

Article

Common Data Environment for University Construction Projects: An ISO 19650-Compliant Information Management Framework

Aleksandra Radziejowska ^{1,*}  and Urszula Kwast-Kotlarek ² 

¹ Department of Geomechanics, Civil Engineering and Geotechnics, Faculty of Civil Engineering and Resource Management, AGH University of Krakow, 30-059 Krakow, Poland

² Central Administration Unit, Department of Investments and Renovations, University of Wroclaw, Plac Uniwersytecki 1, 50-137 Wroclaw, Poland; urszula.kwast-kotlarek@uwr.edu.pl

* Correspondence: aradziej@agh.edu.pl

Abstract

Common Data Environments (CDEs) have become a cornerstone of information management in BIM-enabled construction projects and a key enabler of ISO 19650 implementation. Within the context of sustainable and Smart Construction, CDEs integrate design, construction, and operational information, supporting informed decision-making throughout the building lifecycle. However, their effectiveness depends not only on software capabilities but also on the configuration of processes, roles, permissions, workflows, and information structures. This paper proposes an ISO 19650-compliant CDE implementation framework for university construction projects. The study combines a literature review on CDEs, BIM/FM, HBIM, and information management with two university case studies: a new laboratory and educational building and a specialized facility integrated with a historic campus. Based on the findings, an eight-step implementation model was developed, covering information requirements, CDE structure, information states (WIP, Shared, Published, Archive), roles, metadata, workflows, site data integration, and information audits. A mapping matrix linking ISO 19650 requirements with CDE configuration elements and an issue management workflow are also presented. Exploratory findings from the two case studies indicate that a properly configured CDE can help reduce information-related risks, improve issue management, and enhance decision traceability; these results should be regarded as illustrative and context-dependent rather than statistically generalized. Although environmental impacts were not directly measured, improved information management may indirectly contribute to more efficient resource use and more sustainable university infrastructure management.

Keywords: CDE (common data environment); ISO 19650; BIM/HBIM; information management; smart construction; FM; digital twin; university construction projects



Academic Editor: Sanjeev Adhikari

Received: 25 June 2026

Revised: 16 July 2026

Accepted: 23 July 2026

Published: 25 July 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and

conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

1. Introduction

The digitalization of construction investment processes is shifting the focus from the mere production of documentation toward the management of information flows throughout the entire project lifecycle. Today, this process is recognized as one of the key components of the Smart Construction concept, in which digital technologies support decision-making, improve the efficiency of construction processes, and contribute to sustainable development goals by reducing material, time, and information losses.

In this context, effective information management becomes an important factor supporting the sustainable delivery of construction projects and the management of built assets

throughout their lifecycle. The availability of reliable and up-to-date information enables better planning, coordination, and control of construction processes, contributing to the reduction in errors, rework, and inefficient resource utilization.

This perspective is consistent with the objectives of sustainable campus development and the United Nations Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production). Improved information quality, reduced design changes and rework, and more efficient resource utilization enabled by digital environments can support more sustainable planning, delivery, operation, and maintenance of university infrastructure.

In multidisciplinary, organizationally dispersed, and quality-driven project environments, information-related errors often lead to delays, coordination conflicts, design changes during construction, and cost overruns. These issues are widely documented in the literature on digital information management based on Building Information Modeling (BIM). In response to these challenges, contemporary approaches to construction information management increasingly rely on Common Data Environments (CDEs), defined in ISO 19650-1 [1] as an agreed source of information for a given project or asset, used to collect, manage, and disseminate information containers through a managed process. Such solutions are currently perceived not only as tools supporting design coordination but also as an important element of the digital transformation of the Architecture, Engineering and Construction (AEC) sector, enabling more efficient resource utilization, reducing errors and construction rework, and supporting the implementation of smart and sustainable construction principles.

Current literature emphasizes that a CDE should be understood not merely as an IT tool, but rather as a combination of a technical platform and an organizational framework encompassing roles, permissions, information exchange channels, and access rules [2–4]. Jaskula et al. [5] describe the CDE as a “shared information infrastructure” for construction projects while highlighting numerous implementation challenges, including the lack of mature management processes and difficulties in translating ISO 19650 [1] principles into everyday practice. At the same time, an increasing number of studies position CDEs within the architecture of Digital Twin (DT) and Facility Management (FM) systems, where they function as an intermediary layer between BIM models and dynamic operational data [6–11]. This trend is closely aligned with the development of Smart Construction concepts, in which data generated during design, construction, and operation are integrated to improve building management performance throughout the asset lifecycle.

In university construction projects, the role of a CDE is particularly important due to the complexity of investment processes and the large number of stakeholders involved in creating, transferring, and using information. Such projects frequently include laboratory, educational, research, and technical facilities delivered in stages while maintaining the operation of the existing campus infrastructure. Additional challenges arise from the need to coordinate the requirements of multiple user groups, integrate data from various sources, and ensure information continuity between the design, construction, and operational phases. In many cases, these investments also involve the renovation or adaptation of existing buildings, including heritage assets, which further increases the importance of effective information management and decision-tracking procedures. At the same time, public clients are increasingly incorporating BIM and CDE requirements into public procurement procedures, viewing them as tools supporting transparency, information quality control, and traceability of decisions [12–16].

As a result, effective management of document versions, responsibilities, and decision pathways becomes not only a matter of organizational efficiency but also a key mechanism

for reducing information-related and investment-related risks. From a sustainable construction perspective, university campuses constitute a particularly interesting implementation environment because they combine educational, research, and operational functions while requiring long-term management of infrastructure-related information. Under such conditions, data quality and accessibility become important factors supporting renovation planning, efficient resource utilization, and the development of Smart Campus and BIM-based Facility Management concepts. In this context, a well-configured CDE may serve as an enabling information infrastructure supporting data-driven decision-making, lifecycle-oriented asset management, and the long-term sustainability of university campuses.

Dalux is an example of a commercial CDE platform developed as an integrated environment for document management, BIM model management, issue tracking, information workflows, and field processes [17–19]. In the context of university projects, its potential extends beyond BIM model visualization and lies in its ability to create a unified information structure linking the design, construction, and operational phases of a project. This is consistent with trends identified in the literature on BIM and FM in educational facilities [5,15,20,21]. According to ISO 19650, the primary question is no longer whether a CDE platform is necessary, but rather how it should be configured and organizationally implemented to function as a true “single source of truth” [1,5,17,22]. Moreover, a properly configured CDE may provide the foundation for integrating BIM models with Facility Management systems and Digital Twin solutions. This creates opportunities for further data utilization in operational processes, lifecycle management, and performance analyses, which aligns with current developments in Smart Construction.

Despite the growing number of publications on Common Data Environments, there remains a lack of implementation models that translate ISO 19650 requirements into specific platform configurations applicable to public-sector clients, particularly higher education institutions. Furthermore, limited attention has been paid to the relationship between CDE implementation and the long-term sustainability of public building assets, particularly in university campus environments. Building on these research gaps, the present study adopts a literature-informed multiple case study design. An ISO 19650-compliant CDE implementation framework was developed based on the analysis of scientific literature and relevant standards and subsequently explored through two university construction projects using the Dalux Common Data Environment. The empirical component is intended to illustrate the practical applicability of the proposed framework rather than to provide statistically generalizable evidence.

Accordingly, the paper addresses the following research questions:

- RQ1: How can ISO 19650 information management requirements be translated into a practical CDE implementation model for higher education construction projects?
- RQ2: How can this model be configured within a commercial CDE platform, exemplified by Dalux, while maintaining compliance with ISO 19650?
- RQ3: What insights into CDE performance and information management can be obtained from the exploratory analysis of two university construction projects?

The contribution of the paper is threefold. First, it proposes a CDE implementation model tailored to the specific characteristics of public-sector clients in higher education, a context that has received relatively limited attention in the existing literature. Second, it presents a compliance matrix linking ISO 19650 requirements with specific Dalux configuration elements, thereby facilitating the translation of normative requirements into practical implementation solutions. Third, it reports the results of a pilot evaluation of a CDE in two university projects, highlighting its potential as a mechanism supporting Smart Construction, long-term information management, and the future development of BIM-based Facility Management and Digital Twin solutions.

Accordingly, this study approaches sustainability from the perspective of information management quality and process efficiency. Rather than directly evaluating environmental or economic performance, it examines how an ISO 19650-compliant CDE implementation may support more effective lifecycle-oriented information management in university construction projects and thereby contribute indirectly to sustainable asset management.

2. Research Strategy and Analytical Basis of the Study

The study is based on a review of the literature concerning Common Data Environment (CDE) platforms, information management in accordance with ISO 19650, CDE tools applied in the construction sector, and publications addressing the integration of CDEs with digital representations of buildings (e.g., Digital Twin—DT) and Facility Management (FM) systems [1,3–6,9,10,12,15,21–26]. The review was supplemented by recent industry reports and guidelines issued by international organizations addressing BIM and CDE implementation in public procurement and educational-sector construction projects [13,17,19,27–29].

The adopted research strategy combines a literature review with a multiple case study approach. The review of scientific publications and normative documents served as the basis for developing the proposed CDE implementation model and the ISO 19650–Dalux compliance matrix. Subsequently, two university construction projects were analyzed to assess the practical applicability of the proposed model using system logs and selected indicators describing the performance of the CDE.

The study has an exploratory and implementation-oriented character. Its objective is not to statistically verify causal relationships but rather to identify mechanisms supporting information management within a Common Data Environment and to evaluate their applicability in real university construction projects. Such an approach is consistent with recommendations from contemporary CDE research, which emphasize the importance of combining theoretical analyses with observations derived from real-world implementations and case studies.

From a sustainable construction perspective, the analysis of CDEs is important not only because of their role in organizing information flows during project delivery but also because of their potential impact on the quality of information used throughout the design, construction, and operational phases of a building. Access to up-to-date information and the reduction in information losses may contribute to more efficient resource utilization, fewer errors and rework activities, and improved decision-making aligned with lifecycle-oriented building management principles.

2.1. Method for Identification and Analysis of Scientific Literature

The literature review was conducted using the Scopus, Web of Science Core Collection, and Google Scholar databases, supplemented by selected industry journals, reports, and guidance documents (including publications from the EU BIM Task Group and documents related to public investment management) [5–7,13,17,23,24,29]. The search covered publications published between 2018 and March 2026, with particular attention given to the 2022–2026 period, during which a substantial increase in publications related to CDEs and ISO 19650 implementation was observed [5–7,17,23,24].

The search strategy employed combinations of English-language keywords, including: “common data environment”, “CDE”, “ISO 19650”, “BIM information management”, “BIM-based information delivery”, “Digital Twin CDE”, “public investments BIM”, “campus projects”, “university campus facilities management”, “sustainability projects”, and “HBIM”. The reviewed publications addressed both technical aspects of CDE implementation and broader issues related to information management throughout the asset lifecycle,

including their potential influence on the efficiency of construction and operational processes and their contribution to sustainable construction objectives [5–7,9,12,20,24].

In the first stage, an initial screening based on titles and abstracts was conducted to identify publications directly related to:

- The definition and roles of CDEs within the lifecycle of public-sector construction projects [5–10,23,24];
- The implementation of ISO 19650 in construction practice [1,3,4,17,22];
- The application of CDEs in the context of Digital Twins and environmental monitoring [9,11,18,27];
- The use of BIM/CDE in Facility Management and university campus management [12,15,20,21];
- The role of CDEs in public-sector projects and public procurement processes [13,15,17,29].

In the second stage, full-text publications were analyzed with particular attention to:

- Proposed CDE implementation models [5–7,23,24];
- The structure of information areas, roles, permissions, and workflows [1,5–7,17,22];
- Indicators used to assess CDE maturity [5–7];
- Methods of integrating CDEs with Facility Management systems and Digital Twin solutions [9,12,18,20,21,27].

Additionally, supplementary information provided with selected publications was reviewed, particularly literature review protocols developed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and classification frameworks used in CDE research. These materials supported the systematic organization of the reviewed body of knowledge. Industry materials (Autodesk, Dalux, Construction Industry Council, and Trimble) were used exclusively to describe implementation practices and platform configuration approaches rather than to formulate the study's primary scientific conclusions [5,17–20,22].

The database searches initially yielded several hundred records related to Common Data Environments, ISO 19650 implementation, BIM-based information management, and university or public-sector construction projects. After duplicate removal and title- and abstract-based screening according to the predefined inclusion criteria, several dozen publications were selected for detailed full-text analysis. The final body of literature comprised a focused set of peer-reviewed journal articles and conference papers, complemented by selected standards (including the EN ISO 19650 series) and key industry guidance documents, which together formed the basis for developing the proposed implementation framework.

Peer-reviewed publications and standards formed the primary theoretical basis for the proposed model, whereas industry reports and CDE system documentation were used only in a supporting role to describe implementation practices and configuration examples.

2.2. Empirical Data and Case Study Description

In addition to the literature review, the study draws on observations from two university construction projects in which a Common Data Environment served as either the primary or a supporting information management platform. The projects were intentionally selected as cases representing different functional and organizational contexts, allowing the proposed implementation model to be examined under diverse conditions. The analyzed cases included a newly constructed educational and laboratory building (including musicology facilities and a concert hall) and a specialized project involving a historic building context [3–7,11–15] (Figure 1). The empirical data were used to illustrate the practical applicability of the proposed implementation model and assessment framework in real university construction projects. Given the exploratory nature of the study, the findings should be interpreted as indicative rather than statistically generalizable.

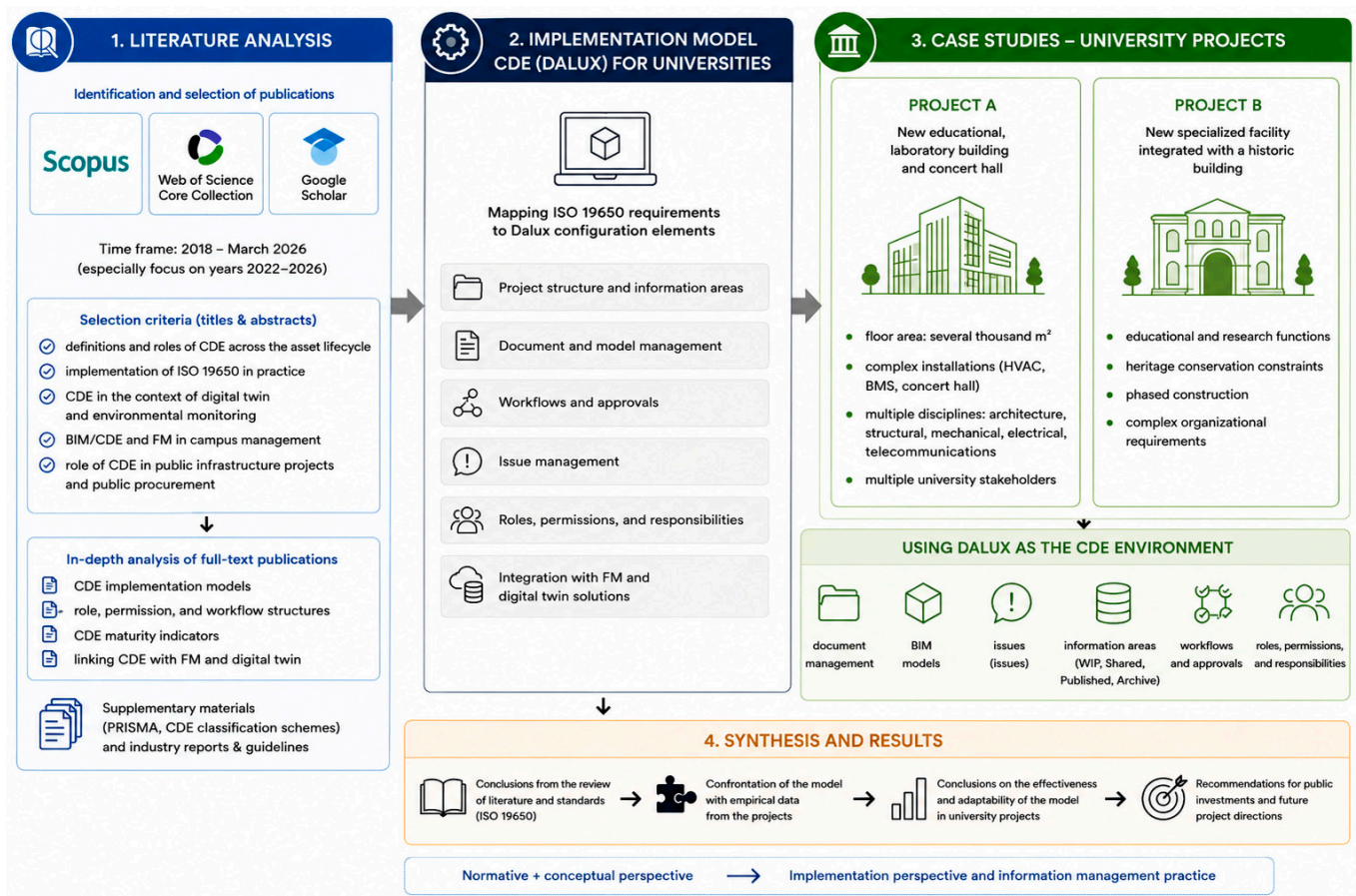


Figure 1. Research framework integrating literature review and case studies in the development of a CDE implementation model for university construction projects.

All data were used in an aggregated and anonymized form, which made it possible to assess the performance of the CDE without disclosing sensitive project information. For Project A, the analyzed dataset covered a period of roughly one to two years and included several dozen active users, a few hundred documents, several dozen BIM models, and a few hundred registered issues in the CDE. For Project B, the available dataset spanned a comparable time frame with a similar order of magnitude in terms of users, documents, models, and issues, reflecting the higher information management complexity associated with the historic campus environment. To protect the confidentiality of the projects and the participating organizations, these values are reported only at the level of approximate orders of magnitude, and all analyses are based on aggregated statistics rather than individual records.

Project A involved the construction of a new educational and laboratory building with a floor area of several thousand square meters and a high level of technical complexity, including advanced HVAC systems, a concert hall, and a Building Management System (BMS) (Figure 2). The project team included representatives of multiple disciplines, including architecture, structural engineering, mechanical engineering, electrical engineering, and telecommunications, as well as numerous university stakeholders, such as laboratory users, library staff, administrative personnel, concert hall operators, and technical services [11–14].



Figure 2. (Left): Fragment of a multidisciplinary 3D model displayed in the Dalux Field CDE platform. (Right): View of Building A within the urban context, Wrocław, 2026.

Project B concerned the construction of a new specialized facility functionally connected to an existing historic building used for educational and research purposes. The project was characterized by conservation-related constraints affecting the historic structure, the need for phased construction works, and the requirement to maintain the operation of surrounding campus infrastructure throughout project execution [11–14] (Figure 3).



Figure 3. (Left): Fragment of the multidisciplinary 3D model of Building B and the adjacent historic structure displayed in the Dalux platform. (Right): View of the administrative building and preserved historic elements of the former Palm House structure, Wrocław, 2026.

The empirical analysis draws on data exported from the Dalux CDE for both projects, including document and model logs, issue registers, and selected workflow statistics. The extracted datasets cover, among others, the number and structure of documents and models published in the WIP, Shared, Published, and Archive areas; the volume and categorization of registered issues; and basic information on workflow durations and approval outcomes. These data were used to calculate the implementation indicators presented in Table 1 and

to qualitatively assess the extent to which the configured CDE environment complied with the ISO 19650 information management requirements summarized in Table 2. The analysis focused on indicators related to information quality, process transparency, and information continuity, as these factors are increasingly recognized as important enablers of sustainable asset management throughout the building lifecycle.

Table 1. Example indicators for assessing the implementation of ISO 19650 requirements in the Dalux CDE.

ISO 19650 Requirement	Implementation in the Dalux CDE Environment	Example Implementation Assessment Indicator
Distinction between WIP/Shared/Published/Archive information states	Structure of information areas and document publication rules	Percentage of documents published in accordance with the established procedure; number of documents placed in an incorrect area
Information containers with statuses and revisions	Metadata of documents and models (status, revision, author, discipline)	Percentage of documents containing all required metadata; number of revision errors
Roles and responsibilities for information	User roles, permission groups, responsibility matrix	Percentage of documents approved by authorized persons; number of permission violations
Managed information flow	Review and approval workflows for documents and models	Average document approval time; number of submissions awaiting approval
Integration of BIM models and documentation	Linking of models, documents, and issues	Percentage of issues linked to a BIM model; number of issues without an assigned location
Agreed source of information (single source of truth)	Published area as the official source of project information	Percentage of documents used outside the CDE; number of cases involving work based on outdated versions
Standardization of naming conventions and metadata	File-naming templates and mandatory metadata fields	Percentage of documents compliant with the adopted naming convention
Issue management	Issues module linked to models, documentation, and workflows	Average issue resolution time; number of open issues; percentage of issues closed within the required timeframe
CDE auditing and continuous improvement	Reports, dashboards, and periodic configuration reviews	Number of audits conducted per year; number of implemented corrective actions

Table 2. Mapping between ISO 19650 requirements, Dalux CDE configuration elements, and implementation benefits for the client.

ISO 19650 Requirement	Dalux CDE Configuration Element	Benefit for the Client
Information container states (WIP, Shared, Published, Archive)	Status/folder structure: WIP (work in progress), Shared (coordination), Published (approved information), Archive (milestone-based data archiving)	Reduced use of outdated documentation, improved version control, and traceability of changes
Roles and responsibilities (Appointing Party, Lead Appointed Party, Task Teams)	User roles and permissions, assignment of access, editing, approval, and publication rights	Clear accountability for information and reduced risk of errors caused by unauthorized actions
Information containers and statuses	Document and model statuses, revision fields, and publication rules	Improved document control and greater transparency of decision-making processes

Table 2. *Cont.*

ISO 19650 Requirement	Dalux CDE Configuration Element	Benefit for the Client
Metadata and naming conventions (revisions, classification systems)	File-naming templates, mandatory metadata fields, data validation mechanisms	Easier information retrieval, filtering, and reporting, as well as improved data quality
Managed information process	Review and approval workflows, automatic status changes	Shorter information circulation times, decision traceability, and more efficient approval processes
Agreed source of information	Published area as the official publication zone, change logs, and access control	Increased trust in project information and reduced risk of using outdated data
Asset lifecycle integration	Linking BIM models, documentation, field data, and as-built information	Easier transfer of information to operation and maintenance, support for BIM-FM and Digital Twin development
Issue management	Issues module linked to BIM models, documentation, and workflows	Faster problem resolution, improved communication, and complete audit trails of issues and decisions

In both projects, the Dalux platform was used as an environment for managing documentation, BIM models, and construction-related issues. The project structure was organized according to the ISO 19650 information states: Work in Progress (WIP), Shared, Published, and Archive [1–3,18,22]. Discipline-specific models were periodically published to the Shared area for coordination purposes, while documentation intended for the client and contractors was transferred to the Published area only after completing predefined approval workflows [3,4,18–20,22]. Construction issues were recorded using the Issues module and linked to specific locations within BIM models or drawings while assigning responsibility to relevant disciplines, consistent with recommendations presented in the literature on issue management in CDE and DT/FM environments [4,5,8–10,12,13,18–20].

The adopted research approach can therefore be described as a literature-informed multiple case study. The proposed CDE implementation model and Dalux configuration framework were developed based on the analysis of scientific literature and ISO 19650 standards and subsequently confronted with empirical evidence derived from two real university construction projects [1–3,5,8,11–13,15–17]. Consequently, the study combines normative and conceptual perspectives with implementation-oriented insights and practical experiences in information management within educational construction projects [3–8,11–13].

All CDE-derived data were anonymized prior to analysis, and no personally identifiable information about individual users was retained in the research datasets. The indicators were therefore used to illustrate the practical applicability of the proposed assessment framework in real university construction projects. Given the exploratory nature of the study, the findings should be interpreted as indicative rather than statistically generalizable.

3. State of Research on CDE and ISO 19650

The most widely accepted understanding of the Common Data Environment (CDE) originates from the EN ISO 19650 series, where it is defined as “an agreed source of information for any given project or asset, for collecting, managing and disseminating each information container through a managed process.” This definition emphasizes that a CDE is not merely a collection of folders or a cloud-based storage service but rather a

component of the information management infrastructure in which information workflows, responsibilities, and access control are equally important [1–3].

Recent literature reviews indicate that a CDE should be understood as a combination of a technical platform and an organizational framework encompassing information areas, roles, permissions, and information flows [3–7]. Jaskula et al. describe the CDE as a “shared information infrastructure” for construction projects, emphasizing that many implementations still focus primarily on document repository functions without fully exploiting the information management mechanisms defined by ISO 19650, such as information statuses, revisions, and information states including Work in Progress (WIP), Shared, Published, and Archive. In the literature on public procurement and public investment management, CDEs are increasingly recognized as tools supporting transparency of decision-making processes and ensuring the integrity of tender and contractual documentation [5–7,15–17,23,24].

From the perspective of information management and project risk management, CDEs are widely recognized as tools that help mitigate problems associated with outdated documentation, fragmented information, and unclear allocation of responsibilities. At the same time, empirical studies emphasize that the benefits achieved depend not only on platform functionalities but also on the quality of organizational processes, user competencies, and the degree to which the CDE is integrated with organizational procedures. Increasingly, researchers also highlight that effective information management supports sustainable construction objectives by reducing design errors, minimizing rework activities, and enabling more efficient use of resources throughout the asset lifecycle [5–7,9,12,20].

3.1. CDE Maturity, Digital Twins, and Facility Management

In recent years, growing attention has been devoted to the maturity of CDEs and their role in supporting information integration throughout the entire lifecycle of a built asset. In this context, a CDE is no longer viewed solely as a project delivery tool but rather as an element of a broader information ecosystem covering the entire building lifecycle. A mature CDE is characterized by its ability to integrate BIM models, design documentation, field data, and operational information within a coherent information management process. The literature emphasizes that maturity depends not only on data storage capabilities but also on mechanisms ensuring version control, permission management, workflow execution, and the maintenance of a single source of truth for all project stakeholders [3–6,8,9].

Within Digital Twin research, the CDE is increasingly regarded as an integration layer linking BIM models with dynamic data generated by monitoring systems, IoT sensors, Building Management Systems (BMS), and other operational data sources. Studies addressing Digital Twin architectures for construction and renovation projects indicate that an integrated CDE can support both project-related information and data generated during construction and operation, ensuring auditability, traceability of changes, and the possibility of reusing information in analytical and decision-support processes [4,5,8–10]. From this perspective, the CDE evolves beyond a project-oriented document exchange space and becomes a core information infrastructure supporting knowledge management throughout the lifecycle of a built asset [4,5,8–10,18,27].

The literature increasingly suggests that the integration of BIM, CDE, and Digital Twin technologies can contribute to sustainable construction objectives by improving the quality of data used in energy analyses, renovation planning, operational monitoring, and technical asset management. In this context, the CDE becomes an important component of the information infrastructure supporting lifecycle-oriented decision-making processes.

One of the most rapidly developing application areas of CDEs is Facility Management (FM) and real estate portfolio management. Research on BIM/FM implementations in complex facilities, including university campuses, indicates that CDE-based environments can

improve asset information accessibility, enhance the quality of handover documentation, and increase the efficiency of operational issue management processes [5,7,11–13]. At the same time, researchers emphasize that transitioning from a CDE focused on design and construction toward an environment supporting FM requires well-structured metadata frameworks, links between BIM models and asset identifiers, and integration with facility management systems used by asset owners and operators. In university campuses, a CDE may serve as a central repository of infrastructure-related knowledge, integrating information generated during successive construction projects, renovations, and operational activities. Such an approach constitutes one of the foundations for developing campus Digital Twins and BIM-based Facility Management systems, both of which are currently recognized as key directions in the evolution of information management within the public sector [11–13,15–17,20,21].

3.2. CDE in Public Investments and University Campus Projects

Public-sector construction projects represent one of the most rapidly developing areas of CDE-related research, primarily because of the importance of transparency, decision traceability, and long-term accessibility of project and operational information. Guidelines issued by organizations such as the EU BIM Task Group, together with publications addressing public investment management, indicate that the incorporation of BIM and CDE requirements into public procurement procedures is becoming standard practice in many countries. In this context, CDE is increasingly perceived as a mechanism for structuring information exchange between clients and contractors. Consequently, the configuration of the environment—including information statuses, publication rules, and approval workflows—acquires not only technical but also regulatory significance [7,15–17].

University campuses are frequently identified as a distinctive subgroup of public-sector clients, simultaneously acting as investors, end users, and long-term asset managers [11–13,15]. This creates a need to ensure information continuity between successive construction projects, renovations, and operational activities while maintaining consistent information management standards across the entire campus. The literature highlights that CDEs can support the development of long-term organizational memory by enabling collection, organization, and reuse of knowledge generated during successive investment projects. This is particularly important in university environments, where infrastructure is often developed incrementally over many years by different design and construction teams.

At the intersection of CDE and cultural heritage management, a growing body of research focuses on Heritage Building Information Modeling (HBIM), where information models of historic assets are used both in renovation projects and in long-term asset management. These studies emphasize the role of CDEs in managing data uncertainty, documenting information provenance, and recording conservation-related decision pathways. Such capabilities contribute to reducing information-related risks, improving decision traceability, and increasing the transparency of processes involving public-sector clients. In the context of university investments, which often include both new laboratory facilities and the renovation or adaptation of historic buildings, findings from research on CDE, BIM/FM, and HBIM provide an important foundation for the development of CDE implementation models tailored to the higher education sector, including solutions implemented through platforms such as Dalux [5,11–15].

4. Dalux Platform Within the CDE Architecture for University Construction Projects

4.1. Functional Scope and Position Within the Digital Tool System

Dalux belongs to a group of commercial Common Data Environment (CDE) platforms developed to integrate document management, BIM models, issue management, approval workflows, and field processes within a single environment [18–20,22]. The literature and implementation reports emphasize that modern CDE solutions should support both the “office” layer (multidisciplinary coordination, document review, revision management) and the “field” layer (site inspections, walkthroughs, construction issue reporting, quality control, and health and safety management), which is reflected in the architecture of Dalux modules [5–7,23,24].

From a functional perspective, Dalux provides document management with version control, BIM model viewing, issue management, review and approval workflows, checklists and field inspections, as well as basic reporting functionalities [18–20,22]. In the context of university construction projects, these capabilities enable the integration of information generated by designers, contractors, clients, and end users within a single environment, in accordance with the logic of ISO 19650 information containers [1–3,12,15,20,21].

Importance is attached to the role of Dalux as an environment that integrates information originating from multiple sources and stages of the investment process. The platform does not replace specialized software used for modeling, design, or engineering analysis (e.g., Revit or Tekla); instead, it functions as a Common Data Environment that consolidates information from various sources. In this approach, BIM models and project documentation are transferred into the CDE as information containers subject to defined publication, review, and approval procedures in accordance with ISO 19650 requirements [1–3,5,6,8]. In practice, this means that the effectiveness of a CDE implementation depends not only on platform configuration but also on established information management procedures, publication rules for models and documents, and the information management competencies and discipline of project participants [5–7,23].

4.2. Implementation Structure (Statuses, Roles, Workflows, and Metadata)

A mature implementation of Dalux as a CDE requires the deliberate mapping of key ISO 19650 requirements into the platform configuration structure. The analysis of the literature and implementation guidelines indicates that effective CDE implementation requires consideration of five groups of elements:

1. Information status and folder structures;
2. Roles and permissions;
3. Information workflows and approval procedures;
4. Metadata and naming conventions;
5. Integration of issues and field data.

The first element is the structure of information areas and folders corresponding to the WIP, Shared, Published, and Archive information states. In practice, this is implemented through dedicated information areas or folder structures representing different stages of information flow: multidisciplinary team working areas (WIP), coordination and review areas (Shared), information approved for use by project participants (Published), and archived information versions captured at predefined project milestones (Archive) [1,3,5,7,8,23]. Such an organization of the CDE separates working information from approved information while enabling the reconstruction of decision and change histories, which is particularly important in publicly funded projects [3,7,9,10,15–17].

The second layer concerns the role and permission model. The platform enables the definition of roles (e.g., author, checker, approver, information manager) and the assign-

ment of permissions related to viewing, editing, commenting, approving, and publishing information within specific areas or folders [1–3,5–7,23]. In accordance with ISO 19650 and the BIM information management literature, these roles should be linked to contractual responsibilities and the RACI matrix rather than solely to organizational hierarchy, thereby reflecting the actual distribution of responsibility for information management [3,6,7,15–17].

The third key element is the information workflow structure, comprising predefined review and approval pathways for documents and models. Dalux supports multi-stage workflows (e.g., author → checker → approver → publication) with defined deadlines, transition rules, and mandatory comments [18–20,22]. Research on CDE implementation demonstrates that formalized workflows reduce misunderstandings, shorten information circulation times, and improve auditability of decisions, provided that the processes are clearly communicated and consistently applied by project stakeholders [3–7,23,24].

The fourth layer concerns metadata and naming conventions. Dalux allows the definition of metadata fields (e.g., project, facility, discipline, document type, project stage, revision, and status) and can enforce their completion when files are added or modified [1–3,5,18–20]. Combined with file naming templates and status control mechanisms (e.g., “WIP,” “For Coordination,” “For Construction”), this functionality supports the practical implementation of information container management principles defined in ISO 19650 [3,5–7,11–13].

An additional important component of the implementation structure is the integration of issues, models, documents, and field data. Dalux enables issues such as clashes, non-conformities, or contractor requests for information to be recorded directly on BIM models or drawings and tracked through predefined workflows [18–20,22]. Integrated issue management is recognized as one of the key mechanisms ensuring information continuity between the design, construction, and operational phases of a built asset [4,5,8–10,12,13,18–20].

In the context of university construction projects, Dalux may therefore function as a platform that integrates ISO 19650 requirements with the information needs of public-sector clients, supporting information management both during project delivery and throughout the subsequent operational phase of the facilities [1–3,5,11–13,18–22]. Table 2 presents the relationship between the main information management requirements defined in ISO 19650 and the corresponding configuration elements available within the Dalux CDE. The table illustrates how normative requirements can be translated into solutions that are directly implementable in project practice.

Although the implementation presented in this study is illustrated using the Dalux platform, the proposed framework itself is platform-independent. Its core elements—including ISO 19650 information states, metadata structures, roles and responsibilities, workflows, and issue-management procedures—are derived directly from the ISO 19650 series rather than from any specific software solution. Consequently, the framework can be implemented in any Common Data Environment platform offering comparable information management capabilities. The Dalux configuration presented in this paper therefore serves solely as an illustrative implementation of the proposed framework, demonstrating how ISO 19650 requirements can be operationalized within a commercial CDE platform. The use of open standards, particularly IFC for information exchange and BCF for issue communication, further supports interoperability, technological neutrality, and compliance with public procurement principles.

Accordingly, the mapping presented in Table 2 should be interpreted as an example of translating ISO 19650 requirements into platform configuration rather than as a Dalux-specific implementation model. Similar implementation principles may be applied in other CDE platforms supporting equivalent information management functions.

5. CDE Implementation Model for University Construction Projects and Discussion

Based on a review of the literature concerning ISO 19650 implementation and information management in public-sector projects, an eight-step implementation model for a Common Data Environment (CDE) using the Dalux platform was developed for university construction projects (Figure 4) [1–3,5–7,12,13,20,23]. The model is intended as a reference framework and can be adapted to the scale, complexity, and specific characteristics of individual university investments. From a sustainable construction perspective, the proposed model aims not only to organize information flows during project delivery but also to establish a foundation for the subsequent use of data in facility operation, renovation planning, and lifecycle management. A properly configured CDE can support information continuity between the design, construction, and operational phases of a building.

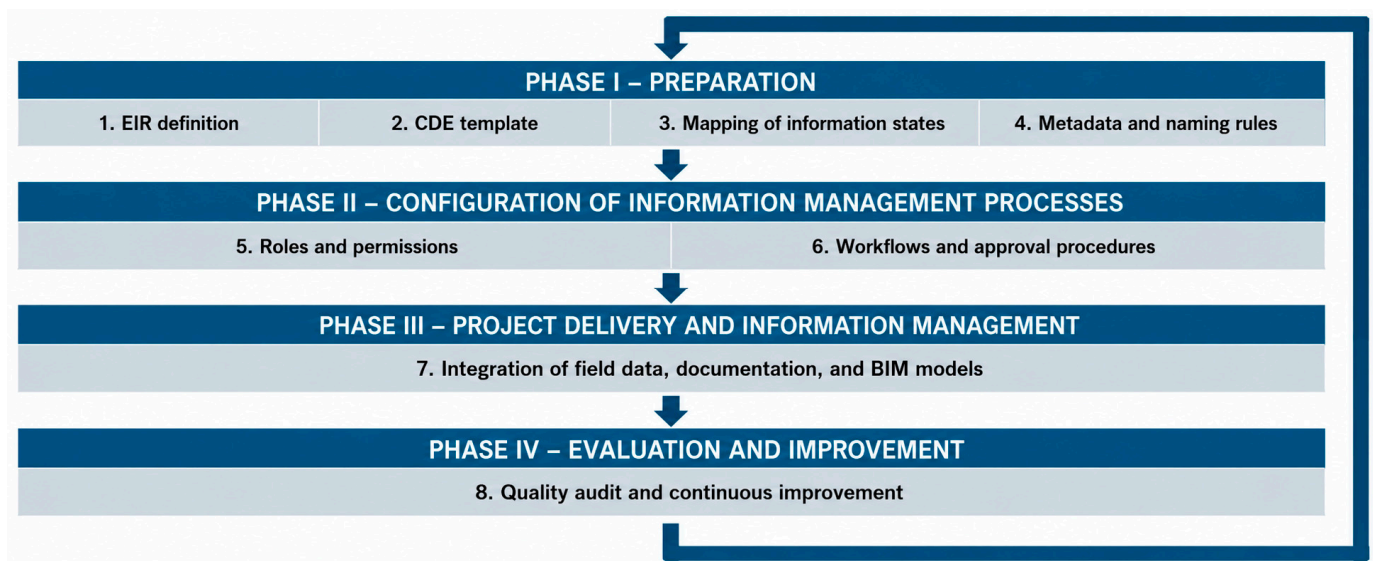


Figure 4. Proposed CDE implementation model for university construction projects.

Phase I—Preparation

(Objective: Definition of the client’s information requirements and preparation of a unified information management structure compliant with ISO 19650.)

1. Definition of Exchange Information Requirements (EIR) and Information Roles

The first step involves the formal definition of the client’s Exchange Information Requirements (EIR) and the assignment of information management roles in accordance with ISO 19650 (Appointing Party, Lead Appointed Party, and Task Teams) within the context of a specific university. At this stage, key projects and operational decisions that should be supported by the CDE are identified and linked to organizational responsibilities (e.g., university departments, technical services, laboratory users).

2. Development of an ISO 19650-Compliant CDE Template

The second step involves the development of a standardized CDE project template reflecting ISO 19650 requirements regarding information organization, information states, and document and model classifications. The template should be reusable across multiple university projects, thereby supporting information consistency throughout the institution’s project portfolio.

3. Mapping WIP, Shared, Published, and Archive Information States within the CDE Structure

The next step consists of translating ISO 19650 information states into the Dalux environment through the creation of dedicated areas (or folder structures) for Work in

Progress (WIP), Shared, Published, and Archive information. The literature emphasizes that a clear distinction between these areas reduces the risk of using outdated documentation and improves the auditability of decision-making processes.

4. Definition of Naming Conventions, Metadata, Statuses, and Revisions

The fourth step focuses on establishing a consistent file naming system and a set of metadata fields (e.g., project, facility, discipline, document type, stage, status, and revision) that must be completed when information is added or modified within the CDE. According to ISO 19650 and CDE maturity studies, the consistent use of metadata and status classifications is essential for filtering, reporting, and the future use of information within Facility Management (FM) and Digital Twin (DT) environments.

Phase II—Configuration of Information Management Processes

(Objective: Translation of responsibilities, permissions, and decision-making processes into the CDE.)

5. Configuration of Roles and Permissions According to the Project Governance Structure

Roles defined at the organizational level (Step 1) are subsequently mapped within Dalux as user groups with specific permissions (viewing, editing, commenting, approving, and publishing) assigned to individual information areas. The literature on BIM information management indicates that effective CDE implementation requires these roles to be linked to contractual and decision-making responsibilities rather than merely reflecting formal organizational hierarchies, which is particularly important in universities characterized by complex organizational structures.

6. Development and Implementation of Information Review and Approval Procedures

This step involves the design and configuration of review and approval workflows for key classes of documents and models (e.g., discipline-specific BIM models, construction drawings, coordination records, and as-built documentation). Research on CDE implementation and project risk management indicates that the formalization of such procedures—with clearly defined stages, deadlines, and responsibilities—is one of the most effective mechanisms for reducing information-related errors and coordination conflicts.

Phase III—Project Delivery and Information Management

(Objective: Operational use of the CDE for information coordination, document management, and field process support.)

7. Integration of Field Data, Documentation, and BIM Models

Following the configuration of the CDE structure, user roles, permissions, and information workflows, the platform enters the operational phase of project use. This stage includes the integration of BIM models, project documentation, and construction-related information such as issues, inspections, checklists, acceptance records, and quality management documentation. Within the Dalux environment, issues can be linked directly to BIM model elements or project documentation, ensuring information continuity between problem identification, analysis, decision-making, implementation of corrective actions, and updates to design and as-built information. Such an approach supports coordination among project participants and reduces the risk of information loss associated with fragmented communication channels. The literature highlights integrated issue management as one of the key mechanisms supporting information continuity between the design, construction, and operational phases of a building. Consequently, the CDE can function as a central hub for information exchange and updates throughout the entire project lifecycle. From a sustainability perspective, improved information continuity, decision traceability, and the reuse of validated information containers may indirectly support more efficient resource utilization and reduce the likelihood of design errors and rework activities throughout the project lifecycle.

Phase IV—Evaluation and Continuous Improvement of the CDE

(Objective: Monitoring information quality and continuously improving information management processes.)

8. Information Quality Audits and Continuous Improvement of the CDE

The proposed eight-step CDE implementation model is derived directly from the information management principles defined in the EN ISO 19650 series and is therefore intended to be platform-independent. It defines the key elements of information management, including Exchange Information Requirements (EIRs), information roles and responsibilities, information states (WIP, Shared, Published, Archive), metadata structures, and review and approval workflows, which may be implemented in different Common Data Environment platforms. The Dalux configuration presented in this paper serves solely as an illustrative implementation example demonstrating the proposed framework in practice.

The final stage of the model involves the periodic evaluation of information quality and the effectiveness of CDE operations. This includes assessing compliance with established procedures, evaluating the completeness and timeliness of information, and monitoring the extent to which the environment is used by project stakeholders. The continuous improvement process may utilize selected performance indicators, including the number and resolution time of issues, metadata completeness, the number of document revisions, the proportion of information published outside the CDE, and workflow completion rates. The analysis of these indicators supports the identification of areas requiring improvement and facilitates the refinement of both platform configuration and information management procedures. For public-sector clients, including higher education institutions, this stage is particularly important because it enables the gradual standardization of information management practices across successive investment projects. As a result, the CDE evolves from a tool supporting individual projects into a component of a long-term information management system for university infrastructure.

5.1. Assessment of the Implementation Level of ISO 19650 Requirements in the Dalux CDE

Based on the proposed implementation model and the requirements of the ISO 19650 standard, a set of example indicators was developed to support the assessment of the implementation level of a CDE in university construction projects (Table 1) [1–3,5–7,20]. These indicators refer to key information management components, including the organization of information states, metadata management, roles and responsibilities, information workflows, BIM model integration, and issue management. Their purpose is to support monitoring of CDE performance and the identification of areas requiring further improvement.

Table 1 presents example indicators that can be used to assess the implementation level of ISO 19650 requirements within the Dalux CDE. The proposed metrics address both technical aspects (information structure, metadata, workflows) and organizational aspects (roles, responsibilities, and process compliance), thereby supporting the monitoring of information management quality and the identification of areas requiring improvement. These indicators may be applied during periodic CDE audits, information maturity management assessments, and comparative evaluations of projects delivered by public-sector clients. They also represent an extension of the “Evaluation and Improvement of the CDE” stage included in the proposed implementation model (Figure 4).

Complementing the presented assessment indicators, Figure 5 illustrates the mapping of ISO 19650 requirements onto the configuration of the Dalux CDE. The diagram demonstrates the relationships between information management requirements, the corresponding mechanisms operating within the CDE, and their implementation through specific Dalux configuration settings.

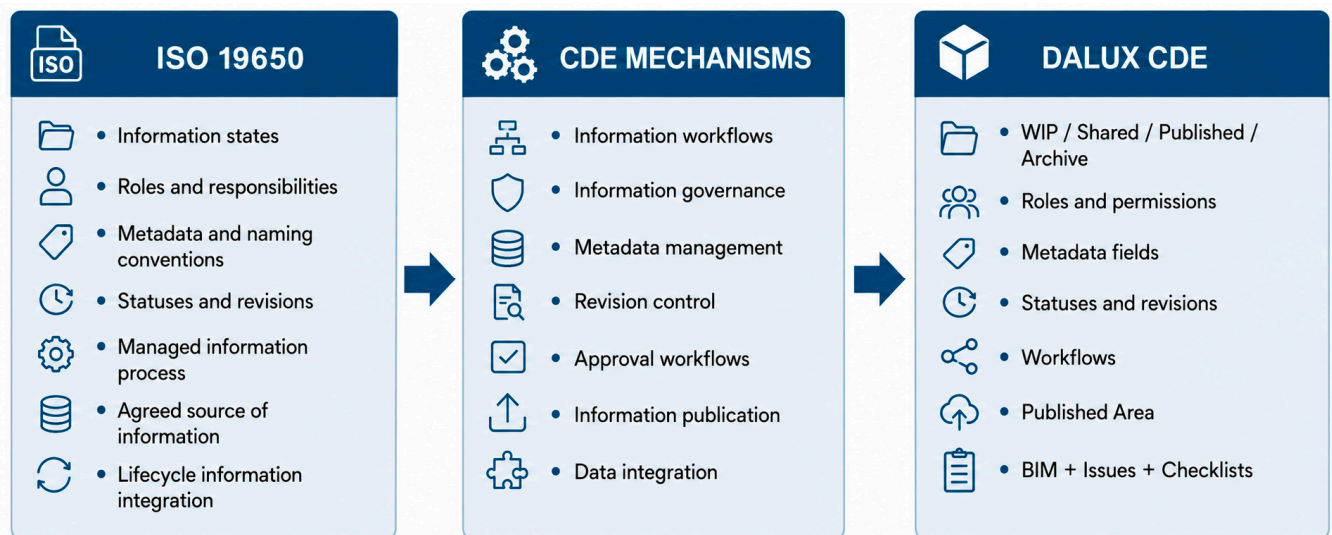


Figure 5. Model for Mapping ISO 19650 Requirements onto the Configuration of the Dalux CDE.

5.2. Issue Management Cycle in the CDE

Once the CDE has been configured in accordance with ISO 19650 requirements, the way it is used in day-to-day information management becomes critically important. A particularly significant role is played by the issue management process, which supports the identification, analysis, and resolution of problems arising during the design, construction, and commissioning stages of a project (Figure 6).

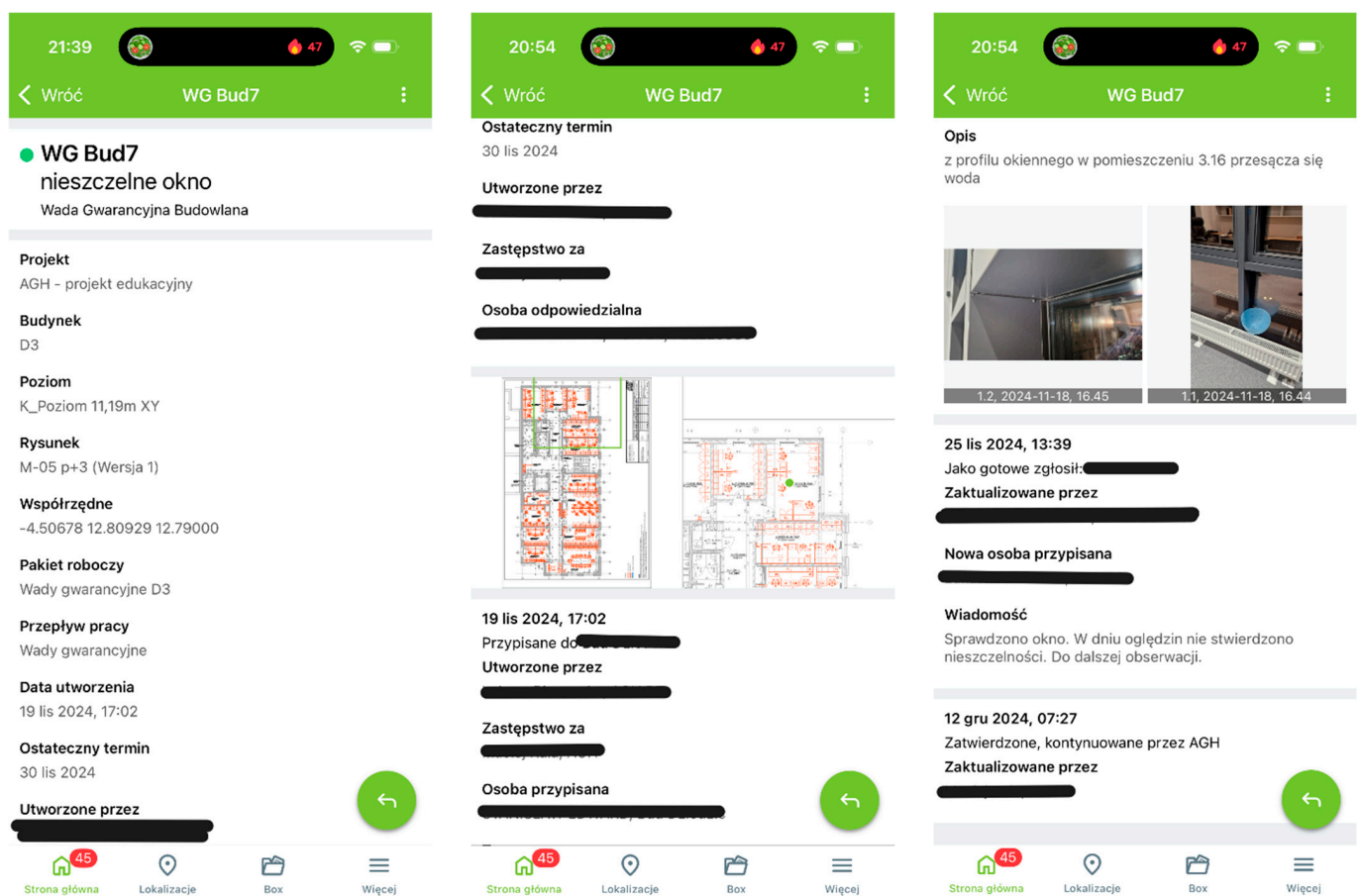


Figure 6. Example of Issue Registration and Management in the Dalux CDE.

Within the CDE, issues may relate to design clashes, construction non-conformities, documentation errors, or the need to clarify technical solutions. Regardless of the nature of the issue, its handling follows a structured process involving identification, registration, assignment of responsibility, analysis, decision-making, implementation of corrective actions, and the subsequent update of documentation and BIM models [4,5,8–10,12,13]. From an information management perspective, maintaining continuity between a problem identified on site or within a BIM model and the information subsequently published for project stakeholders is particularly important. This means that every design or construction decision should be reflected in the current documentation and models, while the history of changes should remain available for future verification and auditing purposes [1–4,8–10].

In university construction projects, integrated issue management supports coordination among project participants, reduces the risk of information loss, and improves the traceability of decisions. From the perspective of a public-sector client, this is particularly important for ensuring process transparency and maintaining the quality of documentation delivered for the operational phase of the asset [7,12,13,15–17,20].

Figure 7 presents a model of the issue management workflow within a CDE, covering the stages from problem identification through issue analysis and processing to the implementation of corrective actions and the updating of models and documentation. The diagram emphasizes the importance of maintaining information continuity between the design, construction, and operational phases in accordance with the information management principles defined in ISO 19650.

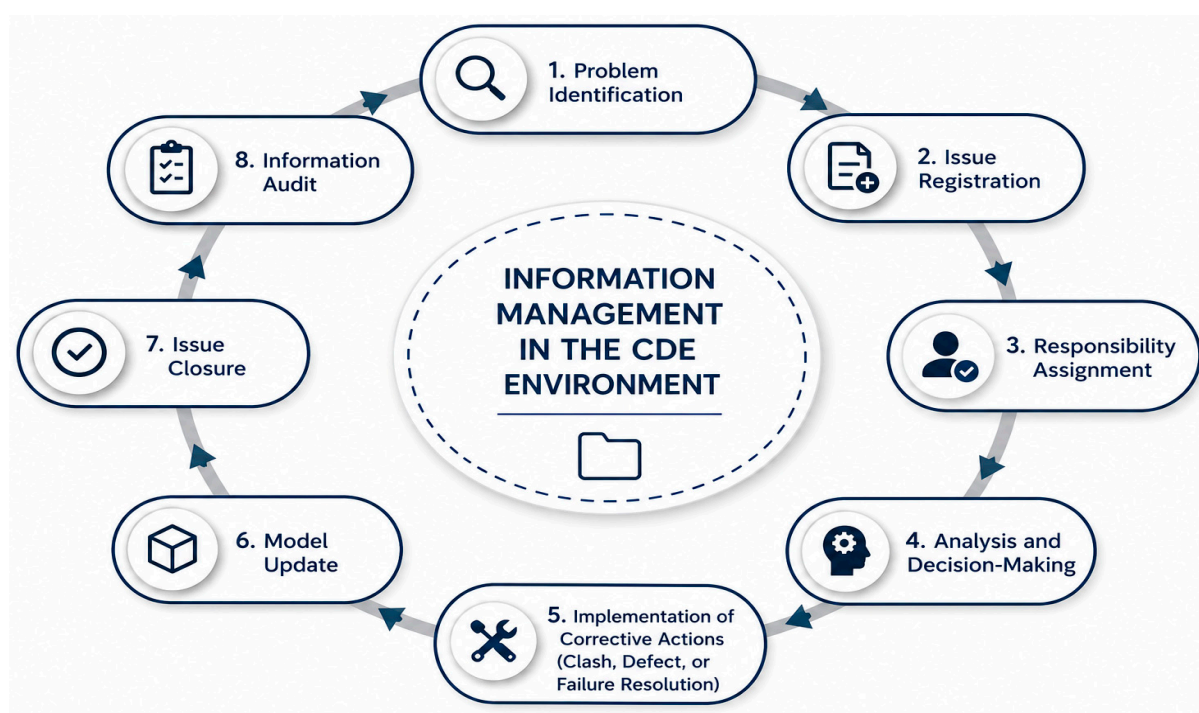


Figure 7. Issue Management Cycle in an ISO 19650-Compliant CDE.

6. Empirical Verification of the Model in University Projects

6.1. Project A—New Laboratory and Educational Building

Project A involved the construction of a new laboratory and educational building with a floor area of several thousand square meters, characterized by a high level of technical complexity resulting from the implementation of extensive HVAC systems, a Building Management System (BMS), and specialized educational and performance spaces. The design and construction team included several major disciplines (architecture, structural

engineering, mechanical services, electrical engineering, and telecommunications), as well as a large group of university stakeholders (laboratory users, library staff, administrative personnel, concert hall users, and technical services) [11–13].

In this project, the Dalux platform served as the central CDE supporting design coordination and information exchange among project participants. Construction-related issues were linked to specific locations within the BIM model and assigned to responsible disciplines, reflecting recommendations found in the literature regarding issue management in CDEs [4,5,8–10,12,13,18–20]. During the design phase alone, 325 issues were analyzed, primarily involving interdisciplinary clashes, contractor queries, and documentation inconsistencies. The analysis of the number of issues, issue resolution times, and the degree of integration with BIM models indicates a gradual increase in information management maturity and improved integration of design and field data throughout project delivery [3–6,8–10,12,13]. These findings are consistent with trends reported in studies on CDE and BIM/FM implementation in complex public buildings [5,7,11–13].

6.2. Project B—New Specialized Facility

Project B involved the construction of a new specialized facility functionally connected to the historic fabric of the university campus, requiring consideration of conservation requirements and restrictions related to cultural heritage protection [11–14].

In this project, Dalux was used as the central CDE supporting both the design and construction processes, with particular emphasis on documenting conservation-related decisions and managing changes resulting from discoveries made during construction activities [4,5,8–11,14]. The project adopted a WIP, Shared, Published, and Archive structure; however, particular attention was devoted to configuring metadata and document/model statuses associated with conservation activities (e.g., distinguishing between proposed, surveyed, and as-built conditions) [1–3,5,11–14,18–20].

During the analyzed period, more than 700 issues were registered in Project B, mainly related to clashes between newly designed building services and elements of the historic structure, discrepancies between survey documentation and actual site conditions, and the need to update HBIM models based on field discoveries. Linking issues with BIM models, design documentation, and survey materials enabled more comprehensive documentation of the decision-making process and reduced the information risks typically associated with projects carried out in historic buildings.

6.3. Analysis of Selected CDE Performance Indicators

Selected performance indicators related to issue and clash management were derived from anonymized Dalux system logs exported from the two analyzed university construction projects. The empirical analysis was based on data extracted directly from the CDE, including issue registers, document revision histories, workflow logs, and BIM-related metadata. The exported datasets were processed using aggregated project statistics without analyzing individual user activity. Time-based indicators (e.g., issue closure time) were calculated from issue creation and closure timestamps automatically recorded within the CDE platform, whereas document-related indicators were derived from document metadata, publication status, revision history, and workflow records.

The data are exploratory in nature and are intended to illustrate methods for monitoring CDE performance in university construction projects. The indicators are not intended for benchmarking purposes but rather to demonstrate the monitoring approach associated with the proposed implementation model. The following indicators were analyzed:

- Number of issues categorized by type (clashes, contractor queries, documentation inconsistencies, operational comments);

- Average response and issue closure times;
- Proportion of issues linked to BIM models compared to issues based solely on drawings;
- Number of revisions of key models and documents, and the proportion of revisions processed through the defined workflow [3–6,8–10,12,13,18–20].

The collected data enabled an assessment of the extent to which the CDE was utilized and supported the evaluation of selected information management performance indicators. For this study, the performance indicators were defined as follows:

- Issues per 100 documentation sheets: The total number of issues registered in the CDE divided by the number of documentation sheets published in the Shared and Published areas, multiplied by 100.
- Issues related to outdated documentation: Issues that, based on their descriptions and status histories, were classified by the information manager as resulting from the use of superseded or incorrectly published documents.
- Average issue closure time: Calculated automatically from the timestamps of issue creation and issue closure recorded in the Dalux issue management module, excluding issues that remained open at the time of data export.
- Share of issues linked to BIM models: Calculated as the proportion of issues assigned to a BIM object or model location within the CDE relative to all registered issues.
- Share of clashes identified only during construction: The proportion of clashes that were first detected on site relative to all registered clashes.

The indicator values were calculated from anonymized and aggregated data exported from the Dalux platform, including issue records, document revision histories, and workflow statistics, and are presented as approximate ranges rather than exact project values. Table 3 summarizes the resulting CDE performance indicators. These indicators relate directly to information management and were selected based on the literature concerning CDE maturity assessment and BIM/FM performance evaluation [3–7,20]. Due to differences in project size and characteristics, the results are presented primarily as relative indicators, enabling comparison of CDE performance independently of project scale.

Table 3. Selected Performance Indicators of the CDE in the Analyzed Projects.

Indicator	Project A—New Laboratory and Educational Building	Project B—Specialized Facility in a Historic Context
Number of issues per 100 documentation sheets (after CDE stabilization)	approx. 12	approx. 15
Share of issues related to outdated documentation	<10% of all issues	approx. 15% of all issues
Average issue closure time (calendar days)	5–7	7–10
Share of clashes identified only during construction (relative to all registered clashes)	approx. 20%	approx. 30%
Share of issues directly linked to BIM models	approx. 75–80%	approx. 75–80%

Note: The indicator values were calculated from anonymized data exported directly from the Dalux CDE platform, including issue registers, document metadata, revision histories, and workflow logs. Due to confidentiality agreements with the project owner, the results are reported as approximate values and aggregated statistics rather than exact project figures. The values are intended to illustrate methods for monitoring CDE performance and are not statistically representative.

The obtained indicator values are consistent with trends reported in studies on CDE and BIM/FM environments, highlighting the potential benefits of structured information management. The relatively low proportion of issues resulting from the use of outdated documentation and the shorter issue closure times observed in Project A correspond with

benefits identified in the literature regarding improved access to up-to-date information, reduced errors, and shorter response cycles. Less favorable results observed in Project B emphasize the importance of source data quality and the complexity of heritage-related constraints, which are frequently identified in HBIM and historic building renovation studies as key factors limiting CDE effectiveness.

In Project A, the relatively low share of issues related to outdated documentation (below 10% of all issues) can be attributed to the consistent use of WIP, Shared, Published, and Archive areas, as well as clearly defined publication procedures for construction-related documents. This finding aligns with research indicating that clear separation of information states and effective control of document statuses and revisions reduce risks associated with fragmented and inconsistent data [5–8,23]. The average issue closure time of 5–7 days is also consistent with studies reporting reduced information processing times achieved through integrated workflows instead of email-based communication and informal coordination channels [5–7]. Furthermore, the high proportion of issues directly linked to BIM models demonstrates extensive use of the model as the primary carrier of design and coordination information, contributing to reduced interpretation errors and improved communication among project participants.

In Project B, the indicator values were less favorable. The proportion of issues related to outdated documentation and the percentage of clashes detected only during construction were higher, while average issue closure times were longer than those observed in Project A. These results can be interpreted because of greater uncertainty in source data, the need to accommodate conservation requirements, and the increased complexity of decision-making processes typical of projects implemented in historic buildings. These findings are consistent with studies on HBIM and information management in renovation projects, which emphasize the influence of source data quality and process efficiency on the performance of CDEs [16].

Nevertheless, both projects provide illustrative evidence of potential benefits in terms of decision traceability and change history management. Linking issues to BIM models and documentation, recording decisions within workflows, and utilizing Published and Archive areas facilitated the reconstruction of responsibility chains and decision rationales. This observation is consistent with the literature on CDE implementation in public-sector projects, which highlights the importance of information transparency and auditability for public clients and university infrastructure managers.

