Conflict-Preserving Harmonization

An Interdisciplinary Theory of Non-Reductive Geospatial Classification and Its Implementation in the

Hierarchical Location Codes (HLC) Framework

A Doctoral Thesis

Interdisciplinary — Information Science · Geography · Knowledge Organization

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Abstract

Every attempt to place the world into boxes eventually collides with the fact that the world has already been placed into other boxes, by other authorities, for other purposes, and that these box-sets do not agree. The dominant response of standards engineering is reductive: choose one authoritative partition, force every entity into exactly one cell, and treat residual disagreement as error to be corrected. This thesis argues for, formalizes, and demonstrates the opposite response. It advances a single organizing principle — here named Conflict-Preserving Harmonization (CPH) — under which classificatory disagreement is retained as first-class information rather than resolved away, and it shows how that principle has been implemented, at scale and in production, by the Hierarchical Location Codes (HLC) Operational Framework.

The framework's own charter states its ambition compactly: its purpose is “harmonization, not replacement.” The contribution of this thesis is to take that plain-language commitment and evolve it into a defensible, general theory of knowledge organization, and then to read the framework back through that theory in order to demonstrate implementation. Working across information science, geography, knowledge organization, and standards governance, the thesis (i) reconstructs the classification problem that HLC confronts; (ii) distils the framework's main principle into eight formal invariants and a compact mathematical model of a scheme-indexed poly-hierarchy over an invariant identifier spine; (iii) traces the implementation of each invariant through the framework's five coordinated files — the common front matter (codehx), the namespace and code-ownership control layer (codehu), the land-based master hierarchy and system anchor (codehl), the water and hydrographic hierarchy (codehy), and the ecoregion and ecosystem sibling views (codehw); and (iv) offers a neutral, evidence-based assessment of the resulting artefact, including its epistemic limitations under single-maintainer governance.

The central finding is that HLC is best understood not as a competing standard but as a coordination substrate: an editorial machine whose distinctive move is to store the topology of disagreement between existing standards rather than to overwrite it. The thesis closes by generalizing CPH beyond geography, proposing it as a design pattern for any domain in which multiple durable, institutionally-backed, and mutually inconsistent classifications must be made interoperable without any one of them being destroyed.

Contents

1 Introduction

1.1 The problem of many maps

Consider a single body of water in Southeast Asia. To the International Hydrographic Organization it is one sea with a code and a boundary polygon. To the Food and Agriculture Organization it is a fishing area with an entirely different numbering. To a marine-ecology programme it is a province in a global system of ecoregions. To the Defense Intelligence Agency it is a geopolitical data element with its own identifier. To half a dozen national statistical offices it barely exists at all, folded silently into a broader region. Each of these authorities is competent, current, and internally consistent. None of them is wrong. And yet no two of them agree on where the sea begins, what it is called, what it contains, or under which larger thing it should be filed.

This is not an exotic edge case; it is the ordinary condition of geographic knowledge. Countries span continents. Territories are claimed by more than one state. Historical entities dissolve into successors. Islands sit in disputed waters. Rivers cross the borders that classifications treat as fundamental. A biogeographic realm and a political region cover the same ground while cutting it into incompatible pieces. The world, in short, admits many maps, and the maps are simultaneously authoritative and irreconcilable.

The engineering profession has a default answer to this predicament, and the answer is to make it go away. Pick a canonical scheme. Define one partition. Assign every entity to exactly one class. Where sources conflict, adjudicate and record a single winner. The result is clean, queryable, and — for a large class of applications — perfectly adequate. It is also lossy in a specific and consequential way: it discards the very information that a user most often needs, namely the structure of the disagreement itself. Once the losing classifications have been overwritten, the question “who says otherwise, and how?” can no longer be answered from the data.

1.2 A different commitment

The HLC Operational Framework begins from the opposite commitment. Its front matter is explicit: HLC “integrates internationally recognized standards … and adds hierarchical HLC extensions where existing standards are insufficient,” and it “preserves multiple coding schemes, versions, and hierarchical interpretations in parallel. Where standards disagree or do not correspond cleanly, that condition is represented explicitly rather than resolved into a single forced answer.” The same document states the governing intent in four words: harmonization, not replacement.

That sentence is the seed of this thesis. It names a principle, but it does not theorize it, defend it, formalize it, or measure its consequences. The purpose of the present work is to do exactly that: to take the framework's plain-language commitment and evolve it into a general theory of non-reductive classification, and then to demonstrate, file by file and mechanism by mechanism, that the theory is not aspirational but implemented.

1.3 Research questions

The thesis is organized around four questions.

1. What, precisely, is the main principle of HLC, once it is lifted out of prose and stated as a set of invariants that an artefact either satisfies or violates?
2. Can that principle be given a compact formal model that captures its distinctive structure — parallel, scheme-indexed hierarchies bound to a stable identifier spine — without collapsing back into a single forced partition?
3. How is each invariant actually realized in the framework's notation, data layout, and file architecture, and what concrete evidence in the five files demonstrates the realization?
4. What are the honest limits of the approach and of this particular implementation, and how far does the principle generalize beyond geography?

1.4 Contributions

The thesis makes four contributions corresponding to those questions.

- **Theoretical.** It names and defines Conflict-Preserving Harmonization (CPH) as a design principle for knowledge organization, and decomposes it into eight invariants (Chapter 3, Figure 4).
- **Formal.** It models an HLC-like system as a scheme-indexed poly-hierarchy over an invariant identifier spine, and states several structural properties that distinguish it from ordinary single-parent taxonomies.
- **Empirical.** It traces every invariant to concrete notation and data in the five files, using the framework's own entries as evidence (Chapters 4–8).
- **Critical and generative.** It offers a neutral assessment of the artefact (Chapter 9) and generalizes the principle into a reusable pattern for other domains (Chapter 10).

1.5 Scope and method

This is a conceptual and architectural thesis, not a user manual and not a data-quality audit of individual codes. Its evidence base is the framework as delivered: the shared front matter and the four operational files, together with their internal documentation sheets. The method is interpretive and reconstructive — close reading of the artefact's structure, formalization of its implicit commitments, and confrontation of the theory with the framework's own examples. Where the thesis makes empirical claims about the artefact, it grounds them in specific entries and mechanisms that are visible in the files. Where it makes evaluative claims, it separates the design principle (which may be sound) from the particular implementation (which is the work of a single maintainer and carries the limitations of that fact)

