Agentic AI in Surveying and GIS

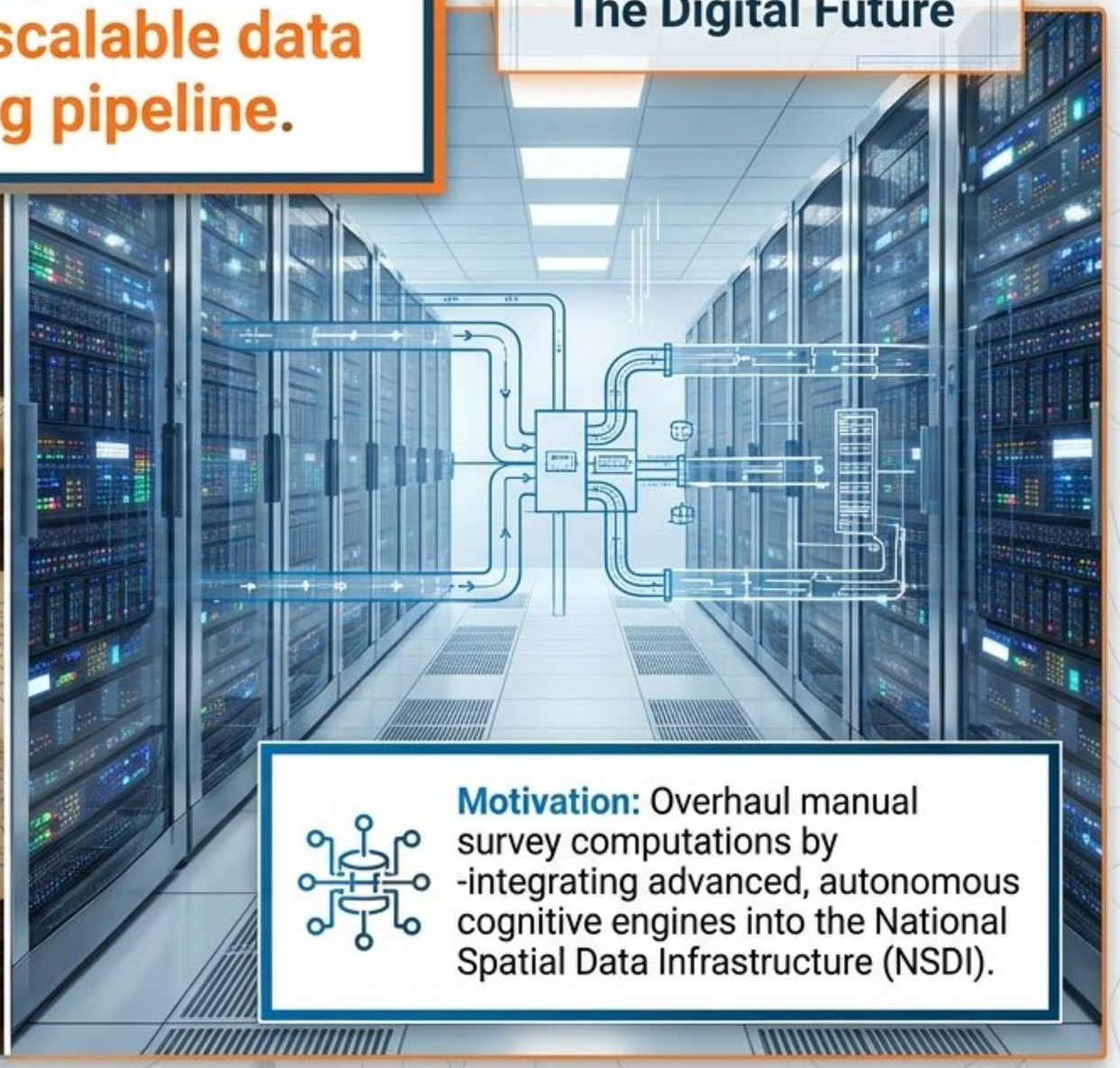
Precision Mapping at PNG University of Technology

The 58th ASPNG Congress: Surveyors Role in Reclaiming the Land, Redefining Laws and Legacy Issues In a Changing PNG.

