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Information Quality Assessment for Facility Management

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ABSTRACT

Assessing the quality of building information models (BIMs) is an important yet challenging task within the construction industry as projects are increasingly being delivered with BIM. This is particularly essential for facility management (FM) users as downstream information consumers that depend on the quality of models developed in the previous project phases. The research presented in this paper addresses this challenge by introducing a framework for information quality assessment (IQA) of BIMs for FM uses. The IQA framework is the outcome of an extensive study of two large owner organizations involving numerous BIM projects. The framework is structured based on the essential FM subjects: assets, spaces, and systems, and the model characteristics: objects, attributes, relationships, and spatial information. The framework is then operationalized through the development and evaluation of information quality (IQ) tests using BIM model checking tools across three projects with different levels of detail and complexity. The proposed IQA framework and associated tests advance the state of knowledge about BIM quality in terms of methods to represent and evaluate conformance to owner requirements.

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1. Introduction

With the growing adoption of BIM (building information modeling) within the AECOO (architecture, engineering, construction, owner and operator) industry, owner organizations are increasingly requiring BIM as part of the project delivery process and exploring how BIM can be leveraged for facility management (FM) purposes [1]. Research shows that a high number of private and public owners believe in the importance of developing capabilities in their organizations to leverage BIM for the operation phase [1]. Owners believe that a key benefit in using BIM for operation and maintenance comes from the complete and accurate information provided by the delivered models [1]. However, several studies have identified the lack of information quality (IQ) as a major barrier for this aim [2–5]. Specifically, researchers confirm that poor IQ of delivered information causes significant costs and rework for the operations phase [6,7]. Therefore, it is critical for stakeholders in the AECOO industry to be able to assess the quality of BIMs at different stages throughout project delivery and at handover to ensure the usefulness of building information for operation and maintenance purposes. This requires clear, structured, and flexible methods for describing and assessing the quality of delivered models in terms of conformance to owner requirements.

IQ is described and interpreted in different ways by researchers and owner organizations. The proposed approaches in related literature mainly focus on assuring the quality of BIMs during the modeling phase. For instance important organizations such as BSI [8] GSA [9] LACCD BIMS [10] SBCA [11] provide measures for modelers to avoid quality related issues in their modeling process without proposing specific quality assessment methods [8–11]. Other research works, such as Tribelsky and Sacks [5], have their focus on the data exchange between different models and propose approaches to assess the quality loss in such exchanges [5]. Furthermore, another research stream aims to develop and improve evaluation methods focusing on the quality of model conformance to industry standards such as conformance of Industry Foundation Class (IFC) outputs [4] and Model View Definition (MVD) [12]. Although these approaches provide an important step forward, these works are limited to generic checks offered by common BIM authoring tools that help modelers avoid different IQ issues. Thus, additional research is needed to better understand how to

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characterize the quality of BIMs and evaluate their conformance to owner-specific requirements.

The main objective of this research is to address this research gap by providing a structured framework for information quality assessment (IQA) of BIMs for facility management purposes. This framework was developed based on an extensive study of two large owner organizations involving a series of BIM-based projects in which we were able to interview the stakeholders and observe their operation and maintenance processes. The specific research questions pursued include the following:

1. What are the information needs of owner organizations for creating intelligent FM systems?
2. What are the relevant IQ dimensions and related characteristics required to systematically understand and assess the models?
3. How can IQ tests be operationalized to evaluate the conformance of a given BIM for owner-specific information requirements?

In response to these questions, we developed an IQA framework based on the identified owner information needs. The framework allows users to systematically characterize the information quality dimensions that are relevant for a particular owner and assess the IQ of BIMs at different project stages with respect to the owner's FM requirements. The structure of this framework is organized based on four different model characteristics: entities, entity attributes, the relationships between entities, and the spatial information (location and shape) of each entity. The structure of the framework also considers the three essential FM terms: assets (equipment), spaces, and MEPF (mechanical, electrical, plumbing, and fire safety) systems. The model characteristics and FM terms describe the subject of each required IQA test in the framework. Moreover, the framework indicates for each IQA test, the required proxy indicators and benchmarks, and it proposes relevant methods to perform the IQA tests. Using this framework, we operationalized the specific IQA tests for three different projects with different size, complexity and level of detail to show the feasibility and adaptability of the introduced framework in practice.

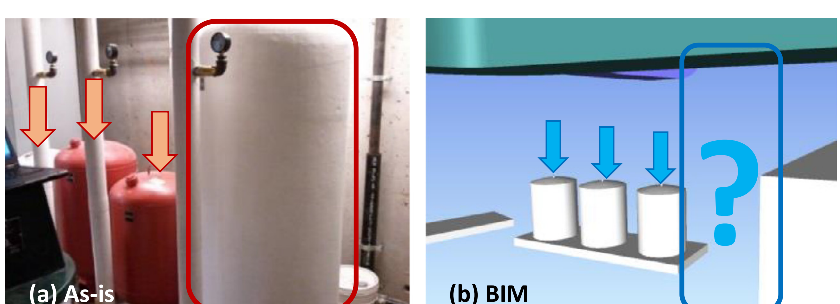
Using the introduced framework in this research is grounded in firsthand observations in actual projects and provides the owners and stakeholders the awareness about the IQ issues and aims to encourage them to support the overall goal of model-based project delivery. The implementation of IQA tests on examples from the practice is a proof of feasibility of establishing structured quality control strategies in construction projects. Furthermore, the variety of the practical examples introduced in this research aims to showcase the comprehensibility of IQA tests to cover different quality issue types in a BIM. The framework's feasibility and comprehensibility in this quality research follow the interpretive and theoretical validity concept introduced in [13,14].

In the next section, we provide examples of representative quality issues in delivered BIMs based on the BIM projects we analyzed. In Section 3, we discuss the research background and related works that includes studies from computer sciences (CS) and the AECOO domain. Then in Section 4, we introduce our case studies and the different steps in our methodology to develop the proposed IQA framework. In Section 5, we provide a detailed explanation of our IQA framework. Then in Section 6, we describe how to operationalize IQ tests from the framework based on selected examples from our case study projects. Finally, Section 7 provides some concluding remarks.

2. Practical motivation regarding current quality issues of BIMs for FM

The motivation of this research has its roots in studying the deliverables of several BIM projects and interviewing numerous FM personnel within two different owner organizations. The provided examples in this section are drawn from what has been observed in those projects and cover all typical quality issues of BIMs for FM. In this regard, we especially focused on the identification of obstacles in establishing methods for model-based analysis and challenges in utilizing delivered BIMs in the operations phase of a building. Analyzing a diverse range of BIM projects through the lens of building operations has highlighted that the quality of BIMs often does not satisfy the expected level of quality for FM purposes, which in turn causes issues for BIMs being useful for operation and maintenance purposes. These IQ issues could be observed across different project phases up to and including project handover. For a better understanding of the various types of issues, the following figures provide typical examples of IQ issues from our case studies and highlight the specific *information quality dimensions* that are exemplified in each example.

2.1. Example 1



Example 1. This example from the Project #3 shows that the large white expansion tank in the as-is photo (left) is missing in the mechanical BIM (right). Therefore, the model has an *incomplete* representation of the as-is.

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