HARMONIZATION WITHOUT ERASURE

The Principle of Non-Destructive Harmonization and Its Implementation in the Hierarchical Location Codes (HLC) Framework

A Doctoral Thesis

in the Interdisciplinary Study of Knowledge Organization,
Geographic Information Science, and the Philosophy of Classification

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HLC Operational Framework, Version 7.9 (2026)
codehx · codehu · codehl · codehy · codehw

Abstract

Reference systems that classify the world — country codes, maritime limits, ecological regionalisations — routinely disagree. The conventional response is what this thesis names **mononomic reduction**: heterogeneous source classifications are collapsed into a single authoritative answer, and the distinctions that do not survive are discarded as error. This thesis argues that a different and largely un-theorised design principle governs the Hierarchical Location Codes (HLC) Framework, and it develops that principle into a formal, testable construct.

Beginning from HLC's own surface maxim — *harmonization, not replacement* — the thesis evolves the idea through five stages into what it calls the **Principle of Non-Destructive Harmonization (NDH)**: a harmonizing reference system shall render the agreements of its sources navigable and their disagreements explicit, without deleting, overwriting, or collapsing any source distinction, while guaranteeing internal non-contradiction through stable identifiers and single-sourced attribution. NDH is decomposed into six axioms — source sovereignty, parallel coexistence, explicit conflict, referential stability, attribute locality, and interpretive transparency — and characterised by formal properties including information-monotonicity, conflict-preservation, and idempotent re-harmonization. A central result, the **Non-Contradiction Lemma**, shows that preserved contradiction does not entail dataset inconsistency: because HLC confines disagreement to placement-and-label space while single-sourcing every attribute, the system can hold mutually incompatible classifications without ever contradicting itself in fact.

The thesis then demonstrates, through close reading of the five-file corpus, that HLC's architecture, notation grammar, and operative mechanisms are each derivable from the axioms. The front-matter file supplies the axiomatic layer; the namespace-control file governs code ownership so that ISO, UN M49, SDMX+, DIAM+, GENC and CWWN+ identifiers coexist without collision; and the land, water, and ecoregion files instantiate the principle in three domains. Six mechanisms are analysed in depth and mapped to the axioms: the asterisk-duplicate device paired with the attribute-locality rule; retention-by-redirect of deprecated entities; inline attribute tags carrying source provenance; deterministic identifier derivation; the deliberate refusal to extend into polygon geometry; and neutral encoding of territorial disputes.

The framework is evaluated against a conformance test derived from each axiom and positioned comparatively against ISO 3166, UN M49, GeoNames, the Getty Thesaurus of Geographic Names, Wikidata, and SKOS-based crosswalks. The thesis finds strong axiomatic conformance alongside real limits — single-maintainer provenance, onboarding complexity, manual verification burden, and snapshot currency — several of which are inherent to the principle rather than incidental. It closes by generalising NDH beyond geography into a design principle for pluralistic reference systems, offering eight design guidelines, a conformance maturity model, and

a route to expressing NDH in linked-data terms. The contribution is thus at once theoretical (a new principle with axioms and a lemma), analytical (a principle-to-implementation mapping of a working system), and constructive (transferable guidelines for building reference systems that harmonize without erasing).

Keywords: non-destructive harmonization; knowledge organization; classification pluralism; boundary objects; gazetteers; crosswalks; referential integrity; geographic ontology; interoperability; single source of truth.

Table of Contents

1 Introduction

1.1 The problem: classification forces a single answer

Every system that assigns places to categories must decide what to do when its sources disagree. National statistical offices, international standards bodies, hydrographic authorities and ecological surveys each partition the surface of the Earth differently, and their partitions are not reconcilable by fiat: a strait may belong to two oceans, a state may straddle two continents, an island may be claimed by two governments, and an ecoregion may be a leaf in one scheme and a branch in another. The dominant engineering response is to force a resolution — to select one parent, one code, one boundary — and to treat the alternatives as noise. Bowker and Star (1999) show that such choices are never neutral: classifications privilege some realities and render others invisible, generating what they call residual categories and 'torque' on the lives and objects that do not fit. The lost distinctions do not merely inconvenience specialists; they encode contestable political, scientific and historical judgments that the reduced record silently naturalises.

This thesis calls the dominant response **mononomic reduction** (from *monos*, single, and *nomos*, rule): the imposition of a single classificatory rule where several are simultaneously defensible. Mononomic reduction is not irrational — it yields compact, computable identifiers — but it is lossy and irreversible, and it misrepresents genuine plurality as settled fact. The question this thesis pursues is whether a reference system can be built on the opposite commitment: integrating heterogeneous sources while preserving, rather than erasing, their disagreements, and doing so without collapsing into incoherence.

1.2 The object of study

The object of study is the Hierarchical Location Codes (HLC) Operational Framework, version 7.9 (2026), a specialist reference and crosswalk system that classifies and connects geopolitical entities, regions, countries, historical states, waterbodies, ecoregions and related structures. HLC is delivered as five coordinated files: a shared front matter (codehx) stating its philosophy, notation and limitations; a namespace-control file (codehu) governing which coding scheme owns each two- and three-character code; a land-based master file (codehl) that anchors the system; a water file (codehy); and an ecoregion file (codehw). HLC declares its purpose in a single phrase — harmonization, not replacement — and states that where standards disagree or do not correspond cleanly, that condition is to be represented explicitly rather than resolved into a single forced answer. HLC is, in other words, a working system explicitly designed against mononomic reduction, and therefore an unusually clear natural experiment in the alternative.

Two properties make HLC a productive object. First, it is comprehensive: it binds political, statistical, hydrographic and ecological standards into one traceable spine, so the tensions of cross-

domain integration are visible in a single corpus. Second, it is self-documenting: the front matter articulates design commitments that can be tested against the data files, allowing the analyst to ask whether the system does what it says. The thesis exploits both properties.

1.3 Aim and research questions

The aim is twofold, following the two verbs of the research brief: to **evolve** the framework's main principle from an informal maxim into a rigorous construct, and to **show** how HLC implements that principle. These are pursued through four research questions.

1. **RQ1 (Recovery).** What deep design principle underlies HLC's surface maxim 'harmonization, not replacement', and how should it be stated so that it is neither a truism nor a mere slogan?
2. **RQ2 (Formalisation).** Can that principle be formalised into a small set of axioms with definite formal properties, such that conformance is testable and violation is identifiable?
3. **RQ3 (Implementation).** By what concrete architectural, syntactic and mechanical means does HLC instantiate each component of the principle, and can each mechanism be traced back to an axiom?
4. **RQ4 (Generalisation and limits).** What are the principle's limits, at what cost is it purchased, and does it generalise beyond geography as a design principle for pluralistic reference systems?

1.4 Thesis statement

The thesis advances a single, defended claim. HLC instantiates a formal design principle — the Principle of Non-Destructive Harmonization (NDH) — that can be stated as six axioms and characterised by definite formal properties; the framework's five-file architecture, its notation grammar, and its operative mechanisms are each derivable from these axioms; and NDH generalises beyond geography as a transferable principle for reference systems that must integrate disagreeing sources without erasing them. The principle is coherent — it does not collapse into contradiction — because HLC separates the space in which classifications may disagree (placement and label) from the space in which facts are asserted (attributes), and single-sources the latter.

1.5 Contributions

The thesis makes four contributions, in descending order of generality.

- **Theoretical.** It names and formalises the Principle of Non-Destructive Harmonization, decomposes it into six axioms, characterises its formal properties, and proves the Non-Contradiction Lemma that reconciles preserved plurality with internal consistency.

- **Analytical.** It provides a complete principle-to-implementation mapping of a working reference system, tracing each of HLC's architectural, syntactic and mechanical features to a specific axiom, and evidencing the mapping with worked examples drawn from the corpus.
- **Evaluative.** It derives an axiom-based conformance test, applies it to HLC, and positions HLC comparatively against six established reference systems along six axes.
- **Constructive.** It generalises the principle into eight design guidelines and a conformance maturity model for building new pluralistic reference systems, and sketches a route to expressing NDH in linked-data terms.

1.6 Method and sources

The method is an interpretive, design-science reconstruction (Hevner et al., 2004). The primary source is the five-file HLC corpus at version 7.9; the analysis proceeds by close reading of the front matter to recover stated commitments, systematic extraction of mechanisms and worked examples from the data files, and rational reconstruction of the implicit principle into an explicit axiom set. The reconstruction is then validated in two directions: downward, by checking that each axiom is realised by concrete features of the files, and upward, by checking that the framework's otherwise heterogeneous features become intelligible as consequences of the axioms. The stance is analytical rather than promotional: the thesis reports where conformance is strong, where it is partial, and where the principle exacts a cost.