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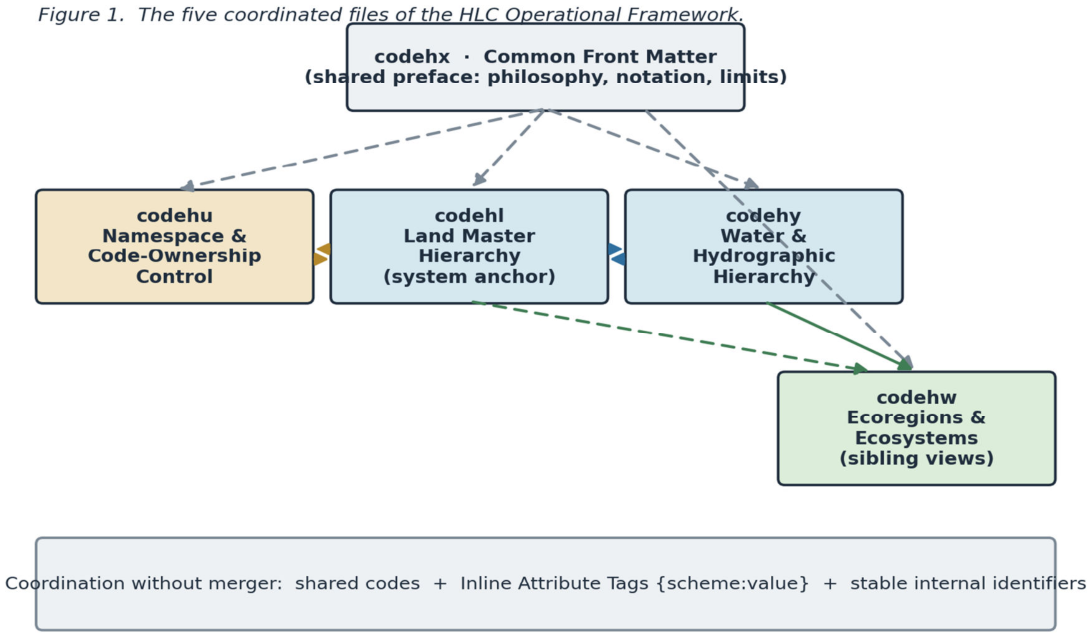

Figure 1. The five coordinated files of the HLC Operational Framework. The front matter fixes shared philosophy and notation; the four operational files are coordinated through shared codes, inline attribute tags, and a stable identifier spine rather than being merged into one table.

2 The Classification Problem

This chapter reconstructs the problem HLC addresses and situates it in the surrounding literatures. The aim is not a survey for its own sake but the establishment of a precise target: the specific way in which geographic classifications fail to compose, and why the standard remedies are inadequate for the uses HLC serves.

2.1 Standards do not compose

A classification standard is a partition of some domain into named classes, usually with identifiers and often with a hierarchy. Individually, the major geographic standards are exemplary engineering. ISO 3166 assigns two-letter, three-letter, and numeric codes to countries and their subdivisions, with a dedicated part (3166-3) for formerly used codes. The United Nations M49 scheme assigns numeric codes to countries and to a hierarchy of regions. The US GENC standard provides geopolitical entities, names, and codes for government use. In the marine domain, the IHO defines limits of oceans and seas; the FAO defines fishing areas; ICES, NAFO, and GFCM define statistical divisions for their respective waters. In ecology, TEOW, FEOW, MEOW, BEOW, PPOW, BPOW, GOODS, the WWF Global 200, GEZ, GIWA, EUNIS, and Longhurst's provinces each partition the biosphere on different principles and at different resolutions.

The difficulty is that these standards do not compose. They were built by different institutions, for different mandates, on different ontological commitments, and they were never intended to nest inside one another. Their boundaries cross. Their granularities differ. Their identifiers are disjoint. Their treatment of the same entity ranges from central to invisible. A user who needs to move between them cannot simply join on a key, because there is no shared key; and cannot simply intersect the partitions, because the intersection is not itself a clean partition. This non-composability is the classification problem in its operational form.

2.2 Four structural sources of conflict

It is useful to separate the conflict into recurring structural types, because HLC's mechanisms map onto them almost one-to-one.

- **Nominal conflict.** The same entity carries several equally valid names or codes across schemes (a country's alpha-2 versus its numeric code; a sea's IHO name versus its FAO number).
- **Temporal conflict.** Entities are created, merged, dissolved, and renamed over time; a former code must still be resolvable to its successors without erasing that it once existed.
- **Mereological conflict.** The same ground legitimately belongs to more than one parent, because two schemes cut the world differently (a sea that is simultaneously part of one ocean under a hydrographic scheme and part of an archipelagic mediterranean under another).
- **Sovereignty conflict.** Two or more authorities claim the same territory, and no neutral fact assigns it to one; a classification that forces an assignment thereby takes a political position.

A reductive standard handles each of these by deletion: it keeps one name, one temporal state, one parent, one sovereign. CPH handles each by retention: it keeps the alternatives, the history, the multiple parents, and the competing claims, and it marks them as such.

2.3 Crosswalks, ontologies, and their limits

The information-science literature offers two established families of remedy, and HLC can be positioned against both. A crosswalk is a mapping table between two schemes; it is invaluable but pairwise, brittle under versioning, and silent about the shape of the disagreement beyond the mapped pairs. An upper ontology with alignment axioms is more expressive but tends toward a single reconciled model in which the alignments themselves must be committed to, reintroducing the reductive move at the meta-level. HLC occupies a deliberately modest middle position. It is not an ontology that reconciles; it is a substrate that co-locates. It does not assert that the IHO sea and the FAO area are the same thing; it records both identifiers on the same row and lets the disagreement stand. This is a weaker epistemic claim than alignment, and that weakness is the point: it is what allows conflicting authorities to coexist without any of them being subordinated.

2.4 Why coordinates are not the answer

A tempting technical escape is to dissolve classification into geometry: give everything a polygon, and derive membership by spatial containment. HLC explicitly refuses this route. Its front matter states that coordinates, where present, are "provided only as reference anchors for orientation and best-fit regional assignment," and are "not boundary definitions, polygon or shapeline geometry, precise spatial extents, or inputs for GIS containment analysis," adding that there is "no plan to implement GIS shapelines." This is not a limitation to be apologized for but a considered commitment, examined in Chapter 3 as the invariant of best-fit assignment. Geometry cannot adjudicate sovereignty conflicts (the polygons themselves are contested), cannot represent historical entities without spurious precision, and cannot express mereological conflict, since a point falls in exactly one polygon per layer and thereby re-imposes single-parenthood. Conceptual best-fit, by contrast, can host all four conflict types.

3 The Main Principle: Conflict-Preserving Harmonization

This chapter performs the central theoretical work of the thesis: it evolves the framework's four-word commitment — harmonization, not replacement — into a named, decomposed, and partially formalized principle. The principle is Conflict-Preserving Harmonization (CPH). Its claim is that when multiple durable, authoritative, mutually inconsistent classifications must be made interoperable, the correct design retains the disagreement as structured information rather than resolving it, and coordinates the schemes through a stable identifier spine rather than merging them into one.

