GeoTZ: A Reproducible Spatial Decision Layer for Civil Time

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GeoTZ 0.1 experimental reference release, compatible with IANA tzdb 2026c
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Abstract

Civil-time databases specify clock rules, but a coordinate-to-time system must also decide which rule set applies at a position and instant. That spatial decision is not defined by the IANA Time Zone Database, and mapped boundary projects necessarily add geographic judgment. Existing lookup implementations can therefore hide ambiguity in feature ordering, leave oceans unresolved, or provide an answer without exposing the policy that produced it. We introduce GeoTZ, a versioned spatial decision contract for civil time. GeoTZ separates temporal rules from spatial applicability, represents source statements as annotated claims, resolves overlaps and exact boundaries through a published deterministic order, and returns a decision certificate with each assignment. GeoTZ 0.1 composes IANA tzdb 2026c, Timezone Boundary Builder 2026c, Natural Earth land geometry, documented Antarctic operating practice, and explicit spatial conventions. Its reference implementation is total by construction over valid WGS 84 surface coordinates. A 0.5° audit resolves 259,200 sampled points; additional tests cover exact vertices and segment midpoints, the antimeridian, mathematical poles, date-shift regions, and operational enclaves. Total decision coverage is not equated with total factual certainty: every result distinguishes civil, mapped, operational, and derived grounds so that unavoidable conventions remain visible, versioned, reproducible, and challengeable.

Keywords: civil time; timezone boundaries; spatial reference; provenance; deterministic resolution; antimeridian; Antarctica

Release and license. GeoTZ 0.1 is an experimental reference release. This manuscript is licensed CC BY 4.0. The software and source-data licenses are recorded separately in the release manifest.

1 Introduction

Computing local civil time from a coordinate appears to be a point-in-polygon query. In practice it is an authority-composition problem on a sphere. The temporal component asks which UTC offset and transition rules apply to a timezone identifier at an instant. The spatial component asks which identifier applies to a position. These components are maintained by different institutions, carry different evidence, and fail in different ways.

IANA tzdb is the dominant maintained reference for temporal rules and identifiers, but its theory document states that the database is not authoritative, does not represent uncertainty, and does not record region boundaries; in many cases those boundaries are not known [Internet Assigned Numbers Authority, 2026]. RFC 7808 anticipated a future action for mapping geographic locations to timezone identifiers but did not define that action [Douglass and Daboo, 2016]. Timezone Boundary Builder (TBB) supplies widely used approximate geometry derived mainly from OpenStreetMap while documenting manual preparation, arbitrary edges in difficult areas, and expected overlaps [Siroky, 2026]. Geometry therefore supplies evidence, not a complete decision contract.

The consequences are visible in current systems. The `timezonefinder` library notes that multiple polygons can contain the same coordinate and returns the first match [timezonefinder contributors, 2026]. Google's Time Zone API documents that locations over oceans or seas can return no result [Google Maps Platform, 2026]. Azure Maps and Amazon Location expose timezone data as geographic services, demonstrating operational demand without exposing a shared, inspectable spatial decision model [Microsoft, 2026, Amazon Web Services, 2026].

GeoTZ addresses the missing layer. It does not attempt to replace tzdb, legislate boundaries, or transform approximate geometry into legal truth. It specifies how heterogeneous spatial evidence is composed into one reproducible answer. The contributions are:

1. a formal separation between temporal rules and spatial applicability;
2. an annotated spatial-claim model with validity, basis, evidence, source, and priority;
3. a total deterministic resolution contract for overlaps, exact boundaries, the antimeridian, and poles;
4. the *operational time enclave* as a non-territorial representation of documented facility clocks;
5. a provenance-aware decision certificate aligned with established provenance concepts;
6. conformance invariants and adversarial tests that distinguish coverage from truth; and
7. an executable reference release compatible with IANA tzdb 2026c.

> **Core design principle.** Coverage is not certainty. GeoTZ guarantees a deterministic decision everywhere in its supported domain while preserving whether that decision rests on official, documented, mapped, or derived evidence.