The provenance of the corpus is itself relevant evidence and is treated as such. HLC is compiled and maintained by a single person without an institutional editorial board or formal review process, a fact the front matter discloses. This bears directly on one axiom (interpretive transparency) and on the evaluation of the framework as research infrastructure, and it is analysed rather than bracketed.

1.7 Scope and delimitations

The thesis is a study of a principle and its implementation, not a data-quality audit. It does not attempt to verify the substantive correctness of individual HLC assignments against every external authority, nor to benchmark computational performance, nor to conduct user studies; these are identified as future work. It treats HLC's coordinate policy — the deliberate refusal to encode polygon geometry — as a principled scope boundary to be explained, not as a deficiency to be remedied. Its comparative claims are positional rather than exhaustive, situating HLC among representative systems rather than surveying the entire field of gazetteers and knowledge-organization systems.

1.8 Structure of the thesis

Chapter 2 assembles the interdisciplinary background against which the principle is developed. Chapter 3 evolves and formalises the principle, states the six axioms and formal properties, and proves the Non-Contradiction Lemma. Chapter 4 shows how the five-file architecture instantiates the axioms. Chapter 5 analyses the notation grammar as the syntactic carrier of the principle. Chapter 6 examines six implementation mechanisms in depth. Chapter 7 evaluates conformance, positions HLC comparatively, and confronts the principle's costs and the framework's limits. Chapter 8 generalises the principle into design guidance. Chapter 9 answers the research questions and identifies future work.

2 Conceptual and Theoretical Background

The principle developed in this thesis sits at the intersection of several literatures that rarely meet: the sociology and philosophy of classification, the theory of knowledge organization and crosswalks, geographic information science, and database engineering. This chapter draws from each the specific ideas the argument requires, and identifies the gap the principle fills.

2.1 Classification and its consequences

Bowker and Star's (1999) study of classification establishes the foundational claim that every classification is simultaneously a technical and a moral achievement: to sort is to decide what counts, and what will be made invisible. Their concepts of the residual category (the 'other' bucket into which non-conforming cases are swept) and of torque (the strain imposed when a person or object is forced to fit an ill-suited class) name precisely the harms of mononomic reduction. Foucault's (1970) reading of Borges' imaginary Chinese encyclopedia dramatises the same point from the other side: the shock of an alien taxonomy reveals that our own categories are contingent orderings, not transcriptions of a natural order. Ranganathan's (1967) facet analysis offers an early constructive response — rather than a single enumerative hierarchy, describe entities along multiple independent facets that can be combined — anticipating the idea that one object may be legitimately placed in more than one way. These works establish that classificatory plurality is not a defect to be engineered away but a fact to be represented; they do not, however, supply an operational principle for doing so at scale while preserving consistency.

2.2 The map is not the territory

Korzybski's (1933) dictum that the map is not the territory, and Borges' (1946) parable of an empire whose cartographers draw a map at 1:1 scale until it must be abandoned, together articulate a discipline of representational humility: a model that tries to capture everything captures nothing usable, and a model that forgets it is a model mistakes its own artefacts for the world. This humility is directly relevant to HLC's most conspicuous self-limitation — its refusal to encode boundaries as geometry — which Chapter 6 reinterprets not as incapacity but as a principled decision to provide orientation anchors rather than manufacture false precision. The lesson taken forward is that a harmonizing system should be explicit about the grain and kind of claim it makes, and should decline to assert more than its sources warrant.

2.3 Incommensurability and conceptual pluralism

Kuhn's (1962) notion of incommensurability — that rival frameworks can lack a common measure, so that translation between them is partial and lossy — explains why crosswalks between classification schemes cannot in general be exact. Feyerabend's (1975) methodological pluralism and Wittgenstein's (1953) family-resemblance account of concepts, in which membership rests on

overlapping similarities rather than a single defining criterion, further undermine the assumption that there exists, for each entity, one correct category awaiting discovery. Lakoff's (1987) work on radial categories and prototype effects gives this a cognitive footing. HLC's stated practice of assigning entities by 'best conceptual fit' rather than strict spatial containment is a direct operational expression of family-resemblance categorisation, and its parallel-hierarchy device is a way of recording that more than one fit may be good.

2.4 Boundary objects and infrastructures

Star and Griesemer's (1989) boundary objects — artefacts robust enough to travel across communities yet plastic enough to mean different things in each — describe how coordination is achieved without consensus. A harmonizing reference system aspires to be exactly such an object: usable by hydrographers and statisticians and ecologists at once, precisely because it does not force them to agree. Star's (2010) later reflection cautions that not everything spanning communities is a boundary object; the concept requires both interpretive flexibility and a shared infrastructure of standardised methods. This dual requirement — flexibility plus standardisation — foreshadows the central tension the principle must resolve: how to be plastic about classification while being rigid about identity and fact.

2.5 Knowledge-organization systems and the lossiness of crosswalks

The knowledge-organization literature provides the immediate technical context. Thesauri and the SKOS model (Miles & Bechhofer, 2009) formalise relations within and between vocabularies, and SKOS in particular distinguishes mapping relations — exact, close, broad, narrow and related match — that admit degrees of correspondence rather than demanding identity. Zeng and Chan (2004) survey interoperability among knowledge-organization systems and document the recurring problem that crosswalks lose information at every hop, because each mapping must choose a single target relation. Svenonius (2000) and Hjørland (2008) frame the organizing choices as theory-laden and domain-dependent. The SKOS mapping vocabulary is the closest prior art to HLC's notation of alternatives and redirects; the difference, developed later, is that SKOS supplies relations between concepts but not an architecture that guarantees the resulting plurality remains internally consistent.

2.6 Gazetteers and the ontology of geographic kinds

Within geographic information science, Hill (2006) and Goodchild and Hill (2008) establish the gazetteer — a triad of name, type and footprint — as the core instrument for associating information with places, and emphasise that names, types and footprints are all historically variable and contested. Smith and Mark (2001) show that geographic kinds are ontologically peculiar: their boundaries are frequently vague, socially constituted, or disputed, so that a single crisp assignment

is often a category mistake. Operational gazetteers — GeoNames, the Getty Thesaurus of Geographic Names, Wikidata's geographic layer — and the political standards ISO 3166 (2020) and UN M49 (1999) each cope with this differently, and Chapter 7 positions HLC against them. Wikidata (Vrandečić & Krötzsch, 2014) is especially pertinent: by attaching multiple sourced statements, potentially mutually inconsistent, to a stable item identifier, it too refuses mononomic reduction — making it the nearest institutional analogue to the principle this thesis formalises.

2.7 Database integrity and the single source of truth

The final ingredient comes from database engineering. Codd's (1970) relational model and the normalization theory that followed (Date, 2003) institutionalise the discipline of recording each fact once, in one place, so that update anomalies and contradictions cannot arise; referential integrity ensures that references to an entity remain valid as the entity evolves. These are the engineering counterparts of two axioms developed below — attribute locality and referential stability — and they supply the mechanism by which preserved plurality is prevented from decaying into inconsistency. The insight the thesis extracts is that pluralism at the level of classification is safe only if it is paired with strict discipline at the level of identity and attribution.

2.8 The gap

Each literature supplies a piece. Classification studies establish that plurality must be represented; the philosophy of science explains why exact reduction is impossible; boundary-object theory shows that coordination without consensus is achievable; knowledge-organization practice offers vocabularies of partial correspondence; geographic ontology specifies the contested nature of place; and database theory supplies the discipline of consistency. What none provides is an integrated, operational **principle** that unites non-destruction, preserved plurality, and internal integrity into a single design commitment for reference systems, together with a demonstration that a working system embodies it. HLC is such a system, and supplying that principle is the task of the next chapter.

3 The Core Principle: Evolution and Formalisation

3.1 The surface maxim and its ambiguity

HLC states its governing commitment as three words: harmonization, not replacement. As a slogan this is evocative but under-determined. ‘Harmonization’ might mean mere co-listing, or crosswalking, or the construction of a superordinate scheme; ‘not replacement’ might be a modest disclaimer of authority or a strong prohibition on overwriting. To function as a design principle — something from which architectural decisions follow and against which conformance can be tested — the maxim must be sharpened. This section evolves it, in five steps, into a precise construct; the trajectory is shown in Figure 1.