The Physical Legacy

Resolving legacy issues demands a scalable data processing pipeline.

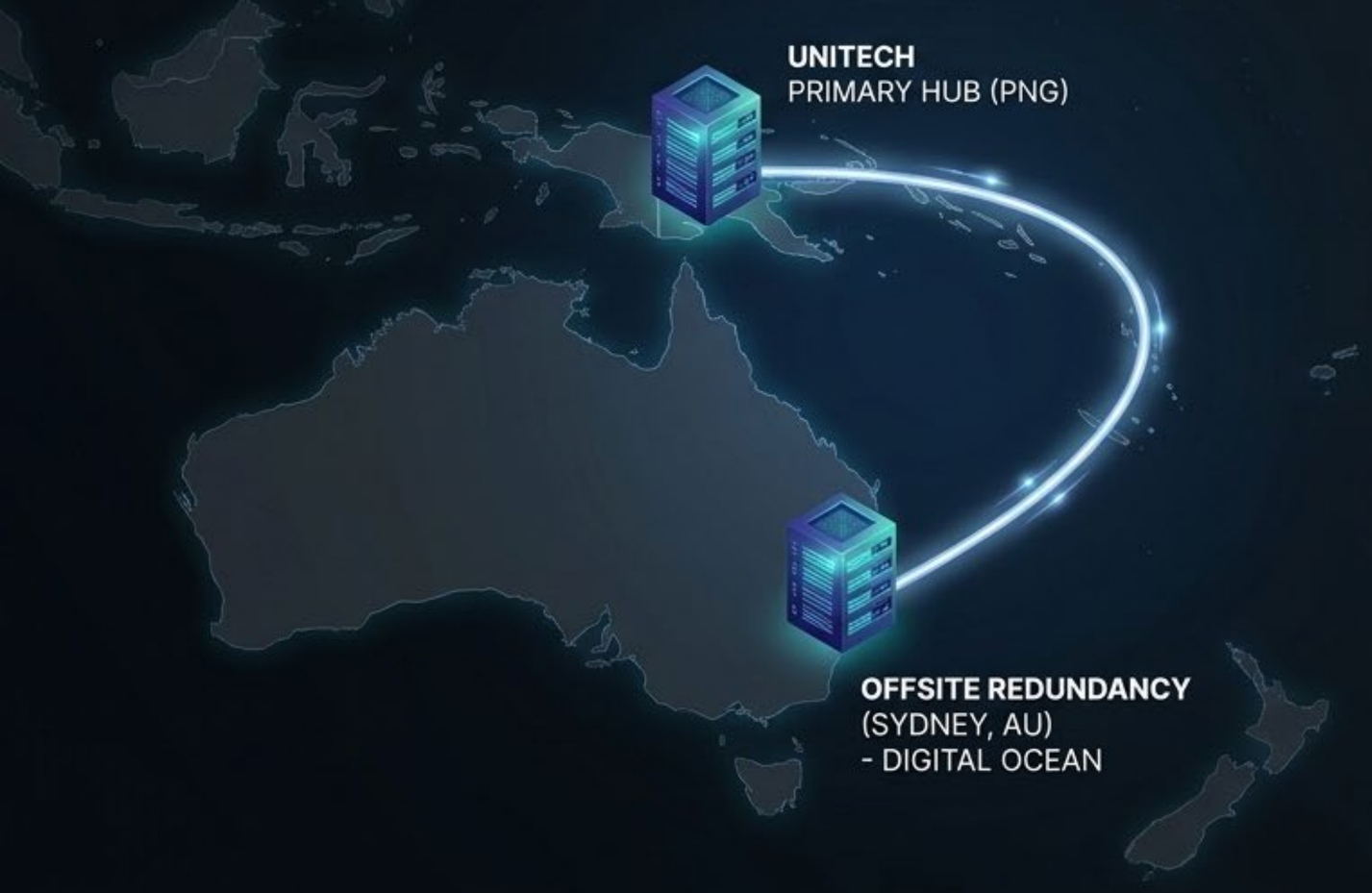
The Digital Future



Motivation: Overhaul manual survey computations by -integrating advanced, autonomous cognitive engines into the National Spatial Data Infrastructure (NSDI).

