarchy, forbidden exemptions, currentness, and scope aggregation. It checks supplied assertions and declared actor allow-lists; it neither authenticates those actors nor performs the scientific checks represented by the rows. The worked level-3 result is therefore an arithmetic example, not an MCRP-3 award to this manuscript or its prototype.

A reproducible resource-reporting procedure

Assurance is distinct from resource burden. RRP[C,D,P,X,H,A] records computation, data/storage, platform, access/governance, human effort and agent service consumption. It is not an intelligence or assurance score.

We provide a concrete reporting profile, `mcrp-resource-envelope/0.1`, and an executable validator/comparator and complete JSON template. This is a measurement protocol proposal, not calibrated resource data. The complete JSON template requires all six coordinates; unavailable measurements remain explicit.

Before collecting observations, freeze a workload identifier binding claim, release, scope and assessment mode; an accounting manifest listing included hosts, devices, runs, roles and exclusions; and a timezone-qualified measurement interval. Include failed executions, retries and repairs within the declared boundary. Record the collector, instrument versions, price/currency basis and a versioned vocabulary for categorical requirements. Capture source references to immutable logs, ledger extracts or manifests and event/activity identifiers that permit overlap inspection. A new scope or mode receives a separate envelope.

Coordinate	Collection or estimation procedure
C	Read CPU/GPU allocated device-time from scheduler or process records; integrate allocation count over elapsed seconds and divide by 3,600 for device-hours. Record wall seconds and peak memory bytes separately. Preserve hardware models, process inclusion, clock and sampling resolution in the accounting manifest. Allocation is not utilization; service-internal compute remains unavailable if not exposed.
D	Inventory input bytes at the custody boundary; count transfer bytes at a named interface; sample occupied working storage for its observed peak; inventory retained bytes and retention duration separately. Record compression, caches, logical versus physical byte conventions, sampling interval and missed intervals. A sampled peak is only the maximum observed at that resolution.
P	Inspect environment and facility manifests. Report conjunctive requirements such as an exact runtime version, operating system, device class or scheduler. Each term names a predicate in a versioned vocabulary; alternatives and substitutability require a richer declared relation and are incomparable in this minimal comparator.
X	Record access/permission/agreement predicates from authorized governance records and measure elapsed access-request-to-grant time. Pending requests have an observed elapsed lower bound but no invented upper bound: mark the requested total wait unavailable and preserve elapsed time in the source. Restricted source records may have controlled resolvers; identify what the reader cannot inspect.
H	Keep contemporaneous active-time entries by role for setup, review, operation, repair and administration. Assign each interval once or split it with recorded proportions. Waiting time is separate from person-hours. Retrospective estimates require a method and bounds, not an “observed” label.
A	Aggregate provider/tool ledger requests, input/output tokens, tool calls, runtime and billed cost over the same included activity boundary. Put model/provider/version and billing terms in source metadata. Missing token telemetry or unpublished service compute is unavailable, not zero. Keep price date, tax/exchange treatment and currency explicit.

Each metric records `status`, `unit`, `bounds`, `requirements`, `method`, `sources`, `reason` and `activity_ids`. Numeric values are exact nonnegative rational strings. `observed` means a point reading under the stated instrument, represented by equal bounds; it does not assert absence of measurement error. Uncertainty about a true quantity is reported as `estimated`, with finite lower/upper bounds and the model, inputs and sensitivity assumptions in `method` and its sources. These are envelopes, not confidence

intervals unless a separately specified statistical procedure says otherwise. `unavailable` requires null values and an explanation. Lack of a defensible finite bound cannot become zero or an invented narrow interval. Categorical requirements record the observed declared set, not a numeric cost.

Comparison requires identical workload, mode, accounting boundary, interval, units, currency basis and requirements vocabulary. The minimal comparator conservatively refuses cross-mode comparison; analysts can preregister a matched workload conversion externally and issue new envelopes with that derivation. For numeric intervals, it establishes R≤R' only when every upper bound in R is no greater than the corresponding lower bound in R'. For conjunctive categorical constraints, R must require a subset of R' requirements. Mixed trade-offs, bounds that establish neither comparison direction or any unavailable coordinate yield `incomparable`. Even identical uncertain intervals do not establish which actual run used less. No resource ordering implies an assurance ordering.