3.1 From slogan to invariants

A slogan cannot be tested; an invariant can. To move from one to the other, the thesis reads the framework's own charter and mechanisms and extracts eight conditions that an artefact either meets or fails. Together they constitute CPH; individually they are separable, so that a system can implement the principle partially. Figure 4 summarizes them; the subsections that follow define each and connect it to the framework's stated intent.

Figure 4. The principle of Conflict-Preserving Harmonization, decomposed into eight invariants.

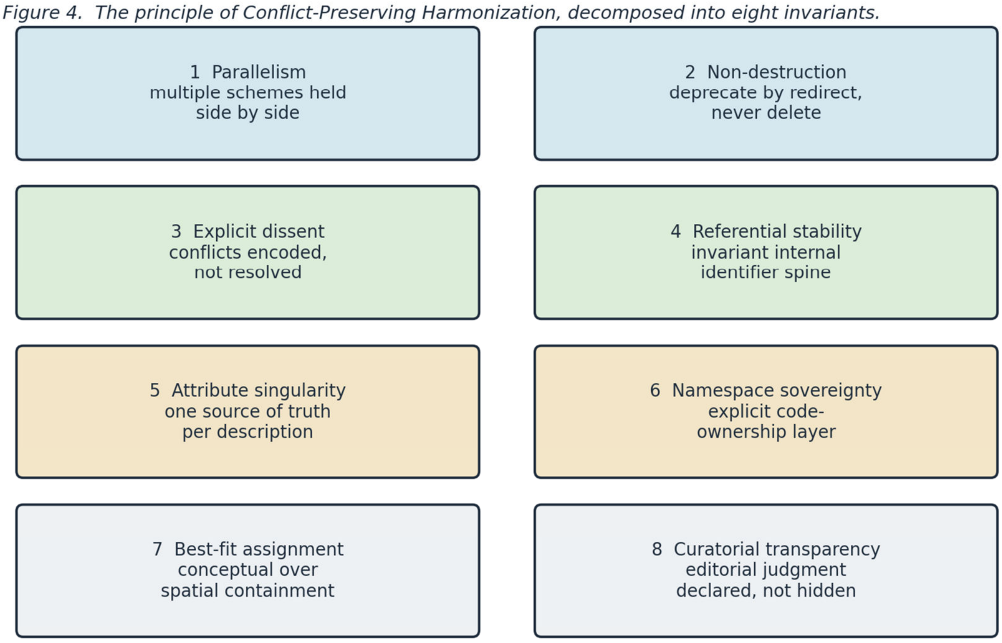

Figure 4. The principle of Conflict-Preserving Harmonization decomposed into eight invariants.

3.1.1 Parallelism

Multiple classification schemes are held side by side, each retaining its own identifiers and internal logic, without any one being designated the single truth. The charter's phrase is that the framework "preserves multiple coding schemes, versions, and hierarchical interpretations in parallel." Parallelism is the load-bearing invariant: the other seven describe how parallelism is made tractable.

3.1.2 Non-destruction

Nothing authoritative is overwritten. When an entity is superseded, its identifier is retained and redirected to its successors rather than deleted. The charter: "deprecated entities are retained with redirects rather than deleted," and "HLC codes are intended to remain stable across releases even when external standards change." Non-destruction is what makes temporal conflict survivable.

3.1.3 Explicit dissent

Disagreement is encoded in the data, not adjudicated out of it. Alternatives (|), logical or institutional entries (:), successions (>), and multiple legitimate parents (*) each receive a dedicated, machine-readable mark, while territorial disputes are recorded neutrally with their claimants stated and no sovereign parent assigned. The charter treats "classificatory disagreement as information, not error," and directs that disputes be "recorded neutrally … with no sovereign parent assigned."

3.1.4 Referential stability

An invariant internal identifier spine underlies the shifting external schemes, so that a thing can be tracked across releases and across schemes even as its external codes change. In HLC this spine is carried by the internal numeric and technical identifiers (HLC-M, HLC-X, HLC-S), which are designed to persist regardless of external churn.

3.1.5 Attribute singularity

Each descriptive fact has exactly one home. Where an entity appears in more than one hierarchy, only one appearance carries its attributes; the others carry placement alone. The charter's attribute-locality rule: for duplicate entries "the descriptive attributes reside only at the original (unmarked) entry. Duplicate copies carry the hierarchy placement only. This guarantees duplicates cannot contradict one another." Attribute singularity is what prevents parallelism from degenerating into inconsistency.

3.1.6 Namespace sovereignty

Code ownership is governed explicitly: for every code space it is defined which scheme owns which values, so that identifiers from different authorities can share a table without silent collision. This is the entire remit of the control file (codehu), examined in Chapter 8; ownership is fixed structurally by the control layer rather than by any single inline mark.

3.1.7 Best-fit assignment

Membership is decided by conceptual best fit, not spatial containment, so that historical, disputed, and mereologically complex entities can be placed without spurious geometric precision (Section 2.4). Coordinates serve orientation only.

3.1.8 Curatorial transparency

The judgments that hold the system together are acknowledged as judgments. The charter concedes that "which alternative hierarchies count as legitimate is a curatorial decision made by the maintainer," and that reproducing an assignment "may require that judgment." Transparency about curation is the ethical counterpart of explicit dissent: the system does not pretend that its harmonization is mechanical.

3.2 A compact formal model

The invariants can be given a small formal skeleton that captures what makes a CPH system structurally different from an ordinary taxonomy. The model is deliberately minimal; its purpose is clarity, not a full algebra.

Let `E` be a set of entities and `S` a set of classification schemes. A CPH system is a tuple `(E, S, id, ↑, name, attr)` where:

- `id : E → K` binds each entity to a value in an *invariant identifier spine* K; id is injective and stable across releases (Invariant 4).
- `↑ ⊆ E × E × S` is a *scheme-indexed parent relation*: (c, p, s) ∈ ↑ means c is a child of p under scheme s. For a fixed s, ↑ restricted to s is a forest; across different s it need not be, so an entity may have many parents by many schemes (Invariants 1, 3 — mereological conflict).
- `name : E × S ⍰ Σ*` is a partial naming: an entity may carry different names and codes under different schemes, and may be unnamed in some (Invariant 3 — nominal conflict).
- `attr : E ⍰ A` assigns descriptive attributes to at most one canonical appearance of each entity; duplicate appearances are placement-only (Invariant 5).

Deprecation is a partial map `⍰ : E ⍰ ⍰(E)` sending a superseded entity to the non-empty set of its successors; ☐ is never realized by removing the entity from E (Invariant 2). Sovereignty is a relation `claim ⍰ E × Sov` that may be many-valued and that does not induce any edge in ↑ (Invariant 3 — disputes carry claims but no sovereign parent).

Three structural properties distinguish this model from a single-parent taxonomy and correspond directly to the framework's behaviour.