The preliminary standards and literature review did not identify an existing specification combining all seven contributions. This observation is not a proof of global novelty. A systematic literature review, standards-registry review, and prior-art search remain necessary before making a priority claim.

2 Background and adjacent infrastructure

2.1 Temporal rule sets

IANA tzdb partitions post-1970 clock behavior into maintained rule sets and supplies identifiers, transitions, representative locations, and compatibility links [Internet Assigned Numbers Authority, 2026]. A location such as `Europe/Paris` names a rule set whose clocks agree for the database's intended period; it is not a polygon published by IANA. TZif specifies an exchange format for transition data [Murchison et al., 2024], while TZDIST specifies distribution and query mechanisms [Douglass and Daboo, 2016]. Unicode CLDR adds stable identifiers, localized display names, metazones, and mappings between naming systems [Unicode Consortium, 2026]. These layers solve temporal computation and naming, not coordinate ownership.

2.2 Spatial geometry

RFC 7946 defines GeoJSON geometry in WGS 84 longitude–latitude order and gives guidance for antimeridian cutting [Butler et al., 2016]. It does not define timezone semantics, priority, boundary ownership, or evidence. TBB creates approximate timezone polygons through operations on OpenStreetMap-derived boundaries and manual edge-case definitions [Siroky, 2026]. Its output is valuable source geometry, but the project discloses arbitrary borders in open waters and sparsely inhabited areas, expected overlaps, and instability caused by changing inputs. Research on volunteered geographic information likewise shows why provenance and fitness-for-purpose evaluation remain necessary even when community mapping attains high positional quality [Haklay et al., 2010].

Table 1: Adjacent infrastructure and the unresolved spatial-decision question.

Layer	Representative work	Primary contribution	Remaining question
Temporal rules	IANA tzdb, TZif	Identifiers, offsets, transitions	Where does each rule apply?
Naming	Unicode CLDR	Display and cross-platform names	Which name wins at a coordinate?
Geometry encoding	GeoJSON	Interoperable points and polygons	What do overlaps and exact edges mean?
Boundary evidence	TBB	Approximate global timezone geometry	How are arbitrary or competing claims resolved?
Lookup implementation	timezonefinder	Efficient coordinate lookup	Is implementation order acting as hidden policy?
Hosted service	Google, Azure, AWS	Operational coordinate-time answers	Can a result be reproduced and explained?
Provenance	W3C PROV-O	Source and derivation vocabulary	How is provenance bound to a decision?

The GeoTZ 0.1 reference build uses Natural Earth physical vectors for its Antarctic land mask [Natural Earth, 2026]. This geometry classifies surface context; it does not supply station operating clocks or civil-time authority. Two closed polygons can both contain an exact boundary point. An island, territorial-water extension, polar vertex, or station practice may require a decision that no ring alone explains. Direct spherical point-in-polygon research addresses numerical classification and edge handling, but an algorithmic inside/outside result still cannot supply absent civil-time policy [Bevis and Chatelain, 1989, Ketzner et al., 2022].

2.3 Lookup, global reference, and provenance

Existing libraries primarily optimize point-in-polygon lookup. Commercial APIs return useful identifiers and offsets, but their published schemas do not expose candidate claims, the winning rule, or source-level provenance [Google Maps Platform, 2026, Microsoft, 2026, Amazon Web Services, 2026]. The Open Geospatial Consortium's Discrete Global Grid System work formalizes global referencing by identifiers with structured geometry [Open Geospatial Consortium, 2021]. GeoTZ is not a DGGS and claims no equal-area-grid conformance, but it shares the goals of a globally defined domain and an unambiguous reference result.

W3C PROV-O supplies reusable concepts for entities, activities, agents, derivation, generation, and primary sources [Lebo et al., 2013]. GeoTZ decision certificates target those concepts rather than inventing an isolated provenance vocabulary. Table 1 places the proposal within the surrounding infrastructure.

