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DIGITALIZATION AND PROCUREMENT IN CONSTRUCTION PROJECTS: AN INTEGRATED BIM-BASED APPROACH

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Bruno C. Matos
Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal
bruno.carvalho.matos@tecnico.ulisboa.pt

Carlos O. Cruz
Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal
oliveira.cruz@tecnico.ulisboa.pt

Fernando B. Branco
Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal
fernando.branco@tecnico.ulisboa.pt

SUMMARY: *The procurement for construction works has been limited in recognizing and integrating the influence of digitalization, particularly through Building Information Modeling (BIM), and thereby capitalizing on its benefits. Hence, a comprehensive and practical framework, coupled with proper documentation, is vital for enhancing not only the effectiveness of BIM-based procurement processes but also ensuring a successful BIM implementation. Despite its significance, the literature remains scarce, particularly in addressing the integration of BIM-specific provisions with conventional construction procurement methods, within the constraints of public procurement. This research introduces a systematic approach for integrating BIM requirements into traditional tendering processes for construction works, applicable to both the public and private sectors, serving as a reference guide for contracting authorities. For this purpose, the following methodology was adopted: 1) conducting an extensive literature review; 2) carrying out interviews with construction experts to identify relevant procurement requirements within a BIM-specific environment; 3) developing a comprehensive BIM-integrated tendering framework, combined with the traditional processes and cross-referenced with recognized BIM standards and public procurement regulations, especially the ISO 19650 standards and the European Directive 2014/24/EU; 4) creating a model BIM specifications document (corresponding to the exchange information requirements), to be used by the contracting authority, according to the previously defined framework; 5) discussing the application and limitations of the proposed BIM-based procurement methodology, along with considerations for future research. In conclusion, to address current limitations, including the absence of BIM-specific procurement guidelines in related standards and regulations, this paper outlines a comprehensive solution for this problem, considering the traditional procurement workflow and documentation, namely the tender and specifications documents, with a particular emphasis on the latter, which includes the exchange information requirements (EIR) and shapes the competitive dynamics of the tendering process. While information from traditional 2D drawings usually takes precedence over that from BIM models, the author believes that a fully contractual BIM implementation and success depend on the opposite scenario.*

KEYWORDS: *building information modeling (BIM), construction, european directive 2014/24/EU, exchange information requirements (EIR), information exchange, information requirements, procurement.*

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1. INTRODRUCTION

Procurement, as the process of locating and agreeing to terms and purchasing goods, services, or other works from an external source, often with the use of a tendering or competitive bidding process, plays a pivotal role in driving digital innovation within the construction industry. Through a proper contractor selection process, contracting authorities (CA) can more confidently choose partners who will be committed to pushing the boundaries of digital technologies to develop more sustainable projects and achieve better value for money (Pérez et al, 2021).

Integrating digitalization into construction projects enables the mitigation of project delivery issues while enhancing cost-effectiveness, productivity, precision, communication, and overall efficiency (Cheng et al, 2016). However, to be effective, it requires a comprehensive procurement process with specific and well-defined requirements, particularly from the CA's perspective, who determines who will do what, when and how throughout the development of the construction project. This becomes relevant in cases of implementing the methodology known as Building Information Modeling (BIM), which presupposes alignment with certain standardization and collaboration protocols to avoid fragmented applications that, ultimately, result in three-dimensional models with no added value.

Nevertheless, the practices and processes for procuring contractors in the construction industry, often derived from those employed in the public sector, have remained largely unchanged. This has prompted a series of studies examining the integration of BIM into construction procurement processes. These studies have illuminated the potential of BIM to enhance project efficiency, reduce costs, and effectively address information asymmetry challenges within procurement strategies. Whether pioneering structured methodologies for the Canadian construction industry (Porwal et al, 2013), extending insights to diverse European contexts (Popov et al, 2021), refining BIM requirements in Spanish public tenders (Pérez et al, 2021), employing longitudinal approaches to track BIM adoption (Gurevich et al, 2020), or highlighting the synergy between relational contracting and BIM (Marino et al, 2021), this body of work have collectively provided a BIM-based procurement roadmap for industry practitioners.

However, previous studies have revealed certain limitations, ranging from small sample sizes and restricted geographic scope to short-term outcomes and limited generalizability, as well as regulation and legal barriers (Gurevich, et al 2020, Marinho, et al 2021). This underscores the need for additional research to bridge these gaps and further enrich the field of BIM adoption in construction procurement.

One of the gaps stems from the lack of evidence, particularly from the CA's perspective, regarding BIM-specific approach and requirements and how to seamlessly integrate them into traditional construction tendering processes. This integration is especially challenging when considering standards such as the ISO 19650 series, which encompass guidelines aimed at assisting all parties in "achieving their business objectives through the effective and efficient procurement, use, and management of information during the delivery phase of assets" (CEN, 2018a). In other words, a comprehensive, detailed and field-tested framework for BIM-integrated tendering, in line with internationally referenced BIM standards, that could serve as a reference guide for CAs, is still absent in practice.

Another gap consists in the non-consideration of specific constraints in public procurement, as outlined by directives such as the European Directive 2014/24/EU (Directive, 2014), which indirectly shapes how BIM requirements can be integrated with the public tender processes and documents. Notably, the public sector is not only the largest customer in the construction industry but also a significant influencer of the private sector, emphasizing its role as a driver of change.

This study aims to address the aforementioned gaps by introducing a comprehensive and systematic approach to integrating BIM requirements into construction works tendering processes for both the public and private sectors, in accordance with ISO 19650 standards and the European Directive 2014/24/EU, thus serving as a reference guide for CA. To achieve this, the process involved an extensive literature review and a series of interviews with national and international construction experts, with the goal of identifying a suitable approach for incorporating and combining BIM with traditional requirements, ultimately leading to the development of a comprehensive BIM-integrated tendering framework. Subsequently, general guidelines for a BIM specifications document, as the CA's information requirements, are proposed. The study concludes by emphasizing its key points and limitations, and suggesting areas for future research.

The paper is organized as follows: section 2 establishes the relevant theoretical background on BIM global progress and practices, particularly in the public procurement field; section 3 presents the adopted research methodology; section 4 introduces the significant concepts and principles for BIM-based procurement, exploring its incorporation and combination with the traditional tender process and documentation, from the CA's perspective; section 5 proposes a BIM specifications document; and, finally, section 6 concludes. Acknowledging that private procurement often lacks specific regulations and frequently refers to public standards, this paper is primarily founded on principles derived from the public sector, particularly those outlined by the European Directive 2014/24/EU.

2. LITERATURE REVIEW

In the era of digitalization, the construction industry undergoes a significant transformation, with BIM leading the way towards enhanced efficiency and collaboration. BIM revolutionizes how built assets are conceived, designed, and operated, offering integrated digital platforms that streamline processes and enrich decision-making. Conventional approaches, reliant on disjointed methods and paper documentation, increasingly yield to the cohesive, data-driven environments enabled by BIM.

However, the adoption of BIM in procurement encounters multifaceted challenges. While some nations mandate BIM for public projects, others lag behind, resulting in a fragmented landscape across Europe. The European Directive 2014/24/EU acknowledges the potential of digital methodologies like BIM to innovate procurement but falls short of enforcing their use, leaving member states to navigate integration independently.

Contractual complexities arise as traditional agreements struggle to accommodate BIM's collaborative nature, often leading to disputes. Key contractual aspects, including structure, relationships, and ownership, require nuanced consideration to ensure seamless BIM implementation. Methodological intricacies in the public tender process, such as delineating competitive and non-negotiable aspects, further complicate BIM's integration. Additionally, current practices often treat BIM as complementary rather than integral, resulting in inefficiencies. While guidelines exist for resolving conflicts between BIM and non-BIM documentation, achieving comprehensive integration demands systematic approaches.

In essence, BIM in construction procurement presents both opportunities and challenges, emphasizing the need to establish a robust theoretical framework for its seamless integration into traditional practices. Drawing from a comprehensive literature review, the following sections delve into the complexities of this integration by illuminating the intricate dynamics between conventional methodologies and emerging digital technologies within the context of BIM, thus providing the theoretical foundation for the present study.

2.1 Building Information Modeling (BIM)

According to ISO 19650-1 (CEN, 2018b), BIM entails "the use of a shared digital representation of a built asset to facilitate design, construction, and operation processes to form a reliable basis for decisions.". In this sense, BIM relies on advanced information technologies to create and manage three-dimensional models that can incorporate all pertinent data on built assets throughout their lifecycle. This methodology helps overcome certain inefficiencies of traditional processes, which often lack cohesion, with participants frequently depending on conventional paper-based methods and two-dimensional file formats. The absence of collaboration and standardization in traditional approaches often leads to errors, omissions, and incompatibilities. This, in turn, can result in conflicts, delays, and cost overruns, particularly during the construction phase.

There are countries already mandating BIM for certain types of public construction projects, including Finland, Sweden, the UK, France, Italy, and Russia (McAuley et al, 2017). Others, such as Germany and Spain, are actively implementing BIM programs with the aim of enacting future mandates (Popov, et al 2021, Garcia, et al 2021). Meanwhile, countries such as Portugal, Switzerland and Belgium have no planned BIM mandates.

Thus, the implementation of BIM, especially across Europe, remains notably fragmented.

The European Directive 2014/24/EU merely suggests that "member states may require the use of specific electronic tools, such as building information electronic modeling tools or similar" or, more broadly, that "functional and performance-related requirements are also appropriate means to favor innovation in public procurement and should be used as widely as possible". Additionally, the directive underscores that "public procurement is crucial for driving innovation, which holds great importance for future growth in Europe".

Therefore, the European Directive does not establish any specific or mandatory requirements for BIM adoption in public works contracts, nor does it influence the public tender process with respect to BIM criteria. Similarly, European Union countries like Portugal, where local legislation primarily stems from European directives, do not explicitly integrate detailed BIM considerations into their public legal frameworks, although some initiatives have been undertaken. For instance, the Portuguese Public Contracts Code, introduced by Decree-Law 18/2008 (Decree-Law, 2008), which governs the procurement and execution of public contracts in Portugal, even considering the several amendments it has undergone since its publication, only states that, in the formation of public construction contracts, specific electronic means for modeling construction data should be used whenever possible. Other examples are the Portuguese Ordinance 255/2023 (Ordinance, 2023), which pertains to the development of public projects design and facultatively proposes the use of BIM models in the development of public projects design, and the Decree-Law 10/2024 ((Decree-Law, 2024), which only mandates the submission of the architectural design in an open data format and in accordance with the BIM methodology for urban licensing purposes by 2030.

Nevertheless, according to the standard ISO 19650-2 (CEN, 2018a), BIM should be integrated as far as possible with existing processes for technical procurement. Therefore, during the preparation of the bidding documents, the CA shall consider the necessary BIM requirements and determine the most effective way to put them into operation.

While the standard offers general recommendations for BIM-specific workflows and documentation, it does not provide specific and practical guidance on which requirements to incorporate and how to seamlessly integrate them with traditional documentation to ensure an effective BIM-based tender process.

For instance, from the CA's perspective, there are no specific and practical referencing guidelines prescribing how to build the EIR and how to integrate them with traditional specifications and tender documents. Even considering more specific normative references, such as the CEN/TR 17439 (CEN, 2020a), which provides guidance on implementing ISO 19650 parts 1 and 2, and the CEN/TR 17654 (CEN, 2021), consisting of guidelines for the implementation of EIRs and BEPs, although they can be a useful complement, they are not pragmatic enough to fully address the challenge at hand.

2.2 BIM in public procurement

Public procurement plays an essential role in fostering innovation and promoting the broader adoption of BIM, while also ensuring the more cost-effective use of taxpayers' money.

However, there are still many public procurers who, whenever possible, avoid developing their projects using BIM processes for various reasons. Firstly, there is a perception that the technological and staffing efforts required for developing BIM-based proposals are too high. Secondly, there is often a shortage of staff capable of effectively introducing and implementing BIM. Lastly, there is a general lack of standardized requirements, and there is not a clear understanding of the benefits derived from BIM utilization (Schwerdtner, 2018).

BIM integration into the tender processes faces significant challenges, largely due to contractual issues. Traditional contracts are not well-suited to handle BIM implementation, and their failure to adapt to the collaborative nature of BIM can result in contractual disputes and conflicts. These factors impede the effective utilization and promotion of the advantages of BIM (Majzoub, et al 2021, Ragab, et al 2021). Several authors have explored issues arising from the insufficient incorporation of BIM into contractual terms and conditions (Alwash, et al 2017, Chong, et al 2017, Celoza, et al 2021).

Key contractual aspects to be considered include: 1) structure and policy of the contract, 2) contractual relationships and obligations, 3) information security, and 4) ownership (Chong et al, 2017).

Regarding the first aspect, including BIM as part of the contract provides the advantage of enhanced work coordination and improved communication among various stakeholders (Celoza et al, 2021). Nevertheless, traditional contract frameworks are not inherently designed to accommodate BIM requirements. BIM implementation introduces new risks, such as additional workload derived from conflict detection, often not accounted for in the initial contract amount (Ragab et al, 2021). Therefore, it becomes essential to develop alternative contract structures that comprehensively and transparently address these issues.

Concerning the second aspect, it is known that the absence or unclear definition of contractual relationships and obligations can result in a lack of legal liability, potentially leading to conflicts between parties (Ragab, et al 2021, Chong et al 2017).

Thirdly, as BIM models' information is digitalized and parameterized, it can be easily extracted and either wholly or partially reused. This introduces a new concern related to information security: how to safeguard BIM model data. Therefore, it becomes important to establish a data management policy that spans all stages of project development, aiming to prevent the exchange of unnecessary or incorrect information. (Chong et al, 2017).

Lastly, another issue that may arise when incorporating BIM into contracts relates to the ownership of generated models. This is particularly relevant to designers and involves concerns about the potential loss of their intellectual property rights. What makes the ownership of models in BIM projects more complex is the collaborative development involving multiple parties, each of whom may claim ownership of their contributions. Therefore, it is important to specify the intellectual property rights of each team in the contracts to prevent future conflicts (Ragab et al, 2021).

Considering the above, for proper BIM introduction and implementation, it is essential to identify a suitable approach for integrating and harmonizing BIM with traditional processes and requirements. This includes adapting the structure of traditional contracts, particularly in the case of public procurement.