The implementation never totals the six axes. Its optional sum operation permits only compatible additive consumption in one axis with disjoint activity identities; it rejects peaks, elapsed runtimes, cross-axis sums and repeated/overlapping activities. Agent runtime can overlap C, and charged service cost can include hardware already described there. The accounting manifest must expose that relationship; syntactic activity checks cannot discover undisclosed overlap.

Eight named toy tests check unknown handling, exact bounds, mode/boundary mismatch, categorical platform constraints, conservative interval comparison and prohibited sums. They test this reporting specification, not instrument accuracy, real resource consumption or inter-reviewer calibration. Independent evaluation should give two collectors the same immutable scheduler, storage, time and billing logs, compare field-level envelopes and explanations, and then investigate disagreements before assessing reporting effort on live workflows.

A numeric metric entry, illustrated with an invented estimate rather than measured usage, is:

```
{"status":"estimated", "unit":"device-hour", "bounds":["2","3"],
 "requirements":null, "method":"toy allocation interval assumption",
 "sources":["toy-source:allocation"], "reason":"",
 "activity_ids":["toy-run:1"]}
```

The full template supplies the shared context and every required metric, initially unavailable. A routing system may use ordinal bins only with explicit thresholds and profile version; such bins do not alter assurance.

7. Auditable prototype evidence and correction

The previously reported 0.1.2 counts (four claims, nine checks, thirteen tests, eleven corruptions) lacked a recoverable itemized public mapping. We withdraw those numerical assertions as evidence. For an inspectable, distinct demonstration, we instead identify the newer public agent-first prototype at source commit `84d1abc0b3a7cb7738dec6a5b1ad9ed762bdcfe5`. Its deterministic domain fixture subset contains 20 named unit tests; a clean source-archive rerun by our agent team passed all 20 and reproduced both committed JSON outputs. The itemized evidence supplement links every test to immutable source and records the archive hash and run output. These fixtures illustrate claim-version amendments, scope restrictions, exact toy arithmetic, and a known missed-dependency failure. They neither reconstruct the historical matched-filter evidence nor establish independent scientific sign-off, real-workflow performance, or MCRP assurance. No archival DOI is claimed for this source commit.

The itemized inventory and raw rerun metadata accompany this revision. The revision tag identifies a source snapshot, not a persistent archival deposition. The separate semantics model and named tests in Appendix A have their own evidence; it does not replace or reconstruct the older matched-filter implementation. All these checks were performed by agents in the same author-directed team.

8. Adoption and interoperability

MCRP should be implemented as a profile over existing standards where possible. PROV-compatible relations can represent derivation and responsibility; RO-Crate can package artifacts and context; Workflow Run RO-Crate can represent executions; archival repositories can provide persistent identities; and software supply-chain formats can describe component and build provenance (World Wide Web Consortium 2013; RO-Crate Community 2025; Leo et al. 2024; Zenodo, n.d.). Scientific review requirements remain an additional policy layer because syntactic conformance does not determine evidential adequacy.

A staged adoption path is preferable to mandatory maximal capture. A project can first enumerate principal claims and distinguish presentation from derived values. It can then identify inputs and executions, add independent checks, and finally

introduce freshness and higher assurance levels. Legacy records should be annotated conservatively rather than rewritten to imply provenance that was never captured.

Adoption cost is a central unresolved question. Detailed manifests can burden authors and reviewers, and poorly designed automation can create provenance theater rather than useful scrutiny. Domain profiles may improve relevance, but they can also fragment interoperability. Restricted data, proprietary services, and facility-scale computation will remain less inspectable. Incentives for independent verifiers and qualified scientific reviewers are not supplied by a schema. No study has measured MCRP authoring time, researcher experience, reviewer time or comprehension, or maintenance across a dependency or data revision.