3 Problem formulation

3.1 Two coupled functions

Let E denote the surface of the Earth, modeled topologically as a sphere; Z the set of temporal-rule identifiers; $\mathcal{T}$ the set of instants; and Δ the set of UTC offsets. For release v, the temporal-rule evaluator is

$$T_v : Z \times \mathcal{T} \to \Delta. \tag{1}$$

Spatial applicability and operating practice can change, so a spatial assignment is

$$S_v : E \times \mathcal{T} \to Z \times \Gamma, \tag{2}$$

where Γ is a decision certificate. The resulting local civil time is

$$L_v(p,t) = t + T_v(\pi_Z(S_v(p,t)),t)\,. \tag{3}$$

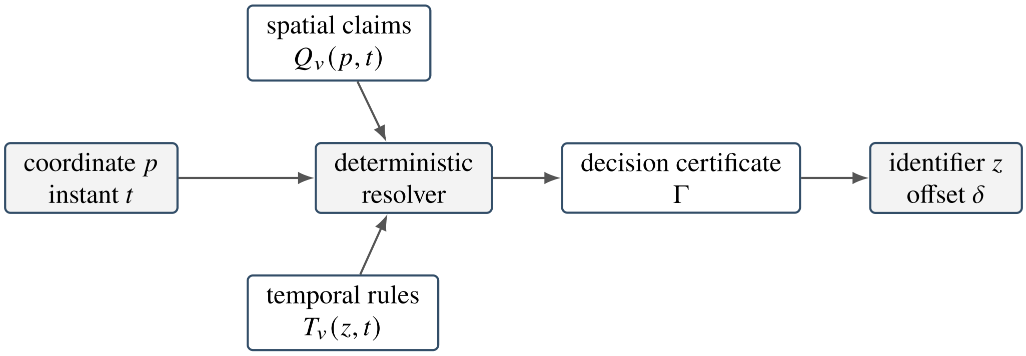

Figure 1: The coordinate-time answer is a composition of temporal rules, spatial claims, and an explicit resolution policy. The certificate preserves the path to the result.

GeoTZ 0.1 publishes a current spatial snapshot and includes validity intervals in its claim model so future releases can represent spatial change. It does not claim complete historical spatial boundaries after 1970. Coordinates are interpreted on a quotient surface: longitudes −180° and +180° identify the same meridian, while every longitude at either 90° latitude denotes a single pole. Treating the coordinate rectangle as an ordinary flat box creates an artificial seam and multiple representations of each pole.

3.2 Spatial claims and output

Definition 1 (Spatial claim)**.** *A GeoTZ spatial claim is the tuple*

$$q_i = (G_i, z_i, I_i, b_i, e_i, s_i, v_i, \rho_i), \tag{4}$$

where G_i is a geometry, z_i a rule identifier, I_i a validity interval, b_i an assignment basis, e_i an evidence class, s_i a source identifier, v_i a source version, and ρ_i a published priority.

For position p and instant t, the candidate set is

$$Q_v(p,t) = \{q_i \mid p \in G_i \wedge t \in I_i\}. \tag{5}$$

Claims remain distinct even when they produce the same timezone identifier: a mapped civil polygon and an operational facility can agree temporally while differing in reason, evidence, validity, and spatial meaning.

A conforming resolver returns at least

$$R_v(p,t) = (z, \delta, c, b, e, a, \Gamma), \tag{6}$$

where z is the temporal identifier, δ its offset at t, c a place classification, b the assignment basis, e the evidence class, a a stable claim identifier, and Γ the certificate. Timezone assignment and country classification are resolved independently, preventing an operational clock from becoming an accidental sovereignty or maritime claim.

4 Deterministic resolution

4.1 Published precedence

GeoTZ 0.1 applies the following precedence profile:

1. documented operational time enclave;
2. named civil timezone geometry;
3. mapped maritime timezone geometry; and
4. derived complete-sphere fallback.

