# Advancing Urban Digital Twin Implementation Through Discrete Global Grid Systems

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## SUMMARY

This paper concerns the dual challenge of managing both AI and human-induced uncertainties in ground data acquisition and integration through provenance-enabled semantic knowledge graphs. While considerable attention to date has focussed on AI hallucinations, our work demonstrates that human biases and errors in data collection and interpretation can be equally challenging for maintaining data integrity in modern ground modelling systems. Recent cost blow outs in projects such as Westgate tunnel in Melbourne and Snowy Hydro underscore this.□□AI hesitancy in civil infrastructure and construction likely stems from trust in human judgment over machine outputs and the perceived novelty of AI technology. Yet, this overlooks the significant potential for AI to enable data and metadata integrations, stakeholder engagement, and rapid benefit articulation and risk mitigation. By leveraging better production data workflows and common data acquisition platforms that integrate all environmental, geotechnical, geophysical, spatial and financial data and data provenance, organisations can create transparent, traceable systems that address both human and AI uncertainties. This dual-focus approach improves productivity, enhances sustainability, and builds trust by demonstrating that reliable outcomes stem from robust data management..□□We present a novel framework that combines spatio-temporal knowledge integration across diverse data sources including satellite imagery, drone data, IoT sensor networks, bathymetry / topography, environmental and geotechnical. The system employs Discrete Global Grid Systems and indexing to ensure consistent spatial referencing, while semantic knowledge graphs maintain comprehensive lineage of both human and AI-driven data transformations and analytical processes. This approach enables validation and verification of results and ensures transparency in decision-making processes, across key stakeholders.□□Through real-world applications in climate and environmental sciences, geophysics, and geotechnical studies, our system demonstrates significant improvements in detecting and managing data and metadata uncertainty. The implementation of a matrix-managed experimental framework enables observation and understanding of any human or

AI-induced errors, by ensuring robust provenance tracking and data integrity. As an additional benefit once data is integrated into a knowledge graph and is trusted and transparent, a new understanding of risk and benefits can be understood and articulated to all stakeholder groups- including engineers, environmental scientists, accountants, insurance companies and the general public.□□□□This research contributes to the broader discussion of data quality in the AI era by highlighting that focussing solely on AI hallucinations overlooks the significant impact of human cognitive biases in ground modelling data collection and processing. Our findings provide valuable insights for owners, developers, contractors and tax payers seeking a competitive edge by implementing comprehensive data quality management systems that address uncertainties in ground modelling and project decision support applications.□