- **Poly-parenthood without contradiction.** Because ↑ is scheme-indexed and attr is single-homed, an entity can sit under several parents without any risk of contradictory description: the extra placements carry no attributes to contradict.
- **Total resolvability.** Because ☐ never deletes and id is stable, every identifier ever issued remains resolvable, either to an entity or, transitively through ☐, to a set of current successors.
- **Neutrality of unassigned sovereignty.** Because claim induces no parent edge, a disputed entity is representable with all its claimants and with no sovereign parent, which is impossible in a system that requires every node to have exactly one parent of a sovereign type.

Figures 2 and 3 illustrate the two halves of the model on real entries: the identifier spine binding many scheme-indexed codes to one entity, and the poly-parent placement of a single waterbody under several valid parents.

4 Architecture and Notation: How the Principle Is Encoded

Having stated the principle, the thesis now turns to implementation. This chapter treats the framework's cross-cutting machinery — the file architecture, the shared notation, the inline attribute tags, and the attribute-locality rule — because these are the vehicles through which the eight invariants are actually carried. Domain-specific realization follows in Chapters 5–8.

4.1 Coordination without merger

The framework is delivered as five files (Figure 1): a shared front matter (codehx) and four operational files (codehu, codehl, codehy, codehw). The design choice that most directly serves Parallelism is that these files are, in the charter's words, "coordinated but not merged. Each uses classification logic appropriate to its domain, and they cross-reference one another through shared codes and attribute tags." Merger would force a single hierarchy and thereby destroy the very parallelism the principle protects; coordination through shared identifiers keeps the domains independent while making them interoperable. The ecoregion file states the same non-subordination even among its own sheets: none of its worksheets is a master sheet or a subset of another; they are, at most, siblings.

4.2 The shared notation as a grammar of dissent

The framework's notation is small, and almost every symbol in it exists to encode one of the four structural conflicts of Section 2.2 or to type an entry. Read this way, the notation is not incidental syntax but the concrete grammar of Explicit Dissent. Table 1 sets out the operators and maps each to the conflict it addresses and the invariant it serves.

Table 1. The shared notation of HLC, read as a grammar of conflict-preservation.

Symbol	Meaning (per front matter)	Conflict / role	Invariant served
|	Alternatives: equally valid codes or names for the same entity	Nominal	Explicit dissent
:	Used for logical, institutional, or organizational entries	Institutional	Parallelism
>	Redirect to the canonical or successor entry	Temporal	Non-destruction
*	Duplicate entry: a legitimate alternative hierarchy, not redundancy	Mereological	Parallelism + attribute singularity
~ + -	Inherited / encroached / extended values from adjacent entries	Mereological (boundary)	Best-fit assignment
!-	Range extension: a contiguous block of numeric codes owned by one entry	Coverage (economy)	Referential stability
{ : }	Inline attribute tag {scheme:value} — a cross-reference to an external standard	Nominal (cross-scheme)	Parallelism
( )	Optional extension or annotation	—	Readability

The economy of this grammar is notable. With a handful of operators plus an open-ended tag construct, the framework can state "this is also called X" (|), "this is an institutional or logical entry” (:), “this became Y” (>), “this is also filed under Z” (*), and “this is disputed between P and Q” (neutral claimant text) — the full vocabulary of preserved disagreement — without leaving the row. Namespace ownership, by contrast, is not expressed by any single inline mark but is fixed structurally by the control file (Chapter 8), so that the operators can remain a pure grammar of dissent.

4.3 Inline Attribute Tags: parallelism made portable

The construct {scheme:value} — an Inline Attribute Tag (IAT) — is the framework's mechanism for holding many schemes' opinions on one row without imposing any of them as the row's identity. The charter documents it as storing cross-references “inline as {scheme:value} (for example {UN:364}, {ISO:IR}, {MEOW:...}) to keep rows readable and editable.” In practice the tag keyspace is large and open: the operational files carry, among many others, {UN:} for M49 numerics, {IE:} for ICES divisions, {NF:} for NAFO, {FM:} for GFCM, {OP:} for OSPAR, {HC:} for HELCOM sub-basins, {US:} for USGS hydrologic unit codes and for GENC, {CM:} for the CCM2 catchment model, {MW:} for MEOW, {OW:} for GOODS, {FA:} for FAO areas, {WN:} for waterbody names, and a long tail of national statistical tags. Each IAT is a parallel view retained without subordination; collectively they turn a single row into a small crosswalk that travels with the entity.

4.4 The attribute-locality rule: why parallelism does not become chaos

The gravest risk of Parallelism is contradiction: if an entity appears in several hierarchies and each copy carries its own attributes, the copies will eventually disagree, and the system will contain internal inconsistencies of exactly the kind it set out to make legible in the external world. The framework forecloses this with a single, powerful rule, quoted in full in Section 3.1.5: for duplicate (*) entries, descriptive attributes reside only at the original, and the copies carry placement alone. The consequence is structural rather than procedural: duplicates cannot contradict one another because they contain nothing that could contradict. Attribute Singularity is thus the precondition that makes Parallelism safe, and its enforcement is what separates a principled poly-hierarchy from an unmaintainable pile of near-duplicates.

Figure 2. The invariant identifier spine: one entity, many scheme-indexed identifiers.

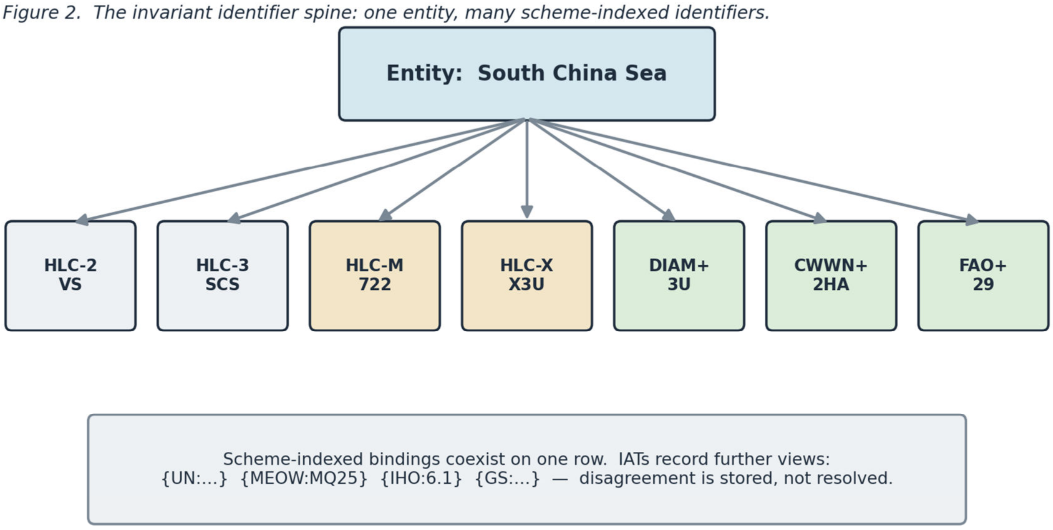

Figure 2. The invariant identifier spine. One entity carries many scheme-indexed identifiers on a single row, with further views held as inline attribute tags; no single code is promoted to be the entity's identity.