The National Spatial Data Infrastructure (NSDI) Topology

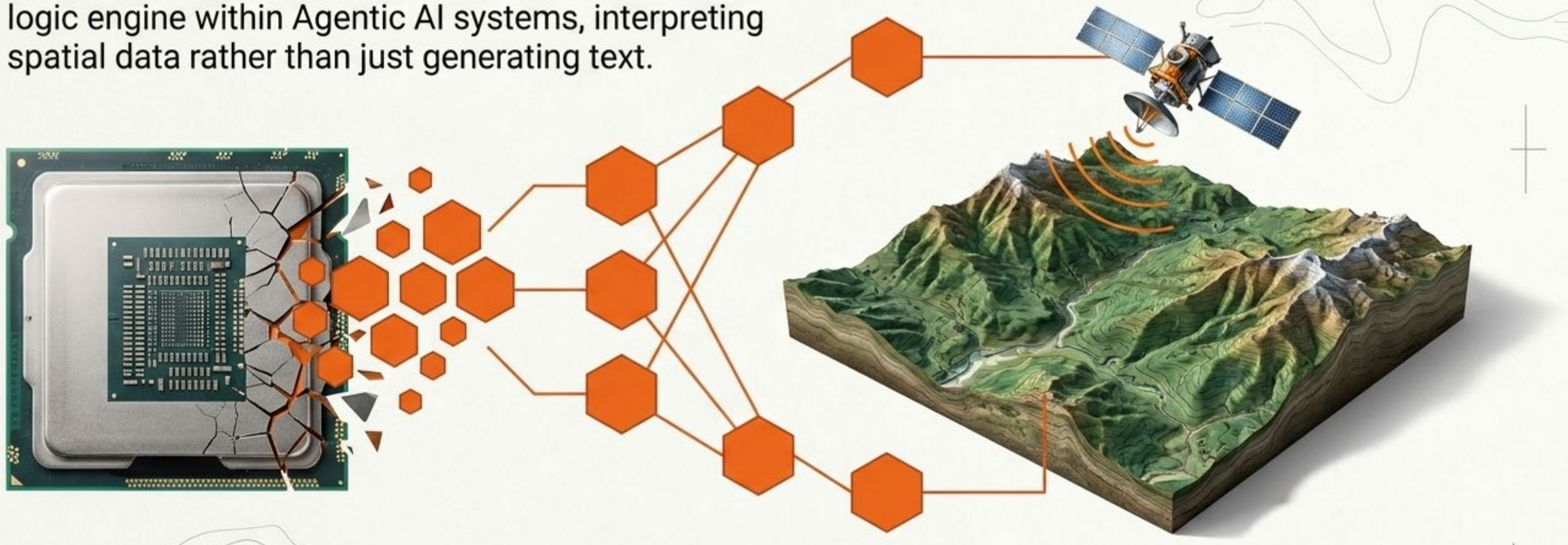
> Initiated in 2013 by the School of Survey, creating a resilient, distributed virtual private server (VPS) backbone.



1	**Campus Nodes (Local Access)**	2x Virtual Private Servers physically located at Unitech (Primary Hub in PNG).
2	**Offsite Redundancy (Cloud Access)**	2x Digital Ocean data center servers located in Sydney, Australia.
3	**Future Integration**	Planned expansion to Dataco infrastructure to complete the national loop.
4	**Operation**	Acts as the primary data pipeline, user portal, and processing engine for the entire spatial system.

Large Language Models as Spatial Reasoning Engines

An LLM functions as the foundational reasoning and logic engine within Agentic AI systems, interpreting spatial data rather than just generating text.



The cognitive engine: structuring Large Language Models.

Data Collection & Curation

Aggregating large datasets, filtering for quality.

Gathering raw field notes

Pre-training

Model learns generic language patterns without labels.

Establishing basic spatial relationships

Fine-tuning

Training on specific tasks using human-curated data.