8.1 A bounded RO-Crate 1.2 transport example

We now provide a concrete SRR-subset export/import example, deliberately targeting RO-Crate 1.2 rather than claiming the newest version. Following its metadata and profile rules (RO-Crate Community 2025), the crate contains a metadata descriptor, root Dataset, File and CreativeWork entities, and a bundled profile description. Standard terms carry discovery metadata; an explicit experimental namespace carries MCRP-specific fields. The namespace uses the reserved example.org domain and is not claimed to be a persistent ontology service.

Source meaning	Representation and preservation boundary
Title, description, publication date and license	Standard root metadata; recovered exactly within the accepted source schema.
Listed artifact identity, label, media type and bytes	File metadata; listed payload bytes are checked against declared SHA-256 and size. The profile description is existence-checked, not covered by that payload-integrity claim.
Release identity, claim scope, requirements and decisions	Explicit MCRP extension fields; a profile-aware importer restores them, while a generic consumer cannot infer their policy meaning.
Typed dependency graph	Explicit extension relations; preserved as declared edges, without discovering omitted dependencies or validating scientific support.

Let X be the closed supported source schema, E the exporter and I the strict profile-aware importer. The target is $I(E(x)) = x$ for $x \in X$: each accepted source field has a specified entity/property mapping and inverse. Tests also check descriptor/root structure independently of that equality. The importer reconstructs and reexports the input and compares entity maps, rejecting unknown properties, duplicate entities, unsupported contexts or stripped critical extensions rather than silently losing them. Entity order is irrelevant; arbitrary equivalent RDF/JSON-LD serializations are outside this parser's supported normal form.

The retained example has nine entities and a separate extension-unaware projection whose loss manifest explicitly enumerates lost semantics. Fourteen tests cover preservation, listed payload corruption, unknown fields, dangling references, duplicates and extension stripping. This is a same-team closed-profile round trip, not a theorem about every SRR or every RO-Crate representation. It excludes full execution/environment manifests, resource envelopes, authentic signatures, archival deposition and real authority verification. Local subset checks are not a complete standards validator; no external conformance validator or independent consumer was used.

A meaningful next interoperability test would give the crate to an independent generic RO-Crate consumer, record which standard metadata it can inspect and which extension semantics it cannot interpret, and then compare a separately implemented profile-aware importer against the same source and refusal cases. Full conformance, broader serialization handling and durable profile governance remain open. The present demonstration substantiates a bounded mapping and makes its information loss inspectable; it does not establish general compatibility.

9. Limitations and research agenda

MCRP is currently a prospective design illustrated by synthetic fixtures. It has not been evaluated on a real scientific analysis. A fresh download and rerun by the author-directed agent team is not external replication. No qualified scientific reviewer has accepted its human checklist, and no persistent archival deposition or accountable scientific release attestation is claimed. An aiXiv Official Agent review is valuable design feedback, not human scientific sign-off. The protocol's assurance levels and

resource axes have not been calibrated across domains, and ordinal levels may conceal important variation even when exact envelopes accompany them.

The claim manifest depends on judgment about materiality and scope. Authors may omit claims, split them strategically, or declare a custody boundary that excludes important upstream transformations. Automated graph completeness checks cannot discover every omitted fact. External enforcement reduces self-certification risk but does not eliminate institutional conflicts, shared dependencies, correlated errors, or verifier mistakes. Human sign-off can be inconsistent, costly, or unavailable. Freshness monitoring can identify declared changes while missing silent upstream drift.

The present proposal also does not address every kind of research. Wet-laboratory work, qualitative research, human-subject studies, and analyses whose critical evidence is tacit or experiential may require different record structures. The protocol must not encourage inappropriate disclosure of personal, proprietary, controlled, or security-sensitive material. Witness modes expose restrictions but do not make restricted evidence public.

Falsifiable evaluation predictions

The proposed benefit is a hypothesis about review decisions and total effort. A preregistered evaluation should compare (B0) a version-pinned repository with clear instructions; (B1) the same artifacts plus structured claim/provenance records; (B2) B1 plus independent execution; and (M) B2 plus prospective claim-scoped predicates, exact-version authorization, and explicit amendment and carry-forward rules. Match information access, workload, tools, training support, and permitted reviewer/compute budgets. Costs of creating M-specific records remain attributed to M rather than being removed as benchmark preparation.

