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Analyzing the Impact of ISO 16739-1:2024 (Industry Foundation Classes, IFC) on Data Sharing and Building Information Modeling (BIM) Collaboration in the Construction Industry

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Abstract

This study conducts a comprehensive analysis of ISO 16739-1:2024 (Industry Foundation Classes, IFC) within the context of Building Information Modeling (BIM) in the construction industry. By addressing six fundamental characteristics-key components, policy and regulatory impact, future outlook, benefits, challenges, and implementations-it evaluates the standard's role in enhancing data interoperability, efficiency, and collaboration. The findings highlight ISO 16739-1:2024's capacity to unify construction processes, improve decision-making, and promote sustainable practices through standardized data exchange. However, technical challenges, training requirements, and resistance to change remain barriers to its widespread adoption. Using case studies and systematic methodologies, this research emphasizes the standard's transformative potential and offers actionable recommendations to address implementation challenges. This study contributes significantly to academic literature and industry by bridging gaps in data sharing and fostering innovation in construction project management.

Keywords: *ISO 16739-1:2024, comprehensive analysis, international organization for standardization, industry foundation classes, construction industry.*

İnşaat Sektöründe ISO 16739-1:2024'ün (Endüstri Temel Sınıfları, IFC) Veri Paylaşımı ve Yapı Bilgi Modellemesi (BIM) İş Birliğine Etkisinin Analizi

Öz

Bu çalışma, ISO 16739-1:2024'ü (Endüstri Temel Sınıfları, IFC) inşaat sektöründeki Yapı Bilgi Modellemesi (BIM) bağlamında kapsamlı bir şekilde analiz etmektedir. Temel bileşenler, politika ve düzenleyici etkiler, gelecek görünümü, faydalar, zorluklar ve uygulamalar olmak üzere altı temel özelliği ele alarak, standardın veri uyumluluğunu, verimliliğini ve iş birliğini artırmadaki rolünü değerlendirmektedir. Bulgular, ISO 16739-1:2024'ün inşaat süreçlerini birleştirme, karar alma süreçlerini iyileştirme ve standartlaştırılmış veri paylaşımı yoluyla sürdürülebilir uygulamaları teşvik etme kapasitesini vurgulamaktadır. Ancak teknik zorluklar, eğitim ihtiyaçları ve değişime direnç, geniş çapta benimsenmesinde engel oluşturmaktadır. Vaka çalışmaları ve sistematik yöntemler kullanılarak yapılan bu araştırma, standardın dönüştürücü potansiyelini ortaya koymakta ve uygulama zorluklarının üstesinden gelmek için uygulanabilir öneriler sunmaktadır. Çalışma, veri paylaşımındaki boşlukları doldurarak ve inşaat proje yönetiminde yenilikçiliği teşvik ederek hem akademik literatüre hem de sektöre önemli katkılar sağlamaktadır.

Anahtar kelimeler: *ISO 16739-1:2024, kapsamlı analiz, uluslararası standardizasyon örgütü, endüstri temel sınıfları, inşaat sektörü.*

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1. Introduction

The construction industry has consistently sought innovative solutions to overcome challenges such as inefficiencies, inaccuracies, and limited collaboration among stakeholders. Building Information Modeling (BIM) has emerged as a transformative approach to address these issues by integrating data management and enhancing collaboration across the entire lifecycle of construction projects (Makisha, 2019; Spiridigliozzi et al., 2019). BIM is a process that enables the creation, management, and sharing of digital representations of the physical and functional characteristics of built assets (Panteli et al., 2020). Central to the success of BIM is the Industry Foundation Classes (IFC), formalized under the international standard ISO 16739-1:2024 (ISO16739-1, 2024). IFC provides a comprehensive data schema that facilitates seamless interoperability among various software platforms, ensuring that construction project data is consistently structured and universally accessible (Clemen, 2022; Honti et al., 2020). This symbiotic relationship between BIM and IFC enables more efficient project delivery by reducing errors, improving communication, and enhancing decision-making capabilities among project stakeholders (Brandenburger et al., 2021; Peng, 2020).

ISO 16739-1:2024 builds upon the limitations of earlier versions of IFC to address the growing demands of the construction industry. It offers a unified framework that promotes consistency and reliability in data exchange, aligning construction processes and practices on a global scale (Karlapudi & Menzel, 2020; Luca Guidi et al., 2022). While its potential for transformative impact is evident, the standard's implementation is not without challenges. Construction companies often face significant technical hurdles when integrating ISO 16739-1:2024 with existing legacy systems (Wildenauer & Basl, 2021). Additionally, the necessity for specialized training and resistance to change among some stakeholders represent barriers to its widespread adoption (Juszczyk, 2022; Karmakar & Delhi, 2023). Despite these obstacles, ISO 16739-1:2024 holds promise for addressing inefficiencies and advancing sustainable construction practices, particularly through its focus on standardized data sharing and enhanced collaboration (Sabaa et al., 2024; Shin et al., 2022).

This study aims to conduct a comprehensive analysis of ISO 16739-1:2024, examining its critical role in fostering interoperability, sustainability, and technological advancements in the construction industry. By identifying six fundamental characteristics—key components, policy and regulatory impact, future outlook, benefits, challenges, and implementations—this research addresses a significant gap in the academic literature (Cassandro et al., 2023; Wu et al., 2022). Furthermore, it provides insights into how ISO 16739-1:2024 aligns with the industry's evolving needs, paving the way for broader adoption of BIM technologies and standardized practices.

This study is organized into four main sections. The first section provides an introduction to the research along with a detailed literature review, examining the evolution and development of ISO 16739-1, its applications and benefits in BIM, and the challenges and future outlook related to its adoption. The second section outlines the material and method used in the study, including a step-by-step explanation of the phases undertaken during the comprehensive analysis. The third section presents the findings, categorized under six fundamental characteristics—key components, policy and regulatory impact, future outlook, benefits, challenges, and implementations—followed by an integrated discussion connecting these findings to broader industry implications. Finally, the fourth section concludes the study with an overview of key insights, practical recommendations for industry stakeholders, and suggestions for future research directions.

1.1 Literature Review

1.1.1 Evolution and development of ISO 16739-1

The International Organization for Standardization (ISO) has been instrumental in establishing standards that facilitate data sharing and integration in the construction industry. A pivotal achievement in this effort was the development of IFC, which has evolved through several iterations to enhance interoperability across the construction and facility management industries. This progression is visually summarized in Figure 1. The basis for ISO 16739-1 can be traced back to the early efforts of ISO Technical Committee 184 (ISO/TC184), established in 1983 to address automation systems and integration (ISO/TC184, 1983). Following this, the subcommittee ISO/TC 184/SC4 was formed in 1984 with a specific focus on industrial data, laying the groundwork for standardized data frameworks (ISO/TC184/SC4, 1984).

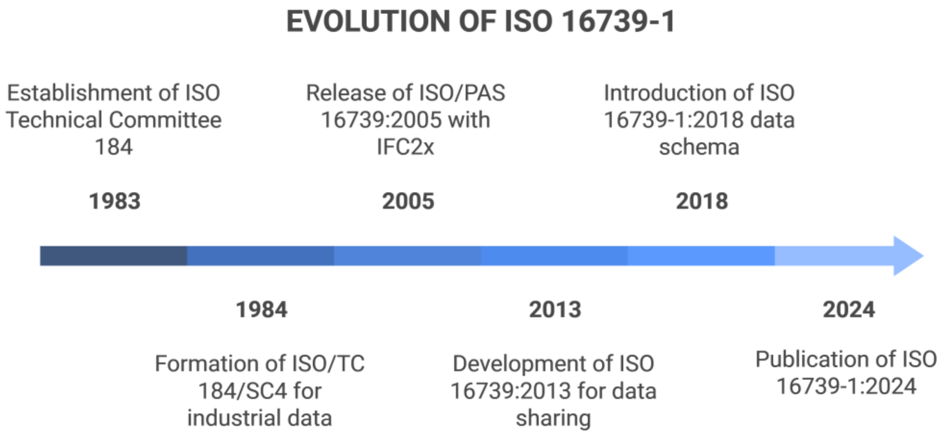

Figure 1. Evolution of ISO 16739-1 (Created by author).

The first major release in this evolution was the ISO/PAS 16739:2005, which introduced the IFC2x platform specification. However, this release was later withdrawn, marking a transition phase towards a more refined framework (ISO/PAS16739, 2005). Eventually, the standard evolved into ISO 16739:2013, specifically designed for data sharing in the construction and facility management industries. Although this version was also withdrawn, it introduced the foundational concepts and principles that would inform subsequent developments (ISO16739, 2013). The evolution and interrelationships of these versions are depicted in Figure 2 along with their references.

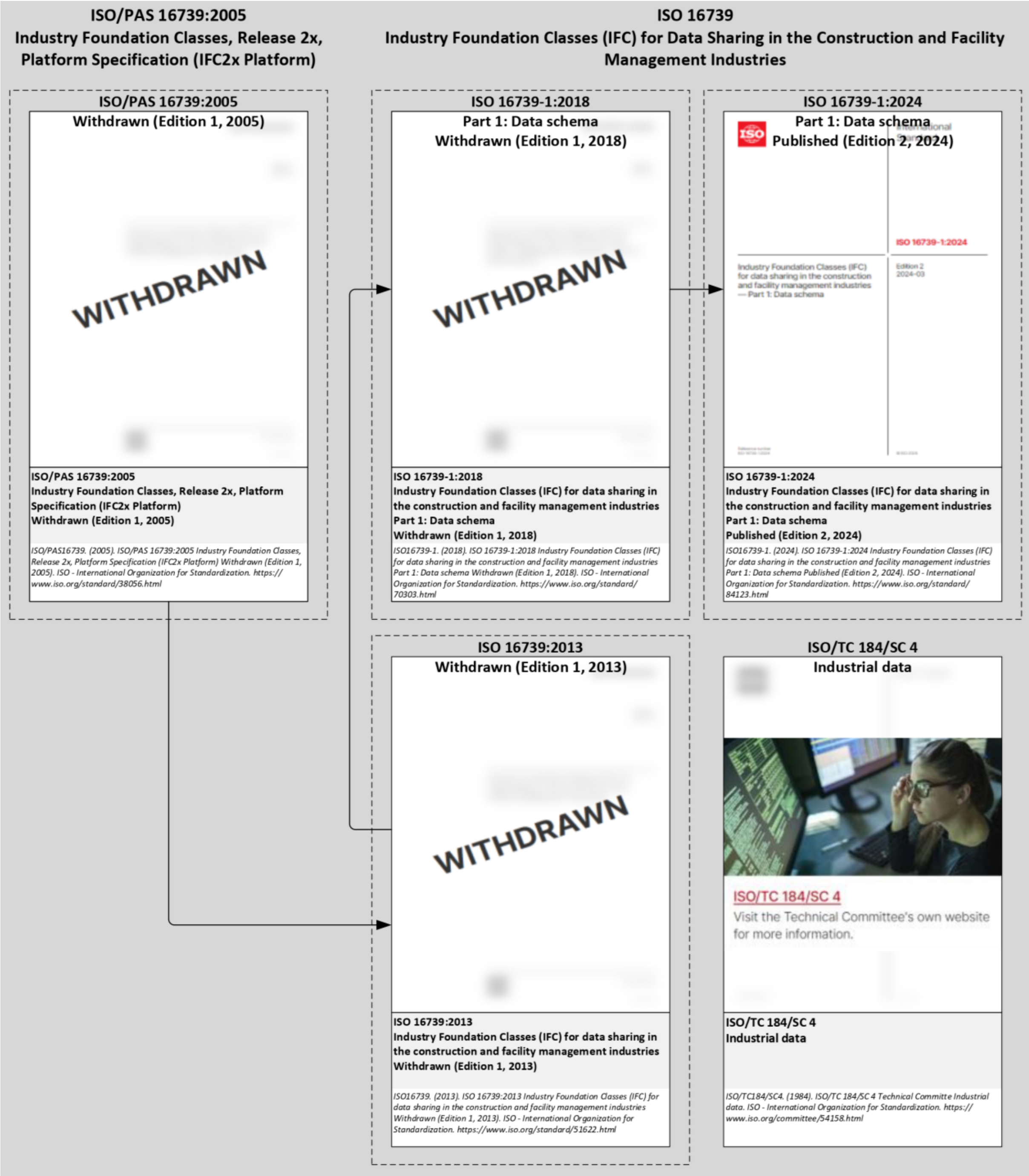

Figure 2. ISO 16739-1 (ISO/PAS16739, 2005; ISO/TC184/SC4, 1984; ISO/TC184, 1983; ISO16739-1, 2018, 2024; ISO16739, 2013) (Created by author).

As illustrated in Figure 2, ISO published ISO 16739-1:2018 in 2018, which introduced a data schema for IFC to facilitate data exchange within the construction industry (ISO16739-1, 2018). However, like its predecessors, this version was eventually withdrawn, giving way to the latest iteration, ISO 16739-1:2024, which aims to address previous limitations and improve usability and integration between various software applications within the construction industry. ISO 16739-1:2024 has recently been published and represents a significant update to the IFC framework. This 2024 version not only revitalizes the schema for data-sharing applications but also reflects the industry's growing need for advanced interoperability and data management solutions (ISO16739-1, 2024).

The ongoing developments in ISO 16739-1 highlight the critical need for standardized data exchange protocols to improve collaboration between various stakeholders on construction projects. The advances captured in ISO 16739-1 not only reflect an evolution that is responsive to industry needs but also serve as a cornerstone for establishing a cohesive digital ecosystem across the construction industry, ultimately contributing to improved project outcomes and efficient resource management. As these standards continue to evolve, they represent a critical aspect of the ongoing digital transformation in the construction industry.

1.1.2 Applications and benefits of ISO 16739-1 in BIM

The ISO 16739-1 standard plays a critical role in advancing BIM technologies by standardizing data exchange protocols, fostering interoperability, and streamlining project workflows in the construction industry. Makisha (2019) discusses a RuleML-based mechanism for verifying building information models, which aligns with the objectives of ISO 16739-1 by ensuring model integrity and enhancing BIM interoperability. Similarly, Pili (2019) highlights the versatility of BIM and the importance of standardized procedures such as those established by ISO 16739-1 for managing and sharing cultural information in architectural heritage projects. Spiridigliozzi et al. (2019) delve into how standardized frameworks like ISO 16739-1 are crucial for streamlining processes that contribute to energy efficiency in construction practices.

The automated verification of building components via BIM models and point clouds, as explored by Honti et al. (2020), further underscores the importance of ISO standards in minimizing errors and improving project outcomes in the construction industry. Karlapudi & Menzel (2020) discuss the automatic generation of Building Energy Performance Simulation models from BIM, demonstrating the benefits of using standardized data formats like those prescribed by ISO 16739-1 to facilitate efficiency in energy assessments. Panteli et al. (2020) provide a critical review of BIM applications in smart buildings, linking their effectiveness to standardized data exchange protocols, reinforcing the significance of ISO standards for coordinated workflows from design to commissioning, as visually depicted in Figure 3, which provides a timeline of studies related to ISO 16739-1.

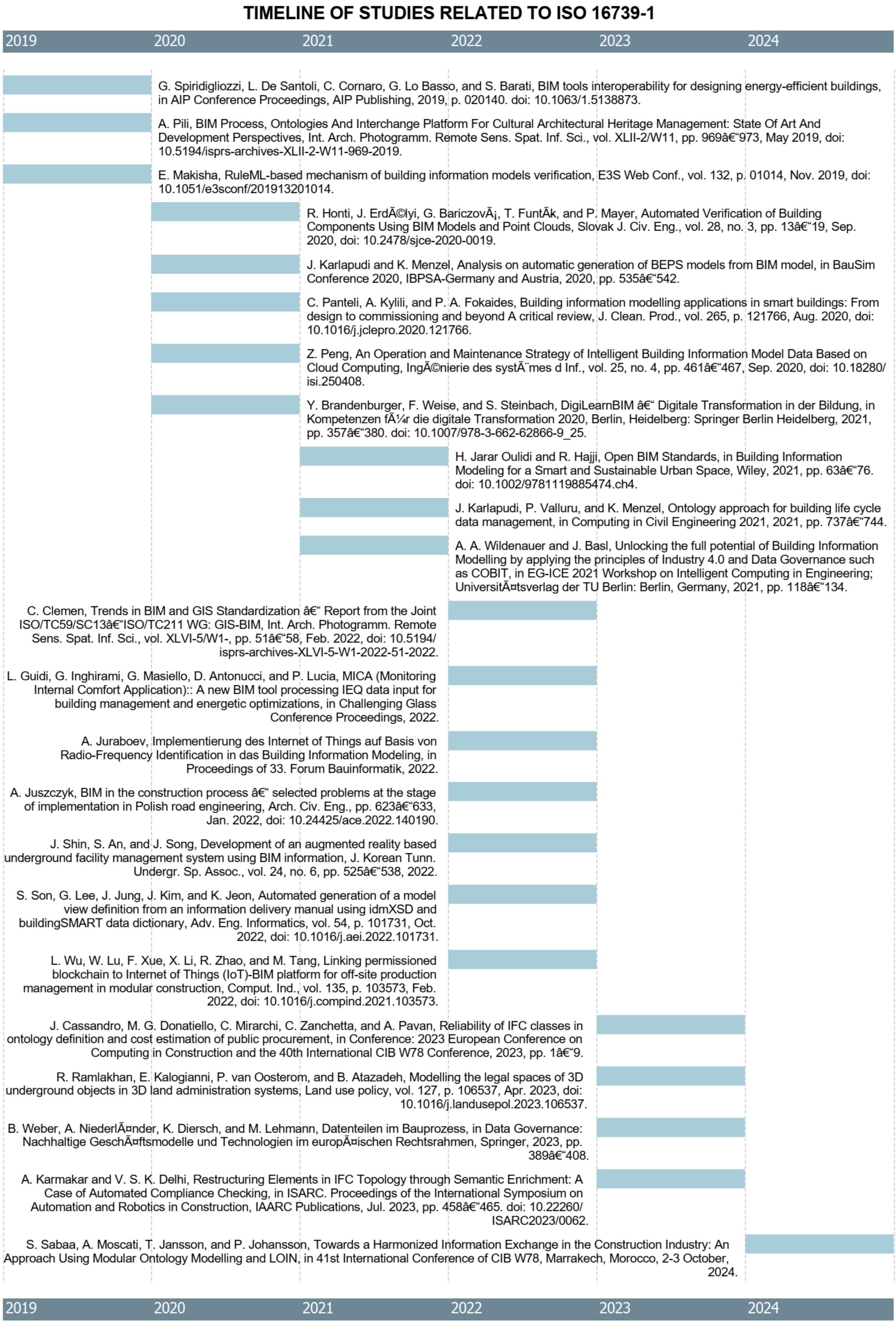

Figure 3. Timeline of studies related to ISO 16739-1 (Created by author).

Research by Peng (2020) places emphasis on operational strategies for intelligent building information models, highlighting how ISO 16739-1 can affect maintenance and data management in construction projects. The intersection of education and BIM is examined by Brandenburger et al. (2021), who stress the need for developing competencies aligned with standards like ISO 16739-1 to keep pace with the digital transformation in the construction industry. Jarar Oulidi & Hajji (2021) explore openBIM standards, which effectively connect to ISO 16739-1 by establishing a framework for interoperability and collaboration across various stakeholders in the construction industry.

Wildenauer & Basl (2021) argue that applying principles of Industry 4.0 and data governance, as proposed by ISO standards, can unlock the comprehensive potential of BIM technologies. Furthermore, Karlapudi et al. (2022) present an ontology approach to building lifecycle data management, showcasing how ISO frameworks can enhance data management practices across different stages of construction. Clemen (2022) reports on trends in BIM and GIS standardization, noting that joint efforts involving ISO standards are critical in achieving efficient integration and functionality across various systems in the construction industry. Guidi et al. (2022) introduce new BIM tools for indoor environmental quality assessments, which rely on data formats aligned with ISO 16739-1 for accurate reporting and management.

1.1.3 Challenges and future outlook in standard adoption

While ISO 16739-1 provides significant advancements, its adoption is not without challenges. The exploration of challenges in implementing BIM in Polish road engineering by Juszczyk (2022) highlights the necessity of standardization to overcome common barriers within the construction process. Juraboev (2022) emphasizes the implementation of IoT technology in BIM, arguing that standardization is necessary for seamless data integration and functionality, which ISO 16739-1 facilitates. Shin et al. (2022) detail an augmented reality system for underground facility management using BIM information, pointing to ISO standards as a foundational aspect for effective integration and utilization of cutting-edge technologies. The study by Son et al. (2022) on automated model view definition generation underscores the relevance of standardized information delivery mechanisms, including those provided by ISO 16739-1. Wu et al. (2022) connect permissioned blockchain technology with BIM platforms, emphasizing how ISO standards can guide interoperability in off-site production management within modular construction.

Cassandro et al. (2023) highlight the reliability of IFC classes in ontology definition and cost estimation, stressing that adherence to ISO standards is vital for accurate and effective public procurement processes. Karmakar & Delhi (2023) present advances in IFC topology through semantic enrichment, illustrating the need for continuous adaptation and alignment with ISO standards to enhance automated compliance checking in construction. Ramlakhan et al. (2023) explore the modeling of legal spaces in land administration systems, which can benefit significantly from standardized practices outlined in ISO 16739-1. Weber et al. (2023) discuss legal governance for BIM, advocating for an understanding of rights management and lawful data use in line with ISO standards to promote compliant BIM practices. Finally, Sabaa et al. (2024) propose a harmonized information exchange approach using modular ontology modeling, which aligns with ISO 16739-1 to improve collaboration and data sharing across the construction industry. These developments reflect the necessity of continuous updates to ISO standards to address the evolving challenges of a digitized construction environment, as summarized in Figure 3.

2. Material and Method

This study employs comprehensive analysis method, a systematic approach designed to offer a multidimensional understanding of the subject matter. This method enables researchers to comprehensively examine a topic by combining multiple perspectives and dimensions, including historical background, current state, and future implications (Kokkos, 2010). It is particularly effective for identifying key components, analyzing impacts, and exploring potential challenges and benefits. Through this approach, a holistic view of the subject is achieved, leaving no critical aspect unexamined (Dallı & Soyluk, 2024; Kalkan & Türker, 2023; Schaffernicht & Groesser, 2011). By synthesizing various data points, the comprehensive analysis method ensures that the findings are not only academically rigorous but also practically applicable.

In this study, the comprehensive analysis method was utilized to examine the ISO 16739-1:2024 standard applied in the construction industry, with the aim of addressing the gap in the academic literature regarding this standard, published in 2024. By conducting a detailed analysis, the study seeks to provide a thorough understanding of the standard's applications, challenges, and potential contributions. To achieve the research objectives, six fundamental characteristics of ISO 16739-1:2024 were identified and analyzed: key components, policy and regulatory impact, future outlook, benefits, challenges, and implementations, as depicted in Figure 4. This approach not only enhances the depth of the research but also aligns with the study's aim to present a holistic perspective.

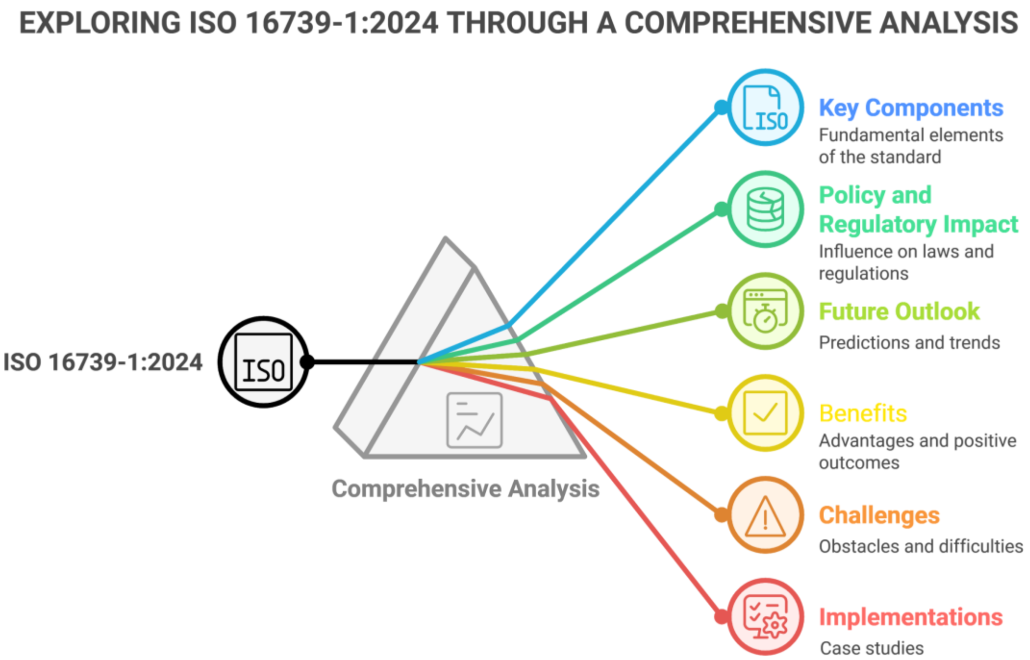

Figure 4. Comprehensive analysis of ISO 16739-1:2024 (Created by author).

2.1. Phases of the Method

The method of this study is organized into distinct phases to ensure a systematic and thorough exploration of ISO 16739-1:2024. These phases include data collection and analysis, justification for the selected method, and the visualization of findings. As shown in **Figure 5**, Each phase plays a critical role in achieving the research objectives and is detailed below:

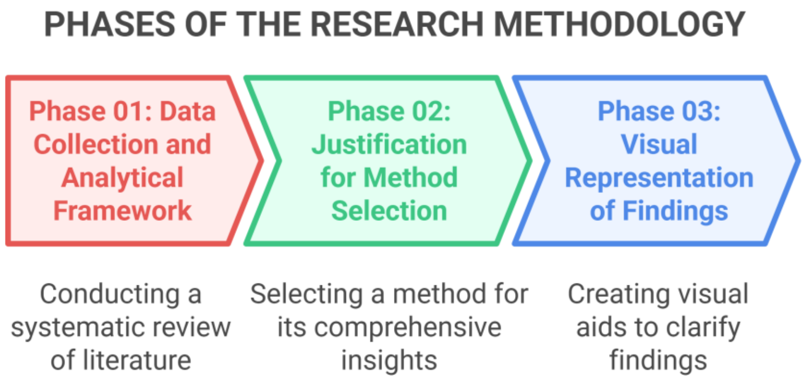

Figure 5. Phases of the research methodology (Created by author).

- **Phase 01: Data Collection and Analytical Framework**

The research incorporates a systematic review of academic and technical literature relevant to ISO 16739-1:2024. The collected data was organized and analyzed within the framework of the six identified characteristics. This structured approach ensures that the findings provide a comprehensive understanding of the standard's role in the construction industry.

- **Phase 02: Justification for Method Selection**

The comprehensive analysis method was chosen for its ability to systematically address multiple dimensions of a complex topic, offering both theoretical insights and practical solutions. By thoroughly examining the multifaceted aspects of ISO 16739-1:2024, the study aims to contribute valuable knowledge to both the academic community and industry professionals. The method's structured framework also ensures that the findings are reliable, detailed, and relevant for future applications.

- **Phase 03: Visual Representation of Findings**

To enhance clarity, the findings of this study were visualized using tools such as Microsoft Visio and Napkin software (Napkin, 2024; Visio, 2024). For instance, Figure 4 illustrates the interconnectedness of the six fundamental characteristics of ISO 16739-1:2024, providing readers with an intuitive understanding of the research outcomes. These visual aids were designed to complement the written analysis and make complex relationships more accessible.

3. Findings and Discussion

This section serves to bridge the comprehensive analysis of ISO 16739-1:2024 with its broader implications for the construction industry. By presenting the six fundamental characteristics identified during the analysis, this section aims to provide a detailed evaluation of the standard's features and their practical impact. Furthermore, the discussion contextualizes these findings within current industry trends, addressing both the strengths of ISO 16739-1:2024 and the potential challenges associated with its implementation. This holistic approach not only highlights the standard's transformative potential but also underscores areas requiring further attention and refinement.

3.1. Findings

A comprehensive analysis of ISO 16739-1:2024 has identified six fundamental characteristics that are explained in detail below.

3.1.1. Key components

ISO 16739-1:2024 focuses on defining the critical information required throughout the lifecycle of buildings and infrastructure, ensuring consistency in data exchange (ISO16739-1, 2024). As illustrated in Figure 6, three key components underpin this standard: IFC Schema, Information Requirements, and Application Domains. Below, these components are explained in detail.

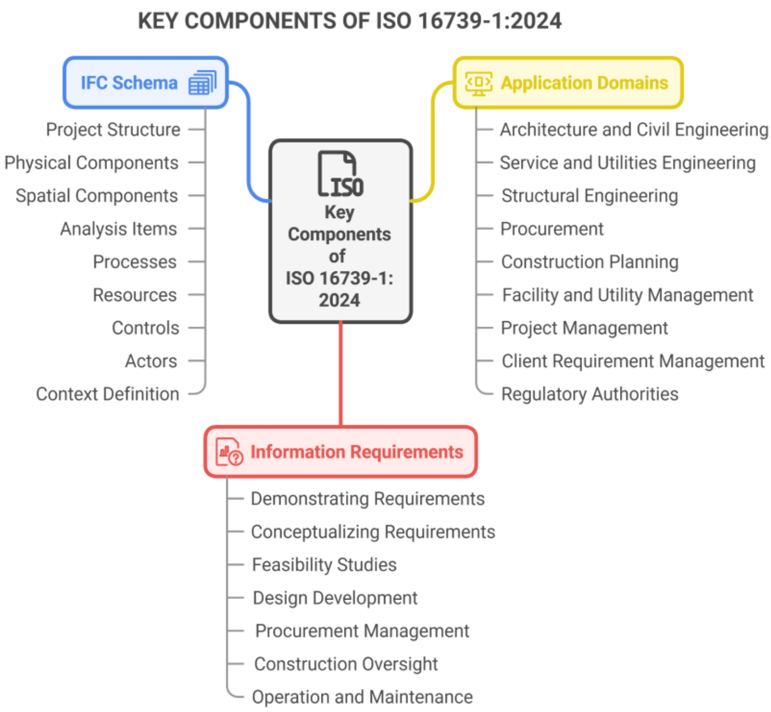

Figure 6. Key components of ISO 16739-1:2024 (Created by author).

- **IFC Schema**

The IFC Schema serves as the backbone of ISO 16739-1:2024, offering a comprehensive structure for defining and organizing building elements and their relationships. As illustrated in Figure 6, the schema encompasses critical components such as project structure, physical and spatial elements, analytical items, processes, resources, controls, actors, and contextual definitions (ISO16739-1, 2024). These components collectively enable a standardized framework for information exchange.

The schema supports a wide range of entities, including but not limited to walls, windows, beams, doors, stairs, ceilings, and spaces. Each entity is meticulously characterized by attributes such as material properties, dimensions, performance metrics, and spatial relationships. By defining both physical characteristics and interrelationships, the IFC Schema provides a holistic view of construction projects, facilitating collaboration and reducing misunderstandings among stakeholders.

One of the key advantages of the IFC Schema is its extensibility. As the construction industry evolves, the schema can accommodate emerging needs by incorporating new entity types and properties. This adaptability ensures its continued relevance and usability, making it a pivotal tool for enhancing BIM capabilities and improving project outcomes.

- **Information Requirements**

As shown in Figure 6, Information Requirements are critical to the lifecycle phases of construction projects, from early conceptualization to long-term operation and maintenance. This component defines the specific types of information needed at each stage, ensuring clarity and precision in data exchange.

The phases addressed include feasibility studies, conceptual and detailed design, procurement, construction, and maintenance operations (ISO16739-1, 2024). For each phase, the Information Requirements component establishes a clear framework for collecting, organizing, and disseminating data. This standardized approach not only streamlines project workflows but also reduces risks associated with inconsistent or incomplete information.

Furthermore, the emphasis on timely and accurate data supports better decision-making, improves project control, and minimizes the likelihood of rework. By standardizing information flows, ISO 16739-1:2024 helps project teams stay aligned and efficiently achieve their objectives.

- **Application Domains**

The Application Domains component outlines the diverse fields where ISO 16739-1:2024 can be applied, catering to the varied needs of stakeholders throughout the construction lifecycle. Figure 6 illustrates how this component addresses the requirements of disciplines such as architectural design, civil and structural engineering, utilities management, project management, and regulatory compliance (ISO16739-1, 2024).

In architectural design, for example, the standard aids in creating detailed BIM models that incorporate geometric, spatial, and aesthetic information. For structural engineering, it facilitates the integration of detailed analysis models with architectural designs, enabling seamless coordination and reducing conflicts. Similarly, in regulatory processes, ISO 16739-1:2024 ensures that submissions meet consistent data standards, expediting approvals and reducing bureaucratic delays.

By establishing a unified framework, the Application Domains component promotes interdisciplinary collaboration, enhances communication, and minimizes errors across project phases. Its focus on standardized practices ensures that all stakeholders can effectively contribute to and benefit from the shared BIM environment.

3.1.2. Policy and regulatory impact

The policy and regulatory impact highlight the broader implications of ISO 16739-1:2024. As seen in Figure 7, it promotes regulatory compliance, guides government initiatives, and encourages sustainable construction practices and environmental benefits. ISO 16739-1:2024 is essential for regulatory compliance in the construction industry as it provides a comprehensive data exchange framework that aligns with building regulations, including safety, planning, fire protection, accessibility, and environmental standards (ISO16739-1, 2024; buildingSMART, 2024). By standardizing the data exchange process, it ensures that all stakeholders adhere to the necessary legal requirements throughout the lifecycle of construction projects. For example, the framework facilitates the documentation of fire safety measures and accessibility features in compliance with local and international building codes (Karmakar & Delhi, 2023). This not only improves the safety and quality of construction projects but also helps avoid potential legal penalties for non-compliance.

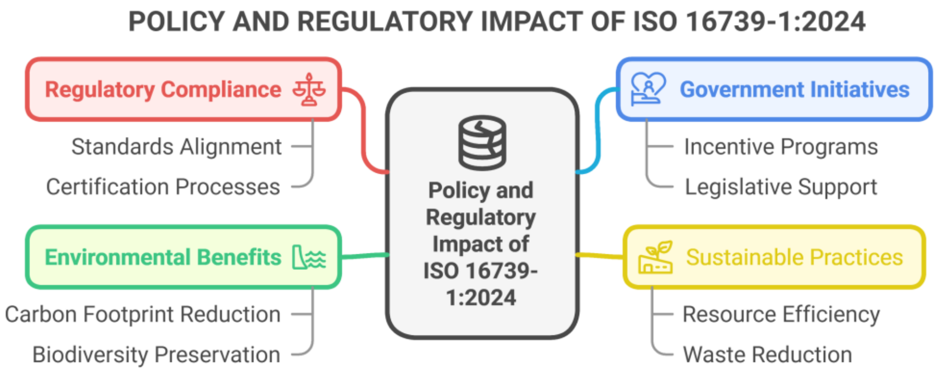

Figure 7. Policy and regulatory impact of ISO 16739-1:2024 (Created by author).

Additionally, as demonstrated in Figure 7, government initiatives have recognized the importance of ISO 16739-1:2024 by incorporating its principles into policies and providing incentives for its adoption. These initiatives aim to enhance project efficiency, reduce delays, and improve construction quality by establishing a unified approach to data management. Moreover, ISO 16739-1:2024 fosters sustainable construction practices by offering a standardized database for the analysis of energy-efficient designs, sustainable material selection, and waste reduction strategies. It supports the modeling of building performance, enabling stakeholders to optimize energy usage and minimize environmental impacts. The standard's framework encourages the use of energy-efficient systems and environmentally friendly materials, which not only reduce ecological footprints but also align with regulatory sustainability goals.

3.1.3. Future outlook

ISO 16739-1:2024 is poised to meet future expectations in the construction industry by focusing on technological advancements, global adoption, and continuous improvement, as illustrated in Figure 8. Innovations such as the Internet of Things (IoT) and Artificial Intelligence (AI) integrated with ISO 16739-1:2024 promise transformative impacts on project management and data sharing. For instance, AI enhances decision-making by analyzing complex project data, while IoT devices provide real-time insights by monitoring equipment, systems, and construction sites within the IFC framework.

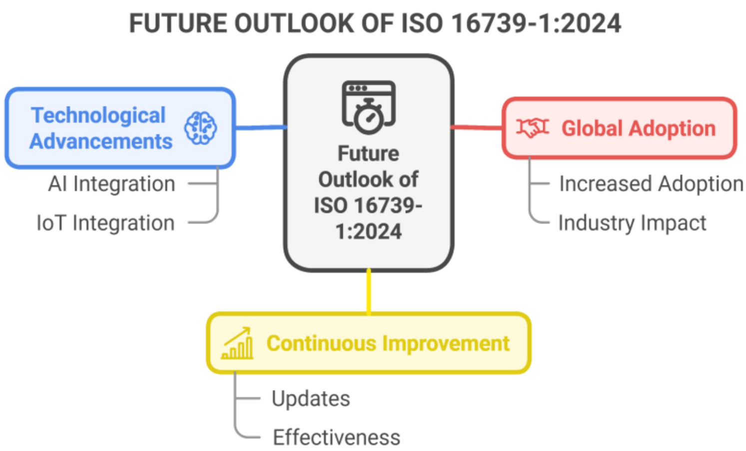

Figure 8. Future outlook of ISO 16739-1:2024 (Created by author).

As digitalization accelerates in the construction industry, the global adoption of ISO 16739-1:2024 is expected to rise. Construction companies recognizing the benefits of standardized data exchange will increasingly align with IFC standards, gaining a competitive edge in global projects. For example, companies adhering to ISO 16739-1:2024 have demonstrated improved project efficiency and seamless cross-border collaboration.

Continuous improvement forms the backbone of ISO 16739-1:2024's evolution. Regular updates by governing bodies and stakeholders address industry needs, resolve emerging challenges, and integrate cutting-edge technologies. As highlighted in Figure 8, these efforts ensure adaptability to sustainability demands, including carbon footprint reduction and resource optimization. By staying relevant to global trends, ISO 16739-1:2024 supports the construction industry's transition toward sustainable and resilient infrastructure.

3.1.4. Benefits

The ISO 16739-1:2024 standard offers several key benefits to the construction industry, as depicted in Figure 9. Chief among these is its ability to enhance interoperability, enabling seamless data exchange across diverse BIM software platforms and reducing project delays due to compatibility issues. This results in improved data accuracy and ensures that stakeholders can rely on consistent, high-quality project information. The standard also fosters optimized collaboration among project participants by providing a unified framework for coordination. Teams can work more effectively, irrespective of their technical expertise or software preferences, thereby reducing miscommunication and aligning project goals.

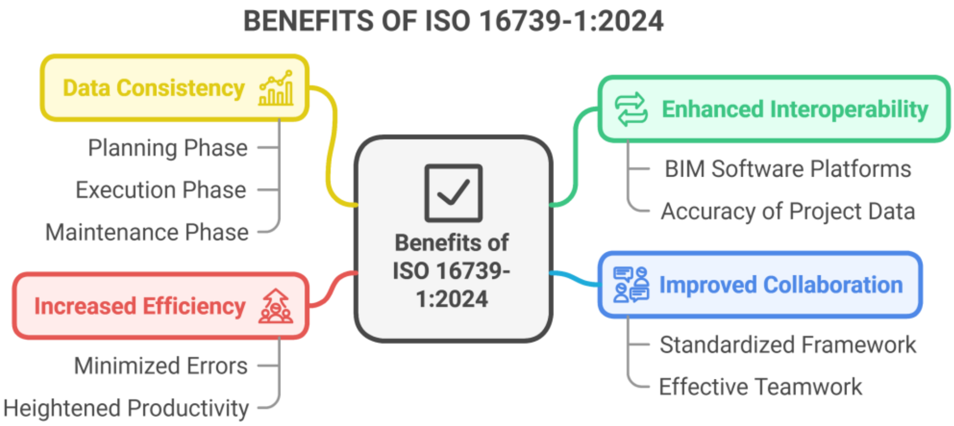

Figure 9. Benefits of ISO 16739-1:2024 (Created by author).

Another significant benefit is the streamlining of workflows. By minimizing errors in data processing and enhancing productivity, ISO 16739-1:2024 empowers construction teams to execute projects with greater efficiency. Simultaneously, the standard guarantees consistency of information throughout all project phases, from planning to maintenance. This ensures that critical data remains accessible and standardized, facilitating seamless transitions across the project lifecycle. Figure 9 illustrates these benefits, emphasizing how interoperability, collaboration, efficiency, and consistency converge to drive better project outcomes. Collectively, these advantages establish ISO 16739-1:2024 as a cornerstone for advancing digitalization and integration in the construction industry.

3.1.5. Challenges

The implementation of ISO 16739-1:2024 in the construction industry introduces several significant challenges, as illustrated in Figure 10. Technical hurdles arise from the necessity of integrating this standard with pre-existing systems and software across diverse construction projects. For example, ensuring compatibility between legacy software tools and ISO 16739-1:2024 can be both time-intensive and resource-demanding, making workflow efficiency and data consistency difficult to maintain.

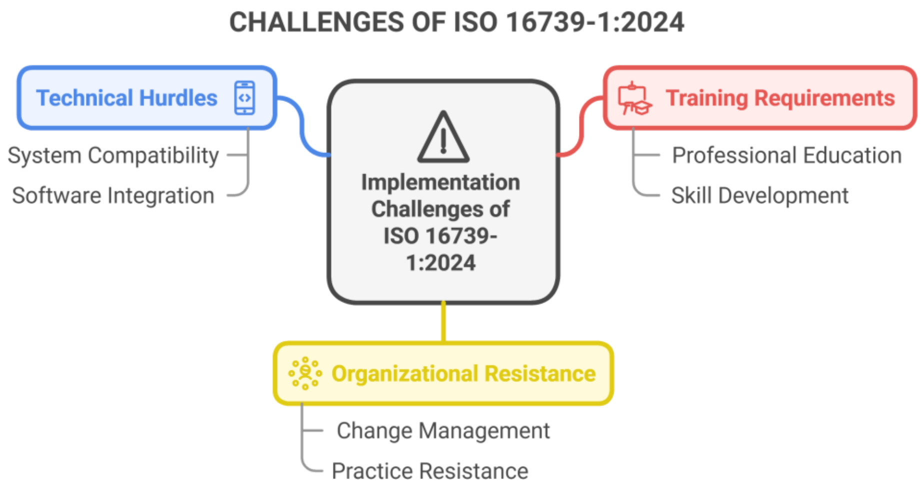

Figure 10. Challenges of ISO 16739-1:2024 (Created by author).

Training requirements further underscore the need for extensive education and skill development among industry professionals. Without adequate training programs, stakeholders may struggle to adopt the standard effectively, leading to inefficiencies during its implementation phase. Organizational resistance remains a significant barrier, encompassing both cultural resistance and the inertia of traditional practices. For many companies, the adoption of ISO 16739-1:2024 demands changes to well-established workflows. These changes can be perceived as disruptive, resulting in reluctance or outright opposition to adopting the new standard.

As shown in Figure 10, these challenges collectively highlight the complexities of implementing ISO 16739-1:2024. Left unaddressed, they could hinder the full realization of the standard's potential, leading to missed opportunities for productivity gains, cost savings, and improved collaboration. Addressing these obstacles requires a strategic approach, including technical support, targeted training programs, and effective change management strategies.

3.1.6. Implementations

Successful implementations of ISO 16739-1:2024 can be analyzed through detailed case studies, such as the Transport for New South Wales (TfNSW) project in Australia. As depicted in Figure 11, TfNSW has established itself as a benchmark for the effective application of this standard. By mandating IFC for future projects, TfNSW developed a comprehensive digital engineering framework that enhances interoperability and efficiency through open data exchange and consistent data structures (buildingSMART, 2024).

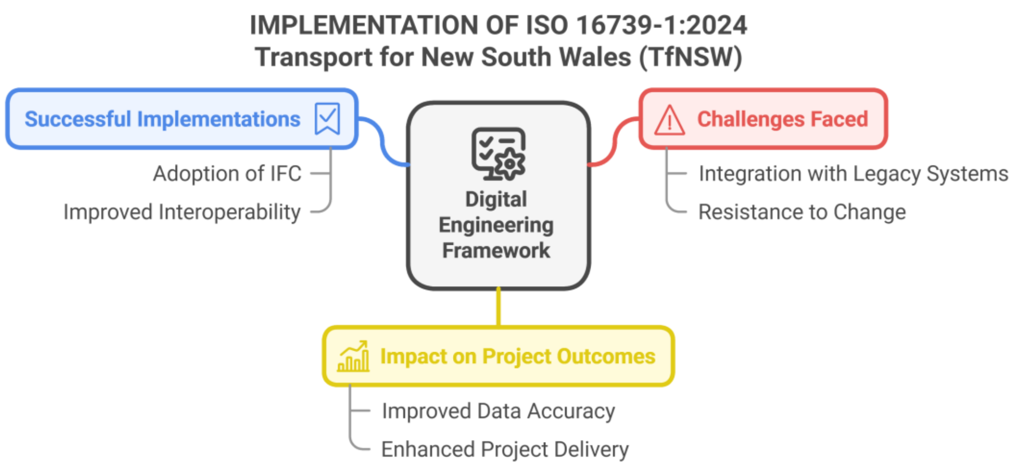

Figure 11. Implementation of ISO 16739-1:2024 at TfNSW (buildingSMART, 2024) (Created by author).

The implementation process was not without its challenges. Integrating the IFC data model with existing systems demanded significant technical expertise and effort. Additionally, resistance from project teams unfamiliar with the new standards highlighted the importance of robust training and change management strategies (buildingSMART, 2024). Despite these hurdles, the benefits of implementing ISO 16739-1:2024 at TfNSW have been substantial. Data accuracy and project delivery timelines improved significantly, leading to fewer errors and enhanced project quality through reliable data exchange. For example, standardized workflows reduced rework rates and increased stakeholder collaboration.

Figure 11 illustrates the critical steps in this implementation process, emphasizing how TfNSW successfully transitioned to ISO 16739-1:2024 while navigating its associated challenges. This case study not only demonstrates the potential of the standard to transform project outcomes but also offers valuable lessons for its broader adoption in the construction industry.

3.2. Discussion

The findings highlight the pivotal role of ISO 16739-1:2024 in addressing the complexities of information management in the construction industry. By standardizing data exchange protocols through its IFC Schema, the standard not only facilitates seamless interoperability among BIM software platforms but also ensures data consistency across project phases. This consistency enhances decision-making, minimizes errors, and fosters collaboration among diverse stakeholders, effectively streamlining workflows. Furthermore, the emphasis on Information Requirements and Application Domains demonstrates the adaptability of ISO 16739-1:2024 in catering to the diverse needs of construction professionals while promoting effective coordination across multidisciplinary teams.

Despite its significant benefits, challenges such as technical integration, training requirements, and organizational resistance remain critical barriers to its widespread adoption. The Transport for New South Wales case study underscores these challenges but also illustrates the tangible benefits of implementing ISO 16739-1:2024, including improved data accuracy, project efficiency, and quality. The standard's alignment with regulatory frameworks further emphasizes its capacity to enhance compliance and promote sustainable construction practices. As the industry moves toward greater digitalization, the potential for integrating ISO 16739-1:2024 with emerging technologies such as IoT and AI presents an exciting opportunity for continuous improvement and global adoption.

In conclusion, ISO 16739-1:2024 embodies a transformative approach to construction project management by addressing present inefficiencies and paving the way for future innovations. While overcoming implementation challenges is essential, the standard's focus on interoperability, sustainability, and adaptability positions it as a cornerstone for advancing the construction industry's digital transformation.

4. Conclusion and Suggestions

The Industrial Foundation Classes (IFC) defined in ISO 16739-1:2024 represent a significant advance in the development of collaboration and data sharing in the construction industry. This standard enables project stakeholders to exchange information seamlessly throughout the project lifecycle and utilize this data effectively. In this study, the ISO 16739-1:2024 standard was analyzed through a comprehensive review to provide a holistic understanding of its impact on the construction industry. During the research process, six fundamental characteristics of this standard were clearly identified: key components, policy and regulatory impact, future outlook, benefits, challenges, and implementations.

The findings highlighted the importance of ISO 16739-1:2024 in defining information requirements and its critical role in ensuring consistency in data exchange throughout the lifecycle of buildings as well as infrastructure. The impact of the standard on regulatory compliance, technological developments, and global adoption was emphasized, demonstrating its potential to deliver significant improvements in project management and data sharing.

In addition, the study summarized, in detail, the many benefits of ISO 16739-1:2024, such as improved interoperability, increased collaboration, higher efficiency, and consistent data management. However, the challenges associated with integrating this standard into existing systems were also considered, as well as factors such as the need for training and organizational resistance. As demonstrated in the Transport for New South Wales (TfNSW) project, the successful implementation of ISO 16739-1:2024 has further reinforced the value of the standard in improving data accuracy and project delivery. Despite the obstacles encountered, the benefits from the adoption of ISO 16739-1:2024 far outweigh the challenges posed, making it a critical framework for the future of the construction industry.

Overall, this analysis underlines the importance of ISO 16739-1:2024 in promoting sustainable, efficient, and collaborative practices in the construction industry. As the industry continues to evolve and embrace digitalization, the adoption and continuous improvement of this standard will play a crucial role in shaping the future of construction. In this context, it is becoming essential for the construction industry to adopt this standard to harmonize with international standards and improve information sharing.

4.1. Practical Suggestions

To fully leverage the benefits of ISO 16739-1:2024, stakeholders in the construction industry are encouraged to prioritize the adoption of this standard to improve data interoperability, accuracy, and efficiency. Investing in training programs will help project teams master the IFC schema, facilitate integration into existing workflows, and reduce resistance to change. Collaboration with software developers is essential for ensuring compatibility between BIM tools, which can maximize the advantages of this standard. Additionally, industry associations and regulatory bodies should actively support the implementation of ISO 16739-1:2024 through policies, incentives, and initiatives that promote best practices. By embracing this standard, the construction industry can enhance project delivery, ensure regulatory compliance, and foster innovation through sustainable practices.

4.2. Suggestions for Future Studies

Future research should focus on evaluating the real-world impact of ISO 16739-1:2024 through case studies in diverse geographic regions, assessing its adoption challenges and success factors. Comparative analyses of its integration with other BIM standards can offer insights into more cohesive and comprehensive data-sharing strategies. Moreover, further studies could explore the long-term implications of ISO 16739-1:2024 on digital twin technologies and their role in optimizing lifecycle management in the construction industry.

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References

Brandenburger, Y., Weise, F., & Steinbach, S. (2021). DigiLearnBIM – Digitale Transformation in der Bildung. *In Kompetenzen für die digitale Transformation 2020* (pp. 357–380). Springer Berlin Heidelberg. Access Address (01.12.2024): https://doi.org/10.1007/978-3-662-62866-9_25

buildingSMART. (2024). Global IFC Mandates 2024 Edition: A playbook of IFC Mandates from around the world. *BuildingSMART International*. Access Address (01.12.2024): https://www.buildingsmart.org/wp-content/uploads/2024/10/IFC-Mandate-Final-1.pdf#page=3.00

Cassandro, J., Donatiello, M. G., Mirarchi, C., Zanchetta, C., & Pavan, A. (2023). Reliability of IFC classes in ontology definition and cost estimation of public procurement. In Conference: 2023 European Conference on Computing in Construction and the 40th International CIB W78 Conference (pp. 1-9). nHeraklion, Crete, Greece. Access Address (01.12.2024): https://re.public.polimi.it/bitstream/11311/1256381/1/EC3_RELIABILITY%20OF%20IFC%20CLA

SSES%20IN%20ONTOLOGY%20DEFINITION%20AND%20COST%20ESTIMATION%20OF%20PUBLIC%20PROCUREMENT.pdf

Clemen, C. (2022). Trends in BIM and GIS standardization – report from the joint ISO/TC59/SC13–ISO/TC211 WG: GIS-BIM. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLVI-5/W1-, 51–58. Access Address (01.12.2024): https://doi.org/10.5194/isprs-archives-XLVI-5-W1-2022-51-2022

Dallı, M., & Soyluk, A. (2024). Damage catalogue software and the role of architecture & architects: a comprehensive review. *Mimarlık Bilimleri ve Uygulamaları Dergisi (MBUD),* 9(Special Issue), 22–40. Access Address (01.12.2024): https://doi.org/10.30785/mbud.1317394

Eremenco, S. L., Cella, D., & Arnold, B. J. (2005). A comprehensive method for the translation and cross-cultural validation of health status questionnaires. *Evaluation & the Health Professions,* 28(2), 212–232. Access Address (01.12.2024): https://doi.org/10.1177/0163278705275342

Guidi, L., Inghirami, G., Masiello, G., Antonucci, D., & Lucia, P. (2022). MICA (Monitoring Internal Comfort Application):: A new BIM tool processing IEQ data input for building management and energetic optimizations. *In Challenging Glass Conference Proceedings (Vol. 8).* Access Address (01.12.2024): https://doi.org/10.47982/cgc.8.399

Honti, R., Erdélyi, J., Bariczová, G., Funtík, T., & Mayer, P. (2020). Automated verification of building components using bim models and point clouds. *Slovak Journal of Civil Engineering,* 28(3), 13–19. Access Address (01.12.2024): https://doi.org/10.2478/sjce-2020-0019

ISO/PAS16739. (2005). ISO/PAS 16739:2005 industry foundation classes, release 2x, platform specification (IFC2x platform) withdrawn (edition 1, 2005). *ISO - International Organization for Standardization.* Access Address (01.12.2024): https://www.iso.org/standard/38056.html

ISO/TC184. (1983). ISO/TC 184 technical committee automation systems and integration. *ISO - International Organization for Standardization.* Access Address (01.12.2024): https://www.iso.org/committee/54110.html

ISO/TC184/SC4. (1984). ISO/TC 184/SC 4 technical committee industrial data*. ISO - International Organization for Standardization.* Access Address (01.12.2024): https://www.iso.org/committee/54158.html

ISO16739. (2013). ISO 16739:2013 industry foundation classes (IFC) for data sharing in the construction and facility management industries withdrawn (edition 1, 2013). *ISO - International Organization for Standardization.* Access Address (01.12.2024): https://www.iso.org/standard/51622.html

ISO16739-1. (2018). ISO 16739-1:2018 industry foundation classes (IFC) for data sharing in the construction and facility management industries part 1: data schema withdrawn (edition 1, 2018). *ISO - International Organization for Standardization.* Access Address (01.12.2024): https://www.iso.org/standard/70303.html

ISO16739-1. (2024). ISO 16739-1:2024 industry foundation classes (IFC) for data sharing in the construction and facility management industries part 1: data schema published (edition 2, 2024). *ISO - International Organization for Standardization.* Access Address (01.12.2024): https://www.iso.org/standard/84123.html

Jarar Oulidi, H., & Hajji, R. (2021). Open BIM standards. in building information modeling for a smart and sustainable urban space (pp. 63–76). *Wiley.* Access Address (01.12.2024): https://doi.org/10.1002/9781119885474.ch4

Juraboev, A. (2022). Implementierung des Internet of Things auf Basis von Radio-Frequency Identification in das Building Information Modeling. Proceedings of 33. Forum Bauinformatik. Access Address (01.12.2024): https://mediatum.ub.tum.de/doc/1688408/document.pdf

Juszczyk, A. (2022). BIM in the construction process – selected problems at the stage of implementation in Polish road engineering. *Archives of Civil Engineering,* 623–633. Access

Address (01.12.2024): https://doi.org/10.24425/ace.2022.140190

Kalkan, M., & Türker, H. B. (2023). Exploring the resilience of natural disasters: a comprehensive bibliometric analysis. *Mimarlık Bilimleri ve Uygulamaları Dergisi (MBUD),* 8(Special Issue), 26–41. Access Address (01.12.2024): https://doi.org/10.30785/mbud.1335211

Karlapudi, J. & Menzel, K. (2020, September). Analysis on automatic generation of BEPS models from BIM model. *In BauSim Conference 2020* (Vol. 8, pp. 535-542). IBPSA-Germany and Austria. Access Address (01.12.2024): https://doi.org/10.3217/978-3-85125-786-1-64

Karlapudi, J., Valluru, P., & Menzel, K. (2022). Ontology approach for building life cycle data management. *Computing in Civil Engineering 2021,* 737–744. Access Address (01.12.2024): https://doi.org/10.1061/9780784483893.091

Karmakar, A., & Delhi, V. S. K. (2023). Restructuring elements in IFC topology through semantic enrichment: a case of automated compliance checking. *ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction,* 40, 458–465. Access Address (01.12.2024): https://doi.org/10.22260/ISARC2023/0062

Kokkos, A. (2010). Transformative learning through aesthetic experience. *Journal of Transformative Education*, 8(3), 155–177. Access Address (01.12.2024): https://doi.org/10.1177/1541344610397663

Lyu, M. R., Jiqiang Song, & Min Cai. (2005). A comprehensive method for multilingual video text detection, localization, and extraction. *IEEE Transactions on Circuits and Systems for Video Technology,* 15(2), 243–255. Access Address (01.12.2024): https://doi.org/10.1109/TCSVT.2004.841653

Makisha, E. (2019). RuleML-based mechanism of building information models verification. E3S Web of Conferences, 132, 01014. doi: https://doi.org/10.1051/e3sconf/201913201014

Napkin. (2024). Napkin AI. Access Address (01.12.2024): https://www.napkin.ai

Panteli, C., Kylili, A. & Fokaides, P. A. (2020). Building information modelling applications in smart buildings: From design to commissioning and beyond critical review. *Journal of Cleaner Production,* 265, 121766. Access Address (01.12.2024): https://doi.org/10.1016/j.jclepro.2020.121766

Peng, Z. (2020). An operation and maintenance strategy of intelligent building information model data based on cloud computing. *Ingénierie Des Systèmes d Information*, 25(4), 461–467. Access Address (01.12.2024): https://doi.org/10.18280/isi.250408

Pili, A. (2019). BIM process, ontologies and interchange platform for cultural architectural heritage management: state of art and development perspectives. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* XLII-2/W11, 969–973. Access Address (01.12.2024): https://doi.org/10.5194/isprs-archives-XLII-2-W11-969-2019

Ramlakhan, R., Kalogianni, E., van Oosterom, P., & Atazadeh, B. (2023). Modelling the legal spaces of 3D underground objects in 3D land administration systems. *Land Use Policy,* 127, 106537. Access Address (01.12.2024): https://doi.org/10.1016/j.landusepol.2023.106537

Sabaa, S., Moscati, A., Jansson, T., & Johansson, P. (2024). Towards a harmonized information exchange in the construction industry: an approach using modular ontology modelling and loin. 41st International Conference of CIB W78, Marrakech, Morocco, 2-3 October. Access Address (01.12.2024): https://itc.scix.net/pdfs/w78-2024-paper_66.pdf

Schaffernicht, M., & Groesser, S. N. (2011). A comprehensive method for comparing mental models of dynamic systems. *European Journal of Operational Research*, 210(1), 57–67. Access Address (01.12.2024): https://doi.org/10.1016/j.ejor.2010.09.003

Shin, J., An, S., & Song, J. (2022). Development of an augmented reality based underground facility management system using BIM information. Journal of Korean Tunnelling and Underground

Space Association, 24(6), 525–538. Access Address (01.12.2024): https://doi.org/10.9711/KTAJ.2022.24.6.525

Son, S., Lee, G., Jung, J., Kim, J., & Jeon, K. (2022). Automated generation of a model view definition from an information delivery manual using idmXSD and buildingSMART data dictionary. *Advanced Engineering Informatics*, 54, 101731. Access Address (01.12.2024): https://doi.org/10.1016/j.aei.2022.101731

Spiridigliozzi, G., De Santoli, L., Cornaro, C., Basso, G. Lo, & Barati, S. (2019). BIM tools interoperability for designing energy-efficient buildings. *AIP Conference Proceedings,* 2191(1), 020140. Access Address (01.12.2024): https://doi.org/10.1063/1.5138873

Visio. (2024). Microsoft Visio. Access Address (01.12.2024): https://www.microsoft.com/tr-tr/microsoft-365/visio/flowchart-software

Weber, B., Niederländer, A., Diersch, K., & Lehmann, M. (2023). Datenteilen im Bauprozess. *In Data Governance: Nachhaltige Geschäftsmodelle und Technologien im europäischen Rechtsrahmen* (pp. 389–408). Springer. Access Address (01.12.2024): https://doi.org/10.1007/978-3-662-67556-4

Wildenauer, A. A., & Basl, J. (2021). Unlocking the full potential of building information modelling by applying the principles of industry 4.0 and data governance such as COBIT. *EG-ICE 2021 Workshop on Intelligent Computing in Engineering; Universitätsverlag Der TU Berlin*: Berlin, Germany, 118–134. Access Address (01.12.2024): https://books.google.com.tr/books?hl=tr&lr=&id=5mJMEAAAQBAJ&oi=fnd&pg=PA118&dq=Wildenauer,+A.+A.,+%26+Basl,+J.+(2021).+Unlocking+the+full+potential+of+building+information+modelling+by+applying+the+principles+of+industry+4.0+and+data+governance+such+as+COBIT.+EG-ICE+2021+Workshop+on+Intelligent+Computing+in+Engineering%3B+Universitätsverlag+Der+TU+Berlin:+Berlin,+Germany,+118–134.+&ots=WkpHZOdADW&sig=-D8uGDfVpR8x92vnJpEuFQTH5jU&redir_esc=y#v=onepage&q&f=false

Wu, L., Lu, W., Xue, F., Li, X., Zhao, R., & Tang, M. (2022). Linking permissioned blockchain to Internet of Things (IoT)-BIM platform for off-site production management in modular construction. *Computers in Industry,* 135, 103573. Access Address (01.12.2024): https://doi.org/10.1016/j.compind.2021.103573