Calibrating instruments for specific terrain

Alignment & RLHF

Aligning model with human values via preference feedback.

Peer review and boundary adjustment

Deployment & Inference

Integrating finalized model for live use.

Publishing the verified map

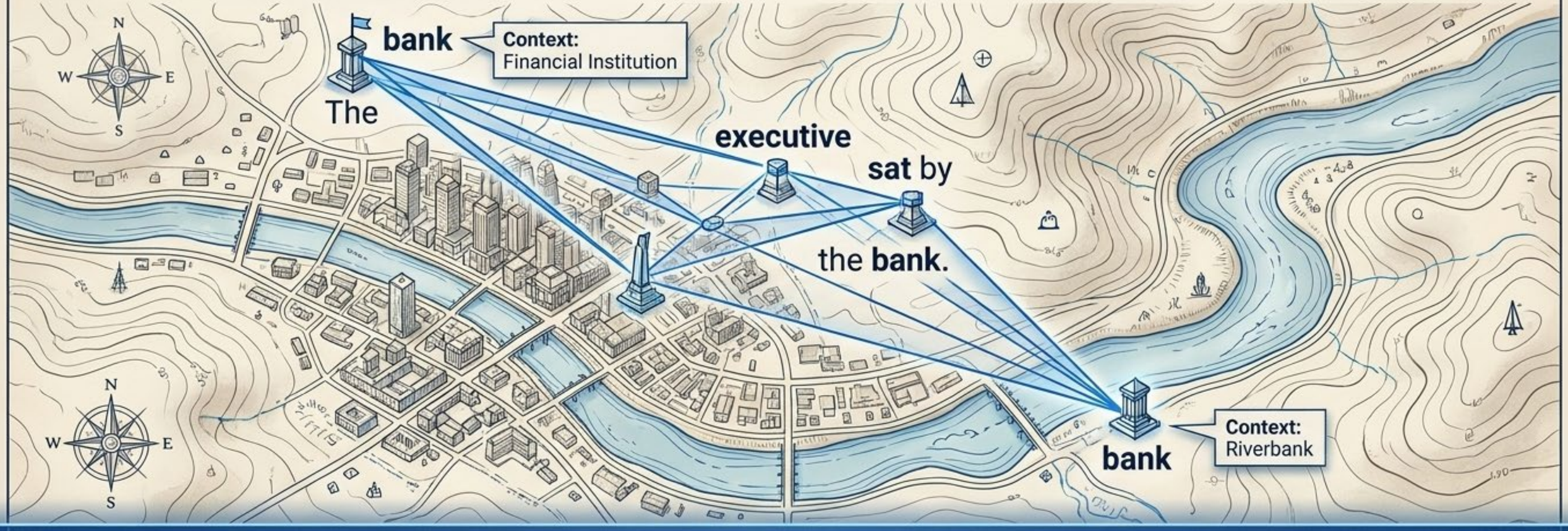
Evaluation & Iteration

Continual assessment against benchmarks.

Ongoing land registry updates

Transformers: Attention operates like digital triangulation

The Breakthrough:
Vaswani et al. (2017)
“Attention Is All You Need”



The Mechanism: Instead of reading linearly, the Transformer model looks at the entire landscape of context simultaneously. By taking “bearings” (attention weights) from surrounding words, it precisely locates the correct meaning of a term.

The limitation of sequential, word-by-word processing.

Reads 1st word

Identifies “bank” as a financial institution.

Processes intermediate text

Context begins to fade as new words arrive sequentially.

Reads 2nd word

Model is confused.
Model is confused. Both “banks” are treated identically, leading to critical computation or reasoning errors.

The evolution of autonomy: Simple Agents vs. Agentic workflows

Simple AI Agents
(The Digital Calculator)

- Linear workflow (Step 1 -> Step 2 -> Target Achieved -> End).
- Performs a specific, isolated task and stops.
- Halts if an unexpected error occurs.

Agentic AI
(The Autonomous Surveyor)

- Cyclic workflow (Planning <-> Execution <-> Feedback <-> Adaptation).
- Plans multiple steps and executes them until a distant goal is achieved.
- Autonomous and Self-Correcting: Able to make decisions and choices on its own based on dynamic feedback.