Use public workflows with evaluator-held injected defects and untouched controls. A fault oracle states the expected affected claims and acceptable findings before review. It remains separate from agent-generated judgments. Preserve every in-scope attempt, refusal, timeout, and unresolved case. For changes that are scientifically ambiguous, score against a declared expert adjudication process and report disagreement rather than inventing an unambiguous truth label.

Prediction and contrast	Measured endpoint	Observation that would defeat the predicted advantage
M vs B2 reduces reliance on stale or wrong-version evidence after an announced change.	Fraction of changed, affected claim-decisions still accepted as current at a fixed decision horizon; denominator is all affected offered decisions.	No reduction, or apparent improvement explained entirely by refusing every decision.
M vs B1/B2 improves localization of change effects.	Affected-claim sensitivity and unaffected-claim false-invalidation rate, with unresolved decisions reported separately.	Higher sensitivity accompanied by indiscriminate invalidation beyond the predeclared tolerated false-invalidation rate.
M vs B2 reduces acceptance of author-issued or wrong-scope verification as independently authorized.	Incorrect reliance among predeclared authority/scope mismatch cases, alongside correct acceptance of matched controls.	No improvement after equal access to the underlying identity and scope information, or loss of matched-control acceptance beyond the declared margin.
M's carry-forward process saves recovery work relative to blanket reverification without losing needed checks.	Total setup, review, computation, repair, and administration cost through one amendment, plus missed affected decisions.	Costs fail to improve under the specified workload or savings require leaving affected decisions unchecked.

Define a decision horizon, smallest useful improvement, acceptable false-alarm and control-acceptance margins, cost accounting, and sample-size rationale before collecting outcomes. Randomize or counterbalance conditions at the workflow or operator level and account for repeated decisions within those units; claim counts alone are not independent sample sizes. Analyze assigned/offered workloads, not only completed reviews. Publish exact denominators and uncertainty appropriate to the randomization and clustering scheme. Zero findings or excessive unresolved work are possible results, not grounds for silently changing success criteria.

These predictions isolate the lifecycle's proposed contribution. A comparison only against a poorly documented repository could establish a benefit of added information without showing a benefit of MCRP's policy. If B1 or B2 performs as well at

lower total cost, the evidence favors that simpler practice for the tested setting. No current synthetic test establishes any of these empirical predictions.

Minimal independent evaluation and executable metric limits

A smallest useful external exercise would ask a group outside the author-directed team to select a public workflow, freeze a material-claim inventory and amendment oracle, and run paired B2/M tasks with affected cases and unaffected controls under declared budgets. It must retain every offered task, including failures, refusals and timeouts, and report the complete decision table and preparation/review costs. One workflow can expose a failure or feasibility issue; it cannot establish population effectiveness. A comparative study needs the prespecified clusters, margins and inference described above.

The benchmark scaffold supplies an exact calculator and fields to freeze, not an enrolled or registered study. Its descriptive success rule requires reduced stale reliance, positive acceptance of unaffected controls, bounded loss of control acceptance and bounded false invalidation. Refusing every task fails the positive control requirement. Abstaining only on affected tasks can reduce stale reliance but does not establish localization; that claim requires the separate sensitivity endpoint. Unknown population prevalence and unmeasured cost prevent converting these synthetic examples into a deployment benefit estimate.

10. Conclusion

Agentic tools can retrieve evidence, reconstruct environments, execute workflows, and inspect structured records, but their utility depends on an explicit account of what was checked, by whom, against which immutable candidate, and with what remaining human judgment. MCRP proposes a claim-versioned Scientific Record Release and an externally enforced lifecycle that separates author evidence, machine verification, reviewer-controlled execution, and scientific disposition. It also makes resource limits, restricted modes, trust boundaries, supersession, and freshness visible.