Figure 1. Evolution of the core principle

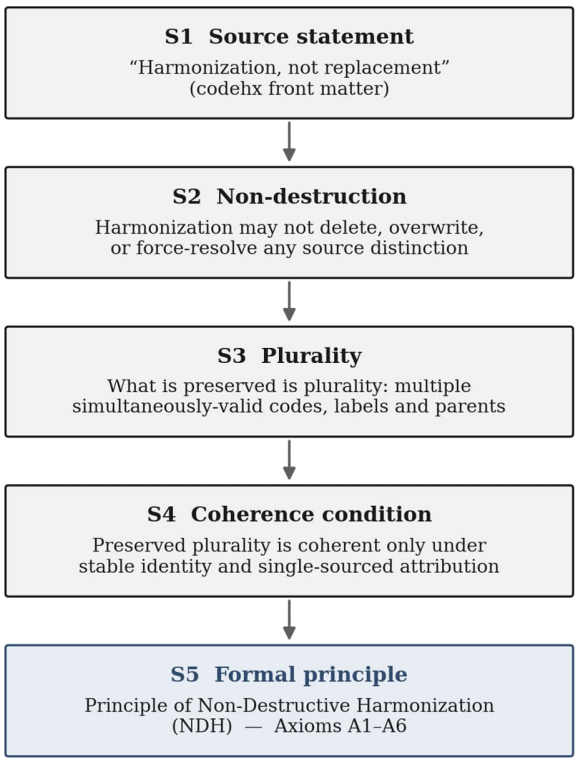

Figure 1. The five-stage evolution of the core principle from surface maxim to formal axioms.

3.2 Five steps from maxim to principle

Step 1 — the source statement. We begin where HLC begins: harmonization is to add value by connecting standards, not by supplanting them. This fixes the intent but not the constraints.

Step 2 — non-destruction. ‘Not replacement’ is strengthened from a disclaimer into a prohibition: the act of harmonizing may not delete, overwrite, or force-resolve any distinction present in a

source. What integration adds must be strictly additional. This converts a statement of humility into an operational constraint that can be violated and therefore tested.

Step 3 — plurality is the thing preserved. If no source distinction may be destroyed, then when two sources disagree, both classifications must survive in the integrated record. The object preserved is therefore plurality: an entity may legitimately bear several codes, several labels, and several parents at once. Disagreement is reclassified from error to information — exactly HLC's stated stance that classificatory conflict is to be recorded, not resolved.

Step 4 — the coherence condition. Unbounded plurality threatens incoherence: if an entity may be described in contradictory ways, what prevents the dataset from asserting a thing and its negation? The evolution's decisive step is to recognise that preserved plurality is coherent only if it rests on two disciplines borrowed from database theory: a stable identity for each entity that persists across time and across schemes, and single-sourced attribution so that each descriptive fact is asserted exactly once. Plurality is then confined to how an entity is placed and named, never to what is asserted of it.

Step 5 — the formal principle. Combining these yields a single commitment with an internal safeguard. We name it the Principle of Non-Destructive Harmonization.

3.3 Statement of the principle

> *Principle of Non-Destructive Harmonization (NDH). A harmonizing reference system shall integrate heterogeneous source classifications by making their agreements navigable and their disagreements explicit, without deleting, overwriting, or collapsing any source distinction, and shall guarantee its own internal non-contradiction by resting all preserved plurality on stable entity identifiers and single-sourced attribution.*

NDH is deliberately stronger than ‘harmonization, not replacement’ in two respects. It converts the negative disclaimer into a positive, testable prohibition (non-destruction), and it adds the coherence safeguard (stable identity plus single-sourced attribution) that the surface maxim leaves implicit. It is this safeguard that distinguishes NDH from a mere licence to accumulate contradictions.

3.4 The six axioms

NDH decomposes into six axioms. Each is stated as a constraint on a conforming system; Chapters 4 to 6 show how HLC satisfies each, and Chapter 7 uses them as conformance tests.

Table 1. The six axioms of Non-Destructive Harmonization.

Axiom	Name	Constraint on a conforming system
A1	Source sovereignty	Source standards remain authoritative in their own domain; the system references and links them but never overwrites or supersedes them, and it records their identifiers verbatim and reversibly.
A2	Parallel coexistence	When sources disagree, all their classifications survive as first-class entries; an entity may hold multiple codes, labels and parents simultaneously, none privileged as the sole truth.
A3	Explicit conflict	Disagreement is inscribed in the record itself, in an interpretable notation, rather than hidden by a silent choice; alternatives, successions and disputes are visible and typed.
A4	Referential stability	Each entity has an internal identifier that persists across releases and across schemes; deprecated entities are retained and redirected, never deleted, preserving longitudinal reference.
A5	Attribute locality	Each descriptive attribute is asserted exactly once, at a single canonical location; parallel placements carry structure only, so that no two locations can assert conflicting facts.
A6	Interpretive transparency	The system declares that its assignments are interpretive harmonizations, discloses the curatorial judgment and provenance behind them, and versions its changes so that any state is reconstructible.

3.5 Formal properties

From the axioms follow several properties that give NDH testable bite. They are stated informally but precisely; each is later checked against HLC.

- **Information-monotonicity (from A1–A3).** Integration never removes information: for any source distinction *d*, if *d* is present before harmonization it is present, and recoverable, after. Formally, the information content of the integrated record is a superset of the union of the sources', modulo identity resolution.
- **Conflict-preservation (from A2–A3).** For any pair of sources that disagree about an entity, the integrated record contains an explicit, typed representation of the disagreement; disagreement is never silently collapsed to agreement.
- **Idempotence of re-harmonization (from A4–A5).** Re-integrating an already-integrated source produces no change beyond identity linking: because identifiers are stable and attributes single-sourced, harmonization applied twice equals harmonization applied once. This is the formal signature of a non-destructive, side-effect-free operation.
- **Referential stability (from A4).** A reference to an entity resolves to the same entity across releases; deprecation changes an entity's status and adds a redirect but does not invalidate prior references.
- **Attribute uniqueness (from A5).** No attribute is asserted at two locations; therefore no update can make two locations disagree about a fact.

- **Source-authority preservation (from A1).** For every borrowed classification, the originating scheme and its native identifier are recoverable from the record, so that any harmonized statement can be traced back to, and if desired replaced by, its source.

3.6 The Non-Contradiction Lemma

The obvious objection to NDH is that preserving disagreement makes the dataset inconsistent: if it records that an entity is Asian and that it is African, has it not asserted a contradiction? The following lemma answers the objection and is the theoretical keystone of the thesis.

> *Non-Contradiction Lemma. A system satisfying A2 and A5 can preserve mutually incompatible classifications of an entity without asserting any contradiction.*

Argument. Partition the system's assertions into two disjoint spaces. The *placement-and-label space* contains statements of the form 'under scheme S, entity E is classified as C' or 'scheme S names E as N'. The *attribute space* contains statements of the form 'E has property P with value V'. A2 permits multiplicity only in the first space: the record may contain 'under M49 conventions E is grouped with Asia' and 'under continental-geography conventions E is grouped with Africa'. These are not contradictories, because each is indexed to its scheme; they are two true statements about two schemes, not two conflicting statements about the world. A5 forbids multiplicity in the second space: each attribute of E is asserted once, at E's canonical entry, so the attribute space cannot contain $P = V$ and $P = V'$. Since contradiction requires two assertions of the same proposition with incompatible truth-values in the same space, and the first space is scheme-indexed (blocking sameness of proposition) while the second is single-sourced (blocking multiplicity), no contradiction can be formed. ■

The lemma explains why NDH is not merely a licence to hoard conflicts. Its two structural axioms do complementary work: A2 opens a space in which plurality is safe because every entry is relativised to a scheme, and A5 closes the space in which plurality would be dangerous by permitting exactly one assertion per fact. Non-destruction and consistency are thus not in tension; they are secured by different axioms operating on different spaces. This result is what elevates NDH from a slogan to a principle.

3.7 Relation to prior constructs

NDH can now be located precisely against the background of Chapter 2. Boundary-object theory describes, sociologically, the achievement of coordination without consensus; NDH specifies, operationally, the constraints under which a single artefact can achieve it and remain consistent. SKOS supplies a vocabulary of partial correspondence between concepts but neither mandates non-destruction nor guarantees consistency of the resulting mapping graph; NDH is architectural where SKOS is relational. Faceted classification (Ranganathan) permits multiple placements but

does not address cross-scheme provenance or referential stability across time. The closest institutional analogue is Wikidata's model of multiple sourced statements attached to a stable identifier; NDH can be read as an explicit articulation of the design principle Wikidata approximates, but applied to a curated hierarchical reference system rather than a crowd-sourced triple store, and made falsifiable through its axioms.

3.8 Falsifiability: what would violate NDH

A principle worth defending must be violable. A system violates NDH if it does any of the following: silently selects one source classification and discards the others (violates A1–A3, breaking information-monotonicity); deletes a deprecated entity so that prior references dangle (violates A4); records the same attribute in two places so that they can drift apart (violates A5); presents interpretive assignments as authoritative fact without disclosing provenance (violates A6); or resolves a territorial or scientific dispute by assigning a single contested parent without marking the contest (violates A3). These are the tests Chapter 7 applies to HLC and to comparator systems; their existence shows that NDH makes empirical, checkable claims rather than merely commending a virtue.

4 Architecture as Principle-Instantiation

This chapter shows that HLC's division into five files is not an arbitrary packaging decision but a direct instantiation of the axioms: the architecture separates the concerns that NDH requires to be separated. Figure 2 summarises the mapping.