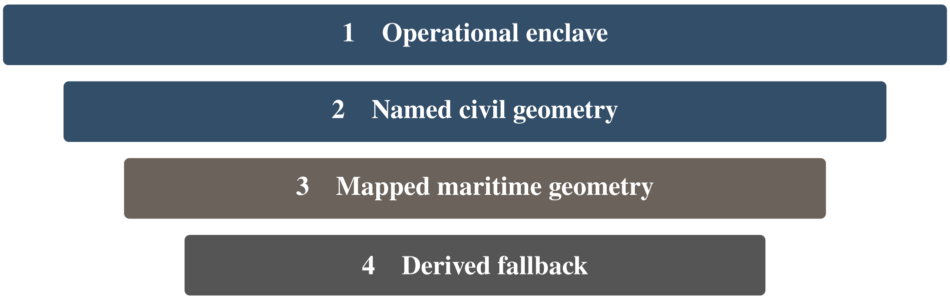

Figure 2: Normative GeoTZ 0.1 precedence. Higher tiers override lower tiers, while published tie-breaks make every tier deterministic.

Within a tier, candidates are ordered by numeric authority priority. Equal-priority polygon candidates use smaller bounding extent, then stable lexical authority identifier. Point claims carrying an authority-radius field are evaluated by geodesic distance. Polygons use boundary-inclusive, antimeridian-aware containment. A change to precedence, tie-breaking, enclave extent, or exact-boundary behavior requires a new GeoTZ release.

4.2 Totality and uniqueness

Proposition 1 (Resolution totality)**.** *If the fallback claim covers E for every supported instant and the candidate order is total, then every valid surface coordinate has exactly one winning claim.*

Proof. The complete-sphere fallback makes $Q_v(p,t)$ non-empty. A finite non-empty set under a total order has one maximal element after the stable final identifier tie-break. The resolver therefore returns one q^* for every valid (p,t). This proves algorithmic decision coverage, not empirical correctness of every claim. □

4.3 Antimeridian equivalence and exact boundaries

Longitude is canonicalized by

$$\kappa(\lambda) = ((\lambda + 180) \bmod 360) - 180. \tag{7}$$

Proposition 2 (Seam invariance)**.** *If containment is evaluated on canonical longitude and crossing geometries are normalized consistently, queries at $(\phi, -180°)$ and $(\phi, +180°)$ return the same decision certificate apart from the caller's raw input representation.*

This property is tested for 721 latitude pairs in the reference audit. At an exact shared edge, both closed polygons may be candidates. GeoTZ exposes all candidates in the decision trace and selects the winner through the published ordering; it does not pretend that geometry alone owns the edge. A future release may adopt explicit half-open boundary ownership. Version 0.1 retains its current rule because it is implementable and covered by machine-readable vectors.

5 Evidence, basis, and decision certificates

Assignment basis answers *why* a spatial decision exists; evidence class answers *what supports it*. The concepts are intentionally orthogonal (Tables 2 and 3).

The decision certificate is

$$\Gamma_v(p,t) = (v, \hat{p}, t, C, q^*, r, E_s, H), \tag{8}$$

where $\hat{p}$ is the canonical coordinate, C the ordered candidate list, q^* the winner, r the applied resolution rule, E_s the evidence references, and H a release or artifact hash. Source datasets can be represented as `prov:Entity` objects, the generator as a `prov:Activity`, and the release as a generated entity with

Table 2: Assignment basis.

Basis	Meaning	Example evidence
Civil	Established territorial timekeeping represented spatially	Legislation, official notice, mapped administrative boundary
Maritime	High-seas time convention	Longitude-derived nautical convention or mapped ocean zone
Operational	Clock maintained by a facility or activity	First-party operator publication
Derived	Explicit resolution needed for completeness	Published fallback or tie-break rule

Table 3: Evidence classes.