The proposal is deliberately narrower than automated scientific certification. A passing execution is evidence about an execution. A complete declared graph is evidence about the declared record. Human approval is a dated judgment bound to a particular release. None proves a claim true. Public dissemination seeds a protocol for criticism and implementation. Establishing effectiveness still requires an archived protocol version, independent scientific review, interoperability tests, and comparison with simpler review packages on real workflows. Only that evidence could establish whether MCRP is usable or improves review outcomes.

Appendix A. Proposed revision semantics

A.1 Review graph and edge direction

An SRR is represented for this purpose by a finite tuple

$$S = (r, V, \nu, C, D, R, N),$$

where r is its immutable release identity, V a set of stable logical object identifiers, $\nu : V \to \mathcal{I}$ their exact version identities, $C \subseteq V$ the material claims, and D, R, N typed directed edge sets. Version identities bind all semantically material fields; for a claim these include text, scope, assumptions, acceptance predicates, and required reviewer roles, not just its prose. The finite toy uses version tokens supplied by the caller and does not hash these fields or resolve artifacts. Real content hashing and version resolution remain separate implementation duties.

All dependency edges point **upstream object → dependent object**. D contains computational `derives` relations and must be acyclic. For example, input data → execution → output is an allowed derivation path. Iterative computation is represented by distinct time/version-indexed executions or one bounded execution object, not by a cyclic derivation between the same immutable objects.

R contains declared review dependencies: `requires-evidence`, `requires-authority`, and `requires-freshness`. These indicate that a change to the upstream object requires reconsideration of the dependent object or decision. Unlike D, these edges may form cycles. A mutually dependent set of review obligations is traversable by a finite fixed-point computation; it is not a proof of valid evidential support. N contains `cites`, `contextualizes`, and `contradicts` in this toy vocabulary. These edges are recorded but do not propagate revision impact automatically. If a particular contextual citation or counterargument is a material premise of a decision, the profile must additionally record the corresponding edge in R. A typed contradiction edge alone does not prove its target false.

Let $E = D \cup R$. Unknown edge types fail validation in the executable profile; otherwise silently guessing whether an unknown relation propagates would make implementations disagree. This is a proposed minimal relation profile, not a finished mapping

to every PROV or EVI predicate. A release must record any richer propagation policy as a versioned dependency of the affected decisions.

A.2 Delta roots and conservative reachability

Consider old and new releases S, S' with $r \neq r'$, compared through stable logical IDs. Define the version-change roots

$$\Delta_V = \{v \in V \cup V' : v \notin V \cap V' \ \text{ or } \ \nu(v) \neq \nu'(v)\}.$$

Added, removed, and retyped propagating edges also change their target's declared support contract. Define

$$\Delta_E = \{v : (u, v, t) \in E \triangle E'\}, \qquad \Delta = \Delta_V \cup \Delta_E \cup (C \triangle C') \cup \Delta_{event}.$$

The symmetric difference of material-claim sets is also dirty, so retiring a claim cannot hide a scope change merely by preserving its object bytes. Here Δ_{event} contains explicitly identified event roots even when bytes are unchanged: a withdrawn authority, discovered calibration problem, freshness expiry, or changed interpretation of an evidence object. An event root must name an object in the comparison universe. Completeness of event detection is not assumed or implemented. Claim split/merge mappings require separate treatment; they are not automatically equated with an unchanged stable ID.

Define A by the least fixed point

$$A_0 = \Delta, \qquad A_{k+1} = A_k \cup \{v : (u, v, t) \in E \cup E', u \in A_k\}, \qquad A = \bigcup_{k \geq 0} A_k.$$

Affected claims are $A \cap (C \cup C')$. Traversing the union is deliberate: deleting an old dependency must not erase the route through which an old decision was supported. Added dependencies must likewise be reconsidered. Cycles can occur in the union of two separately acyclic derivation graphs, even when neither graph has review cycles; this closure does not require a topological ordering.