5 Implementation I — The Land Master Hierarchy (codehl)

The land file is described in its own role statement as the "land-based master hierarchy and system anchor." It is where the framework's most politically charged conflicts live, and therefore where CPH is most visibly exercised. This chapter reads codehl as an implementation of the principle, concentrating on four mechanisms: the entity-type ontology, the biogeographic–political double hierarchy, the neutral treatment of disputes and successions, and the parallel national-scheme columns.

5.1 A typed ontology of places

Before conflicts can be preserved they must be typed, and codehl carries an unusually rich type system. Its dedicated type sheet enumerates entry kinds — global, region, subregion, multiples, country, division, province, historical, water, and functional/logical placeholders — and then subdivides several of them by principle: a region may be geographical, economic, historical, or botanical; a subregion likewise; a country may be current or historical; a division may be administrative, geographical, historical, or economic. This typology is not decoration. It is what allows the same ground to be occupied by, say, a historical region and a botanical region without the two being confused, because each carries a type that declares the principle on which it cuts the world. Typing is the quiet enabler of parallelism: it lets multiple partitions coexist by making the basis of each partition explicit.

5.2 Two hierarchies over one earth

The clearest demonstration of Parallelism in codehl is that the file maintains, over the same land surface, both a political-administrative hierarchy (continents → regions → subregions → countries → divisions) and a biogeographic hierarchy (biogeographic realms → biomes → ecoregions, cross-referenced to the ecoregion file). Climate and ecological zones — arctic, temperate, equatorial, and their subtropical and subpolar refinements — form a third, geographical partition. These are not reconciled into one tree; they are held as distinct hierarchies whose entries cross-reference one another through shared codes and IATs. A user may therefore ask both "which country contains this place?" and "which realm and biome contain it?" and receive answers from partitions that were never forced to agree.

5.3 Disputes recorded, not decided

Sovereignty conflict is where reductive classification is most quietly political, because forcing a single parent is taking a side. codehl instead implements Explicit Dissent and the neutrality property of the formal model: disputed entities are represented with all their claimants and with no sovereign parent. The file is dense with such entries. Table 2 gives a representative sample drawn directly from the framework, illustrating the range — bilateral disputes, unclaimed land, occupied territories, and demilitarized neutral zones — each recorded with its claimants stated and no forced sovereign.

Table 2. Sovereignty conflict handled by neutral recording (representative entries from codehl / codehu).

Entity	Recorded condition	CPH mechanism
Abu Musa & Tunb Islands	claimed by IR, AE	claimants stated, no sovereign parent
Halaib Triangle	claimed by EG, SD	neutral recording
Bir Tawil	unclaimed territory (terra nullius)	represented without a parent
Nagorno-Karabakh (Artsakh)	AM-occupied AZ area; historical entity retained	dissent + non-destruction
Senkaku / Diaoyu Islands	claimed by CN, TW	claimants stated
Liancourt Rocks (Takeshima/Dokdo)	claimed by JP, KP/KR	claimants stated
Aksai Chin; Spratly; Paracel	multi-party claims recorded	many-valued claim, no parent edge
Kalapani; Siachen; Doumeira	bilateral claims recorded neutrally	neutral recording

The significance is methodological as much as political. By refusing to assign a sovereign parent to contested ground, the framework keeps its data usable by parties who disagree about the ground, and it makes the dispute itself queryable. A downstream user can enumerate disputed entities and their claimants precisely because the framework declined to resolve them.

5.4 Succession without erasure

Temporal conflict is handled by Non-destruction, and codehl carries the full apparatus. Former countries are retained with redirects to their successors: the Netherlands Antilles is kept and redirected to its three successor entities; the German Democratic Republic is retained and redirected to unified Germany; the USSR, Yugoslav and other dissolved states, and a long roster of historical polities down to colonial-era territories remain in the file with successor pointers and historical type-marks. ISO 3166-3 four-letter codes for withdrawn countries are preserved rather than dropped. The effect is Total Resolvability in the sense of the formal model: an identifier once issued can always be resolved, either directly or transitively through the redirect chain, so that longitudinal data referencing a vanished entity does not become dangling.

5.5 Many national schemes in parallel

Finally, codehl demonstrates Parallelism at the level of institutional viewpoint. Alongside the international codes, each entity row carries columns for a wide range of national and organizational classifications — among them the statistical country-code systems of Germany, Switzerland, France, Norway, Australia, New Zealand, South Africa, Japan, Argentina, and Italy, the EU geonomenclature, ISTAT, GENC, ITU, NATO, WID, ESSD, and Correlates of War, each recorded via its own column or IAT. No single national view is promoted to canonical; the framework holds them concurrently, so that a user embedded in any one institution can find their own identifiers without the framework having taken that institution's partition as the truth. This is Parallelism at its most concrete: dozens of authorities' opinions about the same country, co-located and none subordinated.

6 Implementation II — The Water and Hydrographic Hierarchy (codehy)

The water file's role statement is a “water and hydrographic hierarchy and crosswalk: oceans, seas, rivers, lakes, currents, straits, gyres and undersea features,” which “preserves multiple marine/hydrographic standards in parallel.” If codehl is where sovereignty conflict is most acute, codehy is where mereological conflict is most acute, because waterbodies nest differently under every marine authority. This chapter reads codehy as the framework's purest exhibit of Parallelism and multi-parenthood.

6.1 A crosswalk in columnar form

codehy is structured so that each waterbody row simultaneously carries its HLC internal identifier, its DIAM+ code, its CWWN+ waterbody-name code, its FAO+ area code, and a battery of IATs for FAO / NAFO / ICES, GFCM, OSPAR, HELCOM, GIWA, USGS hydrologic units, the CCM2 catchment model, Longhurst provinces, MEOW, GOODS, and the several editions of the IHO Limits of Oceans and Seas together with the ACIC chart. A single row is therefore a horizontal crosswalk: the same sea appears under every scheme that has an opinion about it, and the schemes' disagreements about numbering and extent are simply adjacent columns rather than a resolved verdict. The dedicated IHO sheet inverts the same data to be navigable by IHO identifier, and the DIAM sheet by DIAM+ code — the same entities, re-indexed by different owners, which is Parallelism realized as alternative access paths over one dataset.