Figure 2. Five-file architecture as principle-instantiation

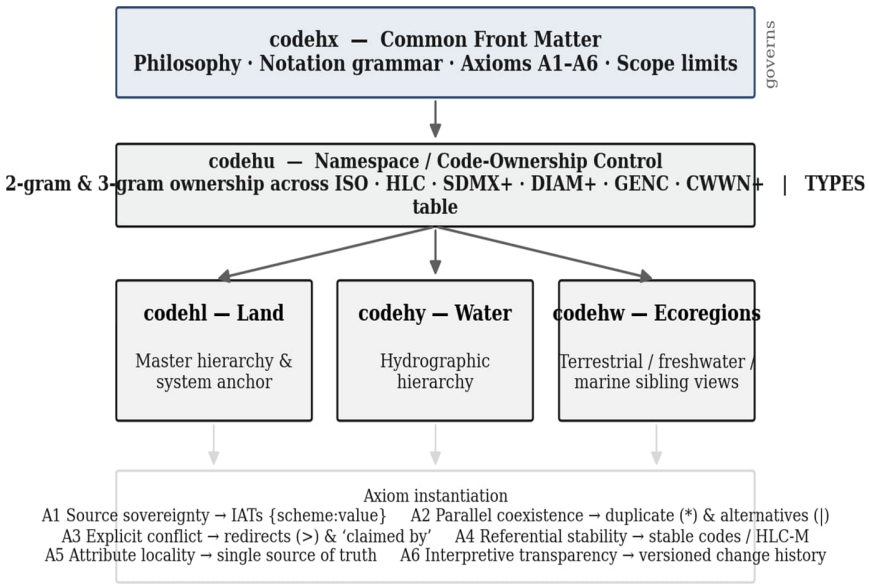

Figure 2. The five-file architecture as an instantiation of the six axioms.

4.1 Separation of concerns

NDH imposes three distinct obligations that are cleanly separable: to declare the principle and its notation (so that every file interprets marks the same way); to govern identity and code ownership (so that plurality across schemes does not degenerate into collision); and to instantiate the principle in each substantive domain. HLC assigns each obligation to a dedicated layer. The front matter is the axiomatic layer; the namespace-control file is the governance layer; and the land, water and ecoregion files are the domain layer. The layering is what lets the same discipline apply uniformly across otherwise incompatible domains.

4.2 codehx: the axiomatic layer

The front matter is not documentation appended to the data; it is the constitutional layer that the other four files presuppose. It fixes the shared notation, states the attribute-locality rule that underwrites the Non-Contradiction Lemma, defines the inline-tag convention that carries source provenance, declares the coordinate policy that bounds the system's claims, and enumerates the

standing limitations. In the vocabulary of this thesis, codehx is where A3, A5 and A6 are established as system-wide invariants: it is the single place that says what a redirect means, what a duplicate marker means, and that assignments are interpretive. Because these definitions live once and govern all files, codehx is itself an application of attribute locality at the level of the framework's own semantics.

4.3 codehu: the governance layer

The namespace-control file discharges the obligation that makes cross-scheme plurality safe. When a single record may carry an ISO code, a UN M49 number, an SDMX+ organization code, a DIAM+ water code and a GENC code at once, the code space must be partitioned so that no two schemes contend for the same slot. codehu is precisely this partition: for every two-character slot it declares which scheme owns it — an ISO country code, an HLC pseudo-region code, an SDMX+ organization code, or an HLC technical or attribute code — and it repeats the discipline for three-character codes. It also hosts the TYPES table, a controlled vocabulary of entry kinds (global, region, subregion, country, division, province, water, historical, logical, functional, tectonic) that every domain file draws on, and it holds a mirrored copy of the DIAM+ water-code definitions to record that the numeric water-code space is owned by DIAM+. In axiom terms, codehu operationalises A1 (each scheme's identifiers are honoured and kept distinct) and enables A2 (multiple schemes can coexist on one entity because their code spaces provably do not overlap). Without this layer, parallel coexistence would produce ambiguity; with it, plurality is collision-free by construction.

4.4 codehl: the anchor

The land file is designated the master integrator, and the choice is principled rather than incidental. Land carries the densest web of external standards — political, statistical, historical, biogeographic — and therefore the most disagreement to harmonize; anchoring the system where integration is hardest forces the notation and mechanisms to be adequate to the general case. codehl also hosts the shared spine of climate zones and biogeographic realms that the water and ecoregion files reference, so that a single ordering of the Earth's zonation is single-sourced and reused rather than duplicated. Its hierarchies descend from continents through regions, subregions and countries to divisions and provinces, and they carry extensive historical granularity — former states, princely and colonial sub-entities, superseded unions — each retained rather than discarded. This depth is the visible face of A4: history is kept, not overwritten, so that references framed in older classifications still resolve.

4.5 codehy: the domain mirror for water

The water file mirrors the land file's discipline in the hydrosphere, descending from zones and realms through world oceans, ocean basins and seas to gulfs, straits, bays, currents, gyres and undersea features. Its distinctive contribution to the argument is its handling of marine multi-membership: seas that belong, under different authorities, to more than one basin are represented by parallel entries rather than by a forced single parent, and the file carries dedicated re-sort sheets that present the same entries ordered by external schemes such as the hydrographic limits of oceans and seas and the aeronautical charting limits. These re-sort sheets are alternative orderings of one underlying set — an implementation of A2 at the level of whole views — and they demonstrate that the same data can be navigated through several sovereign schemes without any of them being made canonical.

4.6 codehw: sibling-view consolidation for ecoregions

The ecoregion file is the purest architectural expression of parallel coexistence. It consolidates more than a dozen global ecological classifications — terrestrial, freshwater and marine — and states explicitly that none of its worksheets is a master or a subset of another: they are siblings. Here A2 is elevated from row-level marking to schema-level design: entire classification systems coexist as equals under one roof. Two mechanisms keep this coexistence coherent. First, purely ordinal placeholder levels exist only to impose sort order and are declared to be excluded from hierarchical analysis, so that the machinery of ordering does not contaminate the machinery of meaning. Second, a documented replacement table deterministically derives a unique internal identifier for each entry from its native reference code whenever no identifier already exists in the land or water files — an implementation of A4 and A5 together, since it generates stable identity reproducibly rather than by ad-hoc assignment. Chapter 6 returns to this derivation as a mechanism in its own right.

4.7 The architecture theorem

The chapter's claim can be stated compactly. Given the six axioms, an efficient design will (i) factor out the shared semantics into one governing layer, since A3, A5 and A6 demand system-wide uniform definitions; (ii) factor out identity and code ownership into one governance layer, since A1 and A2 jointly require a collision-free partition of the identifier space; and (iii) instantiate the principle separately per domain, since each domain integrates a different family of sources. HLC's five files are exactly this factorisation: codehx realises (i), codehu realises (ii), and codehl, codehy and codehw realise (iii). The architecture is therefore not merely consistent with NDH; it is what the axioms predict.

5 The Notation Grammar as Syntactic Carrier

5.1 Rationale: the principle must be inscribable per row

Explicit conflict (A3) is not satisfiable by prose commentary; if disagreement is to be preserved at scale, it must be inscribable in each record, in a compact notation that a reader or a parser can interpret uniformly. HLC therefore defines a small operator grammar whose marks encode the relationships NDH requires: alternatives, redirects, legitimate duplicates, inheritance, ranges, optional extension, logical or institutional entries, and cross-scheme references. This chapter treats the grammar as the syntactic carrier of the principle and maps each operator to the axiom it serves.

5.2 The operator set

Table 2 lists the operators, their meaning, and the axiom each primarily serves. Together they constitute a controlled micro-language: a domain-specific notation whose every token has a defined semantics fixed once in the front matter.

Table 2. The HLC operator grammar and its mapping to the axioms.

Operator	Reading	Function	Axiom
a n x y z	alpha / numeric / alphanumeric placeholders	Type the shape of a code slot	A1
|	alternatives	Equally valid codes or names for one entity	A2
>	redirect	Points to the canonical or successor entry	A4 / A3
asterisk	legitimate duplicate	A second placement in an alternative hierarchy, not redundant data	A2
~ + -	inherited / encroached / extended	Values shared with or bordering an adjacent entry	A2 / A5
! -	range extension	A contiguous block of codes	A4
( )	optional extension or annotation	Non-obligatory refinement	A6
:	logical / institutional entry	An organizational or logical, non-territorial node	A1
{ scheme : value }	inline attribute tag (IAT)	A verbatim cross-reference to an external standard	A1 / A6

The grammar can be summarised as a production for a record's identity-and-relations field, in an informal EBNF: an entry is a primary code, optionally followed by one or more alternative codes each introduced by the alternatives operator, optionally a redirect to a successor, an optional duplicate marker indicating a parallel placement, zero or more inheritance marks relating it to neighbours, and any number of inline attribute tags carrying external identifiers. The point is not the exact syntax but that the relationships NDH requires — alternative, successor, parallel, inherited, external — are each given a distinct, composable mark.