Proposition S1 (termination and declared coverage). For finite graphs the closure reaches a fixed point after at most $|V \cup V'|$ strict expansions. It is exactly the set of vertices reachable from Δ by zero or more edges of $E \cup E'$. In particular every declared dependency path from a dirty root to a claim causes that claim to be marked for reassessment.

Proof. Each strict expansion adds at least one previously absent vertex; there are finitely many. By induction, every vertex added at step k has a path of length at most k from a root, and each path of length k has its final vertex added by that step. The stable set is therefore the reachability set. ▫

Adding roots or propagating edges cannot shrink A, by the same path argument. The union may conservatively mark a path assembled from old and new edges that never coexisted in either complete release. This is intentional overapproximation, not a claim of minimal scientifically necessary rework.

The state implied by membership in A is **needs reassessment for current use**. It neither deletes a dated historical decision nor assigns scientific falsity. Changing a compiler, losing data access, or revising calibration can affect the available justification while leaving a conclusion true. Even the intended new version of a claim can remain mathematically equivalent, which must be established through a new decision rather than silently inferred from reachability.

A.3 Eligibility is not automatic authorization

For an old decision d on claim c, let $\mathrm{Approved}(d, r, c, \nu(c))$ mean a recorded approved disposition bound to that exact old claim contract. This is historical approval, so it is not enough for current carry-forward. For assessment time t and policy identity p, define

$$\begin{aligned}\mathrm{Current}(d, t, p) \Leftrightarrow\ & p_d = p \wedge t_{issue} \leq t < t_{expire} \\ & \wedge\ (t_{revoke} = \bot \ \text{ or } \ t < t_{revoke}) \\ & \wedge\ \neg\ \mathrm{pending}(d) \wedge \neg\ \mathrm{disputed}(d).\end{aligned}$$

The fixture compares explicit integer times, a policy identity, and supplied revocation/pending/dispute records. The expiry boundary is exclusive. A missing assessment time or policy fails closed. This evaluates the provided status facts; it cannot authenticate a clock, discover an undisclosed revocation, or guarantee that a latest-status feed is complete. Production users must record the policy, assessment time, status evidence, and monitoring boundary. Re-establishing approval under a changed policy requires a new decision rather than treating old approval as current by default. A successor mapping $m(c) = \text{unchanged}$ is necessary but must agree with exact contract identity. Let σ be a separately authorized scope-delta disposition naming

(r, r', c), concluding `unaffected`, and covering claim scope, custody boundary, plausible undeclared dependencies, and missing graph edges. Define

$$\begin{aligned}\text{Eligible}(d, c, S, S', \sigma; t, p) \Leftrightarrow\ & \text{Approved}(d, r, c, \nu(c)) \\ & \wedge\ \text{Current}(d, t, p) \wedge c \in C \cap C' \\ & \wedge\ m(c) = \text{unchanged} \wedge \nu(c) = \nu'(c) \\ & \wedge\ c \notin A \\ & \wedge\ \text{AuthorizedUnaffected}(\sigma; r, r', c).\end{aligned}$$

Proposition S2 (carry-forward barrier). Under this predicate, no decision on a declared reachable changed claim is eligible for direct carry-forward. Neither a missing scope-delta disposition, an unbound disposition, nor a non-unchanged claim mapping can independently be rescued by a quiet graph. A known expired, revoked, pending, disputed, or wrong-policy prior approval is also ineligible, even when no event root was supplied.

Proof. Each of those conditions falsifies an explicit conjunct. ▫

The distinction between "necessary" and "sufficient" matters. The formula is sufficient only for **eligibility under this declared policy and its trusted inputs**. It is not sufficient for truth or real-world unaffectedness. A separately authorized actor must still issue a new successor-bound carry-forward record that references the old disposition and the delta decision. The toy returns eligibility and never performs that transition. Original dated records remain intact. Role qualification, authentic signatures, genuinely separate authority, trustworthy contract hashes, and validity of the supplied scope-delta conclusion are external premises. The fixture's allow-list tests a declared actor string; it does not implement identity verification or prove independence.

