A Framework for AI Agent-Assisted National Mapping

Toward AI-Supported Geospatial Feature Management

Dongpo Deng, Geomni Inc.

The shift from data to values requires execution

GKI represents the shift to knowledge, but knowledge alone doesn't create action

Spatial Data Infrastructure (SDI)

Centralized databases, EO, sensors, authoritative geodetic references

Geo-Knowledge Infrastructure (GKI)

Semantic extraction, analytical models, contextualization

The Missing layer

Executable Knowledge

How do systems independently reason upon and act on this knowledge?

Decision & Action

Validation, Process Automation, Dynamic Services

The next era of national mapping requires transforming static rules into machine-actionable decision systems.

What is executable knowledge?

Executable geospatial knowledge is structured mapping knowledge that an AI system can retrieve, reason over, validate, and operationalize through tools.

Machine-Interpretable

Translating human-readable PDFs, UMLs, and regulations into structured, queryable ontologies and Knowledge Graphs.

Machine-Actionable

Enabling autonomous systems to access, compile, and execute mapping parameters without relying on manual intervention.

Reasoning-Enabled

Allowing AI to inherit logic, detect conflicts in mapping rules, and deduce spatial relationships across multiple sources.

Upgrading to Knowledge-Driven Mapping

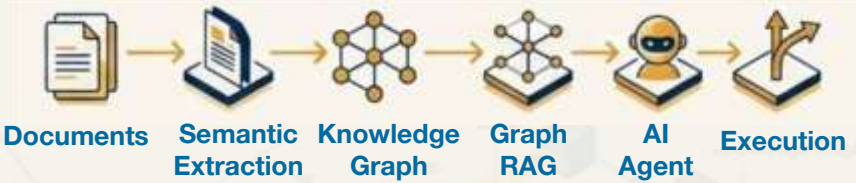
Transitioning from manual document interpretation to automated AI agent execution

Document-Driven (The Old World)

PAIN POINTS:

- Mapping rules are trapped in static PDFs or UML diagrams.
- Heavy reliance on manual expert judgment for every update.
- Systems cannot directly read or reason with passive formats.
- Fragmented logic across disconnected specifications.

National Map Agent (The New World)



BREAKTHROUGHS:

- **Semantified:** Rules converted into a queryable Knowledge Graph.
- **Intelligent:** AI Agent determines workflows and tasks.
- **Automated:** The agent autonomously generates map styles, structural actions, and quality assurance reports.

Construct the Executable Engine

Transforming regulations into a scalable AI mapping infrastructure.

Document Stage

- Graphic specification tables
- Classification schema UMLS
- Topological rules & descriptions

→

Knowledge Stage (KG)

- Category
- FeatureType
- Representation Rule
- Style Parameter
- Evidence Chunk

→

Reasoning Stage (GraphRAG)

- Entity Linking
- Intent Detection
- Subgraph Retrieval
- Evidence Grounding

→

Execution Stage (Agent)

- Tool Routing
- Style Compilation
- Consistency Checking

→

Output Stage

- PMTiles Style
- MapLibre Views
- Compliance Reports

Core Strategy: Rules are converted to a Knowledge Graph. The Agent uses GraphRAG to retrieve exact features, evidence, and tools rather than feeding raw PDFs directly to an LLM.

Fire Hydrant Style Compliance

How the National Map Agent turns specification knowledge into correct mapping output

Operational problem

- Hydrant features are mapped, but symbol use is often inconsistent
- The 1:1000 cartographic specification is difficult to interpret manually
- Wrong symbol output weakens map quality and review efficiency

What the Agent actually solves

- Reads cartographic knowledge from the specification
- Links feature code to correct map symbol
- Generates machine-usable style output
- Supports faster QA and consistent map production

1 Input data

SHP

Category 9350906 消防栓

2 Knowledge retrieval

3 Agent reasoning

AI

- find graphic_element_type=桩
- find symbol =fire_hydrant
- compile style rules

4 Style generation

```
{
  "id": "fire_hydrant",
  "type": "symbol",
  "source-layer": "hydrant",
  "icon-image": "fire_hydrant"
}
```

5 Map output

MapLibre / PMTiles

Before

●

Symbol ambiguous / not compliant

After

Specification-compliant hydrant rendering

Official 1:1000 Map Symbol Reference

Fire Hydrant

Rapid Onboarding of Solar Panel Mapping

How the National Map Agent reduces the time needed to support a new feature type

Operational problem

- A new mapping theme must be added quickly
- Analysts need to understand category meaning, layer rules, and fields
- Without structured knowledge, onboarding is slow and error-prone

1 New feature request

Add solar panel mapping

2 Semantic ingestion

- classification
- layer schema
- field definitions

3 Knowledge graph linking

4 Agent support

AI

- answer mapping questions
- suggest source-layer mapping
- generate style + validation hints

5 Operational output

Source-layer mapping (JSON / Style)

```
{
  "featureType": "SolarPanel",
  "sourceLayer": "solar_panel",
  "geometryType": "Polygon",
  "style": {
    "fill": "#1E88E5",
    "outline": "#1565C0",
    "opacity": 0.85
  },
  "minZoom": 14,
  "maxZoom": 22
}
```

Map preview

What the Agent actually solves

- Connects semantics, schema, and style knowledge
- Shortens onboarding from manual interpretation to guided compilation
- Helps teams generate PMTiles-ready style outputs
- Improves consistency across new mapping themes

Traditional process

manual reading › schema interpretation › style drafting › QA

From fragmented documents to operational knowledge

With National Map Agent

query KG › agent reasoning › style generation

The Anatomy of a National Map Agent

A multi-modular cognitive architecture for sovereign spatial intelligence.

psychology

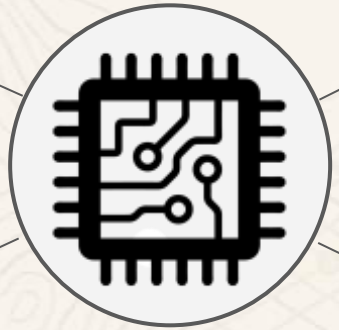
Brain (LLM)

The cognitive engine that understands user intent and formulates high-level planning.

storage

Memory

Vector DBs and Knowledge Graphs storing spatial regulations and ontologies.



Agent Core (LLM)

Orchestrator + LLM + Tool Registry

build

Tools

Hands-on SQL execution, PDF parsers, GIS APIs, and style compilers.

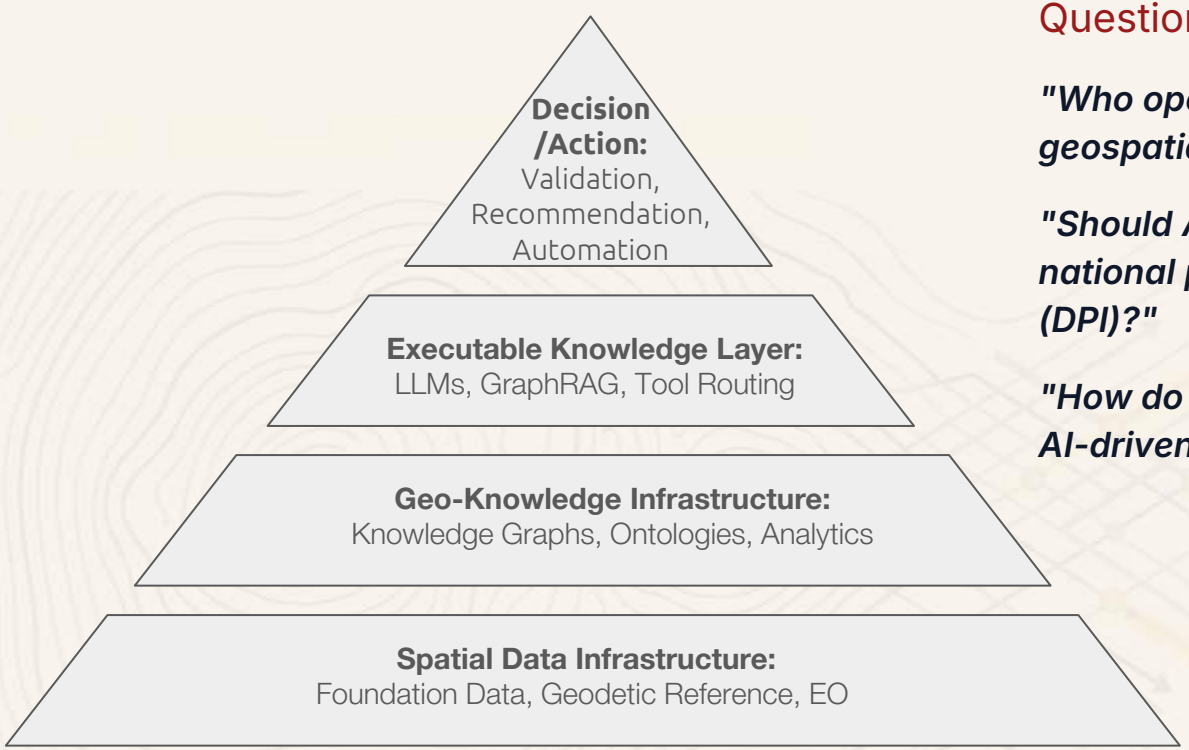
route

Planning

Logical decomposition of spatial tasks into retriever calls, validation checks, and tool execution.

Toward AI-Native Geospatial Infrastructure

Redefining how national maps are created, managed, and operationalized.



Questions remain:

"Who operationalizes sovereign geospatial knowledge?"

"Should AI agents be regulated as part of national public digital infrastructure (DPI)?"

"How do we ensure algorithmic trust in AI-driven map feature management?"

We are not automating mapping. We are redefining the infrastructure of spatial intelligence.