6.2 Multi-parenthood by design

The framework's most theoretically interesting behaviour is on open display in codehy: a single waterbody placed under several valid parents via the duplicate (*) mechanism, with attributes held only at the original. The South China Sea is the canonical example. It appears as a Pacific entity in the Pacific hierarchy, and again — marked with * — under the East-Indian and Australasian-Mediterranean groupings, and its constituent straits and seas are correspondingly duplicated. The Norwegian Sea appears both under the Arctic (as part of the European Arctic complex) and under the North-East Atlantic; the Barents Sea likewise appears under both the Arctic and the North-East Atlantic. In every case the starred copies carry placement only, so the multiple filings cannot diverge in description. Figure 3 renders this structure for the South China Sea: one original entry bearing the attributes, several starred placements expressing that the sea legitimately belongs to more than one larger whole.

Figure 3. A conflict-preserving poly-hierarchy: one waterbody under several valid parents.

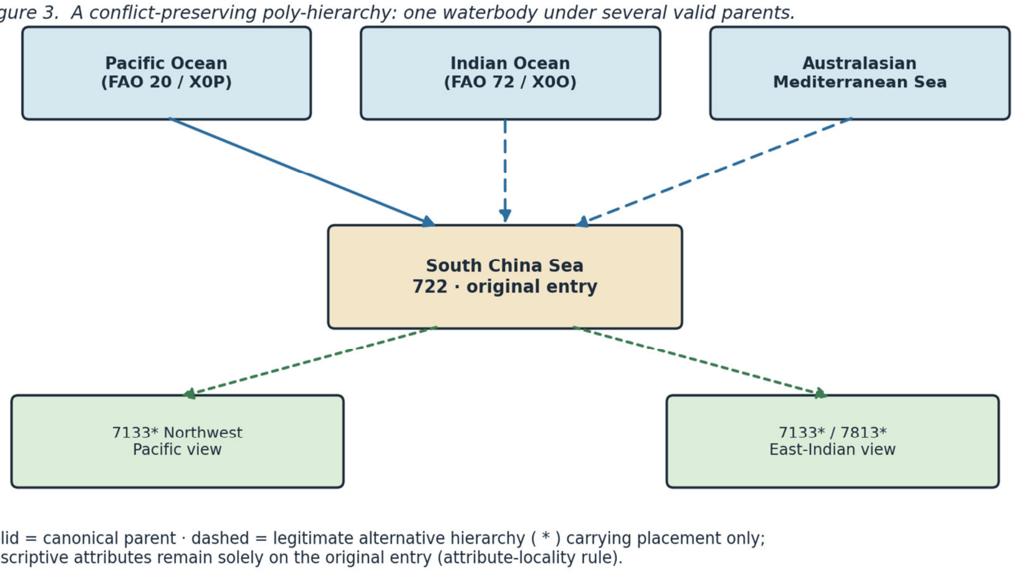

*Figure 3. A conflict-preserving poly-hierarchy in codehy. Solid edges mark the canonical parent; dashed edges mark legitimate alternative placements (*) that carry hierarchy position only, with all descriptive attributes retained on the single original entry.*

6.3 Currents, gyres, and undersea features as first-class entities

codehy also demonstrates that CPH scales below and beside the familiar sea-level partition. Ocean gyres and major currents (the North and South Pacific and Atlantic gyres, the Antarctic Circumpolar Current, and named equatorial currents and countercurrents) are entities in their own right, as are undersea features and the vertical pelagic and benthic zonation from the epipelagic photic zone down through bathyal, abyssal, and hadal provinces. These are partitions on principles orthogonal to the horizontal sea-boundary schemes, and they are held in parallel with them, cross-referenced through the same identifier spine. The water column is thus classified both horizontally (which sea) and vertically (which depth province) without either partition being made subordinate — a further instance of two hierarchies over one domain.

6.4 Deriving new identifiers without collision

Because Namespace Sovereignty is enforced (Chapter 8), codehy can safely mint new codes where source schemes fall silent. Its documentation records the derivation of additional CWWN+ code ranges and FAO+ style areas with a different structure and number ranges, and the version history notes the restoration of mostly original CWWN codes alongside deliberate FAO+ shifts. The ability to extend a namespace while preserving the originals — new values in reserved ranges, originals kept in brackets — is a direct application of Non-destruction to the identifier space itself: the framework grows its coverage without overwriting the codes it inherited.

7 Implementation III — Ecoregions and Ecosystems (codehw)

The ecoregion file's role is “ecoregions and ecosystems: terrestrial, freshwater, and marine classification systems held as sibling views.” The phrase sibling views is itself a statement of principle: the file explicitly declines to make any one ecological classification the master. This chapter reads codehw as the framework's most demanding test of Parallelism, because it must hold together a dozen ecological partitions built on incompatible criteria and resolutions.

7.1 A dozen partitions, no master

codehw carries, each on its own sheet, the WWF Global 200 priority ecoregions; the Longhurst biogeochemical provinces; the Global Ecological Zones (GEZ); the Terrestrial Ecoregions of the World (TEOW); the Biological Ecoregions of the World (BEOW); the Freshwater Ecoregions of the World (FEOW); EUNIS; the Benthic Provinces of the World (BPOW); the Global Open Oceans and Deep Seabed (GOODS); the Marine Ecoregions of the World (MEOW); the Large Marine Ecosystems (LMEs); the Protection of the Arctic Marine Environment (PAME) areas, incorporating the CBMP Arctic Marine Areas; the Pelagic Provinces of the World (PPOW); and the Global International Waters Assessment (GIWA). Its own introduction is unambiguous that these are not nested: none of the worksheets is a master sheet or a subset of another; they are at most siblings. The file is, in effect, a many-fold parallel classification of the biosphere, coordinated but not merged.

7.2 Harmonizing extensions under non-destruction

Where two ecological schemes almost align but not quite, codehw does not force them into congruence; it adds bridging entries in reserved ranges and records the provenance. Its documentation is explicit and instructive: to harmonize BEOW with TEOW, items are added in a reserved high range; TEOW gains grouping items where source regulation is lacking; FEOW entries deriving from the Global 200 are integrated as a reserved number band when needed; MEOW references from the Global 200 are added as an ecoregion band; and PPOW absorbs the Longhurst provinces as subitems or as additional provinces. Each of these is Non-destruction applied to classification structure: the source scheme is left intact, and reconciliation is achieved by adding clearly-marked, range-reserved bridge entries rather than by editing the sources into agreement.

7.3 The replacement machinery and referential stability

codehw is also where the framework's identifier discipline is most explicit. The file documents a replacement scheme by which a stable internal main code (HLC-M) is derived, when no code already exists in the land or water files, from a technical code (HLC-X) via a shortcut (HLC-S) via a reference code, and it states the intention to gradually replace the locally derived values with global values. This is Referential Stability as an explicit engineering programme: a scaffold of internal identifiers that keeps every ecological entity addressable while the external schemes it bridges continue to evolve. The file even notes that fluid hierarchies use zero-valued sort-order placeholders that must be omitted from hierarchical analysis — a small but telling instance of separating presentation order from logical structure so that the identifier spine remains clean.