Orchestrating intelligence: Moving from chains to graphs.

Langchain

A framework for creating linear workflows (chains) for LLMs. Insufficient for complex surveying math.

Langgraph

A non-linear, graph-based approach designed to handle complex, dynamic workflows.

Graph Components:

- Nodes have specific mathematical or operational functions tied to them.
- From each node, the system can make dynamic calls to different, specialized LLMs.
- Core Architecture Elements: MCP Servers, Tools, Resources, Prompts, and Samplings.

Proof of Concept: Autonomous Survey Computations.

Key Insight: We have successfully mapped the rigorous mathematical workflow of a survey traverse directly into a Langgraph node structure.

Phase 1: Ingestion, Validation, and Autonomous Routing.

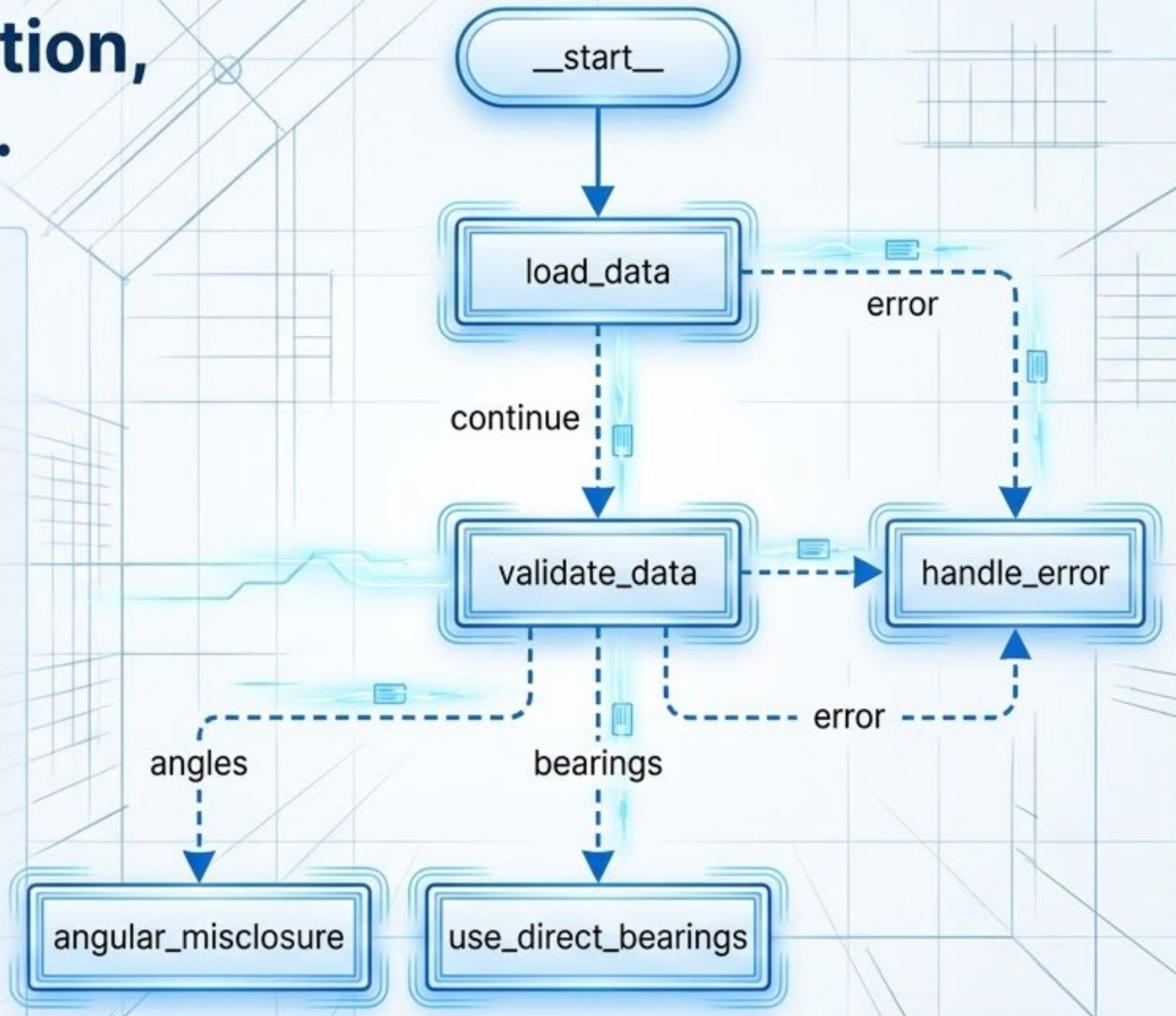
The Workflow:

- **__start__ -> load_data**: The system ingests raw field measurements.
- **validate_data**: The Agentic AI inspects the inputs.

Autonomous Decision Making:

Based on the data type, the agent routes the workflow dynamically:

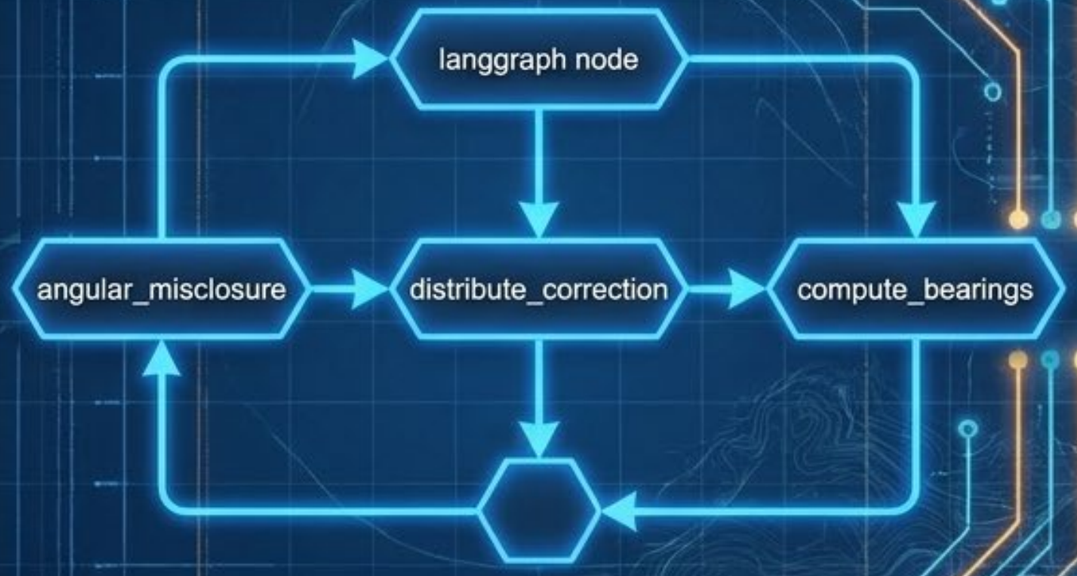
- If raw angles are detected -> Routes to Angular processing.
- If direct bearings are detected -> Routes to Coordinate processing.
- If anomalies exist -> Routes to handle_error.