Class	Interpretation
Official	Legislation or a first-party operator statement
Documented	Maintained primary record such as a tzdb entry or station table
Mapped	Licensed geographic boundary evidence
Derived	A disclosed GeoTZ spatial convention

`prov:wasDerivedFrom` links [Lebo et al., 2013]. A certificate is therefore more than debug output: it is a reproducibility boundary.

Epistemic rule. Total decision coverage is not total factual certainty. A derived answer may be required for conformance while remaining explicitly distinguishable from legislation, territorial fact, or operator authority.

6 Complete-sphere spatial conventions

6.1 High seas and the International Date Line

The U.S. Naval Observatory describes high-seas and Antarctic local time by the nearest meridian whose longitude is an integer multiple of 15° [United States Naval Observatory, 2026]. GeoTZ uses longitude-based fixed-offset bands as a documented baseline convention, not as a claim of universal maritime regulation. Mapped civil land, territorial-water geometry, date-shift regions, and operational enclaves can override the baseline.

Fixed-offset identifiers follow IANA's reversed-sign `Etc/GMT` convention: UTC+12 is `Etc/GMT-12`. The base longitudinal partition does not by itself explain UTC+13 or UTC+14; those values arise through mapped or explicit date-shift claims and do not distort neighboring ocean bands. The International Date Line is a date discontinuity, not a complete timezone polygon boundary. GeoTZ represents it as an informative line plus explicit shift regions, separating the meridian baseline, the civil or mapped departure from it, and the place where the calendar date changes.

6.2 Mathematical poles

At the North Pole, longitude is physically degenerate. GeoTZ 0.1 ignores the caller's longitude and returns one derived polar decision. This is a convention required by totality, not a statement that residents observe UTC. At the South Pole, the documented Amundsen–Scott operating clock applies inside its operational enclave. All coordinate encodings of the exact pole resolve identically. Away from operational enclaves, Antarctic surface continues the longitude-based fallback.

Table 4: Illustrative decision trace; schematic, not a published test vector.

Field	Illustrative value
Query	Coordinate inside the Amundsen–Scott operational enclave at a supported instant
Candidates	Documented station operating-time claim; derived Antarctic surface fallback
Winner	Station operational claim
Resolution rule	Tier 1 operational enclave overrides tier 4 derived fallback
Assignment basis	Operational
Evidence class	Documented / operator record
Interpretation	Localized operating clock; no sovereignty or territorial claim

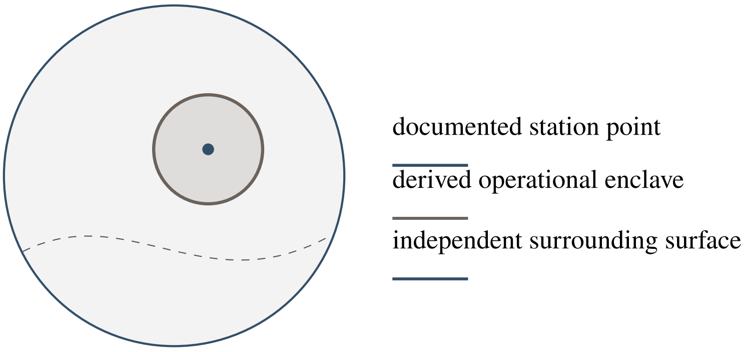

Figure 3: An operational time enclave is a non-territorial decision geometry around a documented facility clock. The point is sourced; the uniform radius is disclosed as a GeoTZ convention.

6.3 Antarctic operational time enclaves

IANA supplies representative Antarctic locations and rules but does not define continent-sized station territories [Internet Assigned Numbers Authority, 2026]. The United States Antarctic Program documents that McMurdo and Amundsen–Scott follow New Zealand time while Palmer uses GMT−03 [United States Antarctic Program, 2026]. Enormous wedges invent spatial authority; zero-area points make operating practice practically invisible.