7.4 Vertical and horizontal ecological parallelism

As in codehy, the ecological file classifies the same space on orthogonal principles held in parallel: terrestrial realms and biomes; freshwater realms, habitat types, and ecoregions; marine realms, provinces, and ecoregions; pelagic and benthic vertical provinces; climate and ecological zones. A given stretch of coast may therefore be simultaneously a TEOW ecoregion, a MEOW province at its shore, a GOODS benthic province offshore, a Longhurst province in its surface waters, and a GEZ zone by climate. None of these is promoted; all are retained and cross-referenced. The ecological file thus generalizes the two-hierarchies-over-one-earth pattern of Chapter 5 into many-hierarchies-over-one-biosphere, and it is the strongest single demonstration that CPH scales to a domain saturated with competing, equally legitimate partitions.

8 Implementation IV — Namespace and Code-Ownership Control (codehu)

The control file's role is "namespace and code-ownership control … which governs 2-gram and 3-gram code ownership across ISO, HLC, DIAM+, GENC and CWWN+ and technical codes." If the other three files hold competing classifications, codehu is what prevents their identifiers from colliding while doing so. It is the least glamorous file and the most structurally important, because it implements the invariant — Namespace Sovereignty — without which Parallelism would degenerate into identifier chaos.

8.1 Governing the two- and three-gram code spaces

codehu partitions the space of two-letter (2-gram) and three-letter (3-gram) codes and assigns ownership of each region of that space to a specific scheme. A two-letter code may be an ISO 3166-1 alpha-2 country code, or an HLC pseudo area/region code, or an HLC pseudo-subregion code, or an SDMX+ organization code, or a dependency code with internal numbering — and codehu records which of these a given code is. The three-letter space is partitioned analogously across ISO alpha-3, HLC extensions, organization codes derived from SDMX+, water-region codes derived from DIAM+, and US-government geopolitical codes. Because ownership is explicit, the same table can host identifiers from many authorities without silent collision: when a code appears, the control layer says whose code it is.

8.2 The ownership table as a conflict register

Read through the thesis's lens, codehu is a register of exactly the nominal and namespace conflicts that Section 2.2 identified. Every alternative-code mark (|), every logical or institutional entry (:), every organization-versus-country disambiguation, and every dependency relationship is recorded here, and code ownership is fixed structurally by the control layer's HLC-2 and HLC-3 columns rather than by any inline mark, so that the operational files can use identifiers freely, confident that the meaning of each identifier is fixed by the control layer. The file also copies in the DIAM+ data definitions with their code ownership intact, so that the water file can reference DIAM+ codes while codehu remains the single authority on what those codes are. This is Namespace Sovereignty functioning as the precondition for everything else: parallel schemes can share a workspace only because a control layer guarantees that their identifiers do not quietly overwrite one another.

8.3 Controlled minting and the HLC-M range map

codehu, together with the ecoregion file's replacement documentation, also governs how the framework mints its own internal main codes. The HLC-M numbering is not ad hoc; it is a controlled namespace partitioned by domain and by continent, with explicit ranges reserved for historical entities, small islands, and countries by continent, for waters and oceans, for realms and ecosystems, for organizations, and for continental and historical structures, and with several ranges deliberately marked unused for future growth. This range map is the internal counterpart of the external ownership table: just as codehu declares which external authority owns which external code, the HLC-M map declares which internal purpose owns which internal number. Both are expressions of the same discipline, and both are what let the identifier spine of Invariant 4 stay stable as coverage expands.

9 Neutral Assessment of the Framework

A thesis that only celebrated its object would be advocacy, not scholarship. This chapter assesses HLC even-handedly, separating the design principle (Chapter 3) from this particular implementation, and drawing the framework's own declared limitations into the evaluation rather than discovering them as flaws. The assessment is organized as strengths, limitations, and the conditions under which the approach is and is not appropriate.

9.1 Strengths

- **Principled non-loss.** The framework's defining achievement is that it retains information every reductive standard discards: the alternatives, the successions, the multiple parents, and the disputes. Its data can answer “who says otherwise, and how?” — a question closed to single-partition systems.
- **Political usability.** By recording sovereignty conflicts neutrally and assigning no contested parent, the framework remains usable across parties who disagree about the underlying territory, and it makes the disagreement itself an object of query.
- **Longitudinal integrity.** Non-destruction plus a stable identifier spine yields total resolvability: historical references do not dangle, and time series spanning entity changes remain joinable.
- **Breadth of integration.** The reference list is unusually wide — ISO, UN M49, GENC, SDMX+, DIAM+, CWWN+, FAO / NAFO / ICES / GFCM, IHO, OSPAR, HELCOM, Longhurst, GOODS, MEOW / BEOW / FEOW / TEOW / PPOW / BPOW / LMEs / PAME, EUNIS, WWF Global 200, GEZ, GIWA, and many national schemes — co-located rather than merged.
- **Internal consistency by construction.** The attribute-locality rule makes duplicate placements incapable of contradicting one another, converting a potential source of chaos into a structural guarantee.

9.2 Limitations

- **Single-maintainer epistemic authority.** The framework is, by its own account, “compiled and maintained by one single person … without any support or external influence,” with “no institutional editorial board, formal review process, or redactional overhead.” The curatorial judgments that decide which alternative hierarchies count as legitimate are therefore concentrated in one person and are not independently reproducible without that person's judgment. The framework states this plainly and asks to be evaluated as a specialist reference, not an official standard; the honesty is a virtue, but the concentration remains a limitation on authority and continuity.
- **Not authoritative and not spatial.** HLC defines no boundaries and is explicitly unsuitable for legal boundary determination, maritime delimitation, cadastral mapping, or polygon-based analysis. Its assignments are interpretive harmonizations, not adjudications, and its coordinates are orientation anchors only.
- **Uneven granularity.** Because it follows its sources, the framework is fine-grained where its sources are and coarse where they are not; depth of coverage varies by domain and region and reflects source availability rather than uniform design.
- **Snapshot, not real-time.** External references are versioned snapshots that do not auto-update; the framework is released in batches, so currency depends on release cadence.
- **Learning curve of the notation.** The very compactness that makes the grammar of dissent powerful also makes it dense; correct interpretation requires fluency in the operators and the tag keyspace, which raises the barrier to casual reuse.

9.3 Fitness for purpose

The correct evaluative question is not whether HLC is a better standard than ISO or IHO — it does not attempt to be, and it disclaims the role — but whether it is a good instance of the thing it is: a conflict-preserving coordination substrate over existing standards. On that question the assessment is positive. Every one of the eight invariants is demonstrably implemented, each through a concrete and inspectable mechanism, and the framework's limitations are, for the most part, the honest and unavoidable costs of the principle rather than failures of execution. The single genuine fragility that is not intrinsic to CPH is governance: a principle designed to preserve plurality is, in this implementation, sustained by a single curator, and its long-term authority and maintenance are correspondingly exposed. The next chapter turns from assessment to generalization, and governance re-appears there as the principal open problem.

