MRRC V4.0: Resource-Constrained Correlation Dynamics
A Categorical Perspective with Plain-Language Dictionary

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GitHub Repository: https://github.com/gubasas/MRRC-Framework-V3

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Abstract

MRRC version 4.0 presents the framework as category-theoretic interpretation of the Minimal Recorded Relational Change framework, developed through five years of independent research, adversarial testing via Kosmos runs, and validation against real quantum hardware data (Google Willow 2024, IBM and Quantinuum 2025 results).

The central observation is that MRRC can be understood as category theory operating under mandatory resource constraints, finite memory, and noise — conditions that reflect the physical reality in which structure must persist.

This document provides:

- A concise restatement of the primitive constraints and core mappings
- A side-by-side dictionary translating key category-theoretic terms into MRRC concepts and everyday language
- Empirical validation of the QEC scaling metric (mean prediction error 3.64% across hardware)
- Responses to common objections (reversible computing, measurement, forces, geometry, etc.)

AI tools such as Grok 4.1, Chat gpt 4.o and Kosmos AI have been used. All ideas are originally developed by Author All code, data, simulations, and previous versions are available at
https://github.com/gubasas/MRRC-Framework-V3

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1 Introduction

The Minimal Recorded Relational Change (MRRC) framework identifies the minimal structural requirements for any system to exhibit persistent, ordered evolution under finite resources. Developed independently since 2020 and iteratively refined through computational testing (Kosmos RUN2–RUN4) and empirical validation, MRRC has shown remarkable convergence with diverse physical phenomena.

Version 4.0 recognises that the mathematical structure of MRRC is essentially that of category theory — but with the crucial addition of unavoidable resource costs at every level. Category theory describes pure structure through objects and morphisms. MRRC describes the only kind of structure that can actually exist in our universe: structure that has to pay to stay written.

This document is written for both specialists and non-specialists. Technical terms from category theory are presented alongside their direct MRRC interpretation and a plain-English explanation, eliminating the need to look up unfamiliar names up.

2 Primitive Constraints (PC1–PC5) — Restatement

The five primitive constraints remain unchanged since V1:

1. **PC1** — Change is only detectable by comparison of current state σ_k to reference r_{k-1}, producing difference Δ_k that is recorded as updated memory m_k.
2. **PC2** — Temporal ordering emerges from the sequence of such operations.
3. **PC3** — Substrate permits both formation and un-formation of distinctions (reversibility at the physical level).
4. **PC4** — Memory capacity is finite and subject to degradation-only noise.
5. **PC5** — Every persistence or refresh operation incurs non-zero dissipation that must be exported.

These are not assumptions about physics — they are the logical thresholds below which ordered change cannot be recorded at all.

3 Category Theory Dictionary — Side-by-Side Translation

Category Theory Term	MRRC Interpretation	Plain English (for normal humans)
Object	Stabilised correlation pattern that persists long enough to be referenced again	A "thing" that stays written
Morphism (arrow)	Comparator cycle: $\sigma \to \Delta \to m$	The act of noticing and writing down a change

Category Theory Term	MRRC Interpretation	Plain English
Composition of morphisms	Sequential comparator cycles	Doing one change, then noticing the next change relative to the new state
Identity morphism	Comparator that finds no difference ("same as last page")	The note that says "nothing changed"
Functor	Mapping rule between layers that preserves structure	How a pattern on one scale looks when viewed from the next scale up
Natural transformation	Consistent way of translating changes across layers	The same rule works at different zoom levels
Monad	Stateful comparator that carries memory forward	The notebook itself — it remembers previous pages when writing the new one
Kleisli arrow	Comparator that uses yesterday's memory as today's reference	Writing today's note by looking at yesterday's note
Adjoint functor	Holographic encoding/decoding pair (boundary interior)	The cover of the notebook contains enough info to reconstruct the whole book
Subobject classifier	The basic yes/no comparator ("is different?")	The fundamental question the notebook can ask
Topos	Complete multilayer MRRC stack with all logical operations	The entire universe as one big notebook with physics built in
Terminal object	Correlation pattern that everything eventually flows into (e.g. heat death, sticky hub)	The final page where everything becomes the same
Initial object	The primordial unresolved state (pure potentiality)	The blank notebook before the first scribble
Limit / Colimit	Most efficient way to combine or distribute correlations	The smartest way to share or merge notes without wasting ink
Yoneda embedding	Full description of a thing by how it affects everything else	Knowing something completely by how it changes other notes

This dictionary is exhaustive for our purposes. Every major concept in applied category theory has a direct, concrete counterpart in MRRC.

4 Empirical Validation — Quantum Error Correction Scaling Metric

Recent quantum hardware data (Google Willow surface code 2024, IBM and Quantinuum 2025) provides quantitative validation of MRRC's resource-scaling prediction.

When logical error rate p_L is plotted against physical resource overhead n, the relationship follows a clean power law:

$$n_2/n_1 = (p_{L1}/p_{L2})^{1/\alpha}$$

is an emergent property of the specific hardware architecture — analogous to thermal conductivity or resistivity.

Fitted values:

- Google Willow surface code: $= 1.539 \pm 0.087$
- Mean prediction error across distance transitions: 3.64%
- Best single transition error: 0.87%

The functional form is universal; the value of is system-specific.

Code and full analysis: https://github.com/gubasas/MRRC-Framework-V3/blob/main/COMPREHENSIVE%20VALIDATION-%20MRRC%20FRAMEWORK%20IS%20A%20PRACTICAL%20ENGINEERIN 20TOOL%20FOR%20QUANTUM%20COMPUTING.pdf

5 Responses to Common Objections

- **Reversible computing / zero dissipation**: Possible only with unbounded memory or infinite time. In finite systems, eventual erasure is mandatory → PC5 holds.
- **Infinite regress in comparator**: Single comparator cycle is ontologically primitive; mathematics emerges from it, not vice versa.
- **No testable predictions**: The QEC scaling law (form) and energy-cost proof of asymmetry are quantitative and already being confirmed.
- **Forces not differentiated**: In progress — gauge symmetries expected to emerge from correlation invariance requirements.
- **Measurement problem**: No collapse required — only irreversible correlation transfer to a more stable comparator (apparatus/environment).
- **Geometry missing**: Spacetime curvature and Lorentz invariance are constraint-preserving correlation flows (to be formalised).

6 Conclusion

MRRC provides a unified constraint-based description of physical reality as resource-limited correlation maintenance. Its categorical structure offers both rigorous formalism and intuitive accessibility through the plain-language dictionary presented here.

The framework is now sufficiently mature for broader exploration and application across physics, information theory, and engineering.

All materials are openly available at the GitHub repository. Detailed additional and supplementary information and code are available upon request via https://platform.edisonscientific.com (registration required). AI tools such as Grok 4.1, Chat gpt 4.o and Kosmos AI have been used. All ideas are originally developed by Author