GEOMETRY INTELLIGENCE

Foundations for Machine Entity Comprehension and Sovereign Web4 Systems

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Canonical field reference: https://geometricintelligence.ai/

Foundational Version 1.2

12 August 2026

DOI: https://doi.org/10.5281/zenodo.21907367

Document hash: to be generated from the final immutable PDF.

Abstract

Modern information systems retrieve records, generate language, classify inputs and connect entities at scale. These capabilities do not by themselves establish that a system preserves identity, distinguishes materially different contexts, maintains evidentiary provenance, contains contradictions or produces outcomes that remain valid when conditions change. The resulting gap is structural: where knowledge is positioned, how relationships are governed and under what conditions a conclusion may be treated as valid.

This paper establishes Geometry Intelligence as a domain-general computational and epistemic discipline for organising entities, claims, evidence, contexts, authorities and constraints through governed relational structures. An informational object is not treated as an isolated token or record. Its meaning and validity depend on its position, neighbourhood, provenance, boundaries and permissible transformations. The relevant geometry is therefore a geometry of knowledge and valid change, not necessarily physical shape or Euclidean space.

The paper provides a canonical definition, minimum geometric commitments, a public object model and an implementation-neutral formal abstraction. It distinguishes Geometry Intelligence from information geometry, geometric deep learning, spatial and computational geometry, knowledge graphs, provenance systems, entity resolution, symbolic systems and generative AI. A black-box evaluation model permits proprietary and open implementations to be tested against common behavioural criteria without mandatory disclosure of confidential algorithms or internal representations.

This is a field-defining foundation, not a claim of completed scientific validation. Its contribution is to define a bounded discipline and falsifiable research programme from which mathematical models, benchmarks, implementation reports, independent evaluations and alternative implementations can develop.

Keywords: Geometry Intelligence; Machine Entity Comprehension; governed relational geometry; evidence architecture; sovereign systems; Web4; entity reasoning; provenance; conformance evaluation; verifiable reasoning.

1. Introduction

1.1 The structural problem

Search locates records. Knowledge graphs represent declared connections. Machine-learning systems identify statistical regularities. Large language models generate plausible sequences. None of these capabilities alone guarantees that a system can determine whether two descriptions concern the same enduring entity, whether a relationship remains valid after context changes, whether contradictory evidence has been contained, or whether an output is supported under the applicable validation regime.

An organisation may therefore possess abundant data while remaining unable to answer:

- Which entity does this claim concern?
- Which evidence supports or contradicts it?
- Under which temporal, jurisdictional or institutional context does it apply?
- Which authority permits the relationship or conclusion?
- Which constraints must survive transfer or derivation?
- What should change when a material fact changes?
- Can another evaluator reproduce the outcome under equivalent declared conditions?

These are questions of position, relationship, neighbourhood, boundary and transformation. They motivate Geometry Intelligence.

1.2 Why geometry

Geometry is used in a precise but implementation-neutral sense. Geometric reasoning concerns structured position, neighbourhood, boundary, relation, invariance and transformation within a space. In Geometry Intelligence, the objects may be entities, claims, evidence records, authorities, contexts, constraints or validation states. Their positions need not be Euclidean coordinates, and this paper prescribes neither one metric nor one internal representation.

The central commitment is behavioural: structure must materially govern outcomes. A change to a material relation must be capable of changing the outcome; irrelevant representational variation should not.

1.3 Scope and contribution

This paper defines the public category layer. It does not standardise an algorithm, coordinate system, metric, schema, protocol, cryptographic primitive or proprietary architecture. It contributes a canonical definition; minimum geometric commitments; a public object model; boundaries against adjacent fields; a relationship among Geometry Intelligence, Machine Entity Comprehension and optional Web4-class deployment; and an external evaluation programme.

2. Canonical definition

Geometry Intelligence is a domain-general computational and epistemic discipline in which entities, claims, evidence, contexts, authorities and constraints are assigned governed positions within a relational space. Intelligence is expressed through the inspection, transformation and validation of relationships among those positions.

The definition has six necessary elements:

1. Objects have positions relative to identity, evidence, time, authority, context and constraint.
2. Positions are governed by declared rules, evidence and validation conditions; they are not arbitrary embeddings.
3. Relationships carry typed meaning, provenance, direction, scope and validation state.
4. Neighbourhoods and boundaries constrain what may be inferred or transferred.
5. Transformations are inspectable for authorisation, evidentiary support and constraint preservation.
6. Invariants distinguish irrelevant variation from material change.

2.1 Executive definition

Geometry Intelligence determines where knowledge stands, how it connects, what supports it and whether it remains valid when context changes.

2.2 Foundational proposition

Intelligence is not only what a system produces. It is the governed structure connecting entities, evidence, context and valid transformation.

2.3 Operational sequence

Entity → Evidence → Relationship → Validation

A system does not become a Geometry Intelligence system because it displays a graph, stores vectors, uses coordinates or draws diagrams. Structured positions and transformations must materially govern behaviour.

3. Public object model

Object	Definition
Entity	A distinct real-world, digital or conceptual subject. Identity remains distinct from names and records.
Representation	An observation, identifier, description, symbol or record concerning an entity.
Claim	A bounded assertion about an entity, relationship, state or event.
Evidence	Information admitted under policy as relevant to evaluating a claim or state; evidence is not automatically truth.
Context	Temporal, jurisdictional, institutional, domain, purpose and system conditions.
Relationship	A typed, directed and governed connection carrying provenance, context, constraints and validation.
Constraint	A condition limiting identity, interpretation, transformation or validity.
Authority	A person, institution, rule or process entitled to make or evaluate a class of assertions.
Validation state	A scoped status such as untested, supported, contradicted, indeterminate, superseded, validated or rejected.

4. Minimum geometric commitments

A candidate formalisation must provide the following public commitments even when its production representation remains protected:

Commitment	Meaning
Position	A governed state assigned relative to identity, evidence, context, authority, constraints and validation.
Neighbourhood	Objects and relationships materially relevant under a declared scope.
Boundary	A condition limiting inference, transfer or transformation.
Transformation	A state transition inspectable for authorisation, support and constraint preservation.
Invariant	A property expected to remain stable under irrelevant variation.
Material change	A perturbation expected to alter affected outcomes while preserving unaffected controls.
Optional metric	An implementation may define distance, cost, similarity or curvature; no universal metric is required here.

These commitments define a governed relational geometry. They do not assert that every implementation uses continuous manifolds, physical coordinates or one universal distance measure.

5. Formal public abstraction

Let Ω be a governed relational space containing admissible informational objects and relations under policy Π. For $x \in \Omega$:

$$P_\Pi(x) = \langle I, E, C, R, A, K, V \rangle$$

I denotes identity conditions; E evidence and provenance; C context; R relevant relationships; A authority; K constraints; and V validation state. This tuple is illustrative and does not disclose a production coordinate system, dimensionality, assignment rule, metric or storage structure.

A governed relationship may be represented as:

$$G_\Pi(x,y) = \langle \tau, d, C, E, A, K, V \rangle$$

Here τ is relationship type and d direction. The governed neighbourhood $N_\Pi(x)$ contains those objects whose relations to x are admitted and material under Π. Boundary $\partial\Pi$ captures policy, authority, jurisdiction, time and admissibility limits.

A transformation $T: P_1 \rightarrow P_2$ is admissible only if it is authorised, preserves required constraints, retains necessary provenance and satisfies the applicable validation regime. For an invariant Inv under scope S, irrelevant variation Δ_i should preserve Inv and the material outcome; material change Δ_m should alter affected positions while preserving unaffected controls.

Claims contradict one another when they concern materially equivalent subjects and contexts yet assert states that cannot simultaneously hold under the applicable validation regime. A conforming system preserves provenance, exposes the contradiction and avoids silently collapsing both claims.

6. Foundational principles

Positionality. Claims occupy governed positions.

Identity–representation separation. Entities remain distinct from their descriptions.

Relational meaning. Meaning and validity depend partly on governed relationships.

Governed transformation. State changes pass through inspectable permissible transformations.

Provenance continuity. Material conclusions remain connected to sources and rules.

Constraint preservation. Scope and limitations travel with derived outcomes.

Domain-specific validation. Different disciplines use different declared standards.

Contradiction containment. Competing assertions remain attributable and examinable.

Bounded uncertainty. Supported, inferred, disputed, missing and invalid states remain distinct.

Repeatability. Equivalent authorised requests under equivalent state produce equivalent outcomes within declared tolerances.

Sovereignty. Dependencies, operator control, storage, access and continuity are explicitly bounded.

Implementation independence. Open and proprietary implementations may be assessed against common behaviour.

7. Machine Entity Comprehension and Web4

Geometry Intelligence → Machine Entity Comprehension → Web4-class deployment

Geometry Intelligence is the underlying discipline. Machine Entity Comprehension (MEC) is a bounded class of externally observable behaviours associated with preserving entity identity, context, relationships and constraints as evidence or state changes. Web4 describes one optional class of federated, sovereign-entity-capable deployment architectures.

Geometry Intelligence does not depend on adoption of the term Web4, a particular network protocol or the KTS Global implementation. A system may demonstrate MEC by another method, and a Web4-class federation may contain heterogeneous methods. MEC does not establish consciousness, sentience, human-equivalent understanding or general intelligence.

8. Prior art and boundaries

Geometry Intelligence is situated within, but not reducible to, established traditions. Priority is claimed for the bounded synthesis and public definition offered here, not for the general proposition that information or learning can possess geometric structure.

Field	Established contribution	Geometry Intelligence boundary
Information geometry	Differential geometry of statistical models and probability distributions [4–6].	Includes identity, evidence, authority, context, constraints and validation that need not be probabilistic.
Geometric deep learning	Learning on graphs, groups, manifolds and symmetry-structured domains [7].	Asks what may validly be concluded under governed relations, not only how models learn structured data.
Knowledge graphs and ontologies	Entity–relationship representation and semantics [8–10].	Requires provenance, authority, context, transformation rules and scoped validation.
Provenance	Interoperable representation of derivation and responsibility [11].	Adds identity persistence, material change, admissibility and validation.
Entity resolution	Record linkage and matching [12].	Adds contextual validity, contradiction and transformation.
Belief revision and truth maintenance	Dependency tracking and rational revision [13–14].	Integrates revision with provenance, authority, federation and external conformance.
Graph transformation	Formal rule-governed graph change [15].	Applies governed transformation to epistemic and institutional positions.
Distributed systems	Ordering, consistency and partition behaviour [16–17].	Federation is a deployment property, not sufficient evidence of Geometry Intelligence.
Generative AI	Statistical content generation.	Generation may propose candidates; authoritative outcomes remain evidence- and validation-bounded.

9. External conformance evaluation

Behavioural reproducibility without mandatory implementation disclosure.

Evaluation should use pre-registered inputs, declared state, observable outcomes, retained evidence and bounded acceptance criteria. A credible record identifies implementation and version; operator and evaluator; evidence and policy state; test boundary; dependencies and network condition; expected outcomes; repetitions and tolerances; retained integrity references; and deviations.

Core profiles

1. Identity persistence across equivalent representations.
2. Disambiguation of similar but distinct entities.
3. Relationship invariance under irrelevant variation.
4. Material-change response when relevant conditions change.
5. Contradiction detection and containment.
6. Repeatability under equivalent declared state.
7. Multi-node outcome equivalence under equivalent node state.
8. Disconnected continuity without undeclared external intelligence services.
9. Differentiation from retrieval-only, similarity-only and cached-answer baselines.

Negative controls should detect exact-text matching, cached answers, superficial name matching, uncontrolled retrieval, indiscriminate sensitivity, hidden dependencies, test leakage and post hoc thresholds. Results remain bounded by tested conditions. Self-evaluation must not be represented as independent verification.

10. Synthetic example

Two organisations have similar names but different jurisdictions. A procurement record attributes a contract to the first; a later database entry attributes it to the second. An authoritative registry update changes the directors of the first without changing its legal identity. A retrieval system may merge the organisations, and a generative system may produce one fluent narrative containing facts from both.

A Geometry Intelligence system should preserve two identities; map each representation or mark ambiguity; retain jurisdiction and registry authority; connect the procurement record to provenance; expose the conflicting attribution; treat the director change as an attribute update rather than a new entity; preserve unaffected relationships; and issue a bounded conclusion.

The contract is supported as belonging to the Jurisdiction X entity by the procurement record. A separate entry attributes it to the Jurisdiction Y entity; that attribution conflicts with the procurement evidence and remains unresolved. The director update changes management but does not, under the test conditions, change stable identity.

11. Applications

- Sovereign and government systems: identity, jurisdiction, policy dependencies and auditability.
- Legal and investigative evidence: competing claims, admissibility and controlling authority.
- Engineering and critical infrastructure: requirements, versions, tolerances, tests and dependencies.
- Formal mathematics: propositions, assumptions, proofs and verification states.
- Institutional memory: time-scoped decision provenance and supersession.
- AI assurance: separation of generative proposals from authoritative outcomes.
- Complex holdings: controlled relationships among assets, entities, jurisdictions and evidence.

12. Reference implementation

The Jacobs MEC Internet-Draft records a KTS Global reference deployment in Dubai [1]. First-party operator records report operation since 26 January 2026 and twenty-one participating nodes as of 5 August 2026. These are implementation-status disclosures, not independent certification.

Evidence should be classified as operator-reported, witnessed, independently evaluated, independently replicated or independently interoperable. No stronger class should be inferred from a weaker one. Multiple nodes running one implementation demonstrate deployment scale, not independent interoperability.

13. Security, privacy and governance

- Protect against entity substitution through authenticated updates and provenance continuity.
- Contain evidence poisoning through source identity, integrity records and admission policy.
- Apply authorisation to derived relationships and outcomes, not only raw records.
- Protect test integrity with pre-registration, withheld cases and evaluator independence.
- Bound sovereignty claims by deployment, duration, network condition and declared dependencies.
- Prefer synthetic or authorised data and minimise disclosure of private topology.
- Support correction and dispute while preserving the original audit record.

14. Limitations and non-claims

- No claim of consciousness, sentience or human-equivalent understanding.
- No universal truth engine or single validation regime.
- No elimination of authorised human judgment.
- No automatic superiority without comparative testing.
- No inference of one internal mechanism from external conformance.
- No IETF endorsement is implied by publication of an individual Internet-Draft.
- No exclusive ownership is claimed over geometry applied to information or intelligence. The contribution claimed is this bounded discipline, synthesis, terminology and evaluation programme.

15. Public and protected layers

The public layer comprises the name and definition, object model, principles, minimum geometric commitments, boundaries, evaluation philosophy, synthetic examples and research roadmap. The protected layer may include coordinate construction, dimensionality, metrics, algorithms, weighting, schemas, cryptographic mechanisms, source code and deployment processes.

The publication target is behavioural reproducibility without mandatory implementation disclosure.

16. Research and publication programme

Paper	Primary contribution
I. Foundations	Canonical definition, scope, minimum geometry, boundaries and research programme.
II. Formal model	Governed relational space, transformations, invariants, materiality and contradiction.
III. MEC conformance	Test profiles, metrics, baselines and reporting format.
IV. Reference architecture	Production boundary, node roles, state controls, dependencies and failure cases.
V. Independent benchmark	Pre-registered comparison with retrieval, graph and generative baselines.

Independent interoperability requires at least two separately developed implementations using a declared public binding or common test harness. Independent evaluators should control withheld cases, adjudication records and acceptance criteria, publish unsuccessful and indeterminate results, and disclose material relationships with the operator.

17. Identity and publication governance

Author identity is anchored by ORCID 0009-0008-7130-1448. The canonical public definition of the discipline is maintained at https://geometricintelligence.ai/. These identifiers establish attribution and publication continuity; they do not independently validate technical or capability claims.

The paper should receive a DOI, dedicated canonical landing page beneath geometricintelligence.ai, selected license, immutable archived copy, cryptographic hash, machine-readable citation record and changelog. Each release should distinguish clarification from substantive revision and retain prior versions.

18. Conclusion

Geometry Intelligence addresses a structural limitation in contemporary systems: retrieval, connection and generation do not by themselves establish preservation of identity, context, evidence, authority, constraints and validity as conditions change. Knowledge has governed position. Claims stand in relation to entities, evidence, contexts and authorities. Conclusions arise through admissible transformations that may preserve or violate constraints. Contradictions must be contained rather than silently merged, and validation remains specific to domain and scope.

Geometry Intelligence is not another name for geometric deep learning, spatial AI, CAD geometry, knowledge graphs, provenance systems or generative modelling. Those fields contribute methods and prior art. Geometry Intelligence is distinguished by the combined governance of epistemic position, neighbourhood, boundary, transformation and external evaluation of coherent relational behaviour.

This foundational version establishes a starting point. Its value will depend on formal development, independent criticism, reproducible evaluation, alternative implementations and demonstrated performance against meaningful baselines.

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Suggested citation

Jacobs, T. (2026). Geometry Intelligence: Foundations for Machine Entity Comprehension and Sovereign Web4 Systems. Foundational Version 1.2. KTS Global, Dubai, United Arab Emirates. ORCID: 0009-0008-7130-1448. https://doi.org/10.5281/zenodo.21907367

Submission metadata

Field	Value
Author	Tim Jacobs
ORCID	https://orcid.org/0009-0008-7130-1448
Affiliation	KTS Global
Location	Dubai, United Arab Emirates
Document type	Foundational technical paper
Version	1.2
Canonical field reference	https://geometricintelligence.ai/
Canonical paper URL	Dedicated landing page to be assigned under geometricintelligence.ai
License	Creative Commons Attribution 4.0 International (CC BY 4.0)
DOI	https://doi.org/10.5281/zenodo.21907367
Document hash	To be generated from the immutable release