5.3 Semantics: each mark discharges an axiom

The alternatives operator realises parallel coexistence at the level of a single entity: two codes or names joined by it are asserted to be equally valid, so neither is privileged and neither is discarded (A2). The redirect realises retention-by-succession: a deprecated or superseded entry is not deleted but points forward to its canonical or successor entry, preserving the old reference while routing the reader onward (A4, and A3 where the succession encodes a historical dispute). The duplicate marker realises multi-hierarchy placement: an entity legitimately belonging under two parents appears twice, once unmarked and once marked, with the marked copy carrying placement only (A2, and A5 via the attribute-locality rule examined in Chapter 6). The inheritance marks record that a value is shared with, encroached from, or extended beyond an adjacent entry, keeping such relations explicit rather than silently copying values (A2/A5). The inline attribute tag realises source sovereignty: every borrowed identifier is written verbatim, tagged with its scheme, and thereby kept both visible and reversible (A1, A6).

5.4 Worked micro-examples from the corpus

The grammar is best understood through instances drawn directly from the files. Each illustrates one operator discharging its axiom.

- **Alternatives.** A country entry that carries both its ISO alphabetic code and an alternative internal code joined by the alternatives operator asserts that the two designate the same entity with equal validity; the reader may use either, and the harmonization has added a link without choosing between them (A2).
- **Redirect.** The former German Democratic Republic is retained and redirected to present-day Germany; the Netherlands Antilles is retained and redirected to its three successor entities; the classical name for Greece is retained and redirected to the current entry. In each case the superseded entity survives and continues to resolve, and the succession is legible rather than erased (A4, A3).
- **Legitimate duplicate.** Transcontinental states appear under two parents: Egypt is entered once under Asia and once, as a duplicate, under Africa; Türkiye, Russia and Kazakhstan are likewise entered under both of their continents. In the water file, the seas of the South China and East-Indian complex appear both under the Pacific basin and, as duplicates, under the Australasian-Mediterranean and East-Indian-Ocean parents. The duplicate marker records the second placement without asserting a second set of facts (A2).
- **Inline attribute tags.** A country entry carries tags such as a UN M49 number, and marine and ecological entries carry tags naming their fishing-area, waterbody-name and marine-ecoregion sources. Each tag is a verbatim, scheme-labelled cross-reference, so the borrowed classification remains attributable to, and replaceable by, its source (A1, A6).

- **Neutral dispute encoding.** Contested territories are entered with an explicit note of the claimants and no sovereign parent: the Abu Musa and Tunb islands are recorded as claimed by two states; a set of islands in the East China Sea is recorded as claimed by two others; unclaimed land is recorded as such. The disagreement is inscribed rather than resolved (A3, A6).

5.5 The grammar as a controlled language

Viewed as a whole, the operator set is a controlled micro-language whose expressive commitments are exactly co-extensive with the axioms: it can say ‘these are the same’, ‘this succeeds that’, ‘this is also placed there’, ‘this is borrowed from that scheme’, and ‘this is contested’, and it deliberately cannot say ‘this is the single correct answer, others discarded’. The grammar's expressive limits are therefore themselves an implementation of the principle: mononomic reduction is not merely discouraged but literally inexpressible, because there is no operator for silent replacement. Compared with the SKOS mapping vocabulary, which offers a comparable palette of correspondence relations between concepts, the HLC grammar is narrower and more opinionated, but it is embedded in an architecture (Chapter 4) and paired with mechanisms (Chapter 6) that jointly guarantee the consistency SKOS leaves to the modeller.

6 Mechanisms of Non-Destructive Harmonization

Architecture and notation establish that the principle can be expressed; this chapter shows that it is enforced. Six mechanisms carry the operational weight of NDH. Each is analysed for the axiom it discharges, the way it works in the corpus, and its limits. The chapter closes with a mechanism-to-axiom matrix.

6.1 The asterisk-duplicate and the attribute-locality rule

The mechanism most characteristic of HLC is the pairing of the duplicate marker with the attribute-locality rule, and it is the mechanism that makes the Non-Contradiction Lemma concrete. When an entity legitimately belongs under more than one parent, it is entered more than once: an unmarked original entry and one or more marked duplicates. The front matter's attribute-locality rule then stipulates that the descriptive attributes reside only at the original; each duplicate carries the hierarchy placement and nothing else. Figure 3 depicts the arrangement.

Figure 3. The asterisk-duplicate mechanism and the attribute-locality rule

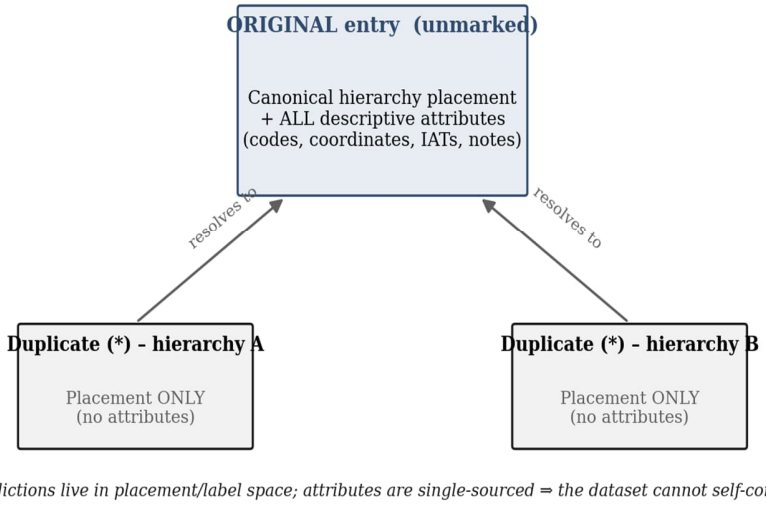

Figure 3. Duplicate entries carry placement only; all attributes are single-sourced at the original.

The design is elegant because it discharges two axioms at once with a single rule. A2 is satisfied because the entity genuinely occupies both hierarchies as equals; A5 is satisfied because there is exactly one place where any fact about the entity is asserted. The immediate corollary is that duplicates cannot contradict one another: since a duplicate holds no attributes, there is no attribute at which two placements could disagree. The transcontinental states — Egypt, Türkiye, Russia, Kazakhstan — and the multi-basin seas of the South China and East-Indian complex are the paradigm cases: each is navigable from either parent, yet its area, coordinates, external codes and notes exist once. The mechanism's cost is maintenance overhead — duplicates must be kept in

structural sync with their originals — and it is a manual discipline rather than an automatically enforced constraint, a limitation revisited in Chapter 7.

6.2 Retention-by-redirect of deprecated entities

Referential stability (A4) is enforced by never deleting. When an entity ceases to exist or is superseded, its entry is retained and a redirect is added to its canonical or successor entry. The dissolved German Democratic Republic redirects to Germany; the dissolved Netherlands Antilles redirects to its three successors; superseded unions and colonial entities are kept with pointers to what replaced them. The consequence is that a reference framed in a historical classification still resolves: a dataset that recorded a place under a now-defunct state does not dangle, because the defunct state is still present and routes forward. This is the longitudinal counterpart of information-monotonicity: not only is no contemporaneous distinction lost at integration, no temporal distinction is lost across releases. The mechanism also serves A3, because a succession frequently encodes a historical or political transition that the redirect makes legible rather than erasing.

6.3 Inline attribute tags and reversible provenance

Source sovereignty (A1) is enforced by writing every borrowed identifier verbatim, tagged with its scheme, inside the record — the inline attribute tag. Where HLC has adjusted a borrowed code to fit its own numbering, the original is retained in brackets alongside the adjusted form, so the modification is disclosed and reversible. The effect is threefold. First, provenance is visible: a reader can see that a given classification comes from a named authority. Second, the harmonization is auditable: any harmonized statement can be traced to its source and, if the source is preferred, substituted for the HLC form. Third, the system's non-authoritative stance is made honest: because the source identifier is present, HLC's own assignment is manifestly an interpretive overlay rather than a replacement. This mechanism is the concrete face of source-authority preservation, and it is what allows HLC to claim harmonization without replacement without that claim being merely rhetorical.

6.4 Namespace ownership and collision-free plurality

Parallel coexistence would be worthless if two schemes could silently claim the same code, because a reader could not then tell which scheme a mark belonged to. The namespace-control file forecloses this by partitioning the identifier space in advance: each code shape is assigned an owning scheme, so that alphabetic country codes, alphanumeric pseudo-region codes, numeric organization codes and numeric water codes occupy provably disjoint regions of the space. Plurality is thereby made collision-free by construction rather than by convention. In axiom terms this is the governance that turns A2 from an aspiration into a guarantee: because the code spaces do not overlap, an entity can carry several schemes' identifiers at once with no ambiguity about

which is which. The mechanism is quiet — it produces no visible mark on ordinary records — but it is what makes the visible marks trustworthy.

