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INTEGRATING BUILDING INFORMATION MODELING (BIM) FOR OPTIMIZED COORDINATION IN ROADWAY PROJECTS AND URBAN UTILITY NETWORKS

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Abstract

This paper develops an integrated Building Information Modeling–Geographic Information System (BIM–GIS) framework to optimize coordination between roadway infrastructure and underground utility networks, addressing critical shortcomings in prior studies that often relied on visualization or ad hoc data conversion without measurable validation. Three main contributions define the novelty of this work: (i) explicit modeling of interdependencies between multi-utility networks and roadway structures, (ii) a systematic semantic mapping strategy to ensure interoperability and attribute consistency across heterogeneous datasets, and (iii) validation on a real-world Algerian case study characterized by fragmented standards and diverse data sources.
The methodology follows a stepwise workflow from topographic data acquisition and GIS structuring to BIM-based 3D modeling, clash detection, and semantic integration. Quantitative validation demonstrates robust performance: 51 spatial conflicts were identified and 92–100% resolved at the design stage; geometric accuracy achieved RMSE values of 0.10–0.15 m; design–validation iterations decreased by 30–34%, resulting in a 28% reduction in change orders, 22% gains in coordination efficiency, and 15% cost savings compared to conventional workflows.
Beyond technical advances, the framework supports sustainable infrastructure management by minimizing unnecessary excavation, reducing material waste, and improving resource allocation. These outcomes highlight the framework's potential to enhance resilience and environmental performance in urban projects. Future research will extend this approach to large-scale urban areas and explore AI-driven semantic mapping, digital twins, and predictive maintenance.

Key words: Building Information Modeling (BIM), BIM-GIS integration, clash detection, 3D modelling, Geographic Information System (GIS), interdisciplinary coordination, road infrastructure, urban utility networks

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