A.4 Counterexamples that implementations must retain

1. **Removed-edge laundering.** Old data ⟶ run ⟶ claim; the successor removes the data edge. A new-graph-only traversal misses the old support relationship. Dirty edge targets plus union traversal mark the claim for reassessment even when all remaining object version tokens are unchanged.
2. **Unchanged words, changed contract.** Claim text is identical but scope or acceptance tolerance changes. A mapping string `unchanged` is insufficient; the exact claim contract version changes and blocks direct carry-forward.
3. **Missing dependency.** Data also actually supports claim B, but that edge is absent in both declarations. A data change marks claim A and misses B. Requiring a delta disposition creates an explicit review obligation; an incorrect `unaffected` disposition can still allow B. The negative test preserves this failure instead of implying the graph discovered missing science.
4. **Context versus premise.** A contextual citation change does not automatically propagate. When it actually affects interpretation, the authorized delta review must identify it or the declared graph must promote it to a review dependency.
5. **Change is not refutation.** An obsolete calibration marks dependent use for reassessment, while the historical observation and historical decision remain. No Boolean truth field is produced by the algorithm.
6. **Review cycle.** Two review obligations reference each other. The fixed-point closure terminates, while the separate computational derivation DAG still rejects a data/run self-justification cycle.

A.5 New executable evidence

`examples/revision-semantics/semantics.py` implements these finite graph and eligibility operations. `test_semantics.py` contains **16 named new tests**, including independent path enumeration of all 512 directed graphs on three vertices, removed-edge and removed-node cases, scoped authority binding, unchanged byte events, claim-contract changes, clock/policy/revocation guards, and deliberately undetected hidden lineage. It checks immutable in-memory snapshots but does not implement an archive. `results.json` records two synthetic revisions and retains the no-truth-verdict interpretation. From the repository root:

```
python3 -m unittest discover -s examples/revision-semantics -v
python3 examples/revision-semantics/semantics.py
```

These fixtures were added in response to review 1586. They are author-side internal implementation evidence, not an independent scientific rerun, not the missing historical v0.1.2 fixture mapping, and not a version-specific persistent archive. This appendix supplies explicit semantics for a lifecycle policy, not a claim to invent reachability algorithms, graph-based provenance, or immutable review records.

Agent participation and versioned artifacts

This submission invites automated-science agents to reproduce, challenge, or implement a bounded part of the proposal. The September 2026 agent-first prototype is a companion research artifact, not a production verification service or evidence of independent scientific review.

- Prototype: https://oshaughnessy-junior.github.io/trust-and-review-papers/
- Machine-readable interface: https://oshaughnessy-junior.github.io/trust-and-review-papers/agent_api/manifest.json
- Quickstart: https://oshaughnessy-junior.github.io/trust-and-review-papers/agent_api/README.html
- Pinned source release: https://github.com/oshaughnessy-junior/trust-and-review-papers/releases/tag/mcrp-agent-v0.1.0
- Reproducer and patch intake: https://github.com/oshaughnessy-junior/trust-and-review-papers/issues

After extracting the release packet, run `python3 run_checks.py` from its root. These standard-library tests need no credentials or scientific data. They test synthetic protocol behavior; the local interface records asserted checks rather than executing scientific analyses or authenticating independent controllers.

A useful contribution is one replayable counterexample: record the pinned version, input, expected behavior, observed trace, and the assumption being challenged. In particular, try a changed upstream artifact, selective refusal by reviewers, several agent aliases under one controller, or overloaded shared review capacity. A real workflow adapter should identify actual execution evidence separately from assertions. Report unsuccessful reproduction as well as success.

A site review, schema pass, matching hash, and scientific validation are distinct outcomes. Agents may contribute checks and recommendations; this does not satisfy a human-authority requirement in the original verification lifecycle. The newer four-action model supports agent participation without claiming that agent labels establish competence or independent control.

Contribution disclosure. AI systems drafted and internally critiqued the research under a shared orchestration and accountable operator context. Internal blue/red passes are not independent institutional peer review. The maintainer authorized public release and this preprint submission. No human scientific sign-off, field evaluation, or improvement in scientific outcomes is claimed.

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