6.5 Deterministic identifier derivation

Stable identity (A4) and single-sourced attribution (A5) both depend on entities having identifiers that are assigned reproducibly rather than by hand. The ecoregion file supplies a mechanism for exactly this: a documented replacement table that deterministically derives a unique internal identifier for each entry from its native reference code, invoked whenever no identifier already exists in the land or water files. Because the derivation is rule-governed, the same source entry always yields the same internal identifier, and an independent party following the rules would reproduce it. This matters for two reasons. It underwrites idempotence: re-importing a source cannot mint a second, divergent identifier for an entity that already has one, so re-harmonization is side-effect-free. And it underwrites auditability, since identity is a function of source data rather than of undocumented editorial choice. The mechanism is a small but consequential piece of engineering: it is where HLC's identity discipline becomes reproducible rather than merely careful.

6.6 The coordinate boundary as a principled limit

HLC's most conspicuous self-limitation is that its coordinates are best-fit orientation anchors and not boundaries: there are no polygons, and none are planned; assignment of an entity to a region is by best conceptual fit, not spatial containment. It would be easy to read this as a gap. On the contrary, it is a disciplined application of the principle and of the representational humility discussed in Chapter 2. Polygon boundaries are exactly the kind of contested, authority-dependent artefact that mononomic reduction manufactures: to draw one line is to adjudicate a dispute that the sources leave open. By declining to encode geometry, HLC refuses to assert more than its sources warrant, and it keeps its claims at the grain — membership and orientation — that harmonization can honestly support. The coordinate boundary is therefore not an absence of the principle but an instance of it: NDH counsels not only against destroying distinctions that exist but against inventing precision that does not. The corresponding limitation — that HLC is unsuitable for legal delimitation or containment analysis — is real, self-declared, and a direct consequence of the same commitment that gives the system its integrity.

6.7 Neutral encoding of disputes

Explicit conflict (A3) and interpretive transparency (A6) converge in HLC's handling of territorial disputes. Contested places are entered with the claimants named and no sovereign parent assigned; unclaimed places are marked as unclaimed. The encoding is deliberately neutral: it neither adjudicates the dispute nor omits the contested entity, but records the state of contestation as a fact about the world. This is ethically as well as technically significant. A system that forced a single

sovereign parent would, by the act of classification, take a side; a system that omitted contested places would erase them. HLC does neither, and in doing so demonstrates that the principle has normative content: non-destruction extends to political distinctions that a less careful system would resolve by fiat.

6.8 Synthesis: mechanism-to-axiom matrix

Table 3 consolidates the chapter. Read with Table 1, it completes the downward validation promised in Chapter 1: every axiom is discharged by at least one concrete mechanism, and every mechanism is explicable as the enforcement of an axiom.

Table 3. Implementation mechanisms mapped to axioms and formal properties.

Mechanism	Primary axiom(s)	Formal property secured
Asterisk-duplicate + attribute locality	A2, A5	Parallel coexistence with non-contradiction
Retention-by-redirect	A4, A3	Referential and longitudinal stability
Inline attribute tags	A1, A6	Source-authority preservation; reversibility
Namespace ownership	A1, A2	Collision-free plurality
Deterministic identifier derivation	A4, A5	Idempotence of re-harmonization
Coordinate boundary	A6 (scope)	No manufactured precision
Neutral dispute encoding	A3, A6	Conflict-preservation with neutrality

7 Evaluation and Discussion

7.1 A conformance test derived from the axioms

Because the axioms are stated as violable constraints (Section 3.8), they yield a direct conformance test: for each axiom, ask whether the framework contains a mechanism that enforces it and whether any feature violates it. Table 4 records the assessment. The verdict is strong but not unqualified conformance: every axiom is enforced by an identifiable mechanism, but two axioms — attribute locality and interpretive transparency — are enforced by discipline rather than by automatic constraint, which bears on the framework's robustness.

Figure 4. Two regimes of integration

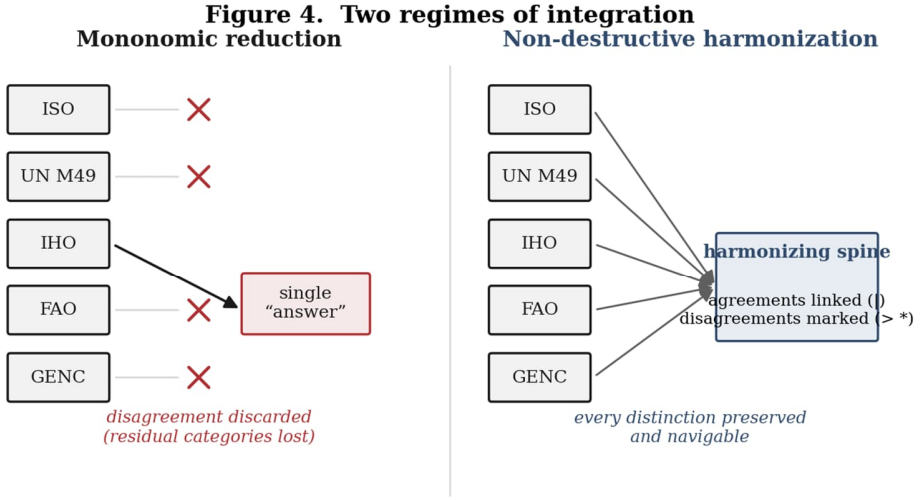

Figure 4. Mononomic reduction discards disagreement; non-destructive harmonization preserves and marks it.

Table 4. Axiom-by-axiom conformance assessment of HLC.

Axiom	Enforcing mechanism	Conformance	Qualification
A1 Source sovereignty	Inline attribute tags; namespace ownership	Strong	Provenance verbatim and reversible
A2 Parallel coexistence	Duplicates; alternatives; sibling views	Strong	Realised at row and schema level
A3 Explicit conflict	Redirects; dispute notes; operator grammar	Strong	Disagreement typed and visible
A4 Referential stability	Retention-by-redirect; deterministic identity	Strong	No deletion; reproducible identifiers
A5 Attribute locality	Attribute-locality rule for duplicates	Partial	Enforced by convention, not by a checker
A6 Interpretive transparency	Declared stance; versioned change history	Partial	Depends on single maintainer's disclosure

7.2 Comparative positioning

NDH also functions as a comparative instrument: any reference system can be scored on whether it preserves distinctions, admits plurality, keeps stable identity, records provenance, is governed, and encodes geometry. Table 5 positions HLC among representative systems. The pattern is instructive. Political standards optimise for a single authoritative code and therefore score low on plurality by design; operational gazetteers add identity and footprints but still tend toward one preferred classification; Wikidata, alone among the comparators, matches HLC on plurality and provenance, differing in that it is a crowd-sourced triple store rather than a curated hierarchy and that it does encode geometry. HLC's distinctive profile is high plurality and provenance with deliberately absent geometry and single-person governance.

Table 5. HLC positioned against representative reference systems on six NDH-derived axes.

System	Non-destruction	Plurality	Stable ID	Provenance	Governance	Geometry
ISO 3166	Low	Low	Medium	Low	Institutional	No
UN M49	Low	Low	Medium	Low	Institutional	No
GeoNames	Medium	Medium	High	Medium	Community	Yes
Getty TGN	Medium	Medium	High	High	Institutional	Partial
Wikidata	High	High	High	High	Crowd	Yes
SKOS crosswalks	Medium	Medium	n/a	Medium	Varies	No
HLC	High	High	High	High	Single maintainer	No (by design)

7.3 Strengths that follow from the principle

Several of HLC's strengths are not incidental virtues but consequences of NDH, and naming them as such is part of the thesis's analytical contribution. Its intellectual honesty about disagreement — recording territorial disputes neutrally and marking rival classifications rather than choosing between them — follows from A2 and A3. Its longitudinal usefulness — old references still resolve — follows from A4. Its auditability — any harmonized statement is traceable to a source — follows from A1. Its internal coherence despite preserved contradiction follows from the joint operation of A2 and A5 as proved in the Non-Contradiction Lemma. That these strengths are derivable from the axioms is evidence that the reconstructed principle genuinely captures the framework's design logic rather than merely describing it after the fact.