GeoTZ 0.1 therefore represents each maintained station record as a 25-km geodesic operational enclave. The radius is a uniform lookup and visualization convention introduced by GeoTZ; it is not reported by station operators. It is not a facility measurement, territorial boundary, assertion of control, or claim that the operator determines time for surrounding land. Antarctica's legal context makes that separation essential: Article IV of the Antarctic Treaty preserves positions concerning territorial claims and prevents activities under the Treaty from creating new sovereignty rights [Antarctic Treaty, 1959].

Where a published operating perimeter becomes available, a later claim can replace the uniform radius with sourced geometry while preserving its operational basis. The enclosing Antarctic surface remains independent and derived.

7 Reference implementation

GeoTZ 0.1 is an executable research artifact. The release contains a normative JSON Schema, deterministic reference generator, ordinary and adversarial test vectors, a standalone verifier with an independent resolution path, dense audit output, a release manifest, and this paper. The build pins a generated timestamp and records SHA-256 hashes of inputs and artifacts. Given byte-identical inputs and generator source, the authority and render outputs are byte reproducible.

The public release exposes the schema, generator, verifier, vectors, audit, and authority hash. Timezone Explorer keeps the complete authority GeoJSON server-side so that publication of the research contract does not silently create a second browser lookup authority. The verifier does not import the production resolver: it independently implements coordinate normalization, geodesic envelopes, antimeridian-

Table 5: GeoTZ 0.1 audit families and observed outcomes.

Audit family	Count	Observed outcome
Global 0.5° grid	259,200	0 unresolved
Antimeridian equivalence pairs	721	0 mismatches
Mathematical pole probes	146	0 failures
Operational center/inside/outside	33	0 failures
Unique authority vertices	22,815	0 unresolved
Unique segment midpoints	23,570	0 unresolved
Generated time enclaves	11	0 invalid features

aware containment, precedence, tie-breaking, and fixed-offset date shifts. This reduces shared-code false confidence, although both implementations can still share a conceptual error.

What is normative in GeoTZ 0.1. Resolver behavior, output vocabulary, precedence, tie-breaking, and the machine-readable test vectors are normative. Rendering is informative. This boundary prevents visual presentation from silently becoming part of the decision contract.

8 Evaluation

8.1 Questions and audit design

The evaluation separates five questions: decision coverage, structural validity, determinism, adversarial behavior, and epistemic honesty. Decision coverage is intentionally not called geographic accuracy because no independent complete ground-truth boundary dataset exists for every oceanic, polar, disputed, or operational result.

The dense audit samples a 0.5° global grid and supplements it with exact source vertices and segment midpoints. Separate families exercise the canonical antimeridian, both mathematical poles, the center, inside, and outside of every operational enclave, required fixed offsets, and named regression coordinates.

The grid resolves 71,754 samples through civil claims, 143,465 through maritime claims, 18 through operational claims, and 43,963 through derived claims. Thus 100% sampled decision coverage partly exists because 16.96% of grid decisions are explicitly derived. The release does not disguise that portion of the surface as equally authoritative evidence.

How to read the audit. The reported zeros mean zero observed failures for the stated test families. They do not mean that every source polygon, every possible coordinate, or every real-world clock practice is error-free. Proposition 1 supplies the constructive totality argument; the audit checks that the implementation behaves consistently with its premises.

8.2 Geometry disclosures and adversarial cases

The render-topology audit reports one duplicate consecutive source point and 25 degenerate source segments. These are upstream or transformation artifacts, not unresolved lookup coordinates. Spherical render deduplication removes degenerate segments from the visual layer. GeoTZ-generated features have no detected structural invalidity in this audit.

The disclosures are deliberately retained. "Zero errors" would be false: the tests establish only the properties they measure. Resolving 259,200 points does not prove coverage over infinitely many coordinates. The constructive argument establishes totality under its premises; the audit checks that the implementation behaves consistently with them.

Named regressions cover a reported Arctic gap, the Antarctic interior, a rounded Luxembourg boundary, the Kiribati date extension, the Chatham-side ocean, and the central Pacific baseline. Test vectors also include invalid-coordinate rejection, exact longitude canonicalization, and operational-enclave exits. Future work should add cross-implementation differential testing, version-to-version change localization, epsilon-neighborhood fuzzing around every shared edge, and externally submitted counterexamples.

9 Discussion

9.1 The missing artifact is policy, not polygons

The ecosystem already contains temporal rules, naming systems, geometry, approximate boundaries, and fast lookup libraries. A public semantic contract for combining them remains absent. The novelty claim is deliberately narrow: not better clock arithmetic and not merely another polygon file, but deterministic composition with inspectable provenance and total surface behavior.

Two vendors need not adopt identical internal geometry to compare results. If both emit compatible decision certificates, disagreement becomes concrete: candidate sources, precedence, boundary behavior, or temporal version can be isolated. RFC 7808's anticipated geographic lookup action provides a protocol context [Douglass and Daboo, 2016], while PROV-O provides a provenance context [Lebo et al., 2013].

9.2 Operational, economic, and public relevance

TBB and downstream lookup libraries demonstrate an established infrastructure need for coordinate-to-timezone lookup [Siroky, 2026, timezonefinder contributors, 2026]. Commercial APIs provide further operational evidence [Google Maps Platform, 2026, Microsoft, 2026, Amazon Web Services, 2026]. These sources do not establish a market size for provenance-aware resolution. A defensible commercial hypothesis is that update discipline, version diffs, offline bundles, conformance testing, decision certificates, and service-level guarantees may be valuable to organizations already maintaining spatial-time exceptions.

The standard and base conformance artifacts should remain open. Services can charge for operational reliability, rapid updates, audit support, private deployment, and integrations rather than restricting access to the decision model. TBB's ODbL license also makes proprietary enclosure of a derived database legally sensitive and strategically weak [Open Data Commons, 2009]; specialist license review is required before commercial distribution.

The plausible public benefit is smaller and cumulative: fewer silent coordination errors, clearer interpretation of geotemporal data, reproducible scientific and operational decisions, and explicit disclosure where software applies convention rather than official fact. These remain hypotheses to be evaluated through adoption and incident evidence.

10 Limitations and non-claims

GeoTZ 0.1 is an experimental reference release. It is not:

- an IANA release or an "improved IANA";
- a legal, administrative, sovereignty, territorial, or maritime boundary source;
- proof that a facility controls land inside an operational enclave;
- a complete registry of seasonal or temporary Antarctic facilities;
- a complete historical geography of post-1970 civil time;
- proof that the 25-km enclave radius is universally optimal;
- a mathematical proof that every source polygon is correct; or
- evidence that external institutions will adopt the model.

Spatial accuracy remains bounded by source evidence and fluid real-world practice. Governments can change rules with little notice; people may use clocks that differ from law; country and timezone classification are related but not identical; source licenses impose obligations; and the novelty review remains incomplete.

> **Most important epistemic limitation.** Totality requires conventions in places where no institution supplies a definitive local clock. GeoTZ addresses this by making those conventions visible rather than claiming to eliminate uncertainty.

11 Governance and future work

Releases are versioned independently from tzdb: for example, GeoTZ 0.1 compatible with tzdb 2026c. A tzdb update does not silently mutate a GeoTZ release. Any change to source versions, precedence, exact-boundary policy, enclave geometry, or polar behavior produces a new release and regenerated hashes.

Governance should require explicit source roles, versions, and licenses; labels for derived decisions; machine-readable adversarial cases for every normative behavior; public limitations and change rationale; coordinate-based counterexamples with expected decisions and evidence; reproducible identifiers and content hashes; and separation between an open specification and commercial hosted services.

The next research steps are to conduct a systematic prior-art review; publish a machine-readable certificate profile aligned with PROV-O; implement epsilon-neighborhood and differential conformance tests; obtain review from TBB and timezone-library maintainers; test the model with OGC temporal and global-reference communities; discuss a geographic lookup profile with relevant IETF participants; replace conventional enclave geometry where primary operating perimeters exist; and establish neutral governance if independent implementations emerge.

12 Conclusion

Temporal rule databases and spatial boundary datasets solve different problems. Applications that combine them inevitably introduce policy at gaps, overlaps, shared boundaries, the antimeridian, poles, oceans, and operational sites. When that policy remains implicit, results can be complete without being reproducible or honest.

GeoTZ makes policy an explicit artifact. It models spatial evidence as versioned claims, resolves claims through a deterministic contract, and binds each answer to a decision certificate. The reference release demonstrates complete algorithmic surface assignment while preserving the distinction between evidence and convention.

> A coordinate-to-timezone system can return one answer everywhere and still disclose where knowledge ends and convention begins.

Data and code availability

The public GeoTZ 0.1 research artifacts comprise the JSON Schema, reference generator, test vectors, independent verifier, audit report, and release manifest in the Timezone Explorer project. The complete authority GeoJSON is intentionally maintained as a server-side build artifact; its byte size and SHA-256 digest are recorded in the manifest. Source roles and licenses are recorded per artifact. This preprint should be updated with a permanent repository URL and archival DOI before journal submission.

Author contributions and AI disclosure

Raphael Altieri originated the problem, directed product and research decisions, supplied empirical counterexamples, rejected unsupported conclusions, selected the release scope, and accepts editorial responsibility. Codex by OpenAI contributed source discovery, evidence synthesis, mathematical formalization, implementation support, test design, vector schematics, and technical drafting. The work emerged through iterative disagreement and correction rather than one-pass generation.

An early statement that 259,200 sampled points were "100% resolved" was initially treated as if it established spatial correctness. Manual inspection of polar and Antarctic cases showed that complete lookup coverage could coexist with semantically wrong assignments. That failure motivated the separation among decision coverage, evidence class, and factual certainty.

Sources were checked against primary standards, official operator material, project documentation, and scholarly publications where available. Implementation claims were checked against the release manifest, independent verifier, and adversarial vectors. Codex is credited as a substantive AI research and drafting collaborator. It cannot independently accept responsibility, consent to publication, disclose conflicts, or defend the work; Raphael Altieri retains final accountability. This transparent credit is a convention of the independent preprint, not a claim that an AI system satisfies any journal's authorship rules.

Competing interests

Raphael Altieri develops Timezone Explorer and may pursue services or products related to GeoTZ. No external funding is declared for this manuscript. Codex by OpenAI has no capacity to hold a financial interest.

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A Conformance invariants

A conforming implementation satisfies:
Domain validity. Finite WGS 84 surface coordinates are accepted; invalid coordinates are rejected.
Totality. Every valid coordinate returns one winning timezone claim.
Determinism. Identical release, coordinate, instant, and input data produce the same decision.
Antimeridian equivalence. $+180°$ and $-180°$ encode the same meridian.
Polar invariance. Alternative longitude encodings of a mathematical pole do not change the decision.
Provenance completeness. Every decision identifies basis, evidence class, source, version, and rule.
Reproducibility. Pinned inputs and generator produce the published hashes.
Locality of change. A release reports which claims and regions changed rather than silently replacing the globe.
Epistemic honesty. Derived coverage is distinguishable from official, documented, or mapped evidence.
Rendering is informative. Resolver behavior, output vocabulary, precedence, tie-breaking, and machine-readable test vectors are normative for GeoTZ 0.1.

B Reference release snapshot

Table 6: Observed release properties. Values describe the released tests, not zero error in all source data or all possible coordinates.

Property	Observed value
Reference status	PASS
Compatible temporal release	IANA tzdb 2026c
Authority features	523
Global grid	259,200/259,200 samples resolved
Resolved zone identifiers	425
Invalid fixed offsets	0 observed
Antimeridian mismatches	0 observed
Mathematical pole failures	0 observed
Operational-site probe failures	0 observed
Boundary vertex/midpoint unresolved probes	0 observed
Invalid GeoTZ-generated features	0 observed