Phase 2: Resolving Angular Misclosure dynamically

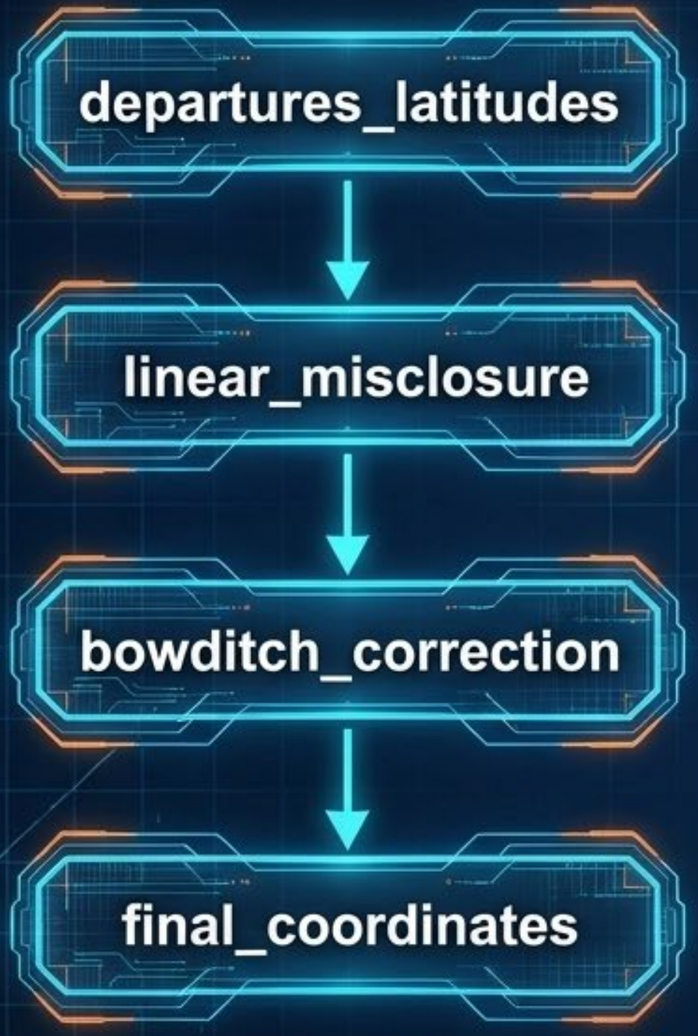
The Workflow:

- **angular_misclosure**: The agent detects deviations in the closed loop.
- **distribute_correction**: Instead of failing, it mathematically distributes the error across the traverse stations.
- **compute_bearings**: Calculates the true bearings only after validation is mathematically sound.



Key Takeaway: The agent self-corrects its trajectory based on strict surveying principles without human intervention.

Phase 3: Coordinate Geometry and Bowditch Correction



The Workflow:

departures_latitudes

Converts bearings and distances into Cartesian vectors.

linear_misclosure

Assesses the final closure error.

bowditch_correction

Applies the Bowditch rule autonomously to snap the traverse closed perfectly.

final_coordinates

Generates the verified spatial data points.

Phase 4: End-to-End Automation and Documentation.

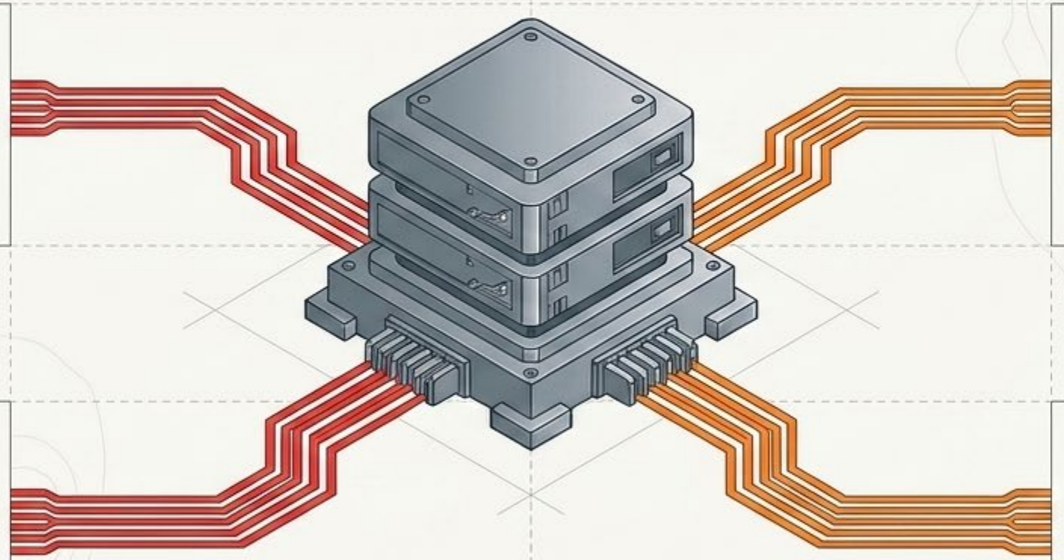
The Workflow: From final_coordinates, the Agent executes the final tasks: plot_mapbox instantly visualizes the corrected boundaries, while generate_pdf drafts the final legal document, terminating at __end__.