7.4 Limits and the cost of plurality

The principle is not free, and several of HLC's limits are the price of conformance rather than failures of execution. First, complexity: a grammar of operators, inline tags, legitimate duplicates and ordinal placeholders imposes a real onboarding cost, and reproducing an assignment can

require the maintainer's curatorial judgment. This is the cognitive tax of refusing reduction — a reduced record is simpler precisely because it has thrown information away. Second, verification burden: because so many external schemes are embedded verbatim, the correctness of a record depends on the correctness of every tag it carries, and the corpus exhibits no evidence of automated validation against source authorities, so error-checking is largely manual. Third, the two partial-conformance axioms: attribute locality and the transparency of curatorial judgment are enforced by discipline, so a lapse would not be caught mechanically. Fourth, scalability: the duplicate-plus-locality mechanism keeps duplicates in sync by hand, which does not scale gracefully as the number of parallel hierarchies grows. Fifth, currency: external references are version-pinned snapshots that do not auto-update. Each of these is a genuine constraint; several are inherent to a system that preserves rather than discards, and the honest conclusion is that NDH trades simplicity and automatic consistency for fidelity and reversibility.

7.5 Single authorship as a research-infrastructure question

The most consequential limit is governance. HLC is maintained by one person without an editorial board or formal review, and this interacts with the principle in a specific way. NDH's transparency axiom (A6) requires that curatorial judgment be disclosed; a single maintainer can disclose judgment but cannot institutionalise its review, so the axiom is satisfied in letter (the stance is declared, changes are versioned) while remaining fragile in practice (there is no independent check, and continuity depends on one individual). This is less a flaw in the framework than a structural property of it, and it reframes a familiar worry — the bus factor — as a question about the axioms: A6 as stated demands disclosure but not distributed governance, and a stronger version of the principle might require the latter. The thesis notes this as a boundary of the current formulation and returns to it as future work.

7.6 When mononomic reduction is preferable

Intellectual balance requires acknowledging that NDH is not universally superior. Where a system must drive a single automated decision — route a shipment, compute a tax, render one boundary on one map — a single authoritative answer is not a loss but a requirement, and the overhead of preserved plurality is dead weight. NDH's proper domain is reference and scholarship: contexts in which the purpose is to understand, cross-reference, and reason about how the world has been classified, and in which the disagreements are part of the subject matter. HLC's own front matter locates it exactly there, declaring it a specialist reference framework unsuitable for legal or spatial determination. The principle, then, is not a replacement for reduction but its complement: reduction for action, non-destructive harmonization for reference.

8 Toward a General Theory

8.1 Generalising beyond geography

Nothing in NDH is specific to places. Its axioms speak of sources, distinctions, entities, attributes and identifiers, and the same tensions arise wherever heterogeneous authorities classify a shared domain. Bibliographic control reconciles rival cataloguing rules and subject vocabularies; biomedical terminology reconciles disease and gene ontologies that partition the same biology differently; legal taxonomy reconciles jurisdictions that categorise the same conduct incompatibly; product classification reconciles national tariff schedules; scientific nomenclature reconciles competing systematic treatments of the same taxa. In each, the dominant practice is mononomic reduction and the recurring complaint is lost distinction. NDH offers these domains a principled alternative and a vocabulary — source sovereignty, parallel coexistence, explicit conflict, referential stability, attribute locality, interpretive transparency — in which to design for plurality without incoherence.

8.2 Eight design guidelines

The axioms translate into concrete design guidance for anyone building a pluralistic reference system. The following eight guidelines operationalise NDH and are stated so as to be directly actionable.

1. **Reference, never overwrite.** Store every borrowed classification verbatim and tagged with its scheme; make the borrowing reversible so the source form can always be recovered (A1).
2. **Admit multiple parents.** Provide a first-class device for an entity to occupy more than one hierarchy at once, and treat such multiplicity as legitimate data, not redundancy (A2).
3. **Inscribe disagreement.** Give conflict its own notation — alternatives, successions, disputes — so that disagreement is visible and typed in the record rather than resolved by a silent choice (A3).
4. **Never delete; redirect.** Retain deprecated entities and point them forward, so that references framed in older schemes continue to resolve (A4).
5. **Single-source every fact.** Assert each attribute exactly once, at one canonical location; let parallel placements carry structure only. This is the safeguard that makes plurality coherent (A5).
6. **Declare interpretation and version everything.** State that assignments are interpretive, disclose curatorial judgment, and version changes so any past state is reconstructible (A6).
7. **Partition the identifier space in advance.** Govern code ownership so that multiple schemes coexist on one entity without collision (A1/A2 governance).

8. **Refuse false precision.** Encode claims only at the grain the sources warrant; decline to manufacture boundaries or values the sources leave open (representational humility; scope of A6).

8.3 A conformance maturity model

Because conformance is testable, it can be staged. A maturity model helps existing systems locate themselves and plan improvement.

Table 6. A conformance maturity model for Non-Destructive Harmonization.

Level	Name	Criterion
0	Reductive	Sources collapsed to one classification; disagreement discarded.
1	Provenanced	Single classification retained, but source provenance recorded (A1).
2	Plural	Multiple classifications coexist and disagreement is marked (A2, A3).
3	Stable	Plurality rests on stable identifiers with retention-by-redirect (A4).
4	Coherent	All attributes single-sourced; non-contradiction guaranteed (A5).
5	Transparent & governed	Interpretation declared, versioned, and subject to institutional review (A6+).

Against this model HLC sits at Level 4 and reaches into Level 5: it satisfies non-destruction, plurality, stability and coherence, and it declares and versions interpretation, but the highest level's requirement of institutional review is unmet under single-person governance. The model thus both credits HLC's achievement and names precisely what would raise it further — not a change of principle but a change of governance.

8.4 Expressing the principle in linked data

NDH can be given a linked-data reading, which matters for interoperability with the wider semantic-web infrastructure discussed in Chapter 2. Source sovereignty maps to typed external identifiers and provenance statements; parallel coexistence maps to multiple mapping relations of graded strength between concepts, in the manner of SKOS; explicit conflict maps to reified statements that carry their own scheme index, so that ‘under scheme S, E is C’ is a first-class node rather than a bare triple; referential stability maps to persistent identifiers with owl:sameAs and successor relations used with care; and attribute locality maps to the discipline of asserting each property once on the canonical resource. The reification of scheme-indexed classifications is the crucial move: it is the linked-data expression of the placement space of the Non-Contradiction Lemma, and it is what would let a triple store hold HLC-style plurality without asserting contradictions. A full serialisation is beyond this thesis, but the mapping shows that NDH is not tied to HLC's spreadsheet substrate and can travel to graph-based infrastructures.

8.5 The principle as a contribution to standards practice

Finally, NDH speaks to standards bodies. The prevailing model of a standard is a single agreed classification; the recurring pain is that reality does not agree with itself and the standard must either arbitrate or fracture. NDH suggests a third posture: a meta-standard whose job is not to adjudicate among classifications but to hold them together non-destructively, making their agreements navigable and their disagreements explicit. Such a meta-standard would not compete with ISO 3166 or UN M49 or the hydrographic limits; it would relate them, in the way HLC does, and its value would be measured not by the singularity of its answers but by the fidelity of its preservation. Articulating that posture as a named principle with testable axioms is the thesis's contribution to the practice, as distinct from the theory, of classification.

9 Conclusion

9.1 Answers to the research questions

RQ1. The deep principle behind HLC's maxim is not ‘co-listing’ or ‘crosswalking’ but a specific commitment to non-destruction paired with a coherence safeguard: harmonize by preserving every source distinction and marking every disagreement, while resting the resulting plurality on stable identity and single-sourced attribution. Stated so, it is neither a truism — it prohibits the near-universal practice of mononomic reduction — nor a slogan — it has definite, checkable content.

RQ2. The principle formalises into six axioms — source sovereignty, parallel coexistence, explicit conflict, referential stability, attribute locality, interpretive transparency — with formal properties including information-monotonicity, conflict-preservation and idempotent re-harmonization, and with the Non-Contradiction Lemma establishing that preserved plurality does not entail inconsistency. Conformance is testable and violation identifiable, so the principle is falsifiable.

RQ3. HLC implements each component by identifiable means: a five-file architecture that factors the axioms into an axiomatic layer, a governance layer and three domain layers; an operator grammar in which each mark discharges an axiom and in which silent replacement is literally inexpressible; and six mechanisms — duplicate-plus-attribute-locality, retention-by-redirect, inline attribute tags, namespace ownership, deterministic identifier derivation, and the principled coordinate boundary — that enforce the axioms and secure the formal properties. The downward and upward validations both succeed: every axiom is realised by a mechanism, and the framework's heterogeneous features become intelligible as consequences of the axioms.

RQ4. The principle generalises beyond geography to any domain in which heterogeneous authorities classify a shared subject, and it yields eight actionable design guidelines and a conformance maturity model. Its costs — complexity, manual verification, and dependence on disciplined attribution and disclosure — are largely inherent, and its proper domain is reference rather than action. Its most serious limit is governance: single authorship satisfies the transparency axiom in letter while leaving it fragile in practice, which locates the frontier of the principle at the boundary between disclosure and institutional review.