2.3 Public tender process

According to European Directive 2014/24/EU, when awarding contracts for public construction projects, several options can be considered. These options range from directly assigning contracts to soliciting bids based on prior qualifications or conducting a public tendering process. The selection of the most suitable procedure depends on various factors, including the estimated contract value, the complexity of the project, the nature of the works involved, the need to ensure fair competition, and the urgency for completing the project.

Among these procedures, public tendering is a common choice. However, it is subject to specific regulations and must adhere to a particular set of rules and procedures, as outlined by governing authorities.

To begin with, it is essential to define the scope of the contract, which includes details such as the design of the construction project. Secondly, it is necessary to specify the supply conditions through a comprehensive specifications document, clearly outlining what is required, including details of all obligations and responsibilities of both the contractor and the CA. The specifications document can be divided into two main sections: general clauses, covering administrative aspects such as deadlines, payment terms, and insurance requirements; and special clauses, addressing the more technical aspects of executing the construction works. Finally, the tender document must be prepared, setting out the framework for managing the tender process, which includes specifying conditions, deadlines, and the format for proposal submissions.

These documents are integral parts of the invitation to tender, which is officially launched through a public announcement.

During the bidding process, tenderers can submit requests for information, that will be addressed by the CA.

After receiving the proposals, a public event is convened to open them, and a committee appointed by the CA, known as the opening committee, oversees this procedure. This committee evaluates the qualifications of competitors and the content of their proposals exclusively by cross-referencing the submitted documents, until a final decision is reached.

After concluding this step, an evaluation committee, previously appointed by the CA, can begin its work. This work can be broken down into two phases: the selection phase, where screening criteria are applied, and the contract award phase, where evaluation criteria come into play. The selection phase primarily involves a pre-qualification stage aimed at excluding firms that do not meet pre-established financial and/or technical requirements, while the contract award phase serves as the pivotal stage.

The evaluation committee may collaborate with experts who specialize in the technical analysis of the proposals and may request clarifications from competitors regarding any uncertainties in the interpretation of submitted materials. Additionally, they may collect information from external sources to assess the actual financial and technical capabilities of the competitors.

The evaluation committee is mandated to support their analysis through evaluation reports, which are then distributed to all competitors for their input. After receiving and analyzing competitors' comments, the committee is expected to formulate a final proposal for submission to the CA.

Following this stage, crucial steps unfold until the contract is awarded.

The CA conducts a review of the final proposal, considering the evaluation committee's findings and recommendations.

In cases where contracts are complex or specific terms require clarification, there may be a negotiation with the selected contractor. This phase aims to resolve outstanding issues, ensure mutual agreement on the contract's terms, and achieve clarity.

Once the CA is satisfied with the final proposal and any necessary negotiations have concluded, the process proceeds to award the contract to the chosen contractor. The contract award typically involves the issuance of an official contract document.

These sequential steps encompass the entire journey, starting with bidding preparation and culminating in the formal award of the contract. The specific duration and complexities of each step can vary depending on factors such as the contract's intricacy, applicable legal requirements, and the unique characteristics of the project.

2.4 Methodological particularities

According to the principles of transparency and competition, as advocated in the European Directive 2014/24/EU, the preparation of the bidding process and its procedural documents is crucial. This is not only to ensure that competitors are immediately aware of the “rules of the game”, but also because bidding documentation will become part of the construction contract in the event of an award, and the contract is a binding agreement that the contractor must comply with under the applicable law.

In this context, in particular, a thorough understanding of the methodological intricacies of the specifications document is pivotal, as it shapes the competitive dynamics of the procurement process and encompasses contractual clauses that will be integrated into the future agreement.

Within the specifications document, a crucial distinction emerges between aspects subject to competition and those exempt from it, which can vary depending on the contract's specificities and the rules established by the CA.

One of the most prominent examples of aspects open to competition is the pricing proposal put forth by the CA. In this scenario, various bidders submit their pricing proposals, each striving to offer the most advantageous terms. There are also other possible negotiable conditions for potential contractors, which can encompass, for instance, the timeline of contract deliverables or their technical and functional characteristics.

In contrast, certain aspects of the contract, such as compliance with legal or safety standards, may be non-negotiable and therefore not open to competitive bidding. These conditions are typically defined by setting specific minimum or maximum limits that all bidders must adhere to, regardless of competition.

Any proposals that, upon analysis, reveal attributes that violate the established reference parameters in the specifications or contain any terms or conditions that violate aspects not subjected to competition will be excluded.

The primary concerns in the preparation of construction specifications typically revolve around aspects related to measurement methods, payment amounts, payment schedules, discounts, and price revisions. However, under the applicable legislation, many other factors can or shall be considered. In the case of Portugal, for instance, reference can be made to the Ordinance 959/2009 (Ordinance, 2009), which provide a template for specifications concerning public construction contracts.

All in all, the completeness and precision of the specifications document are crucial to prevent or mitigate issues related to errors and omissions, which can lead to accountability for both the contractor and the owner, potentially resulting in conflicts, delays, and increased costs. The concept of errors and omissions in the procedural documents can encompass aspects or data that prove to be inconsistent with reality; the type or quantity of works strictly necessary for the complete execution of the contract; technical conditions for executing the contract scope that the interested party does not deem feasible; as well as errors or omissions of the technical design that do not fall under the previous conditions.

The tender document indicates aspects such as the documents that must be included in the tender proposal, the submission deadline, and the evaluation methodology for awarding the contract. This is always done with the assurance that any specific rules concerning the public tender procedure, deemed necessary by the CA, do not have the effect of impeding, restricting, or distorting competition.

Tender proposals include documentation covering attributes subject to competition, as defined in the specifications (e.g., list of unit prices, work plan, and financial schedule), and should also encompass elements related to terms or conditions of aspects not subjected to competition, to which the CA intends the bidder to adhere.

The contract should also meet certain requirements, including a list of errors and omissions identified by the bidders and approved by the contracting entity; the specifications; clarifications and amendments related to the specifications; the awarded proposal; and the clarifications provided regarding the awarded proposal.

This set of methodological constraints poses a collection of challenges when it comes to integrating and harmonizing BIM with the legal and traditional processes and requirements within public procurement, in order to maximize its benefits during the construction works. This situation will be further addressed in section 4.3.

2.5 Current BIM-based contracting practices

According to this paper author's experience, the most used method for integrating BIM into construction tender processes involves simply adding BIM as a parallel and complementary process to the traditional one. In this context, generally, in the event of discrepancies (omissions or conflicts) among the drawn parts (both BIM and non-BIM) of the technical design, traditional 2D drawings take precedence over all others concerning the location, dimensional characteristics and the relative position of the constructive elements. The bill of quantities holds priority over any other parts regarding the nature and quantity of the construction works. In all other respects, the contents specified in the descriptive memory and the remaining parts of the technical design take precedence.

In this sense, the information from the BIM models typically doesn't have a prevailing character but is purely complementary, often resulting in a devaluation of the application of this methodology and diminishing its effectiveness.

Nonetheless, organizations such as the "Construction Industry Council" (CIC, 2018) and "The Associated General Contractors of America" (AGC, 2010) recommend that in the event of any conflict or inconsistency. between a model prepared and delivered in accordance with established requirements and any other related document or information that could be extracted from the model - unless the information requirements state otherwise -. all parties should agree to rely on the model. In this context, it is further suggested that all team members be granted access to and take responsibility for their respective parts of the model, and it is recommended to maintain an audit trail tracking all changes made to the model.

While these guidelines are important for promoting the implementation of BIM in construction projects, parties should always prioritize any applicable provisions in the contract addressing ambiguities, conflicts, or inconsistencies in or between any project information and/or any data extracted from the project information. In the absence of such provisions, if a party becomes aware of any related issue, they should promptly notify the other party, and both parties should collaborate to reach an agreement on how to resolve the issue. Above all, the CA and contractors should make their best efforts to establish understanding with all parties regarding the ability and the right to rely on the model.

Despite this, the risk allocation principles remain consistent. Whether the design is presented in the form of 2D printed documents, a 3D electronic medium, or a combination of both, the responsibilities of the project team members remain unchanged. For example, coordination is traditionally considered a core service rather than an additional one, whether achieved through BIM technology or classic methods. BIM serves solely as a facilitating tool, and even with a BIM approach, architects and engineers retain responsibility for the coordination of the design, not the BIM coordinators.

In terms of BIM-specific requirements, the tender documentation, namely the tender and specifications documents, especially the latter, often falls short by being very incomplete. This insufficiency extends not only to management requirements, such as parties' relationships and obligations and collaboration protocols, but also to technical requirements related to standardization procedures, such as the model breakdown structure, level of information needed, modeling and compatibility criteria, and object classification systems.

Overall, these common practices reinforce the need to introduce a comprehensive and systematic approach to effectively integrate BIM requirements into tendering processes, thereby serving as a reference guide for the CA and enabling proper BIM implementation throughout the execution of construction works.

3. RESEARCH METHODOLOGY

The applied research methodology comprised four essential stages pivotal for thoroughly investigating BIM integration into traditional construction processes. It commenced with an exhaustive review of existing literature, delving into methodical subtleties and prevalent BIM-based contracting practices. This initial phase was succeeded by structured interviews with industry experts, aimed at extracting invaluable insights that bridge theoretical understanding with practical application. The insights garnered from the literature review and interviews were then synthesized into robust frameworks aligned with international standards and informed by real-world experiences. For instance, the development of the BIM tendering framework amalgamated expert insights with global BIM norms, ensuring compatibility with established procurement procedures. Similarly, the creation of the BIM specifications document incorporated industry best practices, furnishing practical guidelines for implementation. The subsequent sections expound upon each stage, offering a comprehensive elucidation of the methodology utilized.

3.1 Literature review

The research journey began with a thorough examination of the existing knowledge base, laying the groundwork for understanding the current state of BIM in construction procurement. This exploration delved into the methodological nuances, particularly within public tender processes, and the prevailing BIM-based contracting practices. This process not only facilitated the identification of research gaps and innovative areas but also provided insights for the subsequent stages of the study. The literature review is elaborated in section 1 and, particularly, section 2.

3.2 Interviews

A systematic approach guided the interview process, extracting valuable insights from seasoned professionals experienced in BIM-based construction projects, both nationally and internationally. The primary objective was to identify an effective strategy for integrating and harmonizing BIM with traditional procurement processes and relevant documentation. These expert interviews played a crucial role in bridging the gap between theoretical knowledge and practical expertise, providing valuable perspectives. Ultimately, these perspectives shaped the development of a holistic BIM-integrated tendering framework.

The interviews followed a meticulously crafted approach, refined from the tried-and-tested expertise of the author of this paper in conducting previous research interviews:

1) Objective definition: establishing interview goals to extract practical insights for BIM integration;

2) Stakeholder identification: identifying key stakeholders representing diverse perspectives in the construction field;

3) Question structuring: formulating targeted questions to extract valuable practical knowledge;

4) Challenges and opportunities: exploring perceived challenges and opportunities in BIM integration;

5) Iterative feedback loop: incorporating iterative feedback to refine and validate insights;

6) Wrap up: synthesizing insights to shape the development of a comprehensive BIM-integrated tendering framework.

This structured methodology ensured the collection of insights, which subsequently informed the following stages of the research.

In addressing saturation, the method encompassed continuous monitoring of the data collection process and analyzing the responses to identify recurring themes and patterns. This facilitated the determination of when saturation was reached, indicating that new information ceased to offer substantially novel insights. Additionally, the participant pool was diversified to ensure representation from various backgrounds and experiences within BIM-based construction projects. This diversity aided in validating the consistency of insights across different perspectives, further affirming the saturation point.

Regarding triangulation, a multifaceted approach was employed to corroborate and validate the insights obtained. This involved cross-referencing information gathered from expert interviews with data obtained from complementary sources such as literature reviews, case studies, and industry reports. By triangulating data from multiple angles, it was possible to enhance the credibility and reliability of the findings, fostering a more comprehensive understanding of the integration challenges and opportunities within BIM and traditional construction procurement processes.

3.3 BIM tendering framework

During this research phase, well-established public procurement processes and documentation were utilized to develop a comprehensive framework that integrates BIM-specific clauses. This was accomplished by incorporating insights obtained from the interviews and cross-referencing them with the ISO 19650 standards and the European Directive 2014/24/EU. This approach ensured the robustness of the framework, aligning with practical construction sectorial experience, including the author's own, and maintaining compliance with international standards.

The process encompassed the following key steps:

1) Interview insights: integrating insights derived from expert interviews into the framework to ensure a practical and value-focused incorporation of BIM-specific clauses;

2) Compliance with BIM standards: cross-referencing the model with global BIM normative references, particularly ISO 19650 standards;

3) Harmonization with public procurement: aligning the structure with public procurement specifications, leveraging the wealth of knowledge obtained from interviews, and aiming to ensure compliance with the European Directive 2014/24/EU;

4) Consensus building: refining and validating the framework involved once again engaging the previously interviewed experts and decision-makers in a collaborative process, also considering this paper author's knowledge and experience in the field; this step aimed not only to confirm the framework's compliance with the BIM standards but, more importantly, to ensure that it remained reflective of practical reality.

The outcome of this process was a BIM-integrated procurement framework, as detailed in section 4 of this paper, including **Appendices 1, 2, and 3**. These appendices pertain to the proposed BIM content to be considered and integrated into the traditional tender and specifications documents.

3.4 BIM specifications document

With the framework in place, the focus shifted to creating a practical model document for establishing BIM specific requirements, namely the exchange information requirements (EIR). This document emerged as a tangible outcome of the research and was designed for use by contracting authorities within the previously established framework. Real-world practice was woven into the document, incorporating insights from the construction BIM project-based interviewed experts and the author's knowledge and experience, as well as the BIM normative framework.

The methodology used to construct this document was similar to that of the BIM tendering framework.

The outcome of this process was an EIR framework, detailed in section 5 of this paper and materialized in the model document presented in **Appendix 4**, which also incorporates **Appendix 5**, serving as a guideline for developing the BIM Execution Plan (BEP).

4. BIM-INTEGRATED PROCUREMENT FRAMEWORK

Integrating BIM into the procurement process for construction projects, including aspects such as contract structure and policy, as well as contractual relationships and obligations, is a crucial step in ensuring its successful implementation throughout the construction phase until the project final delivery and subsequent transition to the operational phase.

In this regard, BIM integration should not only adhere to best practices but also align with existing standardization efforts that have been shaped by collaborative work and consensus among various experts in the construction industry.

Indeed, implementing BIM, based on the concept of interoperability, requires a significant degree of standardization, and it is within this context that BIM standards come into play.

Interoperability is a concept that encompasses seamless collaboration and integration among all stakeholders throughout the project's lifecycle, utilizing elementary, three-dimensional, parametric, and relational construction objects.

Interoperability and its corresponding standardization can be categorized into three main categories: technological interoperability, semantic interoperability, and process interoperability.

Technological interoperability refers to the ability of different information systems and technologies to work together, which involves the capacity for various hardware and software systems to communicate. This ensures that heterogeneous systems can connect and exchange information without any issues. In this context, relevant standards include EN ISO 16739-1 (CEN, 2018c), which defines a data schema and an exchange file format structure called IFC (Industry Foundation Classes), that works as an open international standard for the exchange of BIM data among various software applications; and EN ISO 21597-1 (CEN, 2020b), which establishes an open and stable container format for exchanging files of diverse nature, facilitating the delivery, storage, and archiving of asset information.

Semantic interoperability refers to a common understanding and interpretation of exchanged data between systems, involving the establishment of standards and data formats that enable different systems to understand the meaning of shared information, thereby preventing misunderstandings or incorrect interpretations. This becomes particularly important when systems from different organizations must collaborate and consistently share information. In this context, relevant standards include EN ISO 12006-2 (CEN, 2015), which provides a framework for developing built environment classification systems; and EN ISO 12006-3 (CEN, 2022), which specifies a language-independent information model suitable for creating dictionaries used to store or provide information on construction works.

Lastly, process interoperability refers to the ability of different processes or business procedures, either within different organizations or different parts of the same organization, to work together effectively. This involves coordinating workflows, policies, practices, and procedures to ensure that processes can be executed smoothly, even when different systems or organizations are involved. This type of interoperability is essential for ensuring efficiency and collaboration in complex and interconnected environments. Relevant standards in this sense encompass EN ISO 19650-1 (CEN, 2018b), which outlines concepts and principles for information management, providing recommendations for a framework to manage information; and EN ISO 19650-2 (CEN, 2018a), which specifies information management requirements in the form of a management process within the context of asset delivery and information exchanges using building information modeling.

The present study primarily focuses on the processual aspect. Specifically, it delves into ISO 19650 standards, parts 1 and 2, along with the normative references CEN/TR 17439 (CEN, 2020a) and CEN/TR 17654 (CEN, 2021), which, respectively, serve as guidance for implementing the ISO 19650 standards, and for implementing Exchange Information Requirements (EIR) and BIM Execution Plans (BEP).

This section begins with an overview of concepts and principles deemed relevant to a BIM-based procurement process. It is followed by the delineation of the corresponding methodology, along with the requisite specifications and documentation for incorporating BIM requirements into traditional tendering processes for construction works. This comprehensive approach considers the predefined public procurement procedures (section 2.3) and their methodological particularities (section 2.4).

4.1 Relevant concepts and principles

According to EN ISO 19650-1 (CEN, 2018b), the ISO 19650 series provides recommendations for a framework to manage built assets information, which includes exchanging, recording, versioning, and organizing data for all involved parties. This framework serves as the basis for establishing a shared understanding among all stakeholders regarding information exchange throughout the entire life cycle of any built asset.

While this standard can be potentially applied to construction projects of all sizes and levels of complexity, it should be adopted and applied in accordance with the specific circumstances and requirements of project delivery activities - in this context, the term “shall consider”, as providing a recommendation, is frequently used in the standard. Furthermore, the ISO 19650 series (standards layer) is primarily applicable at stage 2 maturity, although it can also be partly applied at stages 1 and 3, emphasizing the importance of concepts such as the federation strategy (information layer) and the common data environment (technology layer).

Compared to its predecessors, the PAS-1192 series, particularly parts 1 and 2 (BSI, 2007, BSI, 2013), the ISO 19650 series maintains a similar logic in information management processes. However, it shifts the emphasis from contractual relationships to information exchanges, resulting in terminology changes like "contract" becoming "appointment," "employer" becoming "appointing party", and "employer's information requirements" becoming "exchange information requirements". In practice, for the purpose of construction projects procurement, the concepts are interconnected, meaning that information flows necessarily depend on contractual relationships and obligations.

The ISO 19650 standards also distinguish between two fundamental terms: "information requirements" (specifications for what, when, how, and for whom information is to be produced), which are primarily the responsibility and definition of the appointing party; and "information exchange" (the act of satisfying an information requirement or part thereof), which is primarily on the side of the appointed parties. In the context of the current study, as described in section 4.1.2, the term "appointing party" is interpreted as referring to the CA, while the term "appointed parties" refers to the contractors.

4.1.1 Information requirements

In terms of information requirements, considering the basic principle of "begin with the end in mind", it is established that the best strategy for managing information involves defining and aligning requirements at three key levels: organization, asset, and project.

At the organizational level (OIR - organizational information requirements), it is important to define strategic objectives based on the business type and the owner's profile. For instance, operating owners (e.g., those involved in constructing offices, hotels, hospitals), as they tend to place a higher value on the operational phase and have long-term incentives, are more likely to prioritize the design phase and utilize BIM for functionality and sustainability assessments. Conversely, developer owners (e.g., those responsible for building residences), given their shorter-term incentives, will tend to prioritize cost and schedule reduction, particularly during the construction phase.

At the asset level (AIR - asset information requirements), which essentially focuses on the operation and maintenance phase, it is important to define the information required for preventive maintenance rather than corrective maintenance, especially concerning rooms, equipment and systems.

At the project level (PIR - project information requirements), it is important to define the information needed for each phase of the construction project (EIR - exchange information requirements), considering the OIR and AIR. For example, if there is a greater emphasis on sustainable construction, the design phase can focus on BIM requirements related to energy and environmental analysis; if the primary concern is on construction cost-efficiency, it would be more critical to anticipate incompatibilities, errors, and omissions during the pre-construction phase; if the emphasis is on the operation, special attention should be given to asset information requirements starting from the design phase until the final project delivery.

This organization of information requirements will allow for the creation, during the project delivery phase, of the project information model(s) (PIM). These models will encompass all the relevant information until the project final delivery and transition to the operational phase, giving rise to the asset information model(s) (AIM).

4.1.2 Information exchange

Concerning the information exchange, according to EN ISO 19650-2 (CEN, 2018a), Figure 1 illustrates the connections between the different parties and teams for the purpose of information management, which do not necessarily correspond to contractual relationships, although they can - and should - be related, within the context of construction project procurement and contract management. In fact, the term "procurement" is emphasized numerous times throughout the standard - e.g., it states that "the aim of this series is to support all parties towards achieving their business objectives through effective and efficient procurement (...)". For the present case, procurement is typically conducted through a tendering or competitive bidding process, with contracting being one of its stages.

In this context, within a BIM-integrated tendering process and referring to the diagram in Figure 1, after defining OIR and AIR, the CA needs to establish the PIR, encompassing the various stakeholders (project team - 1) and the different stages of the construction project (delivery phase). Subsequently, the EIR are defined for each stage of the construction project.

While the contracting authority (appointing party - A) remains at the core of the project and oversees all its phases, the contractors (lead appointed parties - B) and subcontractors (appointed parties - C, constituting the task teams - 3) can vary for each phase. In fact, for the development of a construction project, one or several phases may occur, each with different teams (delivery teams - 2), composed of one or more contractors and subcontractors responsible for construction works such as, for example, demolitions (phase 1), excavation and retaining wall (phase 2), foundations and structures (phase 3), finishes and special installations (phase 4), although not necessarily in a consecutive manner, as there can be overlaps.

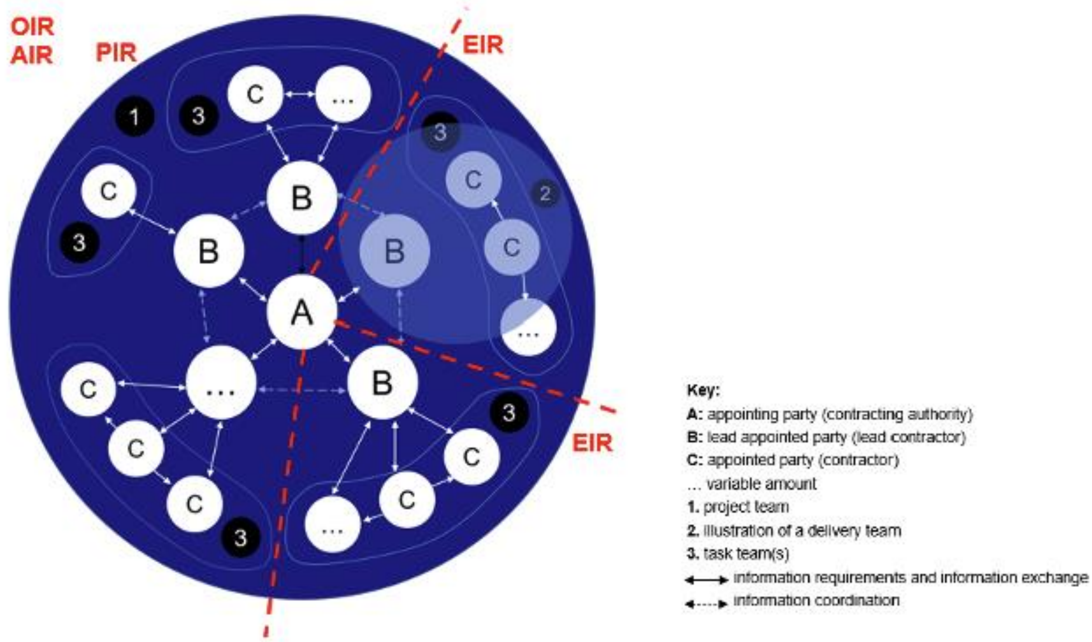

Figure 1: Interfaces between parties and teams for the purpose of information management - adapted from EN ISO 19650-2 (CEN, 2018a).

For each construction project phase, in response to the EIR, which are incorporated by the CA in the invitation to tender, tenderers should address the necessary requirements, including in their response a central document known as the BIM Execution Plan (BEP). The tender response should be submitted jointly and coordinated by the proposing delivery team, represented by the lead appointed party, ultimately resulting, in the event of an award, in an appointment involving all parties (appointing and appointed parties) for that phase of the construction project. The lead appointed party (e.g., general contractor) will also, during the construction works, be responsible for aggregating all information deliverables from the delivery team and formalizing the submissions to the CA.

Given this, procurement and contracting, even if occurring in a fragmented manner, must be managed in a way that ensures the necessary contractual relationships for the flow of information among different stakeholders as established in Figure 1. In other words, for instance, even in a single construction phase involving only finishes and special installations, the CA may separately procure and contract the execution of the finishes and the special installations works, but this should be done in such a way that there is a coordinated response from the service providers, including a consolidated BEP in response to the EIR. As previously stated, this process should involve appointing a general representative of the service providers (lead appointed party - B) or, in certain cases, nominating a coordinating party on the CA's side, if it is preferable or not otherwise possible, due to competency and capacity issues.

It is worth noting that, although the focus of this study is on construction works, the EIR should also be defined in the pre-construction phase to support the development of architectural and engineering design in line with the CA's requirements. In this case, at least one additional stage, prior to the procurement stages for construction works, would be considered according to the diagram in Figure 1. This raises again the common challenge of fragmented procurement and contracting while ensuring contractual relationships that guarantee the centralized and coordinated flow of BIM information, where the lead appointed party could be the design coordinator (e.g., the executive architect, in the case of buildings), and the appointed parties would represent the various contracted disciplines.

The size and the structure of the delivery teams may vary depending on the size and complexity of the construction project and may naturally include the lead appointed parties (e.g., the general contractor himself can contribute to responding to the EIR).

Finally, just as the EIR are adapted for each project phase, in line with the PIR, the BEP - responding to the EIR for each project phase and encompassing contributions from the various parties involved - should also vary coherently. However, it's not that there are multiple BEPs throughout a construction project developed in several phases, but rather their requirements inherently evolve to address the varying information needs throughout the project's development.

4.2 Methodological approach

The methodological approach concerning information management throughout the project lifecycle is illustrated in Figure 2, according to EN ISO 19650-2 (CEN, 2018a).

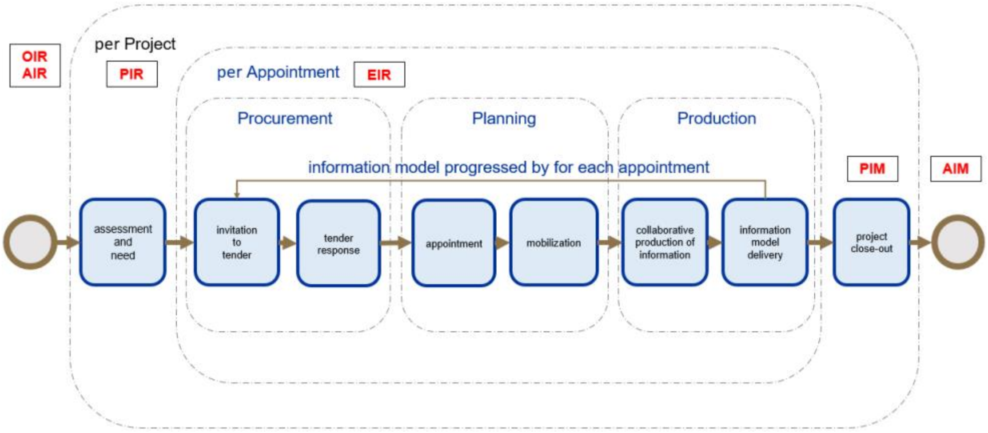

Figure 2: Information management process during the delivery phase of assets - adapted from EN ISO 19650-2 (CEN 2018a).

In line with the information provided in section 4.1.2, following the definition of OIR and AIR, the PIR are established, representing the CA's requirements for the project at this stage of the cycle (assessment and need). Subsequently, still from the CA's perspective, the EIR are defined for each phase of the construction project, properly integrated with the traditional processes and documentation. The procurement phase (invitation to tender) then begins, to which invited proposers shall respond (tender response), including their (pre-contract) BEP proposal.