Impact: What previously took hours of manual ledger work is executed autonomously, accurately, and instantly.

The Infrastructure: MCP Servers

Tools

The specific mathematical instruments and executable functions the AI can use.



Prompts

The defined system instructions, contexts, and boundary constraints.

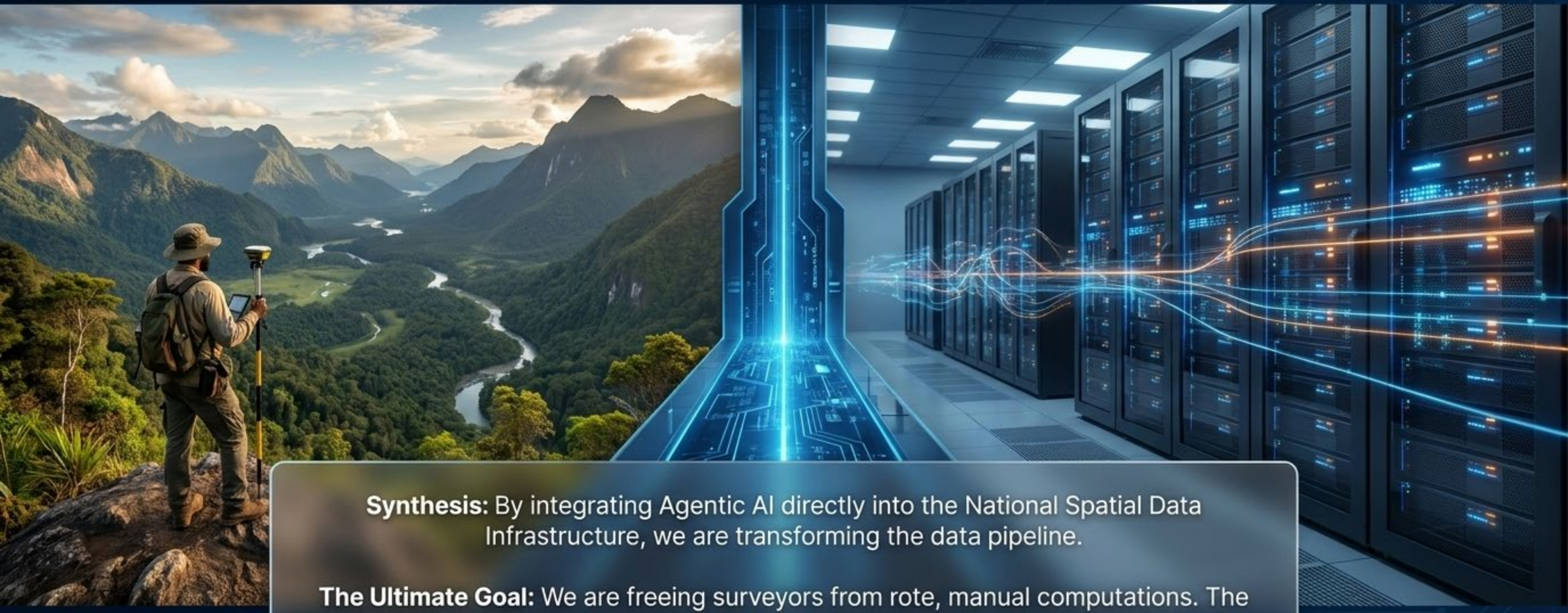
Resources

The raw geospatial data, file systems, and coordinate databases.

Samplings

The data extraction, testing, and verification protocols.

Redefining our legacy in a changing Papua New Guinea.



Synthesis: By integrating Agentic AI directly into the National Spatial Data Infrastructure, we are transforming the data pipeline.

The Ultimate Goal: We are freeing surveyors from rote, manual computations. The technology handles the math, allowing human experts to focus on their true role: reclaiming the land, redefining laws, and managing the physical legacy of PNG.

Q&A

Any Comment or Questions

PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY