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ONTOLOGY-BASED COST MANAGEMENT IN PUBLIC INFRASTRUCTURE PROJECTS: A CASE STUDY ON TRANSFERABILITY AND APPLICABILITY

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Abstract

Cost management in infrastructure projects is complex due to evolving cost information, multiple estimation methods, and national regulations. Ontology-based approaches combined with Building Information Modeling (BIM) can improve cost consistency and decision-making; however, their transferability and applicability across domains and countries remain insufficiently investigated. This paper examines how an existing ontology-based cost management approach can be transferred to German railway infrastructure projects. A case study explores the reuse of cost ontologies across construction domains and under a different national regulatory framework. The results suggest that ontology-based cost structures support cost development and semantic consistency in standardized infrastructure projects.

Introduction

Cost management is one of the most critical and challenging tasks in infrastructure project management. Total project costs are often unknown until after the conceptual design phase and, in some cases, even after construction completion (Moses, 2020; Ashworth & Perera, 2018). The use of different estimation methods, cost indicators, and classification systems throughout the project lifecycle frequently leads to inconsistencies, limited transparency, and error-prone decision-making (Cassandro et al., 2025).

Digital methods such as Building Information Modeling (BIM) have significantly improved the availability and integration of project data. In parallel, ontology-based approaches have been proposed to formalize cost knowledge, enable semantic interoperability, and support structured cost analyses. Previous studies indicate that ontologies enhance consistency and traceability in cost management by providing a shared semantic framework across disciplines and phases (Signorini et al., 2025).

Nevertheless, current ontology-based cost management approaches exhibit two main limitations. First, they often focus on highly detailed and static cost calculations without explicitly considering the evolution of cost information across different project phases. Second, most approaches are developed and validated within a single domain or national context, raising concerns regarding their transferability, applicability, scalability, and generalizability. This paper specifically addresses the second limitation by examining the application of an existing ontology-based cost management approach in the context of German railway infrastructure projects.

In this study, *transferability* refers to the reuse of the ontology-based cost model in a different construction domain, such as infrastructure instead of buildings, without fundamental changes to its core ontological classes and their relationships (Korstjens & Moser, 2018). *Applicability* refers to the feasibility of implementing the approach in a different regulatory and organizational context, including national cost management rules, such as the German instead of the Italian context. *Scalability* denotes the capability of the approach to support different project sizes and work types, for example small-scale rather than large-scale projects or demolition rather than new construction. *Generalizability* addresses the extent to which findings can be applied beyond a single case study, for example through the development of a reference project based on a larger project sample.

Following the recommendations of Farghaly et al. (2023), this paper emphasizes the reuse of existing ontologies rather than the development of new, isolated models. Specifically, it builds on the ontology-based cost management approach proposed by Cassandro et al. (2023), which has so far been validated primarily in building projects within the Italian regulatory framework, while its conceptual structure is designed to support multiple domains and national standards.

The objective of this paper is to explore the transferability and applicability of the ontology-based approach to infrastructure projects and to a distinct national context, namely the German railway sector. German railway infrastructure projects are characterized by specific cost management rules, standards, regulations, and organizational features that differ substantially from those applied in prior case studies in the Italian construction industry, making this context a suitable testbed for assessing cross-national applicability and methodological robustness.

While cost management procedures, aggregation methods, and regulatory requirements vary across national contexts and application domains, the underlying *cost items* – defined as price components and their technical descriptions – remain conceptually comparable. In infrastructure projects, however, unit prices are often unstable and not directly reusable, as they strongly depend on site-specific conditions, construction sequences, access constraints, and track closures.

Therefore, the objective of ontology-based cost management is not to standardize prices, but to semantically structure cost item descriptions in a way that enables consistent association, comparison, and updating of cost values across projects. This study is based on the assumption that variations across contexts primarily affect how cost data are structured, interpreted, and managed, rather than the cost data themselves. By semantically structuring cost items and their descriptions through an ontology-based approach, cost information becomes machine-interpretable, verifiable, and consistently comparable across projects and national frameworks.

By transferring the existing ontology-based cost structure to the German railway context, this paper demonstrates its scalability, semantic depth, and ability to support cost data management despite differences in national regulations and industry practices. The case study of standardized German railway infrastructure projects therefore offers an exploratory validation of ontology reuse in a cross-domain and cross-national setting.

Background

Cost management

Cost management encompasses the processes of planning, estimating, budgeting, and controlling costs to ensure that projects remain financially viable and achieve their intended objectives (Project Management Institute, 2021). These activities enable practitioners to forecast expenditures, establish cost baselines, evaluate cost performance, and implement corrective actions when deviations occur.

In the construction sector, cost management spans the entire project lifecycle and addresses direct and indirect costs, including labor, materials, equipment, subcontractors, contingencies, overheads, and life-cycle expenditures (Ashworth & Perera, 2018; Smith, 2016). Effective cost management relies on structured mechanisms such as cost breakdown structures, detailed budgets, real-time cost tracking systems, and change control procedures (AACE International, 2022). Despite their maturity, these practices often remain dependent on manual processes, fragmented data sources, and heterogeneous classification systems.

The increasing adoption of the BIM technology has enabled more integrated 5D cost workflows. However, commercial 5D BIM tools typically rely on proprietary cost structures and require extensive manual mapping between model elements and cost items. This limits transparency, interoperability, and the systematic verification of consistency between geometric, quantitative, and cost domains (Cassandro et al., 2023). As a result, cost management processes rarely achieve the level of robustness required to meet public procurement, standardization, and auditability requirements, particularly in small-scale public works, where limitations in time, expertise, and budget hinder the adoption of complex digital ecosystems (Nast & Koch, 2023).

Ontology-based approaches

Ontologies, defined as "an explicit specification of a conceptualization" (Neches et al., 1991), have gained traction in the Architecture, Engineering, and Construction (AEC) sector as a means to address interoperability challenges and integrate heterogeneous datasets (Pauwels & Terkaj, 2016). They determine domain-specific concepts and relationships (Farghaly et al., 2023) and enable machine-interpretable knowledge representations using languages such as OWL (Web Ontology Language) and RDF (Resource Description Framework), supporting semantic interoperability, rule-based reasoning, and knowledge reuse. Recent systematic reviews confirm the growing adoption of ontology-based applications across AEC domains to address interoperability issues, although practical applications remain fragmented and constrained by data heterogeneity and scalability limitations (Farghaly et al., 2023; Palihakkara et al., 2025; Speiser et al., 2025).

In the cost domain, early research focused on representing work items, construction methods, and work conditions through ontologies to enable automated cost estimation from BIM models. Lee et al. (2014) proposed a BIM- and ontology-based cost-estimation approach that uses ontological reasoning to infer appropriate work items from BIM-derived work conditions, incorporating contextual information such as room usage and material attributes. Subsequent studies expanded the formalization of specifications and cost rules (Ma et al., 2016) or represented cost classification systems, such as the New Rules of Measurement (NRM), using ontological engineering approaches (Abanda et al., 2017). Similarly, Liu et al. (2016) developed a construction-oriented product ontology for quantity take-off (QTO) in light-frame construction, extending BIM schemas with domain-specific terms and enabling automated reasoning for QTO extraction. Zhang et al. (2022) used an ontological approach to conceptualize knowledge for budgeting real estate developments.

More recent research focuses on integrating cost ontologies with IFC-based models and Linked Building Data to enable semantic links between geometric entities, cost items, and resource information (Hagedorn et al., 2025). These approaches show that ontologies can support automated matching between BIM elements and cost structures, improve the transparency of cost logic, and reduce manual effort in traditional 5D BIM workflows. Further studies demonstrate how ontology-based models support the assessment of IFC class reliability for cost estimation and enable standardized digital cost representations for public procurement (Cassandro et al., 2023).

Infrastructure projects

Transportation infrastructure is typically grouped into asset classes such as roads and highways, railways, bridges, and related asset types (Bradley et al., 2016). However, the research literature offers no widely accepted, sector-wide thresholds for classifying project size. Accordingly, project size is usually defined case-by-case by the contracting authority or the implementing organization. Building on Nast & Koch (2023), this study operationalizes small-scale infrastructure projects primarily based on the physical scale of the asset. Examples include single-sided railway platforms, bus stops, rest areas, and service stations.

In the European infrastructure context, small-scale construction measures are particularly relevant. For example, in Germany, approximately 80–90 % of railway stations are small-scale facilities with side platforms (around 9,300 assets) (DB InfraGO AG, 2025). Additionally, railway infrastructure is selected as the focus of this study, as it represents a highly standardized yet cost-critical domain with substantial cost overruns compared to other infrastructure sectors, such as road construction (Flyvbjerg et al., 2003).

Standardization in AEC

Like other manufacturing industries, the AEC sector relies on standards, guidelines, and codes of practice to ensure safety and reduce errors. Standardization is widely recognized as a prerequisite for BIM implementation (Moses et al., 2020), for effective 5D BIM-based cost planning and management, and for the development of domain-specific ontologies (Signorini et al., 2025). In this context, standardization provides the base for semantic interoperability, and BIM aligns closely with the componentization and integration of building elements.