In the case of an award, the planning phase follows, encompassing the stage of contracting (appointment), which incorporates the bidding documents and the tenderer's proposal - now with a consolidated (post-contract) version of the BEP – and the subsequent stage of mobilization, where the necessary human and technological resources are mobilized to initiate the project.

The production phase involves the creation and delivery of the BIM model(s) under the contracted conditions for the respective project phase. These model(s) then progress to the subsequent project phase, and so on, contributing partially and gradually to the PIM. At the end of the project, the PIM will consist of one or more BIM models, depending on the federation strategy, containing accumulated information from all preceding project phases. Upon project close-out and the transition to the operational phase, the PIM will evolve into the AIM.

One might question whether, in the case of a single project phase with multiple possible contracts, the cycle represented in Figure 1 under “per appointment” should be repeated for each contract. As already explained in section 4.1.2, this analysis pertains to the flow of information rather than the flow of contracting. Therefore, it is not necessary to repeat the cycle. However, it is essential to ensure the necessary contractual relationships that guarantee the flow of BIM information among different stakeholders, as per EN ISO 19650-2 (CEN, 2018a).

Finally, it should be noted that, in this paper, the focus is placed on the “invitation to tender” stage, which is an integral part of the procurement phase adjacent to the CA. The detailed analysis of the remaining stages is beyond the scope of this study.

4.3 Incorporating BIM into traditional bidding documents

As stated in EN ISO 19650-2 (CEN, 2018a), "procurement and mobilization of asset or project-appointed parties should be integrated as far as possible with existing processes for technical procurement and mobilization.". Therefore, while preparing bidding documents, the CA should consider the appropriate BIM requirements and determine the most effective way to incorporate and combine them with traditional documentation.

In this context, according to sections 2.3 and 2.4, the tender and specification documents are the fundamental traditional elements that should be explored, as integral parts of the invitation to tender stage.

4.3.1 Tender document

According to the author of this article, and without violating public procurement constraints, integrating BIM into the tender document should include requesting bidders to submit, in addition to their traditional technical and commercial proposals, a separate BIM proposal. This proposal should encompass elements directly linked to the BIM methodology that will be subsequently evaluated.

The documentation to be submitted as part of the BIM proposal shall include, as per EN ISO 19650-2 (CEN, 2018a): -the (pre-contract) BEP; -the proposed mobilization plan; -the information delivery risk assessment; -the assessment of the tenderer’s capability and capacity.

However, according to the author of this paper, these specifications are overly broad and lack important elements. For instance, the Master Information Delivery Plan (MIDP), even though it is only mentioned for the “appointment” stage (part of the planning phase), should be requested (as a pre-contract MIDP) during the procurement phase. This is necessary to facilitate an early comprehension and assessment of BIM delivery planning and its alignment with construction activities. Additionally, all the human and technological resources required for developing BIM models during the production phase could be incorporated into the MIDP, eliminating the need for a separate mobilization plan. The information delivery risk assessment could be integrated into the BEP. The requirements for assessing the capability and capacity of the tenderers could be detailed in the tender document.

In **Appendix 1**, a list of BIM-specific documents for the submission of a BIM proposal is proposed. This list has been derived and tested based on the author's experience from various BIM-integrated projects, and it also results from the previous interactions with construction experts. It shall be incorporated into a dedicated section of the tender document.

In **Appendix 2**, models of competency and capacity assessment forms are provided at both the tenderer and tender proposal levels. These forms, referenced in the set of requested elements outlined in **Appendix 1**, are intended to be completed by the tenderers and serve as supporting materials for conducting the tender evaluation stage.

It is also within the tender document that the evaluation methodology should be established. In the case of BIM-integrated procurement processes, the methodology should consider BIM-specific criteria, weights, and scoring functions. Given that BIM is regarded as an additional aspect to be subjected to competition, the respective criteria should be clearly defined and used to conduct the tender evaluation and selection process in conjunction with other pertinent criteria.

Although EN ISO 19650-2 (CEN, 2018a) indicates the requirement for assessment, it does not provide specific details on BIM evaluation forms. In this context, the requirements outlined in the assessment forms in **Appendix 2** can serve as a starting point. To ensure effectiveness, a bid evaluation system based on a proper multicriteria decision analysis method is also necessary. An in-depth analysis of a BIM-integrated tender evaluation process is not currently provided, as it falls outside the scope of this study.

Another important point to highlight is the draft contract, typically included as an annex of the tender document. The wording of this document is usually aligned with that of the specifications document, which, in turn, will also be attached to the contract, often resulting in redundancy in some clauses - in any case, if there is a contradiction, the wording of the contract takes precedence over that of the other documents.

Regarding specific BIM contractual clauses, which collectively constitute the BIM protocol, they can typically be directly integrated into the traditional draft contract. Some bibliographic references, such as (CIC, 2018), frequently treat the BIM protocol as a separate document to be appended to a traditional contract. However, based on the experience of the author of this paper, this approach makes more sense in the case of an existing contract, where the BIM protocol would indeed serve as an addendum.

Finally, given the crucial role of the specifications document in defining construction works requirements, as outlined in section 2.4, there is an emphasis in the next section on incorporating BIM requirements into this document - this is mostly evidenced by the inclusion of the EIR. Subsequently, these incorporated BIM requirements can serve as the foundation for the clauses to be included in BIM-based construction contracts.

4.3.2 Specifications document

As previously mentioned, the specifications document, which can be divided into general and special clauses, is a central element in the tendering process, as an integral part of the invitation to tender stage (procurement phase), that will later integrate the construction contract and serve as a reference for developing its clauses.

Concerning the general clauses, as outlined in section 2.5, a key aspect of BIM integration involves prioritizing information derived from 3D model(s) over that from traditional 2D drawings. In cases of discrepancies, be they omissions or conflicts, precedence is given to the BIM models. This necessitates referring to the models for reading and extracting information, which is subsequently analyzed alongside the remaining project data. This step is pivotal in enhancing the value of BIM implementation, both during the bidding process and the execution of construction works.

The remaining aspects of BIM, primarily related to technical requirements, can be addressed in the special clauses and, in general, are subject to competition, that is, BIM requirements are not entirely rigid but are negotiable and open to competitive bidding. In fact, while certain tendering processes may define mandatory baselines, such as those related to the common data environment, federation strategy, model breakdown structure, and the required level of information, in other cases, even the BIM methodology itself can be optional.

The fundamental document governing the implementation of the BIM process, referenced and attached to the special clauses, is the Exchange Information Requirements (EIR). Given its importance, this document is thoroughly examined in section 5, where a structure and recommendations for its development are provided, considering its integration with traditional procedures, and ensuring alignment with the specifications regulated by the European Directive 2014/24/EU.

In **Appendix 3**, proposed BIM requirements for integration into the special clauses of the specifications document are outlined. These requirements, along with the other tender documents, will contractually supersede the terms of the awarded proposal, including the BEP, unless prior clarifications or amendments have been agreed upon. They underscore the contractor's responsibility to implement the BIM process according to the EIR and should be tailored to the specific needs of each project.

Importantly, the special clauses of the specifications document are designed to complement or replace their corresponding general clauses, thereby giving precedence to the former over the latter.

4.3.3 Workflow documentation schema

According to the process previously described for integrating BIM into traditional workflows, in line with EN ISO 19650-2 (CEN, 2018a), Figure 3 illustrates BIM-related reference documentation in a generic manner. This documentation does not necessarily represent unique and individualized documents and should be considered for integration with traditional documentation.

While the present study concentrates on the tendering process for construction works, the outlined process and proposed documents are adaptable for pre-construction stages (e.g., preparation and brief, concept design, spatial coordination, and technical design). This presents a potential avenue for future research, as discussed in section 6.2.

At the "invitation to tender" level, the following elements stand out: the EIR, integrated into the special clauses of the specifications document; competency and capacity assessment forms, at both the company and proposal levels, forming an integral part of the tender document; and the BIM protocol, which includes BIM clauses aligned with the BIM-specific provisions of the specifications document, typically integrated into the traditional draft contract, constituting an essential part of the tender document.

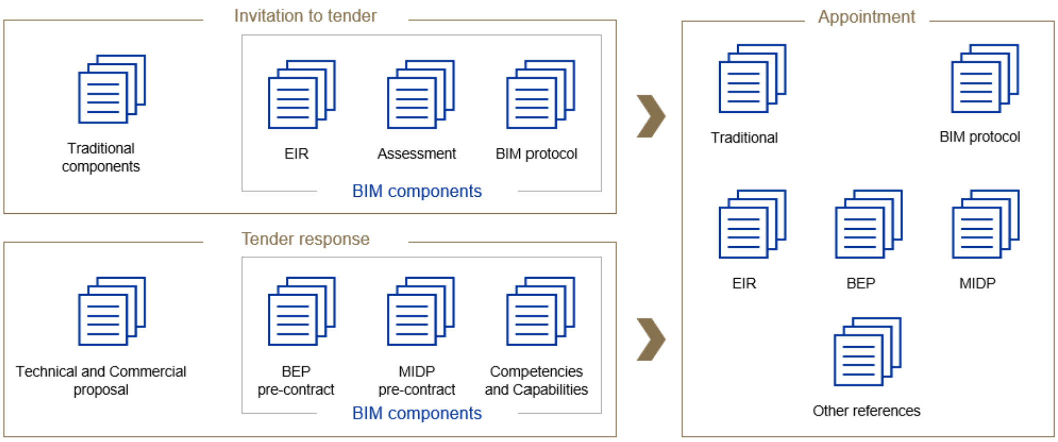

Figure 3: General framework with reference documentation for the BIM-integrated tendering process - adapted from (IST, 2017).

In the context of the "tender response", particular emphasis is placed on the documentation specified in the tender document, which should constitute a part of the BIM proposal. This includes the (pre-contract) BEP and MIDP, along with the completed assessment forms. As discussed in section 4.3.1, according to EN ISO 19650-2, the presentation of MIDP is theoretically reserved for the planning phase (in the appointment stage) rather than the procurement phase. However, recognizing its significance in practice, this study proposes its inclusion in the procurement phase.

In the "appointment" stage, where the contractual relationships are established to ensure the intended flow of BIM information among the involved parties, the following reference documentation generally exists (along with all the documentation referenced within it): -the traditional contract incorporating BIM protocol provisions; -documentation from the invitation to tender (tender and specifications documents), including the necessary BIM provisions and the EIR; -documentation from the tender response, which, in addition to technical and commercial proposals, includes the awarded BIM proposal containing the post-contract version of the BEP and MIDP; -and other elements that traditionally pertain to specifications clarifications and amendments, corrections of errors and omissions, or, particularly concerning BIM, specific standards, such as those related to classification systems or levels of information.

Figure 4 illustrates the implementation of the proposed framework in conjunction with the public tender process described in section 2.3, following the European Directive 2014/24/EU. In this schema, BIM protocol clauses are combined with BIM specification clauses since, as previously mentioned, the latter typically lead to the former.

Procurement phases	Invitation to tender	Tender response	Tender evaluation	Contract award
Procurement Procedures	Tender and Specifications documents; Public announcement	Requests for information; Opening of proposals	Screening and evaluation	Negotiation
BIM integration	BIM tender clauses Assessment forms BIM specification/protocol clauses EIR	BEP pre-contract MIDP pre-contract Competencies and capabilities	Assessment forms	BIM tender clauses BIM specification/protocol clauses EIR BEP MIDP Other references
Appendixes	1, 2, 3 and 4	2 and 5	2	1, 3, 4 and 5
Main authors	Contracting Authority	Tenderer Opening Commitee	Evaluation Committee Contracting Authority	Contracting Authority Selected tenderers

Figure 4: BIM tendering framework integrated into the public tender process.

Finally, according to EN ISO 19650-2 (CEN, 2018a), when compiling BIM-related information for inclusion in the “invitation to tender” package, the CA shall consider: -the tender response requirements; -the delivery milestones; -the evaluation criteria; -the BIM protocol; -the EIR; -the production methods and procedures; -the information standards. While the initial elements have been addressed earlier in conjunction with the tender document (in section 4.3.1) and the EIR in relation to the specifications document (in section 4.3.2), the latter elements, specifically pertaining to production methods and procedures, and information standards, are covered in section 5 integrated with the EIR.

5. EXCHANGE INFORMATION REQUIREMENTS (EIR) FRAMEWORK

According to EN ISO 19650-2 (CEN, 2018a), the exchange information requirements (EIR) shall consider the following aspects: -the project’s information requirements (section 5.1); -the common data environment (section 5.2); -reference information and shared resources (section 5.3); -information production methods and procedures (section 5.4); -and information standards (section 5.5). Additionally, it addresses the information protocol, as previously discussed in section 4.3.1, along with other aspects related to acceptance criteria and supporting information (section 5.6).

Importantly, the standard also emphasizes that “EIR set out managerial, commercial and technical aspects of producing project information”.

Based on this and considering the normative references CEN/TR 17439 (CEN, 2020a) and 17654 (CEN, 2021), a comprehensive framework for the EIR is proposed in **Appendix 4**.

This framework can be integrated into the specifications document as an attachment to its special clauses, serving as a guide for BIM-specific contractual clauses. It aligns with EN ISO 19650-2 (CEN, 2018a), which emphasizes that EIR shall be “expressed in such a way that they can be incorporated into project-related appointments”. Moreover, the proposed EIR framework is consistent with the recommendations in the literature review, specifically those put forth by (Chong et al, 2017) concerning key contractual considerations (section 2.2).

In the following subsections, through specific examples cross-referenced (in brackets) to clauses of **Appendix 4**, the proposed EIR framework is aligned with and justified by the main provisions specified in EN ISO 19650-2 (CEN, 2018a). This analysis is organized following the logic of the aspects indicated at the beginning of this section.

5.1 Project’s information requirements (PIR)

Regarding PIR, reference can be made to the commercial requirements outlined in the proposed EIR framework, specifically the BIM objectives and uses (EIR 3.1.1), which define the scope and responsibilities of the required BIM services, along with the ownership of information (EIR 3.1.2). For a comprehensive understanding of roles and responsibilities, additional insights can be gleaned from the sections addressing this topic (EIR 3.2.1) and the process mapping (EIR 3.2.2), both integral components of the managerial requirements.

Furthermore, the planning of information deliverables (EIR 3.2.3) can also be addressed, particularly through the MIDP, where BIM deliveries shall not only align with the ongoing construction project phase but also synchronize with the overall project planning, as outlined in EN ISO 19650-2 (CEN 2018a), which specifies that “the timing of each information delivery should be included in each information delivery plan, with reference to project and asset management schedules when these are known".

Also, considering the emphasis placed by the standard and within the context of the managerial requirements covered by the proposed EIR framework, a documented risk assessment in information delivery shall be made, as specified by the risk analysis clause (EIR 3.2.7.1), including the identification of the nature of risks, their consequences, and the likelihood of occurrence.

5.2 Common data environment (CDE)

The CDE is an integral part of the EIR managerial requirements (EIR 3.2.4) and holds significant relevance. According to EN ISO 19650-1 (CEN, 2018b), it serves as the basis for supporting “collaborative production, management, sharing, and exchange of all information” during the project delivery phase. The standard suggests that a CDE solution can be implemented in “several ways and using a range of different technologies”.

The strategy for CDE implementation can either be requested as a proposal from potential bidders or defined in advance within the EIR, if no specific supplier is appointed, as this is generally not allowed in public procurement due to the principles of transparency and competition. The organization of information within the collaborative platform should adhere to the standard's recommendations, essentially categorized into the following sections: “work in progress”, “shared”, “published”, and “archive”.

According to the standard, the CDE should also facilitate the development of a federated information model. This requires an appropriate federation strategy, in conjunction with the breakdown of information containers, as outlined in the technical requirements of the proposed EIR framework (EIR 3.3.7). This is important for assisting in the planning of information production by separate task teams at the required level of information.

In this context, normative references under development by the European BIM Technical Committee (CEN/TC442), specifically related to the “framework and implementation of CDE workflow and solution in accordance with EN ISO 19650” and “CDE for BIM projects”, can also be considered.

5.3 Reference information and shared resources

As an integral part of the EIR technical requirements, this topic primarily addresses the information and resources shared with tenderers during the procurement (“invitation to tender” stage) and planning (“appointment” stage) phases.

In terms of reference information, in the “invitation to tender” stage, and as outlined in the proposed EIR framework (EIR 1.5), examples may include specifications for technical design BIM deliverables, including information essential for reading and extracting data from models, covering both geometric and non-geometric information levels, modeling criteria, coordinate systems, references, units, presentation of drawings, and file naming conventions. Other examples include providing a guideline structure for developing the BEP (EIR 3.2.8.3; **Appendix 5**), according to (IPQ, 2022), and any relevant existing information about the asset, such as laser scanning surveys of the site and surroundings, AIM of an existing building, or PIM from previous construction phases.

In terms of shared resources, as an example in the "appointment" stage, one can provide an editable format of the intended modeling layout, derived from the technical design stage, including shared parameters, object libraries, and style libraries (EIR 3.3.12).

5.4 Information production methods and procedures

This topic, addressing the methods and procedures for information production, essentially encompasses technical and managerial requirements as outlined in the proposed EIR framework, such as 1) capturing existing information; 2) generating, reviewing, and approving the information; 3) ensuring information security; and 4) delivering the information to the appointing party.

The first point encompasses activities such as laser scanning surveys (EIR 3.3.5); secondly, examples can include process mapping (EIR 3.2.2) and communication (EIR 3.2.5); thirdly, access control mangement serves as an example, and effectively managing the Common Data Environment (CDE) with proper information security (EIR 3.2.4) can be a significant contributor; lastly, concerning the delivery of information, specific requirements for information deliverables (EIR 3.2.3) can be mentioned, along with more technical aspects such as the used software and formats (EIR 3.3.1, EIR 3.3.11), technological infrastructure (EIR 3.3.2), and information extraction (EIR 3.3.9).

5.5 Information standards

Information standards essentially refer to managerial requirements that encompass the normative framework (EIR 2) and global, national, or project guidelines related to geometric information (EIR 3.3.6), including the breakdown structure of models and the required level of information; to the federation strategy and the modeling and coordination criteria (EIR 3.3.7); and to the non-geometric information, which pertains to the organization and classification of object attributes (EIR 3.3.8).

It is important to reference, according to EN ISO 19650-1 (CEN, 2018b), the concept of the "level of information need (LOIN)", which constitutes a framework for defining the extent and granularity of information. This framework covers both geometric and non-geometric information, with the importance of each type of information depending on the purpose of the information deliverables.

LOIN should never exceed what is strictly necessary, as the standard emphasizes, “anything beyond the minimum is considered as waste". Various metrics are available to determine the levels of information needed, and these can be specified as requirements in the EIR or requested as proposals for evaluation from tenderers.

5.6 Acceptance criteria and supporting information

In the context of managerial requirements, acceptance criteria can be addressed through an effective quality management system (EIR 3.2.6), defining parameters to be controlled and permissible limits. Supporting information pertains to elements that assist the delivery team in implementing the contracted requirements, which may include training (EIR 3.3.3) and technical support (EIR 3.3.4).

6. CONCLUSIONS

6.1 Main findings

The adoption of BIM, as a methodology to enhance the efficient development of construction projects through advanced information technologies, has been on the rise in the global construction industry. However, this evolution has unfolded in a fragmented manner, partially attributed to the absence of universally agreed-upon collaboration and standardization protocols, both at the global and local levels.

In this context, particularly from the standpoint of the contracting authority, procurement processes play a crucial role. They shape BIM requirements and facilitate the selection and contracting of desired BIM services from the most competent and capable bidder. This, in turn, mitigates the risk of subsequent contractual disputes and conflicts arising from inadequately prepared agreements, contributing to a more successful execution of BIM-based construction contracts.

While there have been general discussions on the implications and challenges of implementing BIM at the contractual level, along with recommended guidelines, limited research exists, particularly in terms of integrating BIM into traditional tendering processes for construction works in accordance with global standards such as the ISO 19650. Additionally, there is a need to consider the specific constraints of public procurement in alignment with regulations such as the European Directive 2014/24/EU, which, in turn, can influence private practices.

This situation highlights a noticeable gap in the existing literature, and that is where the current study comes in.

Traditionally, construction procurement practices involve two key documents for incorporating BIM requirements. These documents are integral parts of the invitation to tender: the tender and specifications documents. The specifications document is particularly crucial due to its methodological specificities, which shape the competitive dynamics of the tendering process. In this context, BIM is regarded as a competitive aspect, and the clauses outlined in the specifications document can serve as contractual provisions to be integrated into the forthcoming construction agreement. This integration encompasses an adapted structure and policy, and new contractual relationships and obligations.

While current practices in BIM-based construction procurement characterize BIM as a parallel and complementary process to traditional methods, where traditional 2D drawings hold priority in case of discrepancies, the author of this paper argues that this approach undervalues the application of BIM and diminishes its effectiveness. Therefore, in alignment with international references such as (CIC, 2018) and (AGC, 2010), a fully contractual BIM implementation requires that (3D) BIM models take precedence whenever applicable. This requirement can be established in the general clauses of the specifications document and subsequently reflected in the contract.

The requirements for implementing BIM in procurement processes for the delivery phase of construction projects fall within the context of process interoperability, where the ISO19650 standards, particularly parts 1 and 2 (CEN, 2018a, CEN, 2018b), play a key role, along with normative references such as CEN/TR 17439 (CEN, 2020a) and CEN/TR 17654 (CEN, 2021).

In this context, from the perspective of the contracting authority, a distinction is made between information requirements according to a top-down approach, ranging from the organizational level (OIR) to the project phase level (EIR).

The importance of procurement and contracting is emphasized in the context of information exchange. While this exchange may occur in a fragmented manner, it must be managed to ensure the necessary contractual relationships are in place, facilitating the flow of BIM information among different stakeholders, as specified by the standard.

The definition of information requirements and information exchange, however, necessitates an understanding of their implications throughout the project's lifecycle. In this regard, a methodological approach is presented, following the guidelines of EN ISO 19650-2 (CEN, 2018a), for the information management process during the built asset's delivery phase.

Following this, practical solutions are presented for integrating and harmonizing BIM with traditional bidding documents. These proposed solutions are based not only on the previously mentioned standard guidelines but are also derived from a series of interactions with national and international construction experts and tested based on the author's experience with various BIM-integrated projects.

To enhance the understanding of this study, a workflow documentation schema is illustrated in Figure 3, and its connection with the public tender process is clarified in Figure 4.

Concerning the tender document, **Appendix 1** consists of a list of BIM-specific documents to be requested for the submission of an independent BIM proposal. Additionally, **Appendix 2** includes models of competency and capacity assessment forms at both the company and proposal levels, serving as a reference for the tender evaluation process.

Regarding the specifications document, while general clauses may cover aspects such as the predominant use of (3D) BIM models over traditional 2D drawings, more specific requirements are detailed in the special clauses. To facilitate this, BIM-specific provisions, outlined in **Appendix 3**, are proposed for integration into the special clauses of the specifications document for construction contracts. These clauses, in turn, reference the EIR, a central document containing commercial, managerial, and technical requirements that govern the BIM implementation for the contracted project phase. The EIR takes precedence over all other contractual parts in terms of BIM provisions, unless otherwise defined in the contract.

An EIR framework for construction contracts is presented in **Appendix 4**, and, in this paper, its provisions are cross-referenced with the requirements outlined in ISO 19650 parts 1 and 2, for a more comprehensive understanding. In addition, a guideline for developing the BIM Execution Plan (BEP) is provided in **Appendix 5**.

Finally, despite the potential applicability of the proposed process and documentation frameworks in the context of BIM-based procurement processes for construction works, several limitations in the present study can be identified, along with opportunities for future developments, as described in the following section.

6.2 Limitations and future research

The present study acknowledges certain limitations worthy of highlighting.

To begin with, although the proposed methodological approach and procurement documentation have the potential to be applied to construction works irrespective of their size and complexity, their implementation should align with the specific circumstances and requirements of project delivery activities. Indeed, there are various approaches to managing a BIM-based project, depending on factors such as objectives, risk, timeframe, the project team's experience, resource availability, historical information, the project management maturity of the organization, as well as the specific requirements of the local construction industry.

Additionally, the workflows and specifications proposed in this study, being of a contractual nature and thus legally framed, should undergo a legal review on a case-by-case basis. This review is crucial, especially in the case of establishing public contract templates.

Generally, construction specifications are expected to incorporate a detailed technical design, along with the respective BIM specifications - an assumption on which the present study is based. However, in certain duly justified cases (e.g., design-build models), those specifications may only include a preliminary program and explicitly state that the responsibility for developing the detailed technical design rests with the contractor. In such cases, the methodological approach proposed in this study should be adapted, and future studies can be conducted not only for design-build models but also for other project delivery models, such as collaborative ones (e.g. design-bid-build with early contractor involvement or integrated project delivery).

The type of contracting model directly influences critical factors such as responsibilities, collaboration type, risk-sharing, and incentives - all of which are pivotal to the success of a BIM-integrated project. The selection of the most appropriate contracting model is, therefore, a crucial step, guided by the contracting authority's business strategy, project type and size, prevailing legal constraints, and time horizon.

Another assumption of this study is that BIM model information takes precedence over that of traditional drawings in the event of omission or conflict. This presupposes that the technical design has been fully and accurately developed in accordance with a BEP, and that the relevant technical specifications are appropriately linked with the EIR for the tenderer or contractor to comprehend the BIM models. In case of errors, they should request clarifications – this matter is addressed in the general provisions of the proposed EIR framework. If there is significant non-compliance of the BIM models from the technical design phase, the prevalence or even the use of the BIM models may not be feasible or advisable, potentially leading to a return to traditional processes.

Aligned with ISO 19650, this study recognizes that effective management of BIM-based procurement processes necessitates the contracting authority to possess the requisite competencies, whether through in-house expertise or external resources. The absence of these competencies may result in an ill-defined process and requirements, potentially jeopardizing the successful integration of BIM in project procurement, planning, and execution. In the tender documentation, it is crucial to explicitly outline the necessary competencies and capabilities expected from the tenderer for contract execution. This includes specifying roles such as the “BIM Manager” and the “BIM Coordinator”.

The exploration of new roles in the field of BIM and their impact on project management activities is also a subject for more detailed consideration. This involves examining whether BIM is merely a supplementary process to the traditional one or not, and whether the responsibilities of project team members remain consistent, bearing in mind that relationships or responsibilities cannot be modified beyond what team members are licensed and capable of performing.

The success of implementing BIM in construction projects, alongside appropriate procurement and contracting, requires robust monitoring and control procedures meticulously documented. The responsibility for this lies with the contracting authority, whether exercised directly or indirectly through the delegation of tasks to a designated entity. This responsibility involves ensuring the identification of deviations and promptly undertaking necessary actions. Addressing this aspect is a prospective area for future research, particularly emphasizing its integration with project and contract management activities.

Within the realm of BIM-based procurement, numerous other valuable studies could be conducted as future research endeavors for enhancing the understanding and refining practices in this field. The potential areas of investigation include:

-Exploring the impacts of mandatory BIM adoption in public procurement;

-Aligning the proposed methodological approach with the project management framework of the “Project Management Institute (PMI)”;

-Investigating the risks associated with subcontracting;

-Examining the integration and implications of the open BIM concept in procurement processes;

-Adapting and testing the proposed methodological approach and documentation for pre-construction stages (preparation and brief, concept design, spatial coordination, and technical design);

-Analyzing the utilization of multicriteria decision analysis methods in BIM-based tendering processes;

-Estimating the costs and evaluating the return on investment associated with both proper and improper BIM services procurement.

Finally, it is important to emphasize that BIM procurement and contracting practices should be implemented as early as possible in the construction project lifecycle. In the initial stages, corresponding to project planning and design, the primary focus is on producing information to adequately prepare the BIM deliverables for the subsequent phases. As the project progresses, the focus shifts to the extraction and utilization of information for various purposes, including planning, budget control, and the preparation of as-built models.

Nonetheless, it's important to highlight as well that BIM is essentially a digital methodology designed to enhance traditional processes, and it doesn't necessarily require entirely new processes, but it can and should derive from an adaptation of existing ones.

Above all, BIM should not be seen as a universal solution to construction problems, but rather as an alternative to help mitigate some of them, through adequate procurement and contracting practices.

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APPENDIXES

Appendix 1. BIM-specific documents to be requested for the submission of a BIM proposal (to be integrated into the tender document for construction contracts).

"The BIM proposal must necessarily contain the following documents, letterheaded and signed by a legal representative of the competing company:

a) Price proposal;

b) Justification note for the proposed price;

c) Bill of quantities that supports the proposal, itemizing partial prices for BIM uses and other applicable items; this schedule must be presented independently of the commercial proposal schedule, also specifying monthly values and portions related to human and technological resources (hardware and software);

d) List of activities that the competitor may intend to subcontract, indicating the respective BIM service providers, if applicable, and including curricula of the proposed companies;

e) Pre-contract BIM Execution Plan (BEP) - in accordance with the requirements specified in the Exchange Information Requirements (EIR), included in the special clauses of the specifications document (**Appendix 4**);

f) Pre-Contract Master Information Delivery Plan (MIDP) - in accordance with the requirements specified in the Exchange Information Requirements (EIR), included in the special clauses of the specifications document (**Appendix 4**); the MIDP may be presented as an integral part of the BEP;

g) Provisional billing program, in accordance with the MIDP;

Qualifications*

h) Declaration, signed by a legal representative of the company, identifying those responsible for managing the BIM process, as well as the technicians and technical services assigned to the project, whether integrated into the company or not;

i) Resumes of the company's staff and those responsible for managing the BIM process;

j) Organizational chart of the technical team (resident and non-resident) and their respective resumes, including BIM training certificates;

k) Completed BIM competency and capacity assessment forms, at the company and proposal level (**Appendix 2**);

l) Portfolio of BIM projects of the same nature as the present tender, specifying the contracting entity, start/completion date, and current project status; project name, location, use, and description/typology; gross area, duration, and construction cost; BIM objectives/uses; roles and responsibilities; software and platforms used; collaboration procedures; modeling procedures; quality management and risk analysis. From this portfolio, the competitor must ensure, if requested by the contracting authority, one or more visits to ongoing or completed projects;

m) Recommendation letters from contracting entities regarding BIM services.

(*) Whenever applicable, explicitly differentiate between what pertains to the competitor or to the subcontracting entity/entities."

Appendix 2. Competency and capacity assessment forms, at the tenderer and tender proposal levels.

Assessment form – **Tenderer**

Notes		
This form must be filled out for each company involved in the BIM process, including subcontractors. This form does not exempt the submission of the remaining qualification documents as required in the tender document.		
Ref	**Company information**	**Description**
1	**Identification**	company identification
1.1	Name	
1.2	Activity	
2	**BIM Experience**	Experience in project development using BIM processes
2.1	Number of years of experience	(number of years of experience in BIM implementation)
2.2	Number of projects	(number of projects developed in BIM)
2.3	Key projects	(name, state, location, construction amount, gross construction area, type of use, BIM objectives/uses, functions, and assumed responsibilities)
3	**Human Resources**	Description of the human resources involved in the company's BIM process
3.1	Total number of employees	
3.2	Number of employees with a higher qualification level	
3.3	Number of employees with BIM training	
3.4	Internal BIM team organization? (if applicable)	(to be complemented with a functional organizational chart)
4	**BIM Process**	Description of the company's BIM process
4.1	Status	(implemented; in Implementation; not Applicable)
4.2	Description	(describe the BIM process, if applicable)
4.3	Certification	(is the BIM process covered by any certified system?)
4.4	Standards used	(which standards are used in the context of the BIM process?)
4.5	BIM uses	(applicable BIM uses?)
4.6	Levels of information	(management process?)
4.7	Modelling criteria	(same as above)
4.8	Coordination/clash detection	(same as above)
4.9	Information classification	(same as above)
4.10	BIM 4D and beyond dimensions	(same as above)
4.11	Interoperability	(same as above)

5	**Collaborative Work**	Description of collaborative work in the company
5.1	Common data environment	(collaborative platforms used; management of authorization system and security; use for document management and synchronized modeling)
5.2	Document management	(policy and processes defined; version control and permissions; intra- and inter-organizational sharing)
5.3	Synchronized modelling	(same as above)
5.4	Task management	(technologies used at the individual and team level)
5.5	Communication management	(technologies used at the intra- and inter-organizational level)
5.6	Email management	(technologies used at the organizational/project level)
6	**BIM Software**	Description of BIM software used in the company (name and number of licenses)
6.1	Modeling	(specify by discipline, if applicable)
6.2	Coordination/Clash Detection	
6.3	Planning	
6.4	Budgeting	
6.5	Energy Analysis	
6.6	Asset Management	
6.7	Other	(specify by discipline, if applicable)
7	**IT Infrastructure**	Description of the company's infrastructures
7.1	Servers	(on-premise/cloud-based?)
7.2	Backups	(policy and processes for backup management)
8	**Open-ended Questions**	
8.1	What BIM technologies does your organization use, and how have they been applied in projects??	
8.2	Which companies have collaborated with you in creating, modifying, and updating information models?	
8.3	What lessons have been learned, and what metrics have been used in projects regarding the use of BIM models and tools?	
8.4	How many people in your company are aware of BIM tools, and how are employees educated/trained?	
8.5	Does your organization have specific titles/roles related to BIM?	

Assessment form – **Tender proposal**

Notes
This form must be filled out for each company involved in the BIM process, including subcontractors. This form does not exempt the submission of the remaining qualification documents as required in the tender document.

Ref	**Proposal information**	**Description**
1	**Identification**	company identification
1.1	Name	
1.2	Activity	
2	**Services**	Services to be provided by the company
2.1	Project phase	Preliminary Study/Licensing/Technical Design/Construction/..
2.2	Scope of services	(separate external and internal service providers, if applicable; e.g., Provider A: BIM modeling for MEP)
2.3	BIM objectives/uses	
2.4	Price	(overall, fixed, and non-revisable amount)
3	**Human Resources**	Summary of human resources assigned to the BIM Project
3.1	Internal employees to be assigned	(roles)
3.2	External employees to be assigned	(companies and roles) - if applicable
3.3	Number of employees with a higher qualification level	(separate external and internal, if applicable)
3.4	Number of employees with BIM training	(separate external and internal, if applicable)
4	**BIM Process**	Description of the proposal's BIM process
4.1	Description	(describe the BIM process)
4.2	Standards used	(which standards are used?)
4.3	Leves of information	(management process?)
4.4	Modeling criteria	(same as above)
4.5	Coordination/Clash detection	(same as above)
4.6	Classification of information	(same as above)
4.7	Interoperability	(same as above)
5	**BIM Software**	Summary of software to be used (name and number of licenses)
5.1	Modeling	(specify by discipline, if applicable)
5.2	Coordination/Clash Detection	
5.3	Planning	
5.4	Budgeting	
5.5	Energy Analysis	

5.6	Asset Management	
5.7	Other	(specify by discipline, if applicable)
6	**Hardware**	Summary of the hardware to be used
6.1	Computers	(main features of PCs)
6.2	Others	(description of other devices - e.g., tablets)

Appendix 3. BIM-specific provisions to be incorporated into the special clauses of the specifications document for construction contracts.

Responsibility Assignment Matrix

-The design model responsibility matrix is as follows: In cases where there is more than one responsible entity for the same model, the responsibility of each design element is identified within the model using a dedicated parameter called "XX". The term "Outputs" refers to drawings and bills of quantities.

Ref	BIM Model	Disciplines	Responsible Parties		XX
			Modeling	Outputs	

Technical Design

-Throughout the execution of the construction works, the contractor should submit proposals for variations or additions to the project design, changes to solutions, or construction details based on the predefined BIM methodology.

- After completing the construction works, the contractor is required to deliver the "as-built" models to the contracting authority in accordance with the predefined BIM requirement.

Other Contractor Responsibilities

-The contractor is obligated to ensure the implementation of the BIM methodology in accordance with the Exchange Information Requirements (EIR).

-In response to the EIR, the competitor must prepare and present proposals for the BIM Execution Plan (BEP) and the Master Information Delivery Plan (MIDP) - pre-contract BEP and MIDP. These proposals may require review and adaptation both during the tender stage and during the post-award phase - post-contract BEP and MIDP.

-The contractor is obligated to participate in both periodic and special meetings and to ensure all necessary information exchanges within the scope of the BIM process.

-The development of the technical compilation of construction works must be supported by the BIM process, encompassing various aspects, including but not limited to: digital support for "as-built" records; consideration of existing site and environmental constraints; inclusion of technical information about installed equipment relevant for risk prevention in terms of usage, conservation, and maintenance; and the provision of useful information for health and safety planning regarding the potential future execution of construction works at site locations.

-The contractor is also required to integrate, supported by the BIM process, information from the previous construction contracts' elements, that are integral to the buildings' permanent operation, into the technical compilation.

-The contractor is obligated to ensure a security-minded approach to information management in accordance with EN ISO 19650-5.

Preparation and Planning of the Construction Works

-The preparation and planning of the construction works must adhere to the specified EIR, which include a work plan, construction drawings, and constructive details.

-The partial and cumulative deliveries of the "as-built" BIM models, as outlined in the information delivery plan or MIDP, ought to align with both the interim and binding construction delivery dates.

Supervision and Control

-The contractor is required to assemble a BIM technical team possessing the necessary competencies and capabilities to fulfil the EIR. At a minimum, the roles of BIM manager, BIM coordinator, and BIM modeler must be ensured.

-Information exchanges following on-site technical assistance, provided by the design team, should be carried out based on information derived from the BIM process.

Appendix 4. Exchange information requirements (EIR) framework for construction contracts.

1. GENERAL PROVISIONS

1.1. This document aims to establish the general and specific requirements that the **CONTRACTOR** must adhere to for the implementation of the Building Information Modelling (BIM) methodology within the scope of the (designation of the construction works) associated with the (construction project name).

1.2. The requirements are organized into three types: general requirements, management requirements, and technical requirements.

1.3. The following designation will be added to this document clauses:

BIM MANAGER	The company nominated by the client for managing the BIM contracts and overseeing the execution of the respective works is: (company name)

1.4. In response to the requirements outlined in this document, the bidder is required to prepare and present a proposal for the BIM Execution Plan (BEP).

1.5. The specifications of the technical design BIM deliverables are provided in (attach BIM technical design specifications).

1.6. The bidding BIM elements can contain errors, but the **CONTRACTOR** cannot use these errors as a basis to evade the complete implementation of the recommended BIM practices. Therefore, it is the responsibility of the **CONTRACTOR** to seek full clarification before following instructions and to make the necessary corrections, when applicable. The **CONTRACTOR** is thus directly accountable for the consequences of any errors, unless it is demonstrated that he acted without intent or negligence inconsistent with the necessary knowledge of the BIM processes, and such a demonstration is also accepted by the **BIM MANAGER** or the **CLIENT**.

1.7. Any non-conformities arising in the context of implementing BIM requirements will be the sole responsibility of the **CONTRACTOR**, regardless of the BIM processes and tools adopted. Therefore, the **CONTRACTOR** assumes full responsibility for the products and services delivered within the scope of the contracted BIM process.

1.8. During the construction works, requests for clarification within the scope of the BIM process must be directed to the **BIM MANAGER**, using the template defined by the **BIM MANAGER** for this purpose, or an equivalent alternative proposed by the **CONTRACTOR**, up to 30 (thirty) days after contract signing, for validation by the **BIM MANAGER**.

1.9. The **BIM MANAGER** or the **CLIENT** reserves the right to instruct the changes they wish within the scope of the BIM process, with the necessary agreement of the **CONTRACTOR**, especially concerning any price adjustments.

1.10. The **CONTRACTOR** commits to keeping the BIM modeling up to date with all design changes, without seeking compensation.

1.11. In case of ambiguity, this document takes precedence over the general and special clauses in the specifications regarding the BIM process.

1.12. The bidder and the **CONTRACTOR** commit to ensuring all the competencies and capabilities required to understand and respond to all BIM conditions and specifications within the scope of this bidding process and the project. The **BIM MANAGER** shall not be responsible for providing clarifications related to the fundamentals of BIM methods, standards, and technologies.

1.13. The BIM methodology to be applied aligns with maturity level 2, as per ISO 19650.

1.14. Payment for BIM services will be made according to the following terms:

1.14.1. Payment for BIM services to the **CONTRACTOR** will be made upon the submission of monthly invoices, issued based on the records of contractual works completed each month, previously approved by the **CLIENT** or its representatives. The respective amounts will be calculated based on the contracted unit prices and the quantities carried out, totally limited to the contracted budget.

1.14.2. The justification for the provided BIM services will be prepared in a monthly report with a format to be proposed by the **CONTRACTOR** and approved by the **BIM MANAGER** or the **SUPERVISOR**.

1.14.3. The **CLIENT** reserves the right not to make any payments for BIM services carried out by the **CONTRACTOR** if their quality does not correspond to what is contractually established.

1.14.4. Services that are not executed, even though they were planned and awarded, will be considered as deductions from the total awarded value, and this situation will necessarily result in the deduction of the respective amount.

1.14.5. After the award, the **CLIENT** may decide on reductions in BIM services, which will be reflected in changes to the bill of quantities, without this serving as grounds for any claims.

2. NORMATIVE FRAMEWORK

2.1. For the development of the BIM process, in cases where this document is silent and whenever applicable, the **CONTRACTOR** must adhere to the specifications defined in the following documents, to the latest version: (specify applicable normative references)

EN ISO 16739	Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries
EN ISO 21597	Information container for data drop - exchange specification
EN ISO 12006-2	Framework for classification
EN ISO 12006-3	Framework for object-oriented information (International Framework for Dictionaries - IFD)
EN ISO 23386	Methodology to describe, author and maintain properties in interconnected dictionaries
EN ISO 23387	Data templates for construction objects used in the life cycle of any built asset
EN ISO 16757	Data structures for electronic product catalogues for building services
EN ISO 29481	Information Delivery manual (IDM)
EN ISO 19650	Information Management using Building Information Modelling
EN 17412	Building Information Modelling - Level of Information Need
Uniformat	Uniformat construction classification system - Construction Specifications Institute
Omniclass	Omniclass construction classification system - Construction Specifications Institute
BIMForum LOD Specification	Level Of Development (LOD) specification for building information models
COBie	Information exchange standards - National BIM Standard - United States

2.2. If this document and the documents referenced in clause 2.1 do not establish the practices to be adopted, the practices agreed upon by the **CONTRACTOR** and the **BIM MANAGER** will be considered.

3. INFORMATION REQUIREMENTS

3.1. Commercial requirements

3.1.1. BIM objectives and uses

3.1.1.1. The primary objectives of implementing the BIM methodology in the current context are as follows:

i. Improve the effectiveness, efficiency, and quality of information production, extraction, and management, thereby supporting decision-making and risk management;

ii. Support the bidding process by analyzing design, planning, and budgeting for construction, thus optimizing costs and timelines;

iii. Facilitate the monitoring and control of the construction project concerning costs, schedules, quality, safety, and health;

iv. Streamline the survey, analysis, preparation, and implementation of construction solutions;

v. Assist in the coordination and harmonization of the project, facilitating communication and collaboration among various stakeholders and harnessing the study and implementation of functional and optimized solutions;

vi. Integrate the development of the technical compilation of the construction works, which will include an "as-built" model with the aim of progressing to the building's operation and maintenance phase.

3.1.1.2. BIM uses define the applications, simulations or activities intended to be implemented by the **CONTRACTOR** within the BIM process. The bidder shall propose the processes and procedures suitable for implementing the specified BIM uses, while adhering to the clauses defined in this document. The list of BIM uses to be implemented are the following:

i. Modeling

-The **CONTRACTOR** is responsible for developing and updating BIM models in terms of both geometric and non-geometric information, in accordance with the design and construction needs for modification, preparation, monitoring and control, while aligning with the specified BIM uses.

ii. Design Analysis

-The bidder and the **CONTRACTOR** shall analyze the technical design and they may propose variations or additions in order to optimize construction solutions and construction costs.

-Proposals should be made based on the BIM models, using both 2D and 3D drawings with realistic visualizations and color codes to facilitate interpretation, along with material schedules.

iii. 3D Coordination/Compatibility

-The **CONTRACTOR** will be responsible for integrating and coordinating BIM models from the different disciplines, analyzing potential conflicts and proposing compatibility solutions at the following times: with sufficient lead time to avoid interfering with the ongoing activities; at the partial deliveries specified in the master information delivery plan (MIDP); at the delivery of As-Built models; whenever significant changes occur in at least one of the design models; and when requested by the **BIM MANAGER** or the **CLIENT**.

-Conflict analysis and proposed solutions must be documented in a dedicated report using a structure pre-approved by the **BIM MANAGER**. The proposed structure should be submitted for approval within 15 (fifteen) days following the contract signing. The **CONTRACTOR** is responsible for incorporating the approved solutions into the BIM models.

-The coordination report must be accompanied by the corresponding federated model, encompassing all project disciplines.

iv. Quantity Takeoff/Cost Control

-Within the scope of this bidding process, the bidder must consider the bill of quantities in relation to the modeled BIM objects, whenever applicable, through the bill of quantities references and object classification.

-During the construction works, quantity assessment, for tasks such as work progress control and the preparation of new work proposals and measurement certificates, must be performed by the **CONTRACTOR**, considering the BIM models, whenever applicable. The measurement certificate template to be used will be previously agreed upon between the **CONTRACTOR**, the **SUPERVISOR**, and the **BIM MANAGER** and should be based on the structure of the bill of quantities released in the tender, including the object classification corresponding to each bill of quantities item.

-The **CONTRACTOR** is obligated to illustrate the geometry and clarify the quantities derived from the BIM models to support the measurement certificates.

-The quantity takeoff should be carried out in accordance with the modeling and coordination criteria defined in the technical requirements of this document.

-All additional works must be reflected in the BIM models and related elements.

-Schedule information in the BIM modeling files must be kept up to date throughout the construction works, following the presentation format initiated in the design phase, with any adjustments ordered by the **BIM MANAGER**, thus considering the impact of any changes resulting from the design or construction.

-The bidder shall propose the use of a method, program, and/or plugin to streamline the connection between the extracted quantities and the corresponding costs.

-Material approval requests must be accompanied by a report extracted from the BIM models containing the following information: object/material classification, spaces/zones to which they pertain, and quantities. The **BIM MANAGER**, the **SUPERVISOR**, or the **CLIENT** may request additional information. The report model should be submitted for approval by the **BIM MANAGER** within 15 (fifteen) days after contract signing.

v. Planning/4D Simulation

-The bidder must establish a connection between the work schedule and the BIM models. This aims to create a simulation of the construction planning, resulting in an animation to be made available in video format.

-After awarding the contract and whenever requested, any revisions to the work schedule or BIM models must be incorporated by the **CONTRACTOR** into the conection between the two. This updated version, which should lead to a simulation provided in an editable format and in video format, will be submitted for approval by the **BIM MANAGER**.

-The **CONTRACTOR** must use 4D simulation to assist in work progress tracking (identifying tasks delayed or ahead of schedule).

-The bidder shall propose the use of a method, program, and/or plugin to streamline the connection between the 4D simulation and quantities and costs.

vi. Construction Site Preparation

-The **CONTRACTOR** must use BIM models to support the preparation, analysis, approval, and implementation of construction solutions, as well as for any proposed changes to the technical design.

-For the preparation of reinforced concrete structures, the **CONTRACTOR** is required to create an independent BIM model.

vii. Meetings

-Meetings during the construction works should be facilitated by suitably updated BIM models, prepared in accordance with the agenda of the meeting.

viii. Laser Scanning Survey

-The **CONTRACTOR** must utilize laser scanning technology for surveying all spaces and elements deemed necessary and convenient for the accurate definition of the “as-built” models, with a particular focus on construction parts that will be concealed or have limited accessibility during the operation and maintenance phase. The planning of this survey must be integrated into the MIDP.

-During the construction works, the **BIM MANAGER** or the **SUPERVISOR** may request additional surveys beyond those originally planned for monitoring and project control purposes.

-The surveys conducted must be georeferenced and delivered in their native and processed formats, compatible with the BIM software to be used. Additionally, a report, the template of which must be submitted for approval by the **BIM MANAGER** within 30 (thirty) days after contract signing, should be included. This report should clearly include the mapping of intervention areas, a description of the equipment and personnel used, any limitations encountered, and the results obtained.

ix. <u>Safety and Health</u>

-The **CONTRACTOR**, for the development of the safety and health plan, which includes specific safety procedures, and for the monitoring reports, should, whenever justifiable and upon request by the **BIM MANAGER**, utilize BIM models to extract the necessary information, including the production of realistic 3D visualizations to assess, prevent, and address potential risks.

x. <u>As-Built</u>

-The **CONTRACTOR** must use the "as-built" BIM models as a basis for creating the technical compilation of the construction works, ensuring the accurate location and the appropriate geometric and visual characterization of objects. This includes the proper definition of spaces, systems and equipment. The levels of geometric and non-geometric information, to be determined as outlined in the technical requirements of this document, will enable the extraction of the necessary and sufficient information for quantity takeoffs, fabrication, installation, and maintenance purposes.

-The delivery of the "as-built" models, which is the responsibility of the **CONTRACTOR**, should be accompanied by a 3D coordination report, as stipulated in section iii. This report should not contain any outstanding issues. Additionally, the **CONTRACTOR** must provide a comprehensive list of all software programs, plugins, and other supplementary tools that have been utilized in the BIM process, specifying their versions.

-The **CONTRACTOR** is obligated to provide explicit photographs of technical installations and produce a complete compilation report, with special attention to installations that will be concealed or have limited accessibility in the final phase. The photographs should be organized into separate folders by floor and labeled according to the following nomenclature: "Space Name" (Name) - "Space Reference" (Number) - "Location" For example, "Circulation-10-EastCorridor."

-All documentation related to installed equipment, such as technical data sheets and manuals for installation, operation and maintenance, must be organized in a separate folder and cross-referenced to the respective BIM model using the type parameter Description, considering the following nomenclature: "Date of Record" - "Project/Building Code" - "Classification (Shared parameter)"_"Equipment Type (Type Mark)"-"Description." For example, "20201229-XXX-ME-UIN-AG_UIN01-Operation/Installation/Maintenance/TechnicalSheet."

xi. <u>Facility Management</u>

-The BIM Facility Management (FM) models to be provided by the **CONTRACTOR** will be derived from the "as-built" models by removing details, sheets, and other secondary information for their integration into a Computer-Aided Maintenance Management System (CMMS).

-This delivery should adhere to the criteria for geometric and non-geometric information as specified in the technical requirements of this document.

3.1.2. Ownership of information

-The property rights to all information produced in the application of the BIM methodology will belong solely and exclusively to the **CLIENT**. In this sense, all parties involved in the production and use of BIM information can only use or modify that information within the context of the contract, or under other conditions that have been explicitly and previously authorized by the **CLIENT**.

3.2. Managerial requirements

3.2.1. Roles and responsibilities

3.2.1.1. The bidder must clearly define the functions and responsibilities of the proposed team, according to the BIM uses, by presenting a responsibility matrix for this purpose. This definition should highlight the identification of a top authority (BIM Manager) and a technical coordination authority (BIM Coordinator) within the scope of BIM services, both of whom, preferably, should be part of the bidder's staff.

3.2.1.2. The **CONTRACTOR** must ensure that a resident BIM technical team is available at the construction site.

3.2.1.3. In the context of BIM services, the **CONTRACTOR** will report to the **BIM MANAGER**.

3.2.1.4. During the execution of the construction works the **CONTRACTOR** will assume the following responsibilities:

i. Collaborate fully with the **BIM MANAGER**;

ii. Ensure the complete compliance with the BIM Execution Plan (BEP);

iii. Not implement changes without prior approval from **BIM MANAGER**;

iv. Keep the BEP up-to-date.

v. Provide all requested clarifications to the **CLIENT** or to the **BIM MANAGER**;

vi. Ensure compliance with information deliveries, as per agreed-upon requirements;

vii. Issue reports;

viii. Prepare meetings with updated and coordinated information models;

ix. Adhere to agreed communication, collaboration, and standardization protocols;

x. Proactively promote innovative initiatives applicable to the contract scope.

3.2.2. Process mapping

3.2.2.1. The bidder must present a process mapping creating two distinct types of maps:

1) Global map: an overall map for the construction works, including BIM uses and major information exchanges;

2) BIM uses maps: detailed process maps identifying the responsible parties for each process, reference information, and information exchanges.

3.2.2.2. The process maps should be created to enhance collaboration among the various stakeholders and the implementation of the specified BIM uses.

3.2.2.3. The processes should be mapped according to the Business Process Model and Notation (BPMN) notation.

3.2.3. Information deliverables

3.2.3.1. The bidder must present a MIDP based on the specified BIM uses.

3.2.3.2. The MIDP shall be organized by BIM uses, by models and disciplines, by levels of information, and by building floors or zones, in line with the construction works schedule.

3.2.3.3. The MIDP shall be consistent with the construction works plan and follow the same premises for its preparation and revision. This plan shall detail the resources allocated to each activity, including the human and technological (hardware and software) types, and provide the expected financial allocations in the form of a billing schedule.

3.2.3.4. The MIDP should outline partial and cumulative deliveries to facilitate the systematic monitoring of the progression of "as-built" BIM models. These deliveries should align with the specific parcel and binding dates defined for project delivery, as presented in the construction works plan.

3.2.3.5. For each delivery, the MIDP should specify the following, in individual columns and in correspondence with the process maps: delivery reference, information exchange designation, responsible for the delivery, recipient of the delivery, and format of the information exchange.

3.2.3.6. Additionally, a summary table of the planned information deliveries should be presented, organized according to the following fields: delivery reference, information exchange designation, responsible for the delivery, recipient of the delivery, format of the information exchange, and delivery date.

3.2.3.7. BIM files must be delivered in their native formats and in an open format (e.g. .IFC, IFC, BCF, COBie, CityGML, gbXML, etc.), whenever applicable. Other exportable formats from the used software, whenever necessary, may be determined by the **BIM MANAGER** during the construction works.

3.2.3.8. The bidder or the **CONTRACTOR** may propose alternative or additional formats that are compatible with the software in use, subject to prior approval by the **BIM MANAGER**.

3.2.3.9. Information exchanges related to written documents should occur in common word processing and spreadsheet formats (.DOCX and .XLSX), in addition to .PDF format.

3.2.3.10. The **BIM MANAGER** or the **SUPERVISOR** may, at any time, request information to be delivered in other formats, and the **CONTRACTOR** must respond to these requests within the specified timeframe to ensure optimal interoperability and collaboration between the involved parties.

3.2.3.11. All information deliveries specified in the MIDP must be accompanied by an Information Approval Request, according to the model defined by the **BIM MANAGER** or an equivalent alternative proposed by the **CONTRACTOR**, within 30 (thirty) days of contract signing for validation by the **BIM MANAGER**.

3.2.3.12. All information deliveries specified in the MIDP must be accompanied by a form with the model breakdown structure and information levels, comparing planned with actual, starting from the model indicated in (attach a standard template).

3.2.3.13. The delivery of "as-built" models, which are an integral part of the technical compilation of the construction works, must be accompanied by a file containing all relevant information produced within the BIM process, from clarifications and family records to coordination reports and BEP updates. The content, organization, and sharing method of this information will be decided by the **BIM MANAGER**, in conjunction with the **CONTRACTOR.**

3.2.3.14. All deliveries will always be subject to the approval of the **BIM MANAGER**, which may request any necessary corrections to ensure the quality of the BIM process.

3.2.3.15. The **CONTRACTOR** is committed to full compliance with the approved MIDP.

3.2.3.16. Any changes to the MIDP will be subject to prior approval by the **BIM MANAGER**.

3.2.4. Common data environment

3.2.4.1. The **CONTRACTOR** agrees to use the platform designated and administered by the **BIM MANAGER**, following the rules and permissions determined by this entity after the contract is signed.

3.2.4.2. Information deliveries will be made through this platform.

3.2.4.3. This platform will serve not only as a repository for information exchanges but also as a collaborative environment to connect various stakeholders and disciplines. In this regard, the **CONTRACTOR** commits to maintaining all BIM models and other information, in the agreed formats, up to date on this platform.

3.2.4.4. When using the platform, long names, accents, special characters, and excessive folder levels should be avoided.

3.2.4.5. The **CONTRACTOR** may not share information from the shared data platform with external users without prior approval and determination of sharing conditions by the **BIM MANAGER**.

3.2.4.6. The **CONTRACTOR** must present a backup plan for the platform coordinated with the MIDP. Backups should be available at any time for platform recovery when needed.

3.2.4.7. The **CONTRACTOR** shall ensure a security-minded approach to information management according to EN ISO 19650-5.

3.2.5. Communication

3.2.5.1. The **CONTRACTOR** commits to participating in all pre-scheduled meetings convened by the **BIM MANAGER** or the **CLIENT** within the scope of the BIM process.

3.2.5.2. Emails regarding the BIM technical coordination of this project should be sent to (…).

3.2.5.3. Email management should follow the following practices:

i. Write emails only when necessary: use emails mainly to formalize positions or conclude matters that have been previously discussed;

ii. Avoid placing users in copy (Cc/Bcc): send messages to strictly necessary users, meaning those you want to inform or request action from. Place users in copy only when necessary or justifiable;

iii. Avoid including attachments: primarily use the shared data platform for information exchanges, following the defined rules. If it is necessary to include attachments in emails, opt for compressed folders (.zip, .rar) in which the desired files are included;

iv. Email subject: avoid using long names, accents, and special characters. Keep the email subject description clear to enable the chaining of information exchanges on the same topic. Adopt the following nomenclature for email subjects: Project Code - Project Phase - Subject.

3.2.6. Quality management

3.2.6.1. The bidder must demonstrate his ability to implement the BIM methodology using quality management techniques for each of the specified BIM uses. Therefore, he must provide all relevant information about the Quality Management Plan (QMP) to be implemented within the BIM processes as part of the tender response. This evidence can be presented as a separate document or integrated within the BIM Execution Plan (BEP).

3.2.6.2. Quality control processes should incorporate specific procedures to ensure the integrity of the modeling in each discipline and must be validated by the **BIM MANAGER**.

3.2.6.3. After signing the contract, the initial QMP may require further development by the **CONTRACTOR**, ensuring necessary coordination with the **BIM MANAGER**.

3.2.6.4. The **BIM MANAGER** may, at any time, specify and request changes to the QMP that it deems necessary or appropriate.

3.2.6.5. The **CONTRACTOR** commits to fully complying with the approved QMP.

3.2.6.6. Any changes to the QMP are subject to prior approval by the **BIM MANAGER**.

3.2.7. Risk analysis

3.2.7.1. The bidder must provide a project risk analysis, either as a separate document or integrated within the BIM Execution Plan (BEP). This analysis must, at least, identify the main risks, their risk level, anticipated consequences, mitigation actions, the frequency of these actions, and the responsible parties.

3.2.8. BIM Execution Plan

3.2.8.1. In response to the requirements specified in this document, the bidder must create and submit a proposal for a BIM Execution Plan (BEP) - the pre-contract BEP. The BEP is a document that outlines the responsibilities and obligations, processes, management and technical procedures required to adequately implement the BIM methodology, in accordance with the requirements specified in this document.

3.2.8.2. In preparing the BEP, the bidder may consider the structure provided in **Appendix 05**. This structure is intended for guidance, since the bidder should submit the proposal he considers most suitable in response to the BIM information requirements specified in this tender process, which will be subject to approval by the **BIM MANAGER**.

3.2.8.3. In case of an award, the pre-contract BEP may need to be further developed by the **CONTRACTOR**, ensuring the necessary coordination with the **BIM MANAGER**, within the deadlines set by the **BIM MANAGER** - post-contract BEP.

3.2.8.4. The **BIM MANAGER** may, at any time, determine and request changes to the BEP, which it deems necessary or convenient.

3.2.8.5. The **CONTRACTOR** is committed to full compliance with the approved BEP, ensuring its updating whenever necessary and determined by the **BIM MANAGER**.

3.2.8.6. Any changes to the BEP are subject to prior approval by **BIM MANAGER**.

3.3. Technical requirements

3.3.1. Software

3.3.1.1. The bidder shall propose software to be used in the BIM process that enables open collaboration through digital workflows based on vendor-neutral formats. The proposal will be subject to approval by the **BIM MANAGER**.

3.3.1.2. The software proposed by the bidder does not exclude the possibility for the **BIM MANAGER** to recommend the utilization of additional programs or plugins to meet the established BIM uses more effectively and efficiently.

3.3.1.3. All software, programs, or plugins must be used in the version designated by the **BIM MANAGER**. Therefore, at any time, updates to the software in use may be requested by the **BIM MANAGER**.

3.3.2. Technological infrastructure

3.3.2.1. The bidder must provide a list identifying all the hardware and software proposed for use in the BIM process. This list should include users and their roles, minimum and recommended requirements, and the proposed capacity to meet these requirements.

3.3.2.2. The previous list must be kept up to date by the **CONTRACTOR** throughout the contract.

3.3.2.3. The bidder should consider the most suitable hardware for the selected software and any additional programs or plugins, ensuring maximum efficiency in collaboratively meeting the specified BIM uses.

3.3.3. Training

3.3.3.1. The bidder and the **CONTRACTOR** commit to ensuring all the necessary and sufficient skills to understand and effectively respond to BIM requirements. In this regard, the **BIM MANAGER** or the **CLIENT** will not provide any training as part of the BIM methodology implementation.

3.3.4. Technical support

3.3.4.1. The **BIM MANAGER** will provide specific support for the installation and use of the collaborative platform.

3.3.5. Surveys, inventories, and existing information

3.3.5.1. All existing information, whether topographic or related to buildings, must be georeferenced and delivered in formats that allow their reading and integration into the developing BIM models. The planning of these deliveries must be integrated into the MIDP.

3.3.6. Geometric Information

3.3.6.1. The bidder must submit their proposal for the levels of geometric information for the Construction, As-Built, and Facility Management (FM) models based on the specifications for each discipline and in compliance with the format outlined in (attach a standard template). Regarding the FM models, the bidder should prioritize elements for preventive maintenance over corrective maintenance.

3.3.6.2. The Construction models involve the modeling, based on the technical design components, of all elements deemed necessary for the execution of the established BIM purposes. These models must be submitted within 60 (sixty) days of contract signing and will be developed by the **CONTRACTOR** according to criteria determined or previously approved by the **BIM MANAGER**.

3.3.6.3. The required level of geometric information must be determined with reference to the EN 17412 standard and should never be less than that of the technical design.

3.3.6.4. The proposed levels of information must ensure the proper preparation of the models for the established BIM uses.

3.3.6.5. The **CONTRACTOR** agrees to comply with the agreed-upon levels of geometric information in the event of any design changes that involve work of a foreseen nature, or to propose other levels of information subject to approval by the **BIM MANAGER**.

3.3.6.6. The **CONTRACTOR** must ensure the transformation of As-Built models into FM models following best practices and conditions previously defined and decided by the **BIM MANAGER**.

3.3.7. Federation, Modeling and Coordination criteria

3.3.7.1. BIM modeling should maintain the breakdown structure already derived from the technical design stage. Additionally, the bidder may propose breaking models down into subparts, whenever justified to improve model operability. In such cases, a model breakdown structure must be defined and presented.

3.3.7.2. In implementing the BIM uses, the contractor must also maintain consistency in the BIM modeling and coordination criteria derived from the technical design stage for all disciplines.

3.3.7.3. Spatial coordination should consider the following dimensions: hard, where two objects occupy the same space; soft, where one object occupies the operation and maintenance space of another object; and time, where two objects are present in the same space at the same time.

3.3.7.4. The **CONTRACTOR** must ensure spaces necessary for equipment and verify their compatibility with the surroundings.

3.3.7.5. Any changes to modeling and coordination criteria during the construction phase require prior approval from the **BIM MANAGER**.

3.3.7.6. The **CONTRACTOR** shall adhere to the modeling tolerances defined by the project designers.

3.3.7.7. Models from different disciplines shall be interconnected through the designated collaborative platform and in accordance with defined precedences, thus facilitating the coordination process.

3.3.7.8. The **CONTRACTOR** must verify the parametrization of BIM objects is most suitable for the BIM uses to be implemented and the agreed-upon information levels, in accordance with EN ISO 12006-3.

3.3.8. Non-geometric information and object classification

3.3.8.1. The **CONTRACTOR** shall ensure, for all BIM models and BIM uses, the correct application of the classification system(s) under specified parameterization conditions, nomenclatures, codes, and other criteria derived from the technical design stage and as specified by the **BIM MANAGER**.

3.3.8.2. The bidder and the **CONTRACTOR** can and should propose parameters, whether system-based or customized, for objects to receive applicable and relevant non-geometric information for the prescribed BIM uses.

3.3.8.3. The **CONTRACTOR** may propose new codes to classify objects, following the logic of codes and nomenclatures of the discipline or related disciplines, in accordance with the prescribed classification system(s).

3.3.8.4. The bidder and the **CONTRACTOR** may propose the application of complementary classification systems, preferably internationally recognized and aligned with the principles of ISO 12006-2.

3.3.8.5. The use of other systems or parameters or new codes for information classification must always be subject to prior approval by the **BIM MANAGER**.

3.3.8.6. The bidder must ensure that the proposed levels of non-geometric information serve the proper preparation of the models for the stipulated BIM uses.

3.3.8.7. The **CONTRACTOR** undertakes to classify all new objects, as well as to ensure the correction of the classification of all objects derived from the design stage.

3.3.8.8. The **CONTRACTOR** shall propose, within a timeframe established by the **BIM MANAGER**, a mapping of all modeling parameters designated for Construction Operations Building Information Exchange (COBie) data format parameters, presenting a separate document for this purpose. This mapping will be submitted for approval by the **BIM MANAGER**, who may request any necessary adaptations at any time.

3.3.8.9. Upon delivering the BIM FM models, the **CONTRACTOR** must also provide a COBie data format map for each model/discipline and a global map (consolidating information from all COBie maps) in accordance with the previously approved Modeling-COBie mapping. The **CONTRACTOR** is obligated to complete the maps with all necessary supplementary information, as requested by the **BIM MANAGER** or the **CLIENT**.

3.3.8.10. The **CONTRACTOR** is obligated to comply with the contracted levels of non-geometric information in the event of project design changes that involve foreseen work or to propose other levels of information, subject to approval by the **BIM MANAGER**.

3.3.9. Information extraction

3.3.9.1. Any information extraction should be directly supported by the BIM models, whenever applicable, through parameters of the modeled objects. Alternative methods using formulas or other auxiliary modeling elements, or resorting to traditional procedures, will only be applicable to tasks previously authorized by the **BIM MANAGER**. With alternative methods, the adopted process must be clearly explained when presenting the respective quantities.

3.3.9.2. Information extraction from BIM models should be based on project parameters, system-specific parameters, and/or other specific criteria organized in dedicated schedules, depending on the type of information required.

3.3.9.3. The **CONTRACTOR** is obligated to organize and present any information extraction upon request from the **BIM MANAGER** or the **CLIENT**, in the format designated by them.

3.3.9.4. Regarding quantities, the **CONTRACTOR** must always ensure that all modeled elements have an unequivocal correspondence with the bill of quantities items in the quantity takeoff sheets, and vice versa (whenever applicable).

3.3.10. Coordinate System, References, and Units

3.3.10.1. The **CONTRACTOR** must ensure the adequacy and consistency of the coordinate system, reference axes and levels, and units for all BIM models, as derived from the project design stage.

3.3.11. Industry Foundation Classes (IFC) Format

3.3.11.1. In all information deliveries and exchanges that involve the Industry Foundation Classes (.IFC) format, the **CONTRACTOR** must ensure the quality of information, consistent with the respective native files.

3.3.11.2. The .IFC files must be delivered in the Standard for the Exchange of Product Model Data (STEP) format, in versions IFC4 and IFC2x3, and in the following Model View Definitions (MVD):

IFC4: Reference View and Design Transfer View;

IFC2x3: Coordination View 2.0.

3.3.11.3. The configuration of the .IFC files to be produced may need to be adapted or supplemented with specific properties necessary for their proper reading and use. The **CONTRACTOR** is obliged to make the necessary changes requested by the **BIM MANAGER** in this regard.

3.3.12. Information Layout

3.3.12.1. The **CONTRACTOR** commits to adopting file naming conventions, drawing sheet formats, object styles, and model view settings, among other specifications derived from the technical design stage and as determined by the **BIM MANAGER**. The **CONTRACTOR** may propose alternative solutions, subject to approval by the **BIM MANAGER**.

3.3.12.2. The **CONTRACTOR** shall ensure that, in the project browser of the models, there are two sections, "Working" and "Issuing". In the working view, information can be edited, hidden, and filtered without altering the configuration of the issuing view, which remains independent and can be printed or exported at any time.

3.3.12.3. The **CONTRACTOR** shall ensure view templates for all disciplines derived from the technical design stage, enabling differentiation of various types of elements in different models through color coding. When applicable, the color scheme from the technical design stage must be maintained. Any alternative proposed color scheme for each discipline, considering the prescribed BIM uses and its relationship with the family or type of objects, must be submitted for prior approval by the **BIM MANAGER**.

3.3.12.4. Whenever necessary, convenient, or as requested by the **BIM MANAGER**, the **CONTRACTOR** shall introduce tags in certain views and types of elements, with data from parameters that are relevant for facilitating the reading and interpretation of information.

Appendix 5. Guideline for developing the BIM Execution Plan (BEP).

1. Introduction

-BIM-based project context;

-Applicable standards.

2. Project Information

-General project information;

-Relevant contacts;

-Overall project phasing;

-BIM objectives and uses.

3. Roles and Responsibilities

-Roles and responsibilities of project stakeholders.

4. Process Mapping

-Mapping of BIM processes.

5. Information Exchange Requirements

-Required information levels by discipline.

6. Information Delivery Plan

-BIM-based project development planning;

-Milestones for information exchanges and approvals.

7. Collaboration Procedures

-Shared data platform;

-Worksets/File naming/Drawings presentation/Model views.

8. Modeling Procedures

-Model breakdown structure/Coordinate systems, references and units/Modeling and coordination criteria/Organization and information classification.

9. Quality Management

-Quantity extraction/Project browser and views/Family record/Model verification and control/Risk analysis.

10. Technological Infrastructure

-Software and hardware.