10 Evolving the Principle Beyond Geography

The final substantive chapter returns to the thesis's central ambition — to evolve the framework's main principle — by lifting Conflict-Preserving Harmonization out of geography and proposing it as a general design pattern. The claim is that CPH is not a geographic technique that happens to be reusable but a solution to a domain-independent problem: the coexistence of multiple durable, authoritative, mutually inconsistent classifications that must interoperate without any being destroyed.

10.1 The pattern, stated abstractly

Wherever several institutions maintain incompatible classifications of the same domain, and where those classifications are too entrenched to be replaced and too useful to be discarded, the CPH pattern applies. Its prescription is the eight invariants of Chapter 3, instantiated in whatever notation the domain affords: hold the schemes in parallel; never destroy, only redirect; encode dissent rather than adjudicating it; anchor everything to a stable internal identifier spine; keep exactly one home for each descriptive fact; govern namespace ownership explicitly; assign by conceptual best fit; and declare the curatorial judgments as judgments. A system satisfying these is a coordination substrate for its domain in precisely the sense HLC is for geography.

10.2 Candidate domains

- **Medical coding.** ICD, SNOMED CT, and national billing classifications partition disease incompatibly; a CPH substrate would co-locate their identifiers per condition, record cross-walk dissent, and redirect deprecated codes rather than losing them.
- **Biological taxonomy.** Competing phylogenies and nomenclatural authorities disagree on ranks and boundaries; the scheme-indexed poly-hierarchy of Section 3.2 is a natural fit, with each authority's tree an indexed parent relation over a shared name spine.
- **Bibliographic and subject classification.** Dewey, LCC, and domain thesauri cut knowledge differently; parallel placement with single-homed attributes mirrors the library problem exactly.
- **Administrative and statistical geographies.** Even within one country, electoral, postal, census, and health geographies conflict; CPH offers a substrate that keeps all of them addressable without declaring one canonical.
- **Legal and regulatory ontologies across jurisdictions.** Where the same conduct is classified differently by different legal systems, neutral recording of divergent classifications — with no forced adjudication — is precisely the sovereignty-conflict pattern generalized.

10.3 Open problems

Generalization exposes three problems that HLC's geographic instance also faces and only partly solves. The first is governance: CPH preserves plurality in the data but says nothing about plural authorship of the substrate itself; a principle about not subordinating schemes deserves a governance model that does not subordinate its own maintenance to a single curator. The second is formal query semantics: the model of Section 3.2 defines structure but not a full query calculus over scheme-indexed poly-hierarchies with redirects and single-homed attributes; a complete algebra, with defined semantics for “parent under scheme s,” “resolve through redirects,” and “entities disputed between claimants,” would make CPH systems interrogable in a principled way. The third is provenance and trust: co-locating many authorities' opinions raises the question of how much each is to be trusted, which the current framework answers only through curatorial transparency; a richer model would attach graded provenance to each parallel view. None of these is a defect of the principle; each is a research direction the principle opens.

10.4 From replacement to coordination as an intellectual stance

Underlying the pattern is a stance worth stating explicitly, because it is the deepest sense in which the principle has been evolved. Reductive classification embodies a metaphysics in which there is, in principle, one correct partition of the world and disagreement is a temporary imperfection. CPH embodies a different metaphysics: that for many domains the plurality of authoritative partitions is permanent and informative, that the relations between the partitions are themselves knowledge, and that the proper task of an integrating system is not to end the disagreement but to make it legible, stable, and usable. HLC is one careful, single-handed instantiation of that stance in the geography of the whole earth. The contribution of this thesis has been to name the stance, to give it invariants and a model, to show that HLC implements it, and to argue that it is a pattern the rest of knowledge organization has reason to adopt.

11 Conclusion

This thesis set out to take a four-word commitment — harmonization, not replacement — and to evolve it into a theory, then to show that the theory is implemented. It has argued that the commitment names a genuine and general principle, Conflict-Preserving Harmonization, whose distinctive move is to retain classificatory disagreement as first-class information and to coordinate incompatible schemes through a stable identifier spine rather than merging them into one. It decomposed the principle into eight invariants and gave it a compact model of a scheme-indexed poly-hierarchy with non-destructive deprecation, single-homed attributes, and sovereignty claims that induce no parent.

It then read the HLC Operational Framework back through that theory. The land file was shown to implement parallelism as a typed double hierarchy of political and biogeographic partitions, to record sovereignty conflicts neutrally, to preserve successions by redirect, and to hold dozens of national schemes concurrently. The water file was shown to be the purest exhibit of multi-parenthood, placing single waterbodies under several valid parents with attributes held only at the original, and to classify the water column both horizontally and vertically in parallel. The ecoregion file was shown to hold many ecological classifications as siblings, reconciled by range-reserved bridging entries under non-destruction rather than by forcing congruence. And the control file was shown to implement namespace sovereignty, the precondition that lets all these schemes share a workspace without their identifiers colliding.

The assessment was neutral. Every invariant is implemented through an inspectable mechanism, and the framework's limitations are largely the honest costs of the principle — with the single genuine fragility being that a principle built to preserve plurality is here sustained by a single curator. That fragility became, in the generalization, the principal open problem: a governance model for coordination substrates that does not subordinate their own maintenance.

The larger claim is metaphysical and methodological at once. For many domains the multiplicity of authoritative classifications is not a defect to be corrected but a permanent feature to be represented, and the relations among those classifications are themselves knowledge worth keeping. HLC is a careful, wide-ranging, single-handed demonstration that such representation is achievable at the scale of the entire earth — its lands, its waters, and its living regions. The task of this thesis has been to show that behind that demonstration lies a principle general enough to matter well beyond geography, and precise enough to be built again.

Appendix A The Eight Invariants at a Glance

#	Invariant	Statement	Primary locus in HLC
1	Parallelism	Multiple schemes held side by side, none canonical	All files; codehw sibling sheets
2	Non-destruction	Deprecate by redirect (>), never delete	codehl successions; codehw bridges
3	Explicit dissent	Conflicts encoded (| : > *), not adjudicated	Notation; dispute entries
4	Referential stability	Invariant internal identifier spine (HLC-M/X/S)	codehw replacement machinery; codehu
5	Attribute singularity	One home per descriptive fact; duplicates carry placement only	Attribute-locality rule
6	Namespace sovereignty	Explicit ownership of every code space	codehu control layer
7	Best-fit assignment	Conceptual over spatial containment; coordinates orient only	Front matter §4; all files
8	Curatorial transparency	Editorial judgments declared as judgments	Front matter limitations

Sources. All quotations and structural claims are drawn from the HLC Operational Framework, version 7.9.3 (5 September 2026): the Common Front Matter (codehx) and the operational files codehu, codehl, codehy, and codehw, together with their internal documentation sheets.