Cost management challenges in public projects

Public-sector projects must comply with standardized measurement rules, regional price lists, and strict auditability requirements. However, cost information is often encoded in natural language or non-interoperable software formats, hindering automated verification and cross-project reuse (OECD, 2017). Fragmentation is further exacerbated by the coexistence of diverse standards, such as NRM, UniClass, MasterFormat, and national or regional price books. Although classification systems are recognized as essential in both international and national contexts (Pupeikis et al., 2022), current digital workflows for estimation, budgeting, and cost control frequently lack semantic consistency, particularly in public projects where transparency, standardization, and reproducibility are mandatory.

This study aims to extend the use of existing ontology-based cost management approaches to the domain of small-scale public infrastructure projects. In doing so, it addresses the specific challenges of cost management in infrastructure projects while also helping to close a gap in the practical application of current ontology-based approaches.

Methodology

This study adopts a qualitative research design to investigate the transferability and applicability of existing ontology-based approaches for cost management. In line with Yin (2018), document analysis and expert interviews were used as primary sources of evidence. A representative small-scale railway project was first defined on the basis of publicly available documents from DB InfraGO AG, Business Unit Passenger Railway Stations, expert interviews, and anonymized project data. This reference case was then used to evaluate the ontology-based cost management approach proposed by Cassandro et al. (2023) during the procurement phase. Selected items from the Bill of Quantities (BoQ) were used in the experiment, and the approach was assessed with respect to transferability, applicability, scalability, and generalizability. Finally, the results were discussed and directions for future research were derived (see Fig. 1).

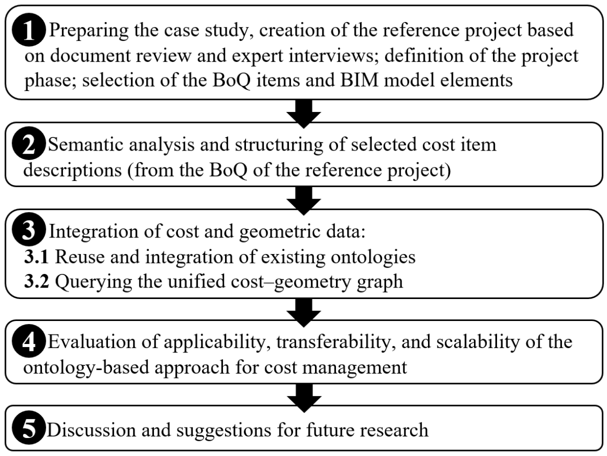

Figure 1: Overview of the research process

The adopted ontology-based approach explicitly separates the semantic definition of cost items from their associated economic values. While cost item descriptions remain stable and reusable across projects, cost values are modeled as context-dependent attributes that vary according to project-specific conditions, construction phases, and estimation scenarios. This distinction is particularly relevant for railway infrastructure projects, where cost estimation is largely driven by construction sequencing, logistics constraints, and site access conditions rather than standardized unit prices.

Case study

To address one of the key limitations of existing ontology-based approaches for cost-related activities – namely the insufficient validation and extension of existing ontologies – a case study was conducted in the German AEC context. The railway station sector was selected because it exhibits a high degree of standardization (DB InfraGO AG, 2025), remains underrepresented in research despite its practical relevance (Bawono et al., 2020), and combines both building and infrastructure construction characteristics.

The German railway infrastructure company DB InfraGO AG has established comprehensive construction standards for major facilities within the railway station domain (DB InfraGO AG, 2025). These standards govern planning, engineering, and construction activities at passenger stations and include standard drawings and details, sample service specifications (BoQ), structural design calculations, technical specifications, planning manuals, and approved building components.

A reference project was developed as a case study representing the typical characteristics of small-scale railway stations. The core scope comprises the construction of a new side platform, elevated and extended to ensure accessibility and improve infrastructure performance. In Germany, railway stations are rarely developed on greenfield sites. Therefore, the reference project involves the complete dismantling and reconstruction of the existing platform at the same location. All structural components, including platform edges, foundations, surface covering, and underground cabling, will be removed and replaced by new installations (see Fig. 2).

Figure 2: A typical railway station project

A key characteristic of the reference project is the strong influence of track closures, logistics constraints, and site conditions on cost calculation, particularly with respect to the selection and quantity of resources such as equipment, labor, and materials. Compared with typical building projects, construction scheduling must be considered much more explicitly when estimating costs for railway stations during the tender phase. Consequently, standardized unit prices are generally of limited applicability. In addition, railway infrastructure projects are subject to a large number of nationally specific guidelines, regulations, and approval procedures.

However, the main challenge is not limited to the coexistence of different national standards and classification systems. Cost information is also fragmented across heterogeneous document types and is often encoded in natural language or stored in non-interoperable formats. As a result, ontology-based representation and querying require concepts, quantities, and rules to be semantically disambiguated and formalized before they can be consistently linked across domains. Moreover, construction cost items are typically defined at a relatively high level of abstraction and do not adequately support resource-based cost analysis, which further complicates detailed semantic modeling.

Results

Based on the methodological steps illustrated in Figure 1, the results are organized to reflect the sequential application of the ontology-based approach to the selected cost items. Each result corresponds to a distinct phase of the research process, ranging from the semantic analysis of cost item descriptions to the integration of cost and geometric data and the evaluation of transferability and applicability.

Due to the limited scope of this paper, the procurement phase, based on the definitive estimate, was selected as the starting point for transferring the ontology-based approach to the infrastructure context. To ensure a focused analysis, the approach was applied to a selected subset of the BoQ items. Specifically, five representative cost items were examined, referring to three key construction elements that are fundamental to most railway station projects and include both construction and demolition activities: the precast foundation element, the precast platform edge, and the precast corner element (see Fig. 3). Despite the limited number of cost items analyzed, the selected elements represent standardized components of railway station projects and therefore provide a suitable basis for assessing the applicability, transferability, and scalability of the approach.

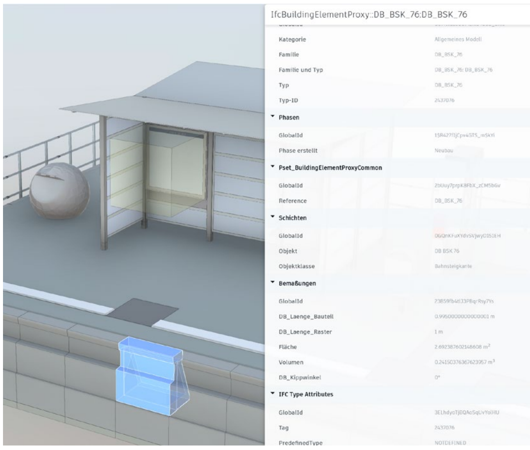

Figure 3: Selection of construction elements

Semantic structuring of cost items

In the first step, the case study focuses on the semantic analysis of railway cost items as defined in the project documentation. As illustrated in Figure 4, individual cost item descriptions typically combine heterogeneous information related to construction work, material resources, activities, and technical specifications within a single unstructured textual entry.

By adopting the ontology-based approach proposed in Cassandro et al. (2025) and Signorini et al. (2025), these cost items can be decomposed into semantically well-defined components, including:

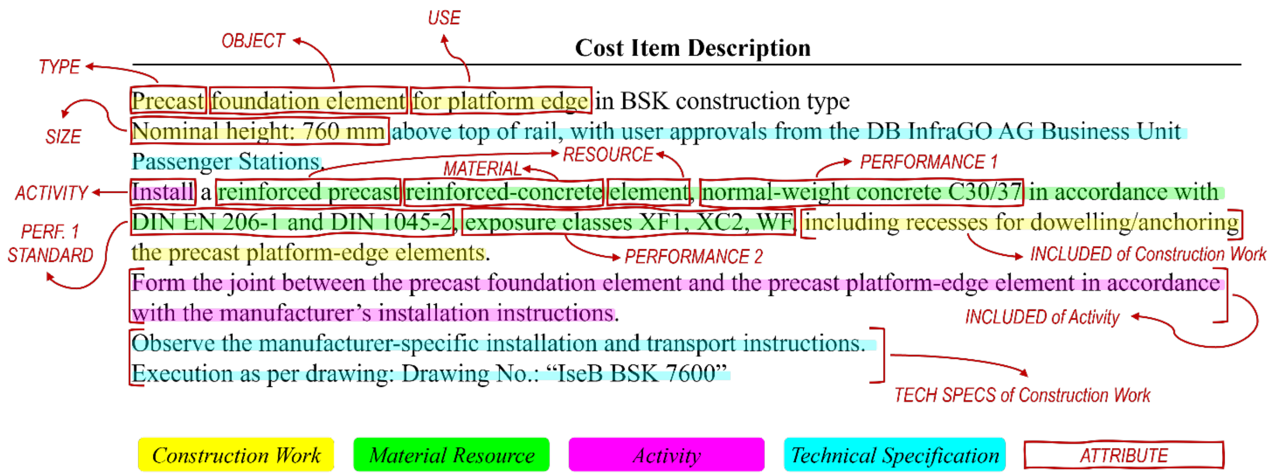

Figure 4: Semantic structuring of cost item 'Precast foundation element for platform edge'

- Construction Work Object (e.g., precast foundation element)
- Activity (e.g., installation)
- Material Resource (e.g., reinforced precast element)
- Technical and performance specifications (e.g., compliance with manufacturer-specific instructions).

This semantic structuring reveals several recurring issues in traditional cost descriptions, such as semantic overlap, implicit assumptions, and ambiguities between objects, processes, and requirements. By making these distinctions explicit and structuring the information into well-defined attributes (e.g., object, type, material, use, and performance), the ontology provides a clearer and more coherent definition of cost items while preserving their original meaning and enabling machine interpretability.

Reuse and integration of existing ontologies for cost – geometry linkage

In a second step, the study demonstrates how existing ontologies can be reused and integrated to structure cost items and establish semantic links to geometric data. Following ontologies were selected:

- *ifcOWL* is employed to generate an RDF representation of the IFC model, enabling access to geometric objects and their properties.
- *Cost Item Ontology (CI)* is used to formalize cost items and their internal structure based on the previously semantic structuring.
- *Construction Resource Ontology (CR)* is used to establish explicit relationships between geometric objects and cost items.

These ontologies were selected because they enable explicit semantic structuring of cost items and their direct linkage to geometric data. Many alternative ontologies focus on process automation or isolated knowledge representation and lack the semantic granularity required to jointly model and evaluate relationships between cost information and geometry (see Chapter 'Background'). In the cost domain, this explicit linkage is essential, as quantities, construction logic, and resource requirements are directly derived from geometric definitions.

Through the integration of these ontologies, a unified knowledge graph is generated in which each cost item is explicitly linked to one or more corresponding geometric objects (see Fig. 5). This linkage enables automated QTO extraction directly from IFC-derived data and their consistent association with cost items within a shared semantic framework.

As a result, quantities, cost item definitions, and unit prices are no longer managed as separate artifacts but are integrated into a single machine-interpretable model. This enables the generation of a computable and extensible BoQ, in which cost values can be updated, revised, or compared across scenarios, provided that such variations are driven by external cost factors that do not affect the semantic definition of cost items, their resource composition, or measurement rules. Typical examples include variations in labor, equipment, and material costs due to geographic location, market conditions, or alternative construction and procurement scenarios, rather than changes in construction logic or resource structure.

The absence of standardized unit prices in German railway projects does not affect the validity of the proposed approach. Project-specific unit prices can be assigned, updated, and modified independently of cost item definitions and object relationships, as long as such modifications reflect contextual cost variability rather than changes in quantity take-off logic or resource breakdown, thereby demonstrating the scalability, adaptability, and reuse potential of the ontology-based cost structure.

Querying the unified cost – geometry graph

Finally, the resulting knowledge graph is queried using SPARQL to demonstrate its practical applicability. The SPARQL queries are not intended for statistical analysis but are employed as a verification mechanism to demonstrate the internal consistency and operational applicability of the ontology-based model.

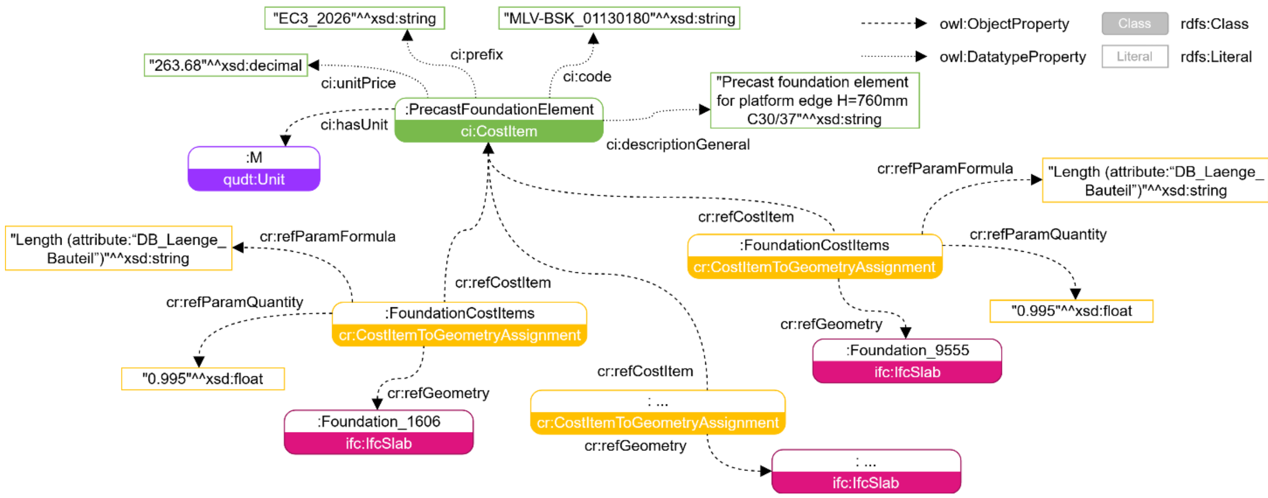

Figure 5: Unified knowledge graph for precast foundation element

The query shown in Listing 1 interrogates the integrated knowledge graph by explicitly crossing the semantic relationships between construction objects (`?obj`), cost assignments (`?assign`), and cost items (`?costItem`). It retrieves all construction objects (`?obj`) participating in a `cr:CostItemToGeometryAssignment`, independent of their specific IFC class. For each object, the query extracts its globally unique identifier (`?guid`) through the `ifc:globalId_IfcRoot` relationship and the associated `IfcGloballyUniqueId` literal (`express:hasString`), ensuring object-level traceability across geometric, cost, and quantity domains.

```
PREFIX rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX ifc:
      <http://standards.buildingsmart.org/IFC/DEV/IFC2x3/TC1/OWL#>
PREFIX express: <https://w3id.org/express#>
PREFIX ci:      <https://w3id.org/ci#>
PREFIX cr:      <https://w3id.org/cr#>
PREFIX xsd:     <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT ?obj ?guid ?qto ?code ?unitPrice
      ?measureCost ?formula
WHERE {
   ?obj rdf:type ?objType .
   ?obj ifc:globalId_IfcRoot ?guidNode .
   ?guidNode express:hasString ?guid .
   ?assign rdf:type cr:CostItemToGeometryAssignment .
   ?assign cr:refGeometry ?obj .
   ?assign cr:refCostItem ?costItem .
   ?assign cr:refParamQuantity ?qto .
   ?assign cr:refParamFormula ?formula .
   ?costItem ci:code ?code .
   ?costItem ci:unitPrice ?unitPrice .
   ?costItem ci:hasUnit ?measureCost .
   }
ORDER BY ?obj
```

Listing 1: SPARQL query

Cost information is accessed via the `cr:CostItemToGeometryAssignment` node, which acts as a semantic mediator between geometry and cost data. Through this assignment, the query retrieves:

- the referenced cost item (`cr:refCostItem`),
- the quantity parameter used for cost calculation (`cr:refParamQuantity`),
- and the applied cost formula (`cr:refParamFormula`).

From the linked cost item, the query extracts:

- cost code (`ci:code`), enabling classification and aggregation of cost items,
- the unit price (`ci:unitPrice`),
- and unit of measurement (`ci:hasUnit`).

The resulting dataset consolidates each cost – geometry association in a single row, explicitly linking a construction object to its cost item, quantity reference, unit price, unit of measurement, and calculation formula. By ordering the results by construction object, the query facilitates systematic object-level inspection and validation.

Unlike traditional document-centric cost management approaches (e.g., Excel files and IFC data) with rigid data schemas, ontologies and knowledge graphs enable an explicit, machine-interpretable representation of the semantic relationships between cost items, construction objects, and quantities. The query results demonstrate that cost and geometric information – traditionally distributed across separate documents, spreadsheets, and software systems – can be consistently retrieved from a single integrated model.

Evaluation of the ontology-based approach

The reuse of the selected ontology-based approach to cost data management would not be feasible if cost items could not be described in a sufficiently structured manner or if their semantic characteristics could not be mapped to the core ontological classes and properties, such as object, material, function, and form. In the present study, however, the cost item descriptions reveal a high degree of semantic consistency, while the alignment with the generic ontology classes is preserved, demonstrating the applicability and robustness of the approach.

Discussion

This case study shows that the ontology-based cost structure remains applicable and robust in German railway projects, even in the absence of standardized unit prices. Project-specific cost values can be assigned, updated, and compared independently of the underlying cost item definitions, which confirms the validity of separating semantic meaning from monetary values. Although pricing mechanisms differ between building construction and infrastructure projects, the study shows a fundamental commonality in cost calculation: the semantic structure, granularity, and progressive development of cost information are consistent across domains, irrespective of national or organization-specific cost management practices.

The prior standardization of railway station projects proved to be a crucial prerequisite for transforming cost information into machine-interpretable structures. This finding further underlines the role of standardization as a fundamental enabler of digitalization and process automation in the AEC sector, particularly in the context of transparent and traceable cost management (Signorini et al., 2025). Establishing a reliable benchmark therefore requires the initial definition of a standardized project typology, followed by the incremental integration of cost information reflecting project-specific conditions.

The mapping between project data and ontology classes is performed manually. While this increases the workload and therefore constitutes a current limitation of the ontology-based approach, the mapping process could be automated using AI-based methods. However, such automation would require appropriate training data to ensure reliable mapping quality. Since sufficiently annotated datasets are not yet available, automated mapping was beyond the scope of the present study.

This paper focuses on the ontology-based approaches using BIM data, which typically represents the detailed stage of an infrastructure project. Early project phases are not covered, as they rely on other geometric data sources, and should be considered in future studies.

Conclusion

While Farghaly et al. (2023) emphasize the importance of testing, reusing, and transferring existing ontologies to new contexts, this paper extends the application of ontology-based cost management approaches to the domain of small-scale public infrastructure projects. In doing so, it explores the scalability, semantic depth, and robustness of the ontology-based cost structure under varying project characteristics, national regulations, and organization-specific cost management practices.

This study builds on previous research by Cassandro et al. (2025) and Signorini et al. (2025) on ontology-based approaches for structuring cost information and improving cost management, particularly with regard to transparency and decision-making. More specifically, it investigates the reuse of the Cost Item Ontology and the Construction Resource Ontology in the context of a German railway infrastructure, including both the representation of cost definitions and the queryability of the encoded data. In this way, the case study addresses one of the key limitations of current ontology-based approaches, namely their restricted applicability due to the lack of validation across different domains and national contexts.

Transferability was demonstrated by applying the ontology-based cost model to both building construction and infrastructure projects without requiring fundamental changes to its core ontological classes and relationships between them. *Applicability* was ensured by adapting the approach to a different national and organizational context, such as the German instead of the Italian context. *Scalability* was supported through the selection of small-scale projects relevant for industry adoption, as well as by including different construction activities such as prefabricated construction and demolition works. *Generalizability* was achieved through the use of a reference project derived from approximately 9,300 railway station platforms.

Across the case study, cost information for the reference project was represented in a structured, consistent, and transparent manner. The results confirm that cost values can be modified, compared, and reassigned without affecting the semantic integrity of cost items, directly supporting the methodological assumption of separating meaning from monetary value.

A limitation of this study is that only a subset of items from the reference BoQ was examined. Accordingly, the findings should be regarded as preliminary evidence of structural similarities between the Italian and German cost management contexts under investigation, as well as of the potential transferability of the ontology-based approach, rather than as confirmation of broad cross-context validity. Future studies should therefore expand the analysis to cover all construction trades.

Another limitation of this paper is its focus on detailed cost estimation during the procurement phase, which was necessary to assess transferability based on fully specified cost descriptions. Future research should extend the ontology-based approach to early cost estimation and demonstrate the dynamic growth and evolution of cost information across the project lifecycle.

Acknowledgement

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Online Resources

The sources and documentation are available via https://github.com/Cassa97/2026_EC3_Infrastructure-Cost-Ontology.

References

Abanda, F.H., Kamsu-Foguem, B. and Tah, J.H.M. (2017) BIM – New rules of measurement ontology for construction cost estimation, Engineering Science and Technology, an International Journal, 20(2), pp. 443–459.

AACE International (2022) Recommended practices: https://web.aacei.org/resources/recommended-practices (Accessed: 8 February 2026).

Ashworth, A. and Perera, S. (2018) Cost studies of buildings. Abingdon: Routledge.

Bawono, A.A., von Schumann, C.M. and Lechner, B. (2020) Study of building information modelling implementation on railway infrastructure, in Proceedings of the 18th ICCCBE 2020. Lecture Notes in Civil Engineering, 98. Cham: Springer, pp. 372–382.

Bradley, A., Li, H., Lark, R. and Dunn, S. (2016) BIM for infrastructure: an overall review and constructor perspective, Automation in Construction, 71, pp. 139–152.

Cassandro, J., Donatiello, M.G., Mirarchi, C., Zanchetta, C. and Pavan, A. (2023) Reliability of IFC classes in ontology definition and cost estimation of public procurement, in Proceedings of the 2023 EC³.

Cassandro, J., Hagedorn, P., Sigalov, K., Gatto, C., Mirarchi, C., Pavan, A. & König, M. (2025) Semantic Integration of Cost, Time and Geometry for a Resource-centred Perspective of Managing Construction Projects, in Proceedings of the 2025 EC³ and the 42nd CIB W78. Porto, Portugal, 14–17 July.

DB InfraGO AG – Passenger Railway Stations (2025) Information platform: https://infoplattform-personenbahnhoefe.deutschebahn.com/pbhf (Accessed: 8 February 2026).

Farghaly, K., Soman, R.K. and Zhou, S.A. (2023) The evolution of ontology in AEC: a two-decade synthesis, application domains, and future directions, Journal of Industrial Information Integration, 36, 100519.

Flyvbjerg, B., Skamris Holm, M.K. and Buhl, S.L. (2003) How common and how large are cost overruns in transport infrastructure projects? Transport Reviews, 23(1), pp. 71–88.

Hagedorn, P., Cassandro, J., Sigalov, K., Mirarchi, C., Pavan, A. and König, M. (2025) A Shared Construction Resource Ontology for Semantically Aligning Cost and Time Domains in Construction Projects, in Proceedings of the 13th LDAC 2025, Porto, Portugal, 9–11 July. CEUR Workshop Proceedings, 4113, pp. 10–24.

Korstjens, I. and Moser, A. (2018) Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing, European Journal of General Practice, 24(1), pp. 120–124.

Lee, S.-K., Kim, K.-R. and Yu, J.-H. (2014) BIM and ontology-based approach for building cost estimation, Automation in Construction, 41, pp. 96–105.

Liu, H., Lu, M. and Al-Hussein, M. (2016) Ontology-based semantic approach for construction-oriented quantity take-off from BIM models in the light-frame building industry, Advanced Engineering Informatics, 30(2), pp. 190–207.

Ma, Z., Liu, Z. and Wei, Z. (2016) Formalized representation of specifications for construction cost estimation by using ontology, Computer-Aided Civil and Infrastructure Engineering, 31(1), pp. 4–17.

Moses, T.G., Heesom, D. and Oloke, D.A. (2020) Implementing 5D BIM on construction projects: contractor perspectives from the UK construction sector, Journal of Engineering, Design and Technology, 18(6), pp. 1867–1888.

Nast, A. and Koch, C. (2023) BIM adoption in small-scale infrastructure projects – investigation on the German railway sector, in Proceedings of the 14th ECPPM, Trondheim, Norway, 14–16 September 2022. Abingdon: CRC Press/Balkema, pp. 695–702.

Neches, R., Fikes, R., Finin, T., Gruber, T.R., Patil, R.S., Senator, T.E. and Swartout, W.R. (1991) Enabling technology for knowledge sharing, AI Magazine, 12(3), pp. 36–56.

OECD (2017) Public procurement for innovation: Good practices and strategies. OECD Public Governance Reviews. Paris: OECD Publishing.

Palihakkara, A.D., Osorio-Sandoval, C.A. and Tizani, W. (2025) A review of the application of ontologies and semantic web for building information modelling and digital twins-based construction management, Journal of Information Technology in Construction (ITcon), 30, pp. 1208–1243.

Pauwels, P. and Terkaj, W. (2016) EXPRESS to OWL for construction industry: towards a recommendable and usable ifcOWL ontology, Automation in Construction, 63, pp. 100–133.

Project Management Institute (2021) The Standard for Project Management and a Guide to the Project Management Body of Knowledge (PMBOK® Guide). 7th edn. Newtown Square.

Pupeikis, D., Navickas, A.A., Klumbytė, E. and Šeduikytė, L. (2022) Comparative study of construction information classification systems: CCI versus Uniclass 2015, Buildings, 12(5), 656.

Signorini, M., Gatto, C., Cassandro, J., Pavan, A. and Lupica Spagnolo, S. (2025) Cost efficiency in buildings: an ontological perspective for sustainable life cycle management, Sustainability, 17(13), 5685.

Smith, J., Jaggar, D.M. and Love, P. (2016) Building cost planning for the design team. 3rd edn. Abingdon: Routledge.

Speiser, K., Seiß, S., Boukamp, F., Melzner, J. and Teizer, J. (2025) From fragmented data to unified construction safety knowledge: A process-based ontology framework for safer work, Automation in Construction, 176, 106293.

Yin, R.K. (2018) Case study research and applications: design and methods. 6th edn. Thousand Oaks, CA: SAGE Publications.

Zhang, Z., Liu, H., Xu, J., Shu, Y., Liu, H. and Xiao, J. (2022) Ontology-based integrated cost management system for real estate development, in ICCREM 2022. Reston, VA: American Society of Civil Engineers (ASCE), pp. 838–854.