9.2 Contribution restated

The thesis has evolved an informal maxim into a formal principle and demonstrated a working system's fidelity to it. The Principle of Non-Destructive Harmonization, its six axioms, its formal properties and the Non-Contradiction Lemma constitute the theoretical contribution; the complete principle-to-implementation mapping of HLC, evidenced from the corpus, constitutes the analytical contribution; the axiom-based conformance test and comparative positioning constitute the evaluative contribution; and the design guidelines, maturity model and linked-data reading

constitute the constructive contribution. Together they answer the two verbs of the brief: the principle is evolved, and its implementation is shown.

9.3 Limitations of the study

The study is an interpretive reconstruction of a single system at a single version, not an empirical audit or a controlled comparison. Its conformance verdicts rest on the presence of mechanisms rather than on measured error rates; its comparative table is positional; and it treats the corpus's self-descriptions as evidence of intent, which is appropriate for recovering a design principle but insufficient for certifying data quality. The Non-Contradiction Lemma is proved at the level of the framework's logic, not verified against every record.

9.4 Future work

Four lines follow directly. First, an automated NDH validator: a checker that enforces attribute locality and flags dangling references would move A5 and A4 from disciplined convention to guaranteed constraint, raising HLC toward the top of the maturity model. Second, a linked-data serialisation implementing the scheme-indexed reification sketched in Chapter 8, enabling triple-store consumption without loss of the non-contradiction guarantee. Third, empirical user studies measuring the onboarding cost that Chapter 7 identifies, to quantify the cognitive tax of plurality and test whether tooling can offset it. Fourth, a governance model that strengthens the transparency axiom into institutional review, addressing the single-authorship limit without abandoning the curatorial coherence that single authorship provides.

9.5 Closing

Classification is unavoidable and unavoidably consequential; the question is only whether a system, faced with sources that disagree, will erase the disagreement or preserve it. This thesis has argued that preservation is not merely more honest but formally coherent — that a reference system can hold the world's rival orderings together without contradicting itself — and that one working framework has already shown how. The Principle of Non-Destructive Harmonization names that possibility and states its conditions. Its lesson is compact: harmonize by adding links and marks, never by taking distinctions away; keep one identity and one place for each fact; and let the disagreements stand, because in a reference system the disagreements are not the noise — they are part of the signal.

References

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The Semantic Web. Scientific American, 284(5), 34–43.

Borges, J. L. (1998). On Exactitude in Science. In Collected Fictions (A. Hurley, Trans.). Penguin. (Original work published 1946.)

Bowker, G. C., & Star, S. L. (1999). Sorting Things Out: Classification and Its Consequences. MIT Press.

Codd, E. F. (1970). A Relational Model of Data for Large Shared Data Banks. Communications of the ACM, 13(6), 377–387.

Date, C. J. (2003). An Introduction to Database Systems (8th ed.). Addison-Wesley.

Doerr, M. (2003). The CIDOC Conceptual Reference Model: An Ontological Approach to Semantic Interoperability of Metadata. AI Magazine, 24(3), 75–92.

Feyerabend, P. (1975). Against Method. New Left Books.

Foucault, M. (1970). The Order of Things: An Archaeology of the Human Sciences. Pantheon.

Goodchild, M. F., & Hill, L. L. (2008). Introduction to Digital Gazetteer Research. International Journal of Geographical Information Science, 22(10), 1039–1044.

Gruber, T. R. (1995). Toward Principles for the Design of Ontologies Used for Knowledge Sharing. International Journal of Human-Computer Studies, 43(5–6), 907–928.

Guarino, N. (1998). Formal Ontology and Information Systems. In Proceedings of FOIS'98 (pp. 3–15). IOS Press.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. MIS Quarterly, 28(1), 75–105.

Hill, L. L. (2006). Georeferencing: The Geographic Associations of Information. MIT Press.

Hjørland, B. (2008). What is Knowledge Organization (KO)? Knowledge Organization, 35(2–3), 86–101.

International Organization for Standardization. (2020). ISO 3166-1: Codes for the Representation of Names of Countries and Their Subdivisions. ISO.

Korzybski, A. (1933). Science and Sanity: An Introduction to Non-Aristotelian Systems and General Semantics. Institute of General Semantics.

Kuhn, T. S. (1962). The Structure of Scientific Revolutions. University of Chicago Press.

Lakoff, G. (1987). Women, Fire, and Dangerous Things: What Categories Reveal about the Mind. University of Chicago Press.

Miles, A., & Bechhofer, S. (2009). SKOS Simple Knowledge Organization System Reference. W3C Recommendation.

Ranganathan, S. R. (1967). Prolegomena to Library Classification (3rd ed.). Asia Publishing House.

Smith, B., & Mark, D. M. (2001). Geographical Categories: An Ontological Investigation. International Journal of Geographical Information Science, 15(7), 591–612.

Star, S. L. (2010). This is Not a Boundary Object: Reflections on the Origin of a Concept. Science, Technology, & Human Values, 35(5), 601–617.

Star, S. L., & Griesemer, J. R. (1989). Institutional Ecology, 'Translations' and Boundary Objects. Social Studies of Science, 19(3), 387–420.

Svenonius, E. (2000). The Intellectual Foundation of Information Organization. MIT Press.

United Nations Statistics Division. (1999). Standard Country or Area Codes for Statistical Use (Series M, No. 49). United Nations.

Vrandečić, D., & Krötzsch, M. (2014). Wikidata: A Free Collaborative Knowledgebase. Communications of the ACM, 57(10), 78–85.

Weynans, J. (2026). HLC Operational Framework, Version 7.9: Common Front Matter (codehx); Namespace Control (codehu); Land Master (codehl); Water (codehy); Ecoregions (codehw). Unpublished working files.

Wittgenstein, L. (1953). Philosophical Investigations (G. E. M. Anscombe, Trans.). Blackwell.

Zeng, M. L., & Chan, L. M. (2004). Trends and Issues in Establishing Interoperability among Knowledge Organization Systems. Journal of the American Society for Information Science and Technology, 55(5), 377–395.

Appendix A Notation Reference

Table A1 reproduces the operator grammar for reference; it consolidates the marks defined in the front matter and analysed in Chapter 5.

Table A1. HLC notation reference.

Mark	Meaning
|	Alternatives: equally valid codes or names for the same entity.
>	Redirect: points to the canonical or successor entry.
* (asterisk)	Legitimate duplicate: a parallel placement in another hierarchy; carries placement only.
~ + -	Inherited, encroached, or extended value relative to an adjacent entry.
!-	Range extension: a contiguous block of codes.
( )	Optional extension or annotation.
:	Logical, institutional, or organizational (non-territorial) entry.
{scheme:value}	Inline attribute tag: a verbatim, scheme-labelled cross-reference to an external standard.
a n x/y/z	Code-shape placeholders: alpha, numeric, and alphanumeric positions.

Appendix B Axiom–Mechanism–Evidence Matrix

Table B1 is the consolidated validation grid: for each axiom it names the enforcing mechanism and the kind of corpus evidence that instantiates it, completing the mapping asserted throughout the thesis.

Table B1. Axiom–mechanism–evidence matrix.

Axiom	Mechanism	Representative evidence in the corpus
A1 Source sovereignty	Inline attribute tags; namespace ownership	Verbatim external identifiers with schemes; original codes retained in brackets.
A2 Parallel coexistence	Duplicates; alternatives; sibling views	Transcontinental states dual-parented; multi-basin seas; equal ecological schemes.
A3 Explicit conflict	Redirects; dispute notes; grammar	Superseded states redirected; contested territories with named claimants.
A4 Referential stability	Retention-by-redirect; deterministic identity	Dissolved states retained and routed forward; rule-derived internal identifiers.
A5 Attribute locality	Attribute-locality rule	Duplicates hold placement only; attributes single-sourced at the original entry.
A6 Interpretive transparency	Declared stance; versioned change history; coordinate policy	Interpretive self-description; version history; anchors-not-boundaries policy.

Appendix C Glossary

Table C1. Glossary of key terms.

Term	Definition as used in this thesis
Mononomic reduction	The collapse of several defensible classifications into one authoritative answer, discarding the alternatives.
Non-Destructive Harmonization (NDH)	The principle that a reference system integrates sources without deleting, overwriting, or collapsing any distinction, while guaranteeing consistency via stable identity and single-sourced attribution.
Parallel coexistence	The property that an entity may hold multiple codes, labels and parents simultaneously, none privileged.
Attribute locality	The rule that each descriptive fact is asserted exactly once, at one canonical location.
Placement space	The space of scheme-indexed classification statements, in which plurality is permitted.
Attribute space	The space of factual assertions about an entity, in which multiplicity is forbidden.
Retention-by-redirect	Deprecation by keeping an entity and pointing it to its successor, never by deletion.
Inline attribute tag (IAT)	A verbatim, scheme-labelled external identifier stored within a record.
Best conceptual fit	Assignment by overlapping similarity rather than strict spatial containment; a family-resemblance criterion.