Overall, the indicator values suggest a relatively mature implementation of information management processes within the analyzed CDEs, particularly with respect to document centralization, standardized naming conventions, and the formalization of issue management workflows. At the same time, the presence of non-compliant files, residual use of e-mail for information exchange, and a limited number of long-open issues indicates the need for periodic CDE audits and targeted training activities, as envisaged in the final step of the proposed implementation model.

The presented findings complement the literature review section and demonstrate the practical applicability of the proposed implementation model in real university construction projects. They may also be interpreted from the perspective of sustainable project management, as reducing errors caused by outdated documentation, shortening issue resolution times, and improving decision traceability can indirectly contribute to reducing material waste, minimizing rework, and promoting more efficient use of organizational and technical resources. These observations suggest that a properly configured CDE can support not only information management quality but also selected objectives of sustainable construction related to process efficiency and resource optimization.

7. Discussion

7.1. The Importance of CDE Configuration for Reducing Information Risk

The findings obtained from the two university projects confirm conclusions reported in the literature, namely, that the mere presence of a CDE platform does not guarantee improvements in information management quality. Instead, the key factors are the way the environment is configured, its integration with organizational processes, and the degree to which established procedures are consistently followed by project participants [3–7]. In particular, the structure of the WIP/Shared/Published/Archive areas, clearly defined roles and permissions, consistent metadata, and formal approval workflows proved to be fundamental elements influencing the reduction in risks associated with working on outdated documentation and improving transparency of responsibilities [1–3,5–7].

Empirical observations from Projects A and B indicate that projects with similar functional characteristics may exhibit different levels of information maturity depending on the consistency with which CDE principles are applied by project stakeholders. These findings confirm that the effectiveness of a CDE is determined not only by the technology employed but also by organizational, procedural, and competency-related factors. In the analyzed university projects, a critical aspect was the alignment of the Dalux configuration with the Employer's Information Requirements (EIRs), the university's organizational structure, and the specific needs of end users. This observation is consistent with the recommendations of the ISO 19650 standards and studies on BIM governance in the public sector [3,5–8].

The obtained results are also consistent with observations reported in the literature, indicating that the effectiveness of a CDE depends to a greater extent on the quality of information management processes than on the software functionalities themselves [3–7]. Importance is attributed to the proper definition of roles and responsibilities, metadata quality, the formalization of information workflows, and the consistent application of document publication and approval procedures. Similar conclusions were presented by Seyis and Özkan [6], who identified organizational and information maturity among project participants as one of the key factors influencing the effectiveness of BIM- and CDE-based environments.

7.2. Implications for Public Clients and Sustainable Campus Management

From the perspective of public clients, including higher education institutions, the proposed CDE implementation model has several practical implications. First, it highlights the need to treat CDE as an element of a broader organizational information management strategy rather than merely as a “file-sharing tool” [3,6,7,13,15]. Second, it emphasizes the importance of developing CDE templates and metadata standards at the level of the entire investment portfolio, thereby facilitating data comparability between projects and supporting the gradual development of a campus-wide organizational memory [5,7,12,15,20,21]. From a sustainable construction perspective, CDEs can contribute to reducing information losses, minimizing design and construction errors, and enabling more efficient use of resources throughout project delivery. Improved information quality may indirectly reduce the number of design changes implemented during construction, decrease construction waste generation, and support more effective planning of operational processes. These benefits are consistent with the principles of Smart Construction and sustainable lifecycle management of built assets. However, the present study evaluates these benefits only from the perspective of information management quality and process performance. The relationship between CDE maturity and quantitative environmental indicators, such as waste generation, energy consumption, greenhouse gas emissions, or lifecycle costs, requires further investigation and remains an important direction for future research.

BIM/FM case studies conducted on university campuses demonstrate that the consistent application of BIM and CDE across successive projects can facilitate the integration of asset-related information, support maintenance planning, improve response to failures, and enable the implementation of Digital Twin and Facility Management solutions. The findings presented in this study suggest that a properly configured Dalux CDE can serve as a platform integrating design, construction, and operational data, thereby acting as a bridge between the investment process and the FM systems used by universities [9,12,15,18,20,21,27]. In the long term, such an approach may support the development of a digital knowledge repository for campus infrastructure, enabling information collected during project delivery to be reused for operation, modernization, and the planning of future investments.

7.3. Research Limitations

The study has several limitations that should be considered when interpreting the findings. First, the empirical data were obtained from only two university projects carried out within a single country and organizational environment, which limits the generalizability of the conclusions to other public-sector investments [3–7,12,15,20]. Second, the analysis of performance indicators (e.g., number of issues, response times, and the proportion of issues linked to BIM models) is illustrative in nature. No formal statistical analysis was performed, nor was a comparison made with a control group of projects that did not use a CDE [3–7,9,10]. Third, the study focuses on a single platform (Dalux). While this strengthens its practical applicability, it also limits comparisons with other CDE solutions discussed in the literature, such as Autodesk Construction Cloud, Bentley ProjectWise, or Trimble Connect [5–7,9,10,18–20]. An additional limitation is the inability to isolate the influence of individual CDE configuration elements on the observed outcomes. The effects identified in the analyzed projects result from the interaction of technological, organizational, and competency-related factors. Consequently, the proposed implementation model and the associated findings should be regarded as a framework and a set of hypotheses for further validation rather than as a universal standard applicable to all project types. Future studies should therefore include a larger number of projects, different categories of public clients, and comparative analyses of multiple CDE platforms. Such research would enable a more comprehensive assessment of the impact of CDEs on information management performance throughout the lifecycle of built assets.

Furthermore, the indicators applied in this study focused primarily on issue and clash management. Other potential effects of CDE implementation, including impacts on project costs, safety performance, and user satisfaction, remained outside the scope of the present research and should be investigated in future studies.

8. Future Research Directions in the Areas of CDE, Digital Twins, and Lifecycle Management

The findings of this study open several promising directions for future research. First, it appears justified to extend the analysis to a larger number of university projects and investments undertaken by other public-sector clients. Such an approach would enable a quantitative assessment of the influence of individual CDE configuration elements, such as information area structures, workflows, metadata, and issue management mechanisms, on information risk levels and overall project performance [3–7,12,20,23].

Another promising research direction concerns the development of the concept of “campus information memory”, created on the basis of data accumulated through successive projects implemented within a CDE. This topic may be explored both from the perspective of integration with Facility Management systems and Digital Twin solutions,

and from an organizational perspective involving the standardization of procedures, development of information templates, and systematic reuse of experience gained from previous projects [5,7,12,15,20,21]. In particular, it would be valuable to investigate how data derived from issues, revision histories, and metadata can support the continuous refinement of Employer's Information Requirements (EIR) in subsequent investment projects [1–3,5–7,13].

An important area for further investigation is the application of CDEs in cultural heritage projects. In particular, in-depth case studies integrating CDE platforms with HBIM models and conservation decision-making processes are needed. Such studies could focus on methods for documenting data uncertainty, ensuring source traceability, monitoring decision-making processes, and assessing the impact of CDE implementation on the long-term management of historic buildings [14,16].

Another significant research direction involves the development of CDE maturity assessment frameworks tailored to the needs of public-sector clients, including universities. Such frameworks should address not only technical aspects related to platform configuration but also organizational factors such as information governance, user competencies, and data-driven working cultures [3–7,20,23]. The integration of maturity indicators with operational data collected from CDE platforms could provide a basis for objectively assessing implementation progress, monitoring organizational development, and comparing outcomes across different institutions and project types.

From the perspective of sustainable development goals, a particularly interesting area for future research is the analysis of relationships between CDE maturity and environmental performance indicators, such as construction waste generation, the number of design and construction changes, energy efficiency, and lifecycle costs. Such studies would contribute to a better understanding of the role of information management as a factor supporting sustainable construction and resource-efficient asset management.

In the longer term, another promising direction involves the application of artificial intelligence (AI) methods to analyze data accumulated within CDEs. Automated analysis of issues, revision histories, project documentation, and operational data could support the identification of recurring problems, prediction of information-related risks, and continuous improvement of information management processes throughout the entire lifecycle of built assets. AI-enabled CDEs may therefore become an important component of future Digital Twin ecosystems and intelligent infrastructure management systems.

9. Conclusions

Common Data Environments (CDEs) are increasingly recognized as one of the key components of mature information management in BIM-enabled construction projects and in projects implemented in accordance with the ISO 19650 series of standards [1–4]. The literature review conducted in this study indicates that a CDE should be understood not merely as a file repository, but rather as a combination of a technical platform and an organizational framework encompassing roles, permissions, workflows, metadata, and access management principles [3–7].

Against this background, the present study contributes to the existing body of knowledge by proposing an eight-step CDE implementation model for university construction projects that directly reflects the requirements of ISO 19650 and translates them into specific configuration elements of the Dalux platform [1–3,5–8,12,13,20,23]. The proposed model combines standard-based requirements, findings from scientific literature, and practical experience gained from university construction projects, thereby providing a coherent framework for implementing CDEs within public-sector organizations. The developed compliance matrix (ISO 19650–Dalux) and the issue management loop illustrate how abstract normative concepts can be operationalized in real university projects while accounting

for organizational constraints and the requirements of public clients [3–7,9,10,15–17]. In this context, the value of the study lies not only in identifying good practices but also in demonstrating how these practices can be implemented within a specific CDE.

The analysis of two university construction projects provides exploratory evidence that implementing a CDE model based on the WIP/Shared/Published/Archive structure, consistent metadata, formalized workflows, and issue-to-BIM model integration may contribute to reducing work performed on outdated documentation, shortening issue resolution times, and improving the transparency of responsibilities and decision-making processes within the analysed project contexts [3–7,12,20,21]. Of particular importance was the alignment of the CDE configuration with the Employer's Information Requirements (EIRs), the organizational structure of the university, and the specific operational characteristics of the campus. This finding is consistent with previous research on BIM/FM and Digital Twin applications in complex building portfolios [6,7,9,12,18,20,21,27]. The results further indicate that the effectiveness of a CDE is largely determined by organizational factors, including the definition of responsibilities, the quality of information management procedures, and the consistency with which adopted standards are applied. Consequently, the benefits achieved are not solely the result of deploying an appropriate software platform but primarily stem from the proper design and governance of information management processes.

The findings also highlight that CDE should be regarded as part of a broader organizational information management strategy encompassing standards, templates, and processes, rather than as a standalone technological solution. In the context of higher education institutions, this implies the need to consider CDE at the campus level as a tool for building organizational information memory, integrating asset-related data, and preparing the foundation for BIM-based facility management, operation and maintenance systems, and Digital Twin implementations [5,7,11–13,15–17]. The results suggest that a properly configured CDE can serve as a central component of campus information infrastructure, integrating design, construction, and operational data throughout the lifecycle of buildings. From this perspective, CDE becomes not only a tool supporting the delivery of individual projects but also a platform enabling the development of long-term organizational knowledge about university assets. Such an approach is consistent with both the Smart Construction paradigm and the principles of sustainable construction, as it may support more efficient information utilization, reduce information losses, and promote more effective management of built assets throughout their lifecycle. These should be interpreted as potential indirect contributions of improved information management rather than outcomes directly measured in this study.

The implementation model and the empirical observations presented in this paper provide a foundation for future quantitative and comparative studies, particularly in the area of developing CDE maturity indicators tailored to the needs of public-sector clients and assessing the long-term impact of CDEs on campus management performance [3–7,11–13,15–17]. A particularly promising direction for future research is the integration of CDEs with artificial intelligence (AI)-based solutions capable of analyzing data generated during the design, construction, and operational phases of buildings, thereby supporting decision-making processes related to university infrastructure management. Overall, the findings suggest that the effectiveness of a CDE is largely determined by organizational and governance factors rather than by software functionalities alone. From a sustainable construction perspective, the study indicates that ISO 19650-compliant CDE implementation may strengthen information governance, support lifecycle-oriented decision-making, and contribute to the long-term management of university infrastructure by providing a consistent and

reliable information environment. Quantitative assessment of environmental and lifecycle performance remains an important direction for future research.

Author Contributions: Conceptualization, A.R. and U.K.-K.; methodology, A.R. and U.K.-K.; software, U.K.-K.; validation, A.R.; formal analysis, A.R.; investigation, A.R. and U.K.-K.; resources, U.K.-K.; data curation, A.R. and U.K.-K.; writing—original draft preparation, A.R. and U.K.-K.; writing—review and editing, A.R. and U.K.-K.; visualization, A.R. and U.K.-K.; supervision, A.R. and U.K.-K.; project administration, A.R.; funding acquisition, A.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The datasets analyzed during the current study are not publicly available due to confidentiality and privacy restrictions associated with the analyzed construction projects. Requests for additional information may be directed to the authors.

Acknowledgments: The authors have reviewed and edited the output and take full responsibility for the content of this publication.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AEC	Architecture, Engineering and Construction
AI	Artificial Intelligence
BIM	Building Information Modeling
BIM-FM	Building Information Modeling for Facility Management
BMS	Building Management System
CDE	Common Data Environment
DT	Digital Twin
EIR	Employer's Information Requirements
FM	Facility Management
HBIM	Heritage Building Information Modeling
HVAC	Heating, Ventilation and Air Conditioning
IFC	Industry Foundation Classes
IoT	Internet of Things
ISO	International Organization for Standardization
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QA/QC	Quality Assurance/Quality Control
RACI	Responsible, Accountable, Consulted, Informed
WIP	Work In Progress

References

1. ISO 19650-1; Organization and Digitization of Information About Buildings and Civil Engineering Works, Including Building Information Modelling (BIM)-Information Management Using Building Information Modelling—Part 1: Concepts and Principles. International Organization for Standardization: Geneva, Switzerland, 2018.
2. Aleksandra, R. *System Zrównoważonego Zarządzania Budynkami z Zastosowaniem Technologii BIM i Platform CDE*; Wydawnictwa AGH: Kraków, Poland, 2025. Available online: <https://badap.agh.edu.pl/publikacja/165031> (accessed on 26 February 2026).
3. ISO 19650-3; Organization and Digitization of Information About Buildings and Civil Engineering Works, Including Building Information Modelling (BIM)-Information Management Using Building Information Modelling—Part 3: Operational Phase of the Assets. International Organization for Standardization: Geneva, Switzerland, 2020.

4. ISO 19650-4; Organization and Digitization of Information About Buildings and Civil Engineering Works, Including Building Information Modelling (BIM)—Information Management Using Building Information Modelling—Part 4: Information Exchange. International Organization for Standardization: Geneva, Switzerland, 2022.
5. Jaskula, K.; Kifokeris, D.; Papadonikolaki, E.; Rovas, D. Common Data Environments in construction: State-of-the-art and challenges for practical implementation. *Constr. Innov. Inf. Process Manag.* **2025**, *25*, 1522–1541. [\[CrossRef\]](#)
6. Seyis, S.; Özkan, S. Analyzing the Added Value of Common Data Environments for Organizational and Project Performance of Bim-Based Projects. *J. Inf. Technol. Constr.* **2024**, *29*, 247–263. [\[CrossRef\]](#)
7. Ozkan, S.; Seyis, S. Identification of Common Data Environment Functions During Construction Phase of BIM-based Projects. In Proceedings of the CIB W78-LDAC 2021, Luxembourg, 11–15 October 2021.
8. Losev, K.Y. The common data environment features from the building life cycle perspective. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *913*, 042012. [\[CrossRef\]](#)
9. Pham, T.A.; Likhitrungsilp, V.; Nguyen, T.A.; Ioannou, P. Common data environment of a BIM-based digital twin for real-time construction pollution management. *Eng. Constr. Arch. Manag.* **2025**, 1–32. [\[CrossRef\]](#)
10. Tao, X.; Das, M.; Liu, Y.; Cheng, J.C.P. Distributed common data environment using blockchain and Interplanetary File System for secure BIM-based collaborative design. *Autom. Constr.* **2021**, *130*, 103851. [\[CrossRef\]](#)
11. D’Uva, D.; Bolognesi, C. Low-cost Real-Time monitoring with BIM Integration in a Polluted Urban Environment. In *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences-ISPRS Archives*; International Society for Photogrammetry and Remote Sensing: Hannover, Germany, 2024; pp. 133–138. [\[CrossRef\]](#)
12. Kassem, M.; Kelly, G.; Dawood, N.; Serginson, M.; Lockley, S. BIM in facilities management applications: A case study of a large university complex. *Built Environ. Proj. Asset Manag.* **2015**, *5*, 261–277. [\[CrossRef\]](#)
13. EU BIM, Task Group. Just Published: Position Paper of the EU BIM Task Group on BIM for Public Procurement. Available online: <https://eubim.eu/just-published-position-paper-of-the-eu-bim-task-group-on-bim-for-public-procurement/> (accessed on 12 June 2026).
14. Ding, L.; Zhou, Y.; Akinci, B. Building Information Modeling (BIM) application framework: The process of expanding from 3D to computable nD. *Autom. Constr.* **2014**, *46*, 82–93. [\[CrossRef\]](#)
15. BuildEXT.com. Case Study—BIM-Based FM Implementation on a 32-Building University Campus-BuildEXT. Available online: <https://buildext.com/en/esettanulmany-bim-alapu-fm-bevezetese-32-epuletes-egyetemi-campus/> (accessed on 12 June 2026).
16. Dauda, J.A.; Bower, N.; Adebisi, W.A.; Saad, A.; Saka, A.B.; Kazemi, H.; Ajayi, S.O. Exploring the application of heritage building information modelling (HBIM) for heritage conservation: Insights from industry practitioners. *J. Arch. Conserv.* **2025**, *31*, 99–112. [\[CrossRef\]](#)
17. Autodesk.com. ISO 19650, the Common Data Environment, and Autodesk Construction Cloud | Autodesk University. Available online: <https://www.autodesk.com/autodesk-university/article/ISO-19650-Common-Data-Environment-and-Autodesk-Construction-Cloud> (accessed on 12 June 2026).
18. Hetherington, J.; West, M. *The Pathway Towards an Information Management Framework—A ‘Commons’ for Digital Built Britain*; Centre for Digital Built Britain: Cambridge, UK, 2020. [\[CrossRef\]](#)
19. “Dalux FM”. Available online: <https://www.dalux.com/pl/dalux-fm/> (accessed on 1 June 2026).
20. Patacas, J.; Dawood, N.; Kassem, M. BIM for facilities management: A framework and a common data environment using open standards. *Autom. Constr.* **2020**, *120*, 103366. [\[CrossRef\]](#)
21. Naticchia, B.; Corneli, A.; Carbonari, A. Framework based on building information modeling, mixed reality, and a cloud platform to support information flow in facility management. *Front. Eng. Manag.* **2020**, *7*, 131–141. [\[CrossRef\]](#)
22. ISO 19650-2; Organization and Digitization of Information About Buildings and Civil Engineering Works, Including Building Information Modelling (BIM)—Information Management Using Building Information Modelling—Part 2: Delivery Phase of the Assets. International Organization for Standardization: Geneva, Switzerland, 2018.
23. Jaskula, K.; Papadonikolaki, E.; Rovas, D. Comparison of current common data environment tools in the construction industry. In Proceedings of the European Conference on Computing in Construction, Crete, Greece, 10–12 July 2023. [\[CrossRef\]](#)
24. Bedoiseau, M.; Martin, D.; Boton, C. Use of KROQI as a Level-2 Common Data Environment in the French Construction Industry. *Sustainability* **2022**, *14*, 10455. [\[CrossRef\]](#)
25. ISO 19650-5; Organization and Digitization of Information About Buildings and Civil Engineering Works, Including Building Information Modelling (BIM)—Information Management Using Building Information Modelling—Part 5: Specification for Security-Minded Approach to Information Management. International Organization for Standardization: Geneva, Switzerland, 2020.
26. ISO 19650-6; Organization and Digitization of Information About Buildings and Civil Engineering Works, Including Building Information Modelling (BIM)—Information Management Using Building Information Modelling—Part 6: Health and Safety Information. International Organization for Standardization: Geneva, Switzerland, 2025.
27. Quinn, C.; Shabestari, A.Z.; Mistic, T.; Gilani, S.; Litoiu, M.; McArthur, J.J. Building automation system-BIM integration using a linked data structure. *Autom. Constr.* **2020**, *118*, 103257. [\[CrossRef\]](#)

28. Gonzalez, R. The Role of the Common Data Environment (CDE) in Strengthening BIM Methodology: Challenges and Opportunities for Latin America. Available online: <https://www.linkedin.com/pulse/role-common-data-environment-cde-strengthening-bim-cubillos-gonz%C3%A1lez-9tyhe/> (accessed on 12 June 2026).
29. Trimble.com. Understanding Common Data Environments in Construction|Trimble Resource Center. Available online: <https://www.trimble.com/blog/construction/en-US/article/what-is-a-common-data-environment-and-how-is-it-used-in-construction-2> (accessed on